HORIZON 2020
The EU Framework Programme
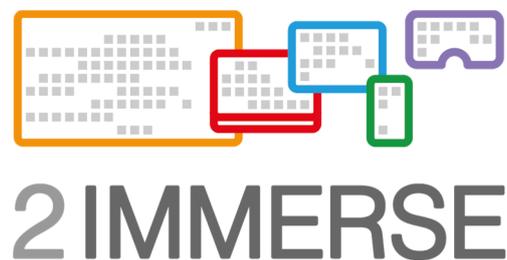for Research and Innovation

Directorate General for Communications Networks, Content and Technology

Innovation Action

ICT-687655

2 IMMERSE

D1.1 - Project Plan
December 2017 Update

Due date of deliverable: 30 Nov 2017

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Lead contractor for this deliverable: **BBC**

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Abstract

This document is a project plan for the 2-IMMERSE project. It is a living document which summarises the progress of the project during the last reporting period in order to present plans for the period ahead.

Target audience

This is a public deliverable and could be read by anyone but is primarily for the benefit of the project team to help coordination and as a record of intended progress for at least the next 6 months. We assume the audience is familiar with television and Internet technologies. This document will be read by the Project Consortium as it implements the infrastructure and the trials to be delivered during the project.

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Executive Summary

This document describes our achievement in 2-IMMERSE between June and November 2017 and outlines our plans for the remainder of the project (from December 2017 to November 2018). It is intended both as a record and summary for the project consortium.

The aim of 2-IMMERSE is to enable multi-screen content services which deliver immersive, customised and shared experiences between homes and in social spaces. We are working to achieve this by developing an extensible infrastructure to support the realisation of customisable multi-screen and shared experiences using object-based media. This is being delivered and tested by building four service prototypes in theatre and sport.

In line with these objectives the outcomes of the project will be:

- an extensible infrastructure to support multi-screen and shared experiences;

- the know-how and tools for producing and delivering object-based multi-screen experiences;

- guidelines for using and extending the infrastructure using industry standard tools;

- four object-based service prototypes in theatre and sport, in homes and in public venues.

To date the project has completed and evaluated one service prototype (Theatre at Home). Lessons from that experience shaped the way we approached the second service prototype (MotoGP) which is now complete and is being evaluated (as of January 2018). In particular we have:

- changed our development approach and devoted considerably more effort to design aspects with a designer leading, and not just being involved with, the definition of the nature of the experience;
- adopted a clear and well-documented acceptance testing methodology, including the instantiation of edge and test servers to enable development and acceptance testing of new features before they are released onto the production platform;
- retained some design ideas that users appreciated within the Theatre at Home service prototype, including the use of the companion screen for control and reference and keeping the main screen to echo strongly the shared experience with which the user is already familiar;
- sought to address some of the deficiencies that users identified in the Theatre at Home service, such as not having enough choice or control over the additional features available in the experience.

The project has refined the software platform used for the delivery of the service prototypes. This refinement included a number of new components to support user identity management, data driven graphics, bandwidth orchestration and an editing service to allow timeline documents to be edited.

In addition the platform was migrated from a private cloud environment to Amazon Web Services; subsequently we migrated the container platform from Mantl to Rancher. These migrations were not in our original plan but their successful negotiation helps illustrate that our architectural approach can accommodate and manage significant changes of host platform.

On the client side we have developed Linux-based HbbTV2.0 emulator firmware that runs on an Intel NUC device to support the prototype services. This device includes:

- an onboarding function that supports user network configuration, sign-in, device pairing, experience discovery and experience launch;

- integrated Wi-Fi router/access point;
- HbbTV2.0 services (App2App server, DVB-CSS server and DIAL server);
- web Kiosk

In parallel the project has concentrated on the design and development of production tools with a focus on live triggering functionality, which has facilitated the authoring of the complex timeline required for the MotoGP service prototype. The Live Triggering Tool is now a working prototype integrated with the 2-IMMERSE platform.

We have three significant variations to report with respect to the service prototypes:

- For the Theatre in School service prototype, we have changed the associate partner (who are the rights holder for the content with which we will work) from Royal Shakespeare Company to Donmar Warehouse.
- We have changed the nature of the football service prototype from being in a pub to being at home.
- We have changed the schedule of delivery of the remaining service prototypes.

In the coming 6 months we intend to:

- complete the evaluation of the MotoGP at Home service prototype;
- continue to work with the Education Department of Donmar Warehouse to understand the requirements and challenges of multi-screen Theatre at School;
- define the UX for Theatre at School, develop wireframes and build the DMApp components;
- finish the definition of the Football at Home service prototype;
- map the requirements of the Football at Home service prototype to the capabilities of the infrastructure;
- conduct a range of system experiments that will show 2-IMMERSE software, including production tools, operating in live outside broadcast production environments for football leading to a full end-to-end live trial;
- define a first draft reference architecture based on the experience in delivering the service prototypes to date;
- continue to work with BT Sport to identify opportunities for using insights from the 2-IMMERSE approach to effect quick wins within the current production environment in order to show that the object-based approach can be embedded in a live production system;
- present 2-IMMERSE results at international conferences including TVX2018, and apply to demonstrate our platform, service prototypes and production tools at key international events including IBC and ICT2018.

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Contents

1   Introduction

The deliverable describes the progress and plans for the project 2-IMMERSE after 24 of the project's planned 36 month duration.

Section 2 provides a range of ways of describing the progress and plans for the project by considering in turn: milestones; deliverables; the schedule for prototype service development and resource consumption.

Section 3 provides a view of the project's progress based on a per-workpackage assessment of the key achievements and Section 4 describes project plans, also on a per-workpackage basis. Much of the detail for these sections has been obtained through a per-partner reporting process. An example of the template used for this has been included in Annex A.

The report is managed through weekly coordination calls. These calls have detailed minutes written in emails. The higher level plans for the whole project are captured in this document the project plan – which receives periodic updates.

Broadly the project has not progressed exactly to plan. Nevertheless the overall shape and ambition of the project remains, in large part, unchanged. The goals of the project still seem attainable and relevant.

2 Overview of progress

Progress within the project can be measured against milestones, against the planned delivery of prototype services and against the intended development detailed in the most recent publication of the project plan.

2.1 Progress measured by milestones to date

The milestones were defined before the project start. As you can see in the table below, all milestones are still relevant. Of the 6 milestones due to have been reached by M24, 4 have been met, 2 are deferred partly due to a planned reorganisation in the order with which the service prototypes are delivered.

#	Title	WP	M	How will we know this has been achieved	Status
1	Scenario demonstrator for school theatre trial	4	9	The proposed design for the school theatre trial will be signed off by the RSC production team in time for implementation of the trial platform.	**Deferred,** due to variation in delivery schedule, to M30 and RSC becomes DONMAR
2	First Technology release	2	10	The first releases of the Distributed Media Application Platform and the Multi-Screen Experience Components will have been delivered (D2.3 & D5.1), in time for the start of the school theatre trial.	**COMPLETED** and available M12
3	Scenario demonstrators for home theatre trial	4	15	The proposed design for the home theatre trial will be signed off by the RSC production team in time for implementation of the trial platform.	**COMPLETED** prior to the implementation of the trials
4	Theatre trials completed	4	18	The results of both the theatre trials will be available in D4.2, and discussions about exploitation will be in progress.	**Deferred**, to M36, as second theatre trial is delayed until Autumn 2018
5	Scenario demonstrator for MotoGP Trial	4	20	The proposed design for the MotoGP trial (based on D4.3) will be signed off by the Dorna Sports production team in time for implementation of the trial platform.	**COMPLETED** on time
6	Second Technology release	2	24	The second releases of the Distributed Media Application Platform and the Multi-Screen Experience Components will have been delivered (D2.4 and D5.2), in time for the start of the MotoGP trial.	**COMPLETED** (technology by M23, deliverables by M25)
7	Scenario demonstrator for football trial	4	28	The proposed design for the football trial (based on D4.4) will be signed off by the BT Sport production team in	**on target**

				time for implementation of the trial platform.	
8	Final Technology Release	2	30	The final releases of the Distributed Media Application Platform and the Multi-Screen Experience Components will have been delivered (D2.5 and D5.3) in time for the start of the football trial. They will also be robust enough for exploitation.	
9	Sports trials completed	4	34	The results of the MotoGP and Football trials will be available in D4.5 and D4.6, and discussions about exploitation and permanent deployment will be in progress.	**Probable delay**, trial should take place in M34 so may be delayed 1 or 2 months

Table 1 Table of milestones with progress statement

2.1.1 Plans - Progress anticipated to May 2018

According to the original schedule, seven milestones should be reached by M30 (May 2018), 4 have been reached so far. We now anticipate that 5 milestones will have been reached though progress towards the outstanding 5 milestones will be made.

Anticipated progress relevant to Milestones due in this period:

- MS1 Scenario Demonstrator for theatre At School Trial
    - Some progress will be made toward this milestones though completion is unlikely. The trial takes place in about M34 (September 2018) and that date is a more realistic target.
- MS4 "Theatre Trials complete"
    - As per MS1, M34 is a more realistic date for achieving this target
- MS7: Scenario demonstrator for football trial"
    - This milestone should be reached. The Football use case is focused on the Key matches in the UK football league. We are hoping to achieve key demos based on one of two Cup Finals taking place at Wembley Stadium in May 2018.

2.2 Progress measured by deliverables to date

The full deliverable list for the project together with the status as of January 2018 are described in Figure 1. This list is essentially the same as the list defined before the project. Previously agreed variations include changing slightly the way the paired deliverables D2.3/D5.1; D2.4/D5.2; D2.5/D5.3 D2.6/D5.4 appear. We had anticipated before the project that it would be sensible to separately describe the components, and the platform. In practice we found it difficult, unwieldy and unwise to force such a distinction. Instead, in each case the D2.x deliverable us a full description of both platform and component software. The D5.x deliverable becomes a video that shows the software in action.

This period we have produced a number of video that are available on the web site (1) and on our YouTube channel (2)

Of the 32 project deliverables, 22 are scheduled for delivery by Month 24. At the time of writing (Month 26):

- 14 of the 22 deliverables due by this date have been accepted

- 8 deliverables are due for assessment this review
  - 3 of these deliverables are re-submissions of previous deliverables following advice from reviewers
  - 5 of these deliverables are being submitted for the first time

	Del.	Deliverable Name	WP	Owner	Type	Diss.	Month	Due Date	Status
1	D4.1	Prototype Service Descriptions: Initial Version	WP4	BT	R	PU	3	01/03/2016	Accepted
2	D2.1	System Architecture	WP2	Cisco	R	PU	4	01/04/2016	Accepted
3	D1.1	Project plan	WP1	BBC	R	PU	6	01/06/2016	Accepted
4	D1.2	Quality Assurance and Review Plan	WP1	BBC	R	PU	6	01/06/2016	Accepted
5	D1.3	Data Management Plan	WP1	BBC	R	PU	6	01/06/2016	Accepted
6	D2.2	Platform-Component Interface Specifications	WP2	Cisco	R	PU	6	01/06/2016	Accepted
7	D6.1	Innovation management tools and initial plan for dissemination, standardisation and exploitation	WP6	IRT	R	PU*	6	01/06/2016	Resubmitted
8	D3.1	General concepts and ideas for multi-screen interaction	WP3	BBC	R	PU	7	01/07/2016	Accepted
9	D2.3	Distributed Media Application Platform: Description of first release	WP2	Cisco	R	PU	10	01/10/2016	Resubmitted
10	D5.1	Multi-Screen Experience Components: Description of First Release	WP5	CWI	R	PU	10	01/10/2016	Resubmitted
11	D1.1	Project plan	WP2	BBC	R	PU	12	01/12/2016	Accepted
12	D1.2	Quality Assurance and Review Plan	WP2	BBC	R	PU	12	01/12/2016	Accepted
13	D3.2	User testing results: Interactions for Theatre	WP3	BBC	R	PU	15	01/03/2017	Accepted
14	D4.2	Theatre trial evaluation results	WP4	BBC	R	PU	18	01/06/2017	Accepted
15	D4.3	Prototype Service Descriptions: First update	WP4	BT	R	PU	18	01/06/2017	Accepted
16	D6.2	Interim report on dissemination, standardisation and exploitation planning	WP6	IRT	R	PU*	18	01/06/2017	Accepted
17	D3.3	User testing results: Interactions for MotoGP	WP3	BBC	R	PU	20	01/08/2017	Accepted
18	D1.1	Project plan	WP3	BBC	R	PU	24	01/12/2017	Submitted to EU
19	D1.2	Quality Assurance and Review Plan	WP3	BBC	R	PU	24	01/12/2017	Submitted to EU
20	D2.4	Distributed Media Application Platform: Description of second release (Doc & Video)	WP3	Cisco	R	PU	24	01/12/2017	Submitted to EU
21	D4.4	Prototype Service Descriptions. Second Update	WP4	BT	R	PU	24	01/12/2017	Submitted to EU
22	D5.2	Multi-Screen Experience Components: Description of Second Release (Doc & Video)	WP5	CWI	R	PU	24	01/12/2017	Submitted to EU
23	D4.5	MotoGP trial evaluation results	WP4	BT	R	PU	27	01/03/2018	TOC prepared
24	D3.4	User testing results: Interactions for Football	WP3	BBC	R	PU	28	01/04/2018	Not started
25	D2.5	Distributed Media Application Platform: Description of Final release	WP2	Cisco	R	PU	30	01/06/2018	Not started
26	D5.3	Multi-Screen Experience Components: Description of final release	WP5	CWI	R	PU	30	01/06/2018	Not started
27	D2.6	Distributed Media Application Platform: Public Software Release	WP2	Cisco	OTHER	PU	34	01/10/2018	Not started
28	D4.6	Football trial evaluation results	WP4	BT	R	PU	34	01/10/2018	Not started
29	D5.4	Multi-Screen Experience Components: Public Software Release	WP5	CWI	OTHER	PU	34	01/10/2018	Not started
30	D1.1	Project plan	WP4	BBC	R	PU	36	01/12/2018	Not started
31	D1.2	Quality Assurance and Review Plan	WP4	BBC	R	PU	36	01/12/2018	Not started
32	D6.3	Final report on dissemination, standardisation and exploitation planning	WP6	IRT	R	PU*	36	01/12/2018	Not started

Figure 1 Full list of the project deliverables (as of January 2018)

2.2.1 Plans - Progress anticipated to May 2018

In the period to M30 (May 2018) 4 additional deliverables are due for completion:

- (M27) D4.5 MotoGP trial evaluation results
  - Completion to date anticipated
- (M28) D3.4 User testing results: Interaction for football
  - Close – Broad details of the user experience design will be agreed by this date but some changes are still to be expected in development. We will try to achieve this deliverable date.
- (M30) D2.5 Distributed Media Application Platform: Description of Final Release
  - This is problematic as the "final version" of the platform will be the one that is also capable of supporting the Theatre In Schools experience. This deliverable should be redefined So it relates to the platform for the football release) or delayed until after the Theatre At School development work has completed (M35)
- (M30) D5.4 Multi screen experience components: Description of second release (this will be the video)

o   It should be possible to deliver a video of the Football at home experience by this date.

2.3   Progress against the schedule for the Prototype Service Development

Prior to this release of the project plan we published the timeline for the delivery of the Prototype Services that is shown in Figure 2. The delivery schedule has again been adjusted to meet the realities of technical delays and of the necessary content access (for the Football Trials) and school access for the theatre in School trials. School term constraints and football season constraints dictate when these trials take place. As can be seen in Figure 3; the football trial is shifted to May when the Wembley finals take place and the School trials shift to September when schools are not doing exams:
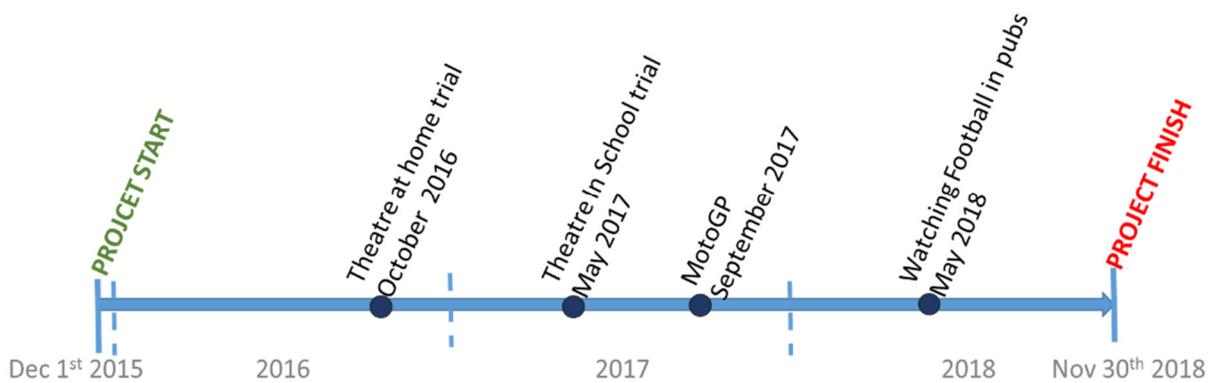
Figure 2 The planned schedule for the delivery of the multi-screen service prototypes as of May 2017

2.3.1   Plans – progress anticipated to May 2018

We presume (and hope) that the development load for both football and Theatre At school trials will start to benefit from the modular software approach and the ability to re-use components developed for previous service prototypes.

Figure 3 The planned schedule for the service prototypes as of January 2018

2.4 Progress against planned deployment of resources

This project is a three year project. The total project budget was €4.76M. If the spend profile is linear and if all partners are spending at the planned rate then the project should be anticipating the effort expended to date to amount to 66% of the total project budget.

At the end of Period 2 all partners went through a review of their effort to date and progress across all packages. All partners completed the forms that can be found in Appendix 3, this allows us to develop and unaudited and forward looking view of project effort expended at the end of year 2 and at the project.

Unsurprisingly actual spend profile is not linear, see Figure 4. Our best estimate of use of resources is that at the end of Nov 2018 the project had applied 61% of the total project resource (nominally 5% under budget).

2.4.1 Plans – progress anticipated to May 2018

Our best estimate of the position at the end of the third year based on estimates of effort that will be applied to the project (the inputs from each partner that allowed us to generate this estimate are include in the Annex. The estimate is that, at project end, the effort expended will amount to 99% of the total project budget.
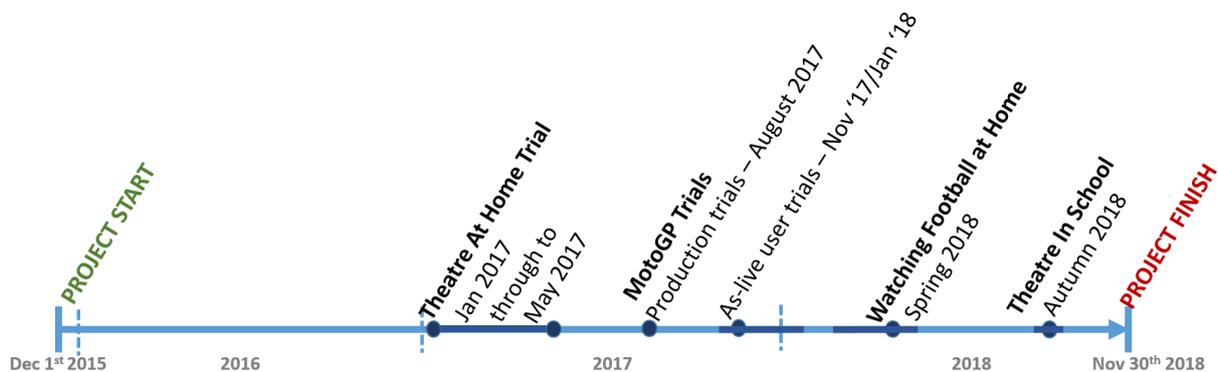
	Total	
Yr1 costs	€	1,157,952.31
Yr2 costs	€	1,742,464.28
Yr3 costs (est)	€	1,792,221.72
Yr 3 Outturn		€ 4,692,638
Budget		€ 4,758,700
Amount of award unspent		€ 66,062
	Total	
Yr1 costs as % of total cost per partner	24%	
Yr2 costs as % of total cost per partner	37%	
Yr3 costs as % of total cost per partner	38%	
Total (% of total award)	99%	

Figure 4 Non- audited estimates of project spend based on inputs from all partners at the end of November 2017

Figure 5 and Figure 6 provide a more detailed analysis of the effort showing the anticipated effort on a per workpackage basis.

Planned Period 3 Effort Per WP

	WP1	WP2	WP3	WP4	WP5	WP6
IRT	0	0	6	1	20	3
Illuminations	0	0	5.5	7.75	0	4.5
CWI	0	5.8	7.9	6.5	22.25	1
Cisco	1.5	15	0	7	4	1.5
CH	1	0	0	9	1	1
BT	2	0	6	6	6	3
BBC	2	3.75	5.5	6	0	4
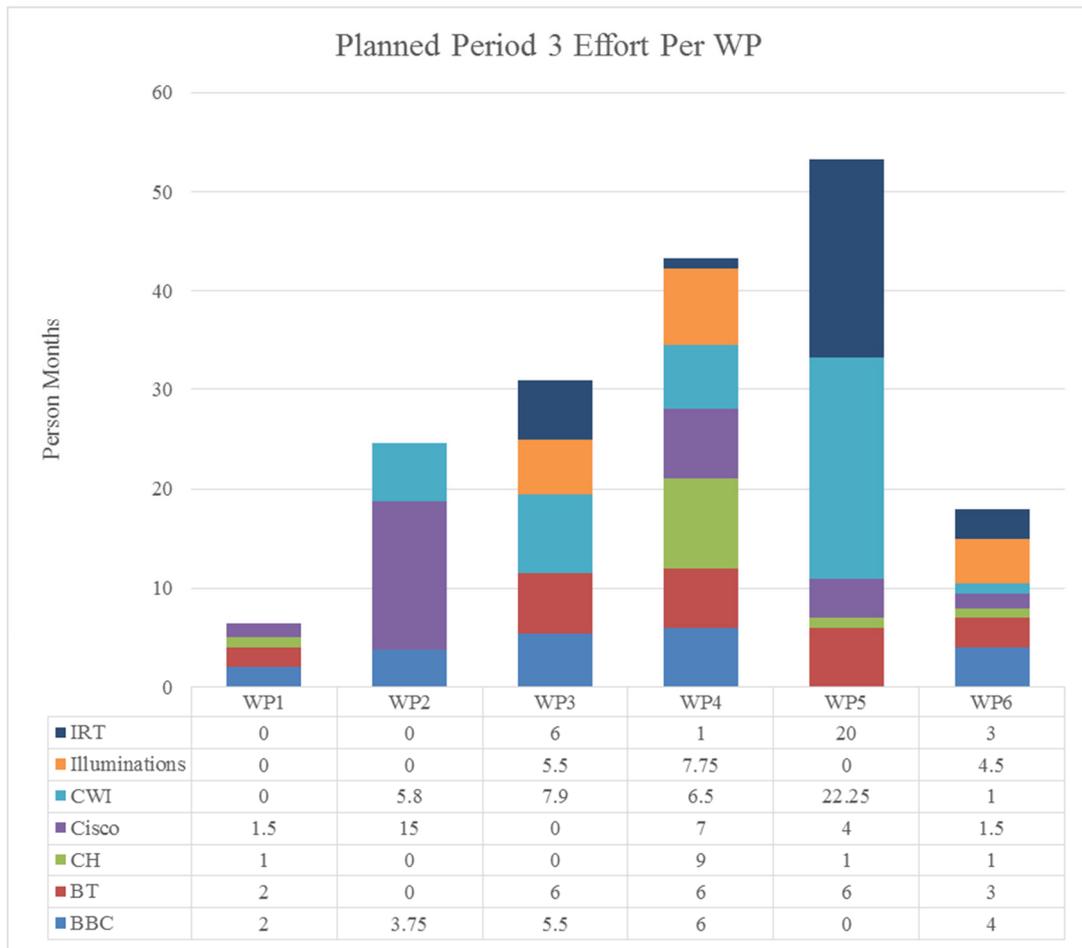
Figure 5 Anticipated spend per partner and per Workpackage for year 3.

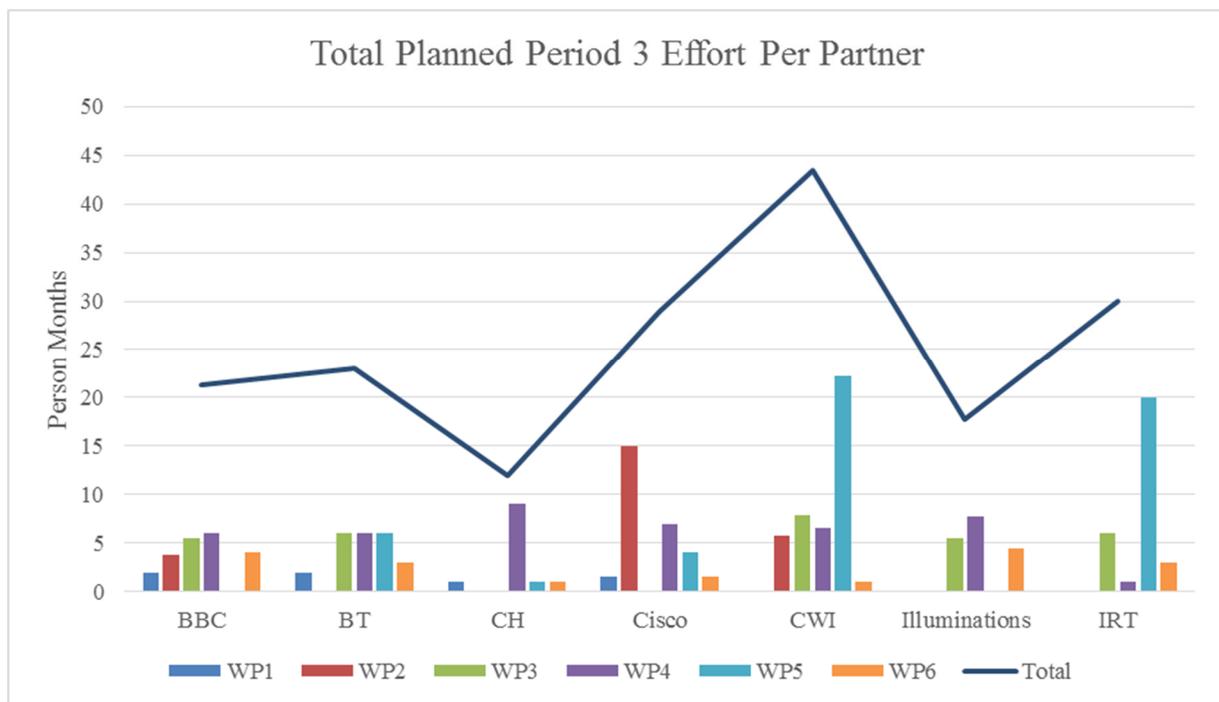Total Planned Period 3 Effort Per Partner

Figure 6 Planned effort per partner per Workpackage for year 3

3 Key achievements

In this section we describe some of the key project plans for the project overall and on a per workpackage. The content of this section is mirrored in the project's Annual Report.

The project is organized in six workpackages. The workpackages work together to achieve the overall project goals as shown in Figure 7 below.
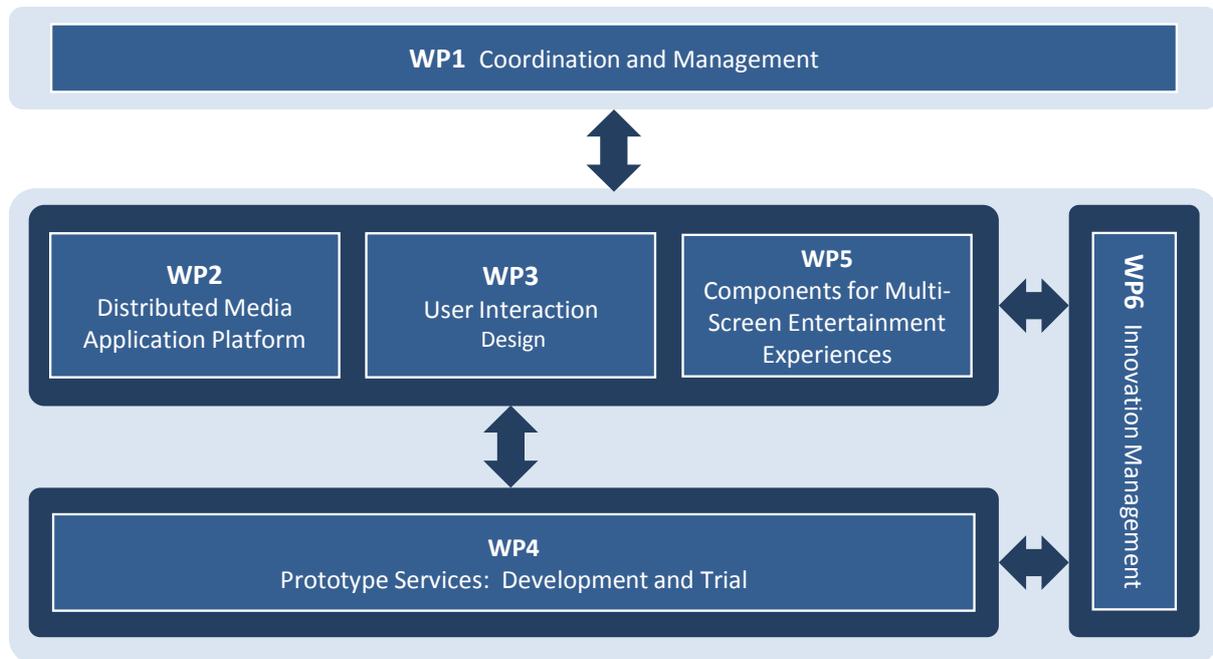

Figure 7 A schematic showing how the six workpackages work together to deliver the project goals.

The project is guided by service prototypes. These provide the requirements for the platform and, through evaluation, show service providers what users think of the experiences and also allow service providers and rights owners to form their own opinions, perhaps nudging them towards adopting some of the principles (object based broadcasting) that underpin what the user sees.

In the first year of the project our work was driven by the project proposal plan, the results of our technical development, lab experiments and collaborations with stakeholders. Key developments in the first project year were the system architecture design, development and deployment of the service platform, carried out lab experiments and built demonstrations some of the capabilities to be enabled in the pilots.

Key technical achievements in the second project year are summarised below, and detailed further in Section 4 of this report:

- Development and deployment of the second release of the service platform to support features for the MotoGP service prototype.
- Migration of the underlying container infrastructure platform from Mantl to Rancher.
- Development of a Linux-based HbbTV2.0 Emulator firmware to run on Intel NUC devices to support service prototypes
- Completed analysis of the Theatre At Home service prototype with a particular focus on divining how this initial prototype could inform the development of subsequent service prototypes.
- Built and showcased a Football in Pubs prototype for BT Sport executives and a list fo high level customers at the BT Innovations event June 2017 (This led to a change in focus to the more commercially important Football at Home Multi screen experience.

- Developed new working relationship with Donmar Warehouse – with whom the project shares many ambitions.
- Developed a 'long list' of technology supported tools that could be used in education to help students learn through engagement with theatre.
- Observed in-school workshops to better understand the way Donmar Warehouse use theatre resources to achieve educational goals.
- Requirements gathering for MotoGP completed including observation of production process at Silverstone. Pre-Live and Live tools included.
- MotoGP visual demonstrator at BT Innovation conference (June 2017)
- MotoGP prototype demonstrated at New Scientist Live event (September 2017)
- Watching MotoGP at home kit designed, created and then distributed.
- Moto GP As-Live service prototype demonstrator built and distributed for evaluation through in-home trials.

The main objectives for the second reporting period were to design and conduct the first 2 scenario trials for Theatre at Home and MotoGP at Home (WP3 & WP4), and inform both the update and refinement of the Distributed Media Application Platform (WP2) and the specification of the proposed system architecture and its essential components (WP2), the definition of the generic concepts to be applied for user interaction design (WP3) and the definition of the use-case scenarios for the remaining prototypes (WP4), and of the essential components for a multi-screen experience (WP5).

An updated strategy for the future exploitation and dissemination of results was provided (WP6), and the project published several articles, blog posts, videos, papers and other dissemination material. The project website was enhanced with new capabilities and the project's deliverables were made available to download from there.

In addition, comments received from the reviewers at the first periodic review in February 2017, and subsequently at the interim technical review in June 2017 were addressed, and relevant deliverables updated and resubmitted as required.

3.1   Achievements of Workpackage 1 – Coordination and Management

WP Lead	BBC
Objectives	To oversee the management of the project and provide administrative and financial coordination.
Deliverables in the period	D1.1, D1.2, D1.3 (second iteration)

3.1.1   Consortium management

The project holds weekly telcos, where progress to date is discussed and any issues arising are flagged. Separately, the project also holds regular telcos for members of specific technical teams to discuss technical issues. At times close to particular key milestones it is not uncommon for the team to have daily stand up calls to ensure timely progress.

The project held 4 face to face consortium meetings in the period, where all partners were represented, and which included a Project Management Committee Meeting, per the governance terms outlined in the project proposal.

Partners are working well together, and close collaboration has been apparent in the production of all the deliverables under each of the workpackages.

This document, and the accompanying Part A of the Periodic Report, were produced in preparation for the Second Periodic Review due to take place on 25 January 2018.

An important development in the course of this year has been staff changes at the BBC, which have affected the overall coordination of the project. Due to internal reorganisations and changes in staff allocation and responsibilities, the BBC's key coordinating contacts for 2-IMMERSE, Phil Stenton and Hélène Waters, have moved to new roles within the organisation, and are therefore no longer able to provide the coordination for 2-IMMERSE. Mark Lomas, who leads the technical work for the BBC has temporarily stepped in as overall coordinator, while a dedicated project manager is being recruited, to take on the role originally fulfilled by Phil and Hélène. It is anticipated that the new project coordinator will be in place in Q1 of 2018.

3.1.2 Data management

In the course of the project's lifespan, data will be collected during experiments and pilots (field trials) exploring the provision and value of multi-screen experiences of drama and sport in private and public venues.

The data will be collected to inform experience design and technology development within and across the pilots: from setting up and configuring multi-screen environments, through signing up for services (on-boarding), enjoying the service and closing down. Guidelines that can be extrapolated beyond the pilot scenarios will also be noted and made public.

Data was collected during the first 2 sets of trials (Theatre at Home, and MotoGP at Home) which took place during the second year. D1.3 "Data Management Plan" (v2.0) was published in January 2018 and updates the description of all of the data generated and collected within the project, and data to be shared, associated metadata and how the data will be stored and made available. For the dataset descriptions we used the official guidelines on Data Management Plan (DMP) from the Horizon 2020 portal.

The contents of this deliverable continue to inform the work of other workpackages, specifically WP3 and WP4 where experimental data is collected and published using these guidelines.

2-IMMERSE will produce a number of technical results resulting from the deployment of 4 pilots and the Dissemination Plan D6.2 discusses the means of promoting those results to the research community and across the industry. The main elements of that plan are open access to scientific publications and open-source releases of 2-Immerse platform software.

The question "*Which data produced and/or used in the project will be made openly available as the default?",* will be outlined later in the project as the research unfolds. Our default intention is to make the results of the project available through Open Source repositories. We are exploring the use of OpenAIRE repository (3). However, in practice we found it easier to clean the code manually, document it, and put it into Github.

3.1.3 Quality Assurance

2-Immerse has built in project-inherent, self-regulating overall measures to encourage inherent quality of the project results. These are described in detail in deliverable D1.2 'Quality Assurance and review plan' and include:

- Encouraging results to be published in peer reviewed journals or conference proceedings as soon as is practical.

- Encouraging results to be presented and demonstrated at recognised international conferences and other events.
- Tracking all dissemination activities via the project repository which provides an easy way of tracing all our dissemination activities and results, and facilitates the process of agreeing on dissemination deliverables and other documents.

3.2 Achievements of Workpackage 2 - Distributed Media Application Platform

WP Lead	Cisco
Objectives	Design and develop a generic platform for delivery of new multi-screen entertainment experiences; provide essential foundation including functions for determining the device environment, delivering and synchronising media and data streams to client, and orchestrating their presentation , for use by innovative components developed within WP5, including media apps, production tools and the User Experience Engine
Deliverables in the period	D2.4

3.2.1 Second release of Distributed Media Application Platform

The second release of the 2-IMMERSE Distributed Media Application Platform, Multi-Screen Experience Components (D2.4) is based on a practical implementation of the system architecture defined in project deliverable D2.1, and the platform component interfaces defined in project deliverable D2.2 both released in Year 1. With the development focus on extending the first release of the platform (which supported the Theatre at Home service prototype), to cover the requirements from the second service prototype (Watching MotoGP at Home), platform development has been focused on the infrastructure, services and client application to support this second service prototype.

Similarly, the development of Production Tools and Multi-Screen Experience Components has been prioritised according to MotoGP requirements.

Technical development therefore focused on extending the first release platform to address the prioritised requirements of this prototype, as expressed in deliverable D4.4.

As the user experience for the MotoGP service prototype was defined, a set of high-level technical requirements for the platform and client application were identified. In some cases, these were clearly new requirements for existing services in the platform architecture or for the re-use of existing DMApp Components at the client, and in other cases they suggested the definition of a new service or set of services, new functionality in the Client API or new DMApp Components.

Early in the development phase, the project team worked closely together to refine these high-level requirements and create a set of prioritised User Experience Key Capabilities for the MotoGP service prototype, which were subsequently listed in D3.3, Section 3.2, with Section 3.4 of the same document providing further details of these capabilities.

When the majority of the detailed design work for MotoGP User Experience had been finished and key enabling work within the platform was well under way, technical delivery was managed through a sequence of technical development milestones. Each milestone represented the completion of a new feature, and its description was used during regular acceptance testing of client and platform functionality. The description included the specifications of the TV Emulator, Companion Device,

network environment and analytics requirements for each milestone. In addition, once a feature was implemented, a simple 'technical sample' DMApp was often developed to show the feature working in isolation prior to integration within the MotoGP DMApp. As would be expected, a degree of iterative development took place as details of the DMApp design were refined, and so the milestone list was updated accordingly.

The following summarises the key technical achievements of the second release:

- Extension of first release platform, to include new services and extend existing services to deliver functionality required by the MotoGP service prototype. New services include:
  - o Auth and Auth-Admin Services – supporting user identity management and authentication.
  - o Data Playback Service – supporting generic methods for the capture, transformation and distribution of production-related non-audio/video data streams.
  - o Bandwidth Orchestration Service – supporting monitoring and management of bandwidth consumed by streaming media components, in accordance with MPEG's Server And Network Assisted DASH (SAND).
  - o Editor Service – supports editing operations to timeline documents via authoring front-end applications, and interaction with the rest of the 2-IMMERSE platform.

- Migration of the service platform from a private cloud environment to Amazon Web Services (AWS) and then subsequently migration from the Mantl container platform to Rancher.

- Development of Linux-based HbbTV2.0 Emulator firmware to run on Intel NUC devices to support service prototypes. Key features include:
  - o Onboarding (supporting user network configuration, sign-in, device pairing, experience discovery and experience launch)
  - o Integrated Wi-Fi router/access point
  - o HbbTV2.0 services (App2App server, DVB-CSS server and DIAL server)
  - o Web Kiosk

- Client API developments to support a DMApp launch configuration document, improve robustness, integration with production tools, bandwidth orchestration, Google analytics, and, improvements to the DMApp component interface.

- Authoring and development of the MotoGP service prototype DMApp and its constituent elements: timeline, layout, HTML and CSS documents, several DMApp components with a focus on data-driven animated graphics, and media asset preparation.

- Production tool development with a focus on the real-time triggering required for the MotoGP scenario, which now is a working prototype integrated with the 2-IMMERSE platform.

As the second instance of a working platform for the delivery of an interactive, object-based multi-screen experience, the second release forms the foundation for the remaining prototypes which will be developed and taken to trial in the final year of the project.

3.2.2 Snapshot of the second release platform and components

3.2.2.1 Service Platform

The service platform architecture has been extended to support features for MotoGP as follows by the integration of new services, and new capabilities added to existing services. The set of services that are integrated and deployed under the second release of the platform are shown below in Figure 8. For clarity, this does not show the underlying infrastructure services, or the common operational support services, which are described in detail in deliverable D2.4.
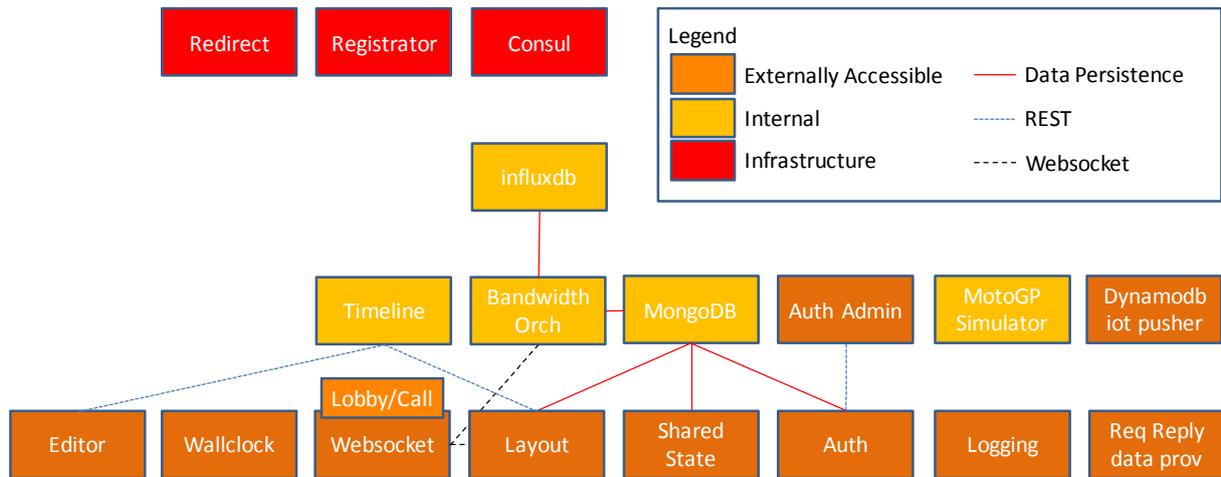
Figure 8 - Service Platform

3.2.2.2   *2-IMMERSE Code Repository (Gitlab)*

The project partners continue to use a set of private repositories hosted on a GitLab server by IRT to manage development of the platform services, client application and DMApp Components.

We have extended our use of the GitLab feature set to support our CI/CD process, including automated service build and deployment to the edge platform instance, and use of container registries

Access to the GitLab repositories can be made available on request.

3.2.2.3   *Container Platform services*

During the last year, we migrated the 2-IMMERSE Service Platform from Cisco's OpenStack-based private cloud platform to AWS public cloud. We have then gone on to migrate from the previous container platform, Mantl, to a new platform, Rancher (still on AWS). The key driver in the decision to migrate from Mantl to Rancher was a lack of ongoing commercial sponsorship of the Mantl project. Rancher provides us with an open-source platform with similar high-level goals to that of Mantl, but with a critical mass of users and a strong roadmap.

We have been able migrate our 2-IMMERSE services to this new infrastructure in a relatively straightforward process (and with minimal changes to our services), and are benefitting from the new container platform. These benefits include: more efficient resource utilisation, the ability to much more simply deploy new platform instances and scale resources accordingly, improved stability and a better integrated operational UX.

3.2.2.4   *HbbTV2.0 Emulator*

For the first release, we adopted a Mac Mini running MacOS X, with local services and Chrome running in Kiosk Mode. Whilst this proved sufficient for the Theatre at Home trials, it was recognised we needed to support the user journey that precedes and follows the actual experience itself, which we generally refer to as 'onboarding'. The requirements for onboarding are detailed in Section 2 of project deliverable D3.3.

For the second release, we have developed a dedicated firmware, built on top of Ubuntu Linux, that supports a number of features including onboarding. In switching to a Linux-based firmware, we are able to more easily build and distribute firmware releases than we were able to for the Mac Mini. For

the MotoGP trials the firmware has been deployed on Intel NUC small form factor PCs. Comprehensive details of the HbbTV2.0 Emulator are provided in Section 5 of deliverable D2.4.

3.3 Achievements of Workpackage 3 – User Interaction Design

WP Lead	BBC
Objectives for the period	To investigate user interaction design issues in order to develop the general interaction vocabulary and mechanisms for interaction with multi-screen productions. Using a consult, design build, test and learn methodology, address each of the three areas of user engagement which are essential to the project: production, configuration and in-the-moment engagement.
Deliverables in the period	D3.2, D3.3

3.3.1 Concepts and Challenges of User Interaction Design

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. For each of the four service pilots to be prototyped and tested there will be a series of UX design activities to inform their design.

We intend the knowledge and design principles generated from this activity to be cumulative across the service pilot trials, iteratively feeding into the next phase through to football in at home. Some design features will be specific to individual trials such as the theatre rituals captured in the 'Theatre in the Home' trials and some general across trials such as multi-screen layout principles and tolerances for degrees of synchronization.

- D3.1, released in Year 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, published in April 2017 reports on the UX-design of the Theatre at Home service. For example, audience requirements gathering, and establishing basic screen layout design across devices.
- D3.3 published in November 2017, 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

3.3.2 UX-Design of the Theatre at Home Service

In order to guide the design of a Theatre in the Home experience and inform the first set of trials to be conducted under WP4, we looked at the experience, practices and rituals of going to the theatre. A small survey was carried out with theatre-goers who responded to the question: "List the processes you recognise as being involved in going to the theatre". The resulting lists where analysed to reveal common topics. Common activities within the theatre were

- Being social: communicating
- Accessing programme material
- Watching the performance

- Responding to the performance

We focused on the 5 stages of the theatre experience in the theatre itself. In each of these phases potential content, services and interaction modes were identified to support the needs of the audience. Potential activities and the services to support them were described. Through this process we understood the timings of service delivery and the need for some services to be available only at certain time on the journey. Hence we implemented a timeline-based delivery where video-chat was only available before and after the performance and during the interval.

This work informed the design of the Theatre at Home service trial, the results of which are described in deliverable D4.2, which gives full details of the methodology and results.

We aimed to provide a sufficient probe to test our hypotheses below, and solicit audience responses regarding the value of features and preferences for choice in a multi-screen environment.

Hypotheses:

- A successful Theatre in the Home experience is one that recreates theatre rituals;

- A coherent multi-devices environment can support and positively augment a Theatre in the Home experience.

- Theatre is a social experience best shared with others (by bringing remote audiences together).

Trial design questions:

- What are the consequences for the architecture of the Multi-Screen service platform?

- How many of these services can we implement in the time available?

- If not all, which would be provide the biggest experimental value in terms of testing user's reactions to the design and extending the service platform?

- Can we get the content and or data to support a service (e.g. 360 capture from the theatre foyer or second camera view of the full stage)?

To test our hypotheses it was important to include: the video-chat service connecting homes; and content synchronised and coherent with the performance of the play that could be viewed across devices; and timings and features of theatre ritual. Timings were realized through the orchestration of interaction components through the timeline service of the 2-IMMERSE service platform. Theatre-style notifications to take your seats, the enforced quiet during the performance and availability of background material with a similar look and feel of an augmented program were all aimed at recreating theatre rituals. Finally and most importantly, "The play's the thing" (Hamlet Act 2 Scene 2) and the presentation of the play was pinned to the largest screen in the home – the TV. The producer was adamant that this should be so.

The system we built for the Theatre in the Home service trial informed the 2-IMMERSE service platform (D2.2, D2.3) and we have implemented most of the features we have explored through the design research. The challenges of devising a simple and instinctive way to register audience responses within and across homes during a performance and the challenge of representing the aggregation of such responses to the performers in the theatre was beyond our time means for the first trial. We decided to probe the need for this through post trial interview.

The final component list for the Theatre in the Home trial was:

- The broadcast of the play

- Synopsis of the play
- Synchronised scrolling script
- Integrated and timed Video chat
- Text messaging
- RSC Background material (supporting)
- Notifications (timing & point in play)

To measure the audience reactions to the pilot designs we collected quantitative and qualitative data from pre- and post-trial questionnaires, interviews and analytics from the system itself.

3.3.3 Generic User interaction design

The design research leading to the production of deliverable D3.2 and the analysis of the results from the Theatre at Home trials informed the Generic User Interaction Design for the various scenarios based on user testing results. The generic UX design is described in detail in deliverable D3.3, which was published in November 2017.

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 and features to inform MotoGP Service Trials, Production Tools, and Onboarding, as well as 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 document will be continuously updated throughout the project.

D3.3 describes the contributions to the preparation for the MotoGP service development and trial, as well as 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:

- **Onboarding and Set-up**: the Onboarding experience, generic to all trial services, was 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). We have designed & built a Set-Up and Onboarding process which includes notifications, troubleshooting, and some tutorial assets.

- **New capabilities of the 2-IMMERSE platform** (utilised 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 and macros. We identified research questions and 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.

- **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.

3.4 Achievements of Workpackage 4 – Prototype Services Development and Trial

WP Lead	BT

Objectives for the period:	Working closely with the project's production associates, Dorna Sports and the Royal Shakespeare Company, to define the requirements for each project field trial, and drive the development of core platform functionality in WP2, the creation of novel user interaction solutions in WP3 and the capabilities of the innovative components in WP5; to manage the technical and logistical delivery of the first field trial
Deliverables in the period	D4.2, D4.3, D4.4

2-Immerse will develop four multi-screen innovation prototypes:

- Watching Theatre at Home
- MotoGP at Home
- Watching Football at Home
- Watching Theatre in Schools

The four service prototypes will be evaluated in turn during the 3-year project lifetime.
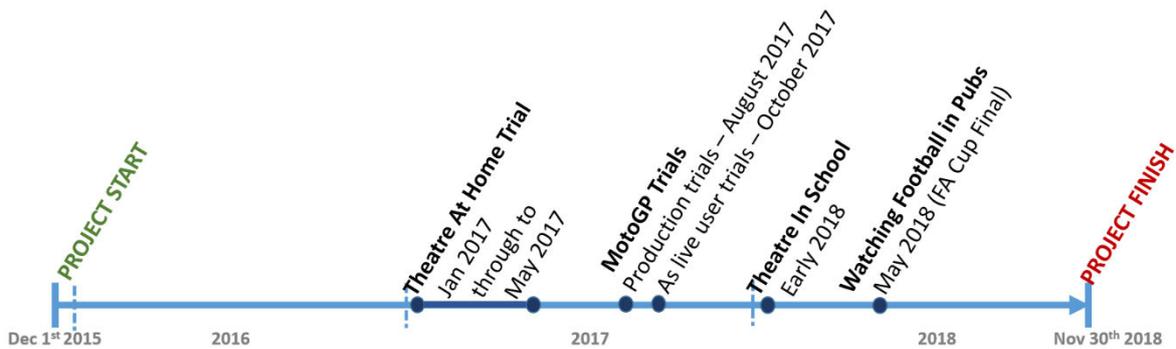
Figure 9 Timeline for the execution of the trials of the service innovation prototypes being developed in 2-IMMERSE

The project has now designed and built the first two service prototypes. The Theatre at Home service prototype has been evaluated, the MotoGP at Home service prototype is being evaluated now (Jan 2018) through trials in 50 households. A summary of the trials and key findings is given below.

3.4.1   Watching Theatre at Home trial and evaluation

This service innovation prototype is called **Theatre at Home** because it offers an enhanced social experience for users in a domestic context to watch a live or "as live" broadcast of a theatre performance. The user will have a second screen device that can access synchronized information streams directly from the provider of the broadcast and from the web through social media applications including Twitter but which can also, at times, feature audio and video chat with others who are watching.

The service innovation prototype will enable a user to watch a theatre production, shot with multiple cameras, as either a live or an 'as live' experience. Viewers will be able to contribute to and monitor different forms of feedback throughout the performance, and to discuss it with others who are watching at the same time, either in a different room or in a different home.

Owner: John Wyver (Illuminations)   **Rights Originator**: Royal Shakespeare Company

The *Theatre at Home Experience* prototype is a multi-screen social TV service based on watching a filmed live performance of Hamlet performed by the Royal Shakespeare Company. The prototype and its evolution is described in deliverable D4.3. "Prototype Service Descriptions - First Update", and the full description and evaluation results of the trials are given in deliverable D4.2 Theatre trial Evaluation Results.

This prototype service allows two households to share the experience of watching a theatre performance together with the production being presented on a TV screen.

Each household has a second screen device, a tablet, and can use this to access synchronized information streams and communication resources directly from the provider of the broadcast. The experience is curated to mirror aspects of the ritualised nature of going to the theatre. The experience thus allows users to:

- Chat to each other (using video chat) before and after the performance and during the interval
- Receive warnings, as they do when they visit the theatre, that the performance was about to start.
- Access additional material related to the production, much as they would in a theatre programme
- Send messages to each other discretely during the performance using text chat

The prototype service, built using a micro service based software platform, became available in early January 2017 and the evaluation took place over the following months. The evaluation served to:

1. Evaluate the technology platform used to support the experience

2. Evaluate this specific experience

3. Provide more generic insights that would be valuable for subsequent prototypes being developed in 2-IMMERSE.

3.4.1.1 Evaluation results – 2-IMMERSE platform

The technical performance of the platform was assessed, through a reflective process involving key stakeholders within the project such as: Platform developers; Application developers; and Cloud deployment specialists. We asked the stakeholders to reflect upon key aspects of the platform such as: extensibility, robustness, scalability, ease of deployment, ease of use and the feature set available.

The micro service based platform has provided the means to create a fully-fledged social inter-home multi-screen TV experience based around watching a theatre performance 'as-live'. The experience uses two devices, provides additional material and information, and allows people to communicate from different locations (video and chat based). Some of the lessons learned during this process, which have now spawned further activity within the project, include:

1. The need for user-friendly tools to help media professionals to craft the experience. This insight is derived from requirements gathered from the producers and authors based on the experience of creating the Theatre at Home experience "manually".

2. The need for the platform to support a number of viewing "modes". This requires enabling the user to have access to greater levels of control over the layout and also to support more dynamic layout alternatives. This should make the experience adaptable to the expectations of the viewer. Such personalization capabilities have been taken into account for the follow-up scenario.

The micro-service approach that we adopted was very well suited to the deployment of distributed media applications across multiple screens and multiple locations. We learned that we needed a very clear separation of concerns between micro services and the supporting infrastructure. Micro service developers should not need to worry about authentication, logging, data storage, message brokering, communications, Application Programme Interface (API) management, caching, load-balancing and

service discovery. These are features that should be provided by the platform. They should allow the developer to concentrate on the business logic of their service.

Extensibility

We believe that the micro service based architecture that we have chosen makes the platform naturally extensible. However, more work is required to give developers the confidence to extend the platform. To improve extensibility further we are considering creating client-side application architecture diagrams and further tutorials, documentation, and overviews to help developers understand and engage with the development of Distributed Media Applications (DMApps). In addition we recognize the importance of structure in distributed applications and how constraints help DMApp developers harness the platform efficiently. This is something we will be taking forward as we develop our other DMApp use cases.

Deployability

Regarding deployment, the platform is built using modern architectural and deployment paradigms using micro services isolated in containers orchestrated and managed in several layers. The platform has been hosted on both an OpenStack cloud service and on Amazon Web Service and the move from one cloud host to another was completed with few issues. Once hosted it is straightforward to deploy the 2-IMMERSE services using a container orchestration platform like marathon.

Scalability

Our initial implementation effort has not been focused on scalability, though we had scalability in mind when taking architectural and technology decisions. We have identified several issues that should be addressed to improve the scalability of the platform. These include:

- The way the layout service persists and accesses data

- The core layout calculation engine in the layout service could be partitioned into a separate micro-service that can be scaled independently of the remaining (context and DMApp management) functionality in the layout service.

- Implementing a way to run multiple websocket service instances that can be load-balanced

- Externalise timeline service state to enable scaling up service instances.

- Explore moving away from REST APIs for inter-service communication and instead use Websockets, or a message bus directly

Robustness

Robustness was the major challenge faced by the technical team for smooth running of the Theatre at Home trial. This is in part due to the complexities of a distributed system and the uncontrolled environments in which they run. The trials were very useful in identifying the main problems with the robustness of our platform and enabled the technical team to investigate and provide platform updates to address the following challenges in preparation for the MotoGP trials:

- Maximizing the efficiency of utilization of network bandwidth by different devices, improving the quality and robustness of the experience.
- Changing the TV Emulator operating system to enable tighter control of the setup and on-boarding process;
- Enabling app support for both iOS and Android operating systems, and providing a range of different companion devices to trialists so that the platform's ability to adapt the experience can be properly tested;
- Investigating how to host compute-intensive operations, such as video compositing and multiple video decode into the cloud as a way of targeting devices and homes with poorer

bandwidth and/or compute capability.

- Modifying the on-boarding process so that it permits 4G connections and supports Wi-Fi access points that lock down visibility of other networked devices (typically done for public access points).
- Changing the architecture so that the master timeline, state authority and synchronisation functions are moved to the cloud.
- Improving visibility of network issues within the user interface of our experiences so that participants are kept informed and can equate the behaviour of the experience to particular issues; improving the assessment of the home network environment during the selection process for trial participants.

3.4.1.2 User evaluation results

The Theatre At Home experience itself was carried out through twelve trials, involving two households per trial with one to three people present at each household. Evaluations were based on questionnaires, qualitative semi-structured interviews with triallists and on analytics of application use based on instrumentation of the app we built.

The results from the user evaluation of the trials are rich and varied, and intertwined. However, they can be summarized into the following key points which we believe may well be generalizable beyond the particular Theatre At Home experience.

1. Users appreciated the fact that the Theatre At Home experience echoed some of the ritualistic aspects of going to the theatre. They did not consider Theatre at Home the same as going to the theatre. Instead it offered something different (a hybrid), that they had not experienced before, and about which they were broadly positive. They saw great potential in the concept, not only for theatre but also for other genres and formats; and as a means to reach-out to underserved – and potentially new - audiences

2. Users endorsed the producer's view that the play should be shown on the shared TV screen and not cluttered by additional content

3. Users were positive about the ability to share the experience through text and video chat

4. Users indicated that choice is important indicating they would like more control over the selection and placement of different features.

5. User responses confirmed a number of insights for multi-screen layout preferences : – attention, distraction, notification, peer to peer vs broadcast messaging on tablet vs TV

6. Theatre at Home unique selling points - participants wanted features within the experience to offer something beyond what they could use/access otherwise –e.g., 3rd party social media, content archives (e.g., IMDB, Wikipedia). The availability of a synchronised script, and a 'curated' selection of content, and the ability to socialise while watching live theatre was unique.

3.4.1.3 Object based production approach

An object based broadcasting approach allows choice, because OB broadcasting enables the experience creators to give curation/composition/layout choice across the value chain from producers, broadcasters, venue owners to audiences.

The responses in the trial indicate that there is an appetite for choice of layout in multi-screen environments amongst audiences. A recurring theme was the ability to adapt and manipulate the experience to suit the requirements/needs of the participants.

The ability to manipulate features of the experience means the experience creators have to make decisions about the framework holding the experience together and how individual objects, that form

the building blocks of the experience, behave (i.e., the rules and the models). For example, decisions have to be made about who should decide what goes where? These decisions are layered:

1. Decisions about the design of the overall experience concept –defining the format, phasing, and essential elements of the experience.

2. Decisions about which features of the experience are predefined and automated (so users have no control over when and where they appear); and features which are adaptable and can be manipulated by users.

3. Decisions on the degree of adaptability of features, and guidelines/rules on how users can manipulate them. E.g., ability to switch features on/off, ability to change the position of features (device/screen, layout), adaptable to change the appearance of features (palette, font, responsive sizing, etc.), responsive personalization of features (novice/expert).

3.4.2   Watching MotoGP at Home

Watching MotoGP at Home

This service innovation will provide a viewer with a personalised experience that can be controlled to suit their interests and level of experience in the sport. Its video and telemetry data to be displayed on a large screen TV and on smaller personal companion screen devices. The 'User Trials' will take place in a series of 'as live' broadcasts in multiple households and lab environments. Research insights will be captured from device/service instrumentation and qualitative questionnaires and interviews with triallists. A 'Production Trial' will be undertaken on site at Silverstone during the live race where the production tools will be tested. We will showcase the work in demos after the trials at selected industry and academic conferences and events.

The trial will focus on the Octo Great Britain MotoGP race held as Silverstone in late August

Owner: Andy Gower (BT)   **Rights Originator**: Dorna Motor Sports

3.4.2.1   Trials plan

As reported in deliverable D4.2, we had hoped to conduct a live production trial, at the UK Silverstone MotoGP race, using software tools developed by the project, to trigger the deployment of the animations and software graphics to be laid out over a clean broadcast feed provided by Dorna Sports. However, we found that the proposed timescale was too aggressive; the production software was not in a fully functioning state and neither did we manage to complete developing the large range of DMApp components required to deploy all the data-driven graphics components that were a feature of the MotoGP presentation.

Nevertheless, the development team attended the 2017 Silverstone MotoGP race in August and this proved helpful in understanding the current workflow for the production of the MotoGP content and that insight has worked its way into the development of the production tools, as described in deliverable D3.3.

As previously planned, the production tools developed in the project were used in an 'as-live' mode through November and December and for the generation of the timeline for the MotoGP experience. Insights from that process are being fed-back into the design process for the production tools. The evaluations results, for both the production tools and the Experience will be published in Deliverable D4.5 which is slated for publication in March 2018.

In broad terms the experience has emerged as envisaged. It is an 'at home' experience offered over at least three screens, with users able to personalise the screen layouts on the big TV based on their

preferences for certain riders and/or their knowledge of the sport and/or based on the size they wish graphics to be displayed.

In parallel an 'on-boarding' process has been developed, providing a robust and generic method for tablets and phones to initiate a multi-screen experience using established methods and protocols and methods such as the captive portal approach (that enables headless devices to access network services using the keyboard capability of a companion device) and the synchronisation methods provided by the DVB groups 'companion screen and streams' - DVBCSS. The on-boarding process is described in D3.3.

Readers may benefit from viewing the videos (2) which show how the experience works.

3.4.2.2   Evaluation approach

The MotoGP experience is being evaluated through as-live trials carried out in home and in labs.

In-home trials

In home user trials started in December 2017. We are aiming for 100 responses from people experiencing the as-live experience within their homes and expect these trials to complete in January 2018.

The trials involve participants taking receipt of a trial kit including:

- A small computer to act a set top box
- A tablet
- A phone
- Cables
- Instructions, which explain what the participants need to do to connect the devices and to start the experience.

Evaluations will include logs – to show usage patterns and questionnaires that probe the perceptions about the overall experience as well the utility and ease of use ascribed to the different capabilities of the experience.

A significant proportion of the home trials (80%) are being coordinated by Acumen Fieldwork, a UK market research agency based in Manchester with recruiters across the UK using test kits provided by the project and with a questionnaire developed jointly between the project and Acumen. Acumen have selected recruiters in major conurbations such as Sheffield, Birmingham and Manchester. The remaining 20% of respondents should come from the 19 respondents to a BT-led recruitment for people who 'watch MotoGP and would like to take part in a trial'.

Lab trials

Lab trials have taken place in the immediate run-up to the experience being evaluated in homes. Lab trials will also take place toward the end of the trial run when the prototype service is in a more mature state. These later trials should provide a more forensic and ethnographically rich investigation of the way people use the experience.

The early lab trials helped identify immediate barriers to the trial proceeding. These trials involve people with varying level of interest in the technology attempting to start and interact with the experience. The trials took place in labs, in the presence of members of the development team and were conducted by colleagues who had less involvement with the design and implementation of the experience. Trials took place at the BBC and at BT labs; about 4-6 such trials took place, they were very informal but very useful. They have resulted in some key design changes including:

- A complete change in the way videos are selected to be shown on the Main TV – the casting metaphor - has now been adopted. This required a change in menu structures but we believe makes the feature easier to use.
- Revisions of the user instructions for on-boarding, to offer greater clarity. Early versions of the instructions tried to describe both WiFi and cable connected use cases in a single document. This proved unwieldy. The revised instructions separate out these two sets of instructions.
- A change in the menu layouts to give greater simplicity. Some features which were buried deep in menu structures were raised up in the menu hierarchy; for example, 'favourite rider' was elevated to make it easier for users to select this feature.
- A change in some menu labels to reduce ambiguity (on the presentation tab in the Watch Live section the words to describe the graphics size were iterated to give users greater clarity about what this feature does – using "Graphics Size" as the label seemed sensible as this is what the feature affects. Previously we listed TV sizes – and what this meant was less obvious.

In the lab-trials planned toward the end of the trial we aim to augment usage logs and questionnaire responses with observations and to use direct observations to prompt questions probing thought processes. The purpose of these later lab trials is to gain different levels of insight into the experience looking at the small details of the way people interact with the devices and the bigger picture about how people arrange devices and how they negotiate to effect user initiated choices in a shared experience.

3.5 Achievements of Workpackage 5 – Components for Multi-screen Entertainment Experiences

WP Lead	CWI
Objectives for the period:	To create innovative components which enrich entertainment experiences. These components will all connect to the Distributed Media Application Platform via its APIs, and will make use of its functions in different ways.
Deliverables in the period	D5.2

In 2-IMMERSE, software is being developed to support the delivery of four multi-screen service prototypes, which are then evaluated. We committed to providing descriptions of the platform and of the associated software components that were developed to enable these multi- screen service prototypes. Originally, we proposed to provide these descriptions in two technical documents deliverables: one focused on the software platform only (D2.3 and subsequent updates) and one focused on the software components only (D5.1 and subsequent updates). In practice we found that this planned separation was unwise; attempting to describe the components without reference to the software platform, and vice-versa, was unwieldy and led to significant repetition between the two documents.

Consequently, we agreed with our project reviewers to submit one written technical document describing the software *Distributed Media Application Platform and Multi-Screen Experience Components*, as D2.3 and its subsequent updates, and provide D5.1 and its subsequent updates as videos illustrating the operation of the software.

The section below summarises the main technical developments and udpates since the first release of the 2-IMMERSE platform and its components. The full details are provided in deliverable D2.4, and the accompanying video D5.2 which illustrates the operation of the software.

The technical highlights of the second release produced in year 2 include:

- Development of Linux-based HbbTV2.0 Emulator firmware to run on Intel NUC devices to support service prototypes. Key features include Onboarding, Integrated Wi-Fi router/access point, HbbTV2.0 and the Web Kiosk.

- Authoring and development of the MotoGP service prototype DMApp, and its constituent elements: timeline, layout, HTML and CSS documents, several DMApp components with a focus on data-driven animated graphics, and media asset preparation.

- Production tool development with a focus on the real-time triggering required for the MotoGP scenario.

As the second instance of a working platform for the delivery of an interactive, object-based multi-screen experience, it forms the foundation for the remaining service prototypes which will be developed and taken to trial in the final year of the project. The additional services and service capabilities, DMApp components and the HbbTV emulator will all be reused (and improved) in the remaining Football at Home and Theatre in Schools service prototypes.

3.5.1   DMApp Components available in the Second Release

DMApp Components are a way to encapsulate functionality and user interface elements in discrete entities which are individually specified and controllable by the Layout Service. They are JavaScript objects which as a minimum meet a defined and documented JavaScript interface. Twelve reusable DMApp Components were developed for the Theatre at Home service prototype, and all were based on the WebComponents web standard.

This section provides details of the specific capabilities of the DMApp Components designed and developed for the Second Release, with notes on how they are being used within the MotoGP trial.

It should be noted that the scope of the MotoGP trial is restricted to a single TV Emulator device, which presents content on the main household TV, and multiple companion devices, which present additional content and allow user interaction with the experience.

The table below provides a summary of all of the DMApp Components included in the second release, and for the MotoGP service prototype. The presentation of a track-based sport has very different requirements to Theatre at Home trial experience which was described in the first release (deliverable D2.3). While basic component functionality such as video playback and the presentation of images and formatted text has been re-used, a significant number of new components have been developed. Many of these components address the requirement to present 'live' and changing data about aspects of the MotoGP race through animated graphical elements on both the TV emulator and companion devices. While the table below focuses on their application to MotoGP, it is expected that a large amount of their functionality will be re-used when implementing the forthcoming Football at Home experience.

Name	Description	Comments
Video	This is an HLS/DASH player which is capable of playing out video and audio on the TV emulator or companion device, at video resolutions up to 1080p25 with stereo audio. Video playback can be synchronized within and between devices.	In the MotoGP DMApp, separate instances of this component are used to present the main race video and two audio tracks (commentary and ambient audio, which can be independently controlled) on the TV emulator.
HTML Snippet	This presents formatted text-based content on the TV emulator or companion device.	In the MotoGP DMApp, this is used for static text overlays such as the "MotoGP™" box and replay/event titles.

Name	Description	Comments
Image	This presents a static image on the TV emulator or companion device.	In the MotoGP DMApp, this is used for static graphical overlays including the channel and MotoGP logos.
PIP	This component plays out 'Picture-in-Picture' video with surrounding overlay graphics on the TV emulator or companion device. This component uses an instance of either the Video or Video Panorama component depending on the media type.	In the MotoGP DMApp, Picture-in-Picture video streams can be overlaid on part of the main race video on the TV emulator. Multiple video streams can also be shown on the tablet companion device.
Video Panorama	This component is an interactive 360 degree video player which plays out panoramic videos on the TV emulator or companion device.	In the MotoGP DMApp, 360 degree video is available for one of the on-board cameras during the live race and is presented in the same way as Picture-in-Picture video streams. The video can be interactively panned on the companion display, and when shown on both the TV emulator and the companion simultaneously, the view position will be synchronised between the two devices.
Leaderboard	This presents the MotoGP leaderboard on the TV Emulator, indicating the current position of each rider in the race, and highlighting changes as the race progresses.	In the MotoGP DMApp, the Leaderboard component is overlaid on the main race video. The position of each rider is determined by live data provided by the Data Spooler component. The Leaderboard presentation is also determined by the Presentation Style and TV Graphics Scale selected by the user. In addition, it can be arbitrarily triggered to show gap times between any two riders.
Laps Remaining	This graphic presents the number of laps remaining, changing as the race progresses.	In the MotoGP DMApp, the number of laps remaining is determined by live data provided by the Data Spooler component.
Replay	This component presents a replay of a race event on the TV emulator, including a sequence of graphics and video clips.	In the MotoGP DMApp, this component may be triggered by the pre-authored timeline to display replays during the race, or interactively by selection of an event in the Companion Control Panel during or after the race.
Companion Stats	This presents a table of lap time statistics for each rider on the tablet companion device.	In the MotoGP DMApp, the contents of the table are determined by live data provided by the Data Spooler component. Part of the table highlights statistics for a favourite rider if one has been selected by the user.
Companion Control Panel	This component presents an interactive control panel on the companion device	In the MotoGP DMApp, the companion control panel can be switched between three different modes during the race:

Name	Description	Comments
	which enables user interaction with MotoGP content.	*Leaderboard* – which indicates the position of each rider in the race and allows the user to view additional information about each rider through a swipe-able 'card' view which can be shown or hidden beneath each rider's name. The position of each rider and other information is determined by live data provided by the Data Spooler component. The 'card' view also offers a video stream from the rider's on-board camera, if available. *Events* – which provides a list of notable events which have taken place during the race so far and allows the user to replay them on demand. *View* – which provides a list of available video streams which can be displayed on the tablet companion device and optionally 'cast' to a Picture-in-Picture view on the TV emulator. When the race is finished, only the *Events* mode is available.
Companion Panel Switcher	This presents an interactive menu on the companion device which enables the user to select between the different modes offered by the Companion Control Panel component, showing which mode is currently selected.	
Companion Top Bar	This presents a title bar on the companion device which includes the current status of the DMApp and provides an interactive drop-down menu to customise and control the experience.	In the MotoGP DMApp, the drop-down menu enables the selection of TV Graphics Scale, Presentation Style, Audio Presentation and Favourite Rider.
Inside MotoGP Panel	This component is a self-contained interactive video-on-demand player for the companion device which enables the user to browse and watch different video clips.	In the MotoGP DMApp, this component is presented during the build-up stage before the race starts and allows multiple users to independently watch different video clips taken from three categories: Tutorial, Technical and Catch-up.
Companion Notification	This presents a pop-up message on the companion devices to inform the user of important information.	In the MotoGP DMApp, this component is displayed at specific times before the race as determined by the pre-authored timeline, for example to remind users to select their favourite rider, or to signal that the race is about to start.
Adobe Animate	This is a generic component which supports the playback and control of a JavaScript-	Several MotoGP-specific animations were developed using Adobe Animate

Name	Description	Comments
	based animation exported from Adobe Animate.	and derived from this component. These are listed below. The information presented in many of these components is determined by live data provided by the Data Spooler component.
		These components are designed to momentarily provide additional information overlaid on the main race video at specific times during the race, as determined by the pre-authored timeline.
Info-Rider	This animation indicates that a specific rider is currently featured in the main race video.	
Leading-Group	This animation indicates that the current race video is showing the leading group of riders.	
Info-Onboard	This animation indicates that the current race video is showing the on-board camera from a specific rider.	
Battle For	This animation indicates that the current main race video is showing the battle for a specific position in the race.	
Battle For Multi	This animation provides more information on the battle for a specific position in the race, especially when more than two riders are involved.	
Lap-Comparison	This animation provides a comparison between the lap timings of two specific riders.	
Multi-Lap-Comparison	This animation provides a comparison between the lap timings of multiple riders over multiple laps.	
Radar	This animation provides a graphical representation of the race circuit and the positions of the riders on it.	
Split	This animation shows the distance (time gap) between two specific riders.	
Fastest Lap	This animation indicates that a new fastest lap has been recorded, providing rider and timing details.	
Info-Crash	This animation indicates that a crash has taken place and provides information about it.	
Info-Incident	This animation indicates that an incident (other than a crash) has occurred during the race and provides information about it.	

Name	Description	Comments
Info-Championship	This animation provides a 'live' view of the current top positions in the MotoGP championship table, based on the riders' positions in the race at that time.	
Info-Result	This animation confirms the winner of the race.	
Info-Standings	This animation shows the current top positions in the MotoGP championship table.	
TV Control	This component changes configuration options on the TV emulator in response to updates from the timeline service. These include whether user-controlled Picture-in-Picture components are enabled, and hiding some graphical elements during Race Review and Inside MotoGP modes.	This is a non-displaying component.
Spooler	This is a data spooler component which enables live data to be distributed to DMApp Components which require it.	This is a non-displaying component.
Google Analytics	This component aggregates user interaction events generated by other DMApp Components and sends them to Google Analytics.	This is a non-displaying component.
IoT Data Fetcher	This component enables live data to be received from the Data Playback Service.	This is a non-displaying component.

DMApp Components in the Second Release of the 2-IMMERSE Platform

3.5.2 Production Tools

Recent technical advances make authoring and broadcasting of object-based multi-screen experiences possible. Most of the efforts to date, however, have been dedicated to the delivery and transmission technology (such as HbbTV 2), 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. Our intention is for 2-IMMERSE to contribute appropriate and adequate production tools for object-based multi-screen experiences that can reshape the existing workflow to accommodate the new watching reality (see Figure 10). In 2-IMMERSE we have followed an iteratively user-centred process (interviews and focus groups, early prototypes), involving the potential users since the beginning, as reported in deliverable D3.3. Our process has led to the definition of three main tools:

1. A multi-screen scripting editor for pre-production and planning the experiences.
2. A near-live event editor for reducing the workload during live broadcasting by providing templates for certain events.
3. A live triggering tool with which the director can trigger in real-time the right events.

During year two we have given priority to the live triggering tool intended for the MotoGP scenario, which is now a working prototype integrated with the 2-IMMERSE platform. The pre-production tool is still under development, with most of the components of the frontend ready, and missing certain functionality in the backend.
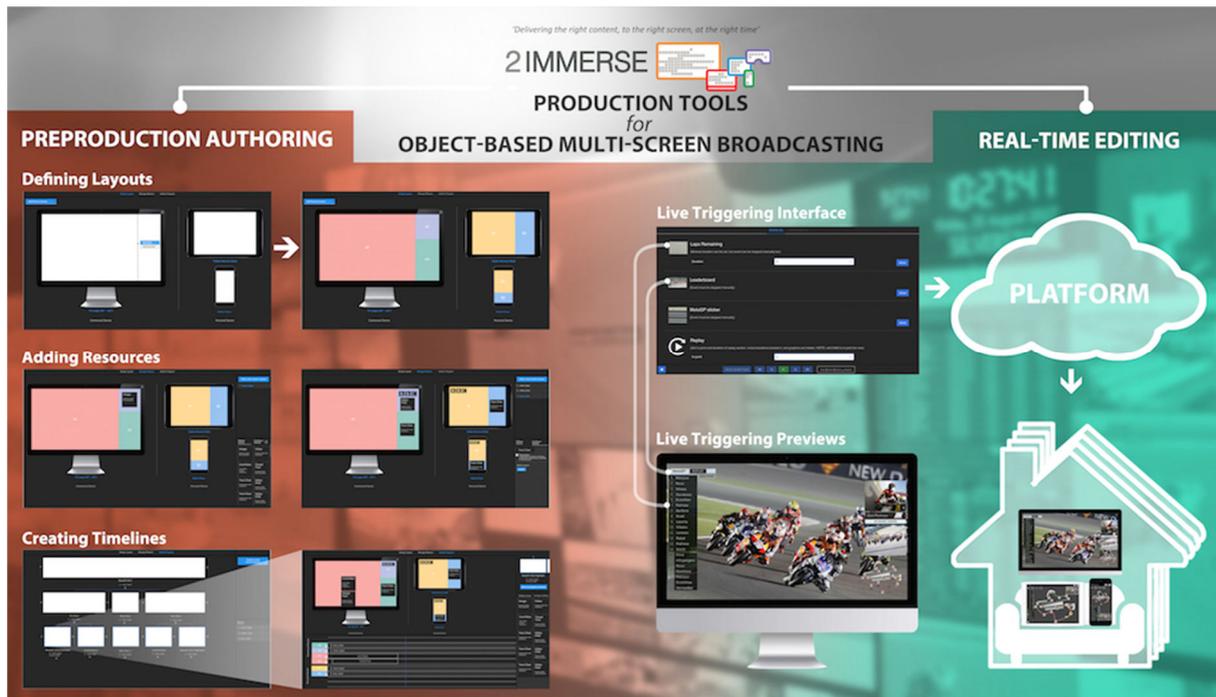
Figure 10 The Production Workflow as envisioned by 2-IMMERSE

In order to implement the tools (pre-production and live triggering), we have devised the following architecture, divided into the following components

- **Authoring backend:** Acts as point of interaction between the frontend, the database and the rest of the 2-IMMERSE infrastructure. This layer is comprised of an HTTP server written in Python, enhanced with the ability to manage timeline documents and communicate with the Timeline service and receive/forward editing operations to it.
- **Pre-Production Authoring frontend:** The pre-production frontend enables the user to create interactive multi-screen experiences. It is implemented as a web application and is largely self-contained in that it only talks to the backend for storing experience data. All other business logic is implemented on the client side.
- **Live Triggering Authoring frontend:** The live triggering frontend tool is a particular part of the application which takes existing timeline documents, containing specially-annotated sections to facilitate the real-time insertion of events into a running timeline. In other words, this tool enables the user to load a document, play it and trigger predefined sequences of events at will in the running experience.

A production tool instance also includes a full Client Application stack, used for preview play during pre-production and to deliver the experience to the end users during live triggering. Figure 11 shows the full architecture of the production tool.
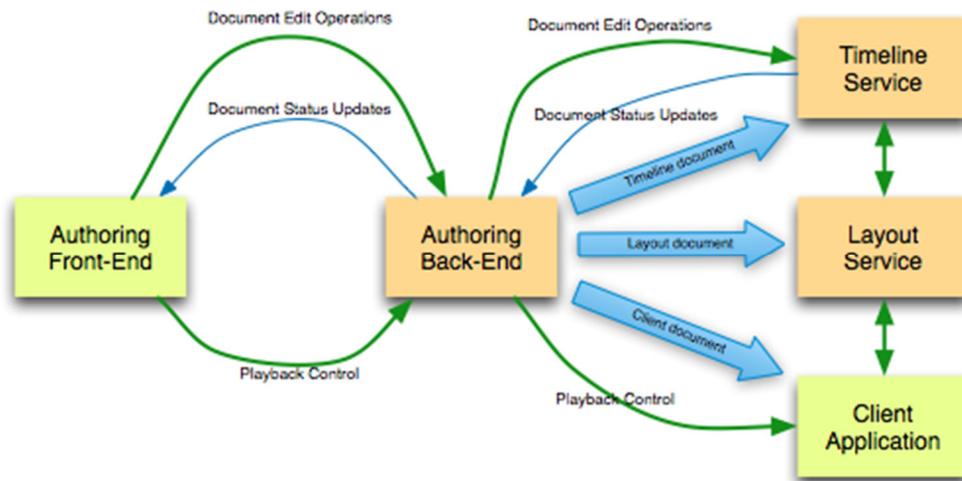
Figure 11 Architecture of the Production Tools

3.5.2.1   Document Format

The production tool document format is the same as the timeline document XML format (described in D2.2 and D2.3) with some additional sections added to encode information on triggerable events, layout, and playback device parameters. For this release, with the live triggering tool fully implemented, the latter two simply store the layout.json and client.json documents almost verbatim inside the XML.

Triggerable events are standard timeline XML elements, using the standard timeline parallel and sequential composition and ref and update elements to control the media components. The main differences between a triggerable event and a normal timeline chapter are as follows:

- Triggerable events are stored in the document in such a way that the Timeline service ignores them during normal execution;
- Each event has a set of parameter elements that outlines which information has to be provided by the live triggering tool operator before the event can be triggered, and where this information needs to be stored in the event parameters (duration attributes, URLs for media items, text for labels, etc.).

It is important to note that the production tool document format is 100% compatible with the Timeline service. At any time during the production workflow, which could last for weeks or even months, the unfinished document can be previewed using the normal 2-IMMERSE platform. This allows judging the current state of production work in diverse settings.

3.6   Achievements of Workpackage 6 – Exploitation and Dissemination

WP Lead	IRT
Objectives for the period:	To ensure the appropriate management of new technologies and innovative solutions developed within the project. To create and deliver a cohesive innovation strategy based on an appropriate balance of dissemination, standardisation and direct exploitation of results.
Deliverables in the period	D6.2

3.6.1 Exploitation

Innovation management in 2-IMMERSE includes the exploitation, dissemination and potential standardisation of project results within and outside the member companies. The exploitation assets identified in the initial plan for exploitation, dissemination and standardisation plan (D6.1) were updated and grouped into the following categories:

- Exemplar productions
- Production Tools and Workflow Insights
- Reference Architectures
- Reference Implementations
- Design Specification and Insights

The details of each partner's specific exploitation plans are described in deliverable D6.2.

3.6.2 Dissemination

The dissemination activities in 2-IMMERSE are targeted at four major groups

Target Group	Dissemination channels
General Public	Project website, public deliverables, media and publicity activities, involvement in the trials and end-user experiments, blogs
Academics	Peer reviewed publications, demonstrations at H2020 related events, blogs.
Programme Makers and commissioners	H2020 related events, presentation of the prototype in the trials workshops and sandbox calls e.g. BBC Connected Studios, blogs
Production Engineers and suppliers	H2020 related events, presentation of the prototype in the trials and at trade shows.

At this stage of the project we can be more specific about the stakeholders and the broader communities for whom the project will be critical for some and of interest to others. In the broadcast and project value chains implicated by the pilot services are:

1. **Commissioners**: who need to be convinced of the value of experiences to their audiences;
2. **Content Producers** who need to be convinced of the value to and consequence for their art and their craft;
3. **Broadcasters** who need to understand the business value against the challenges of delivering broadcast quality content in new interactive formats;
4. **Venue owners** (such as hospitality chains who own pubs and restaurants) who need to understand the business benefits to their establishments;
5. **Audiences** who need to know why they should try new experiences:
6. **Project partner organisations and the EU Commission** who need to know whether the project's targeted and achieved contributions are worth the resource investment;
7. **Software developers and hardware manufacturers** who need to be able to build on and extend the platform and conform to its specifications to deliver the targetted experiences;
8. **Standards bodies and regulators** who need to monitor the performance of standards specifications and the evolution of new ones to enable industries to thrive;
9. **Academics:** who need to have an understanding of the social and technical science behind the contributions made;

In order to deliver the four service prototypes in sport and theatre we are engaging with practitioners in categories 2-7. Individuals and companies are consulted and contribute in the process of designing and delivering the trials but we hope to reach broader audiences within these, and to building a Community of Practice to further explore and experiment with our object-based, multi-screen experience delivery platform beyond the lifetime of the project. By building an extensible platform to support the four service pilots we will test the appropriateness and completeness of standards to support the requirements for delivery.

Attending top conferences since the beginning of the project is important, as it provides a good dissemination outlet and good networking opportunities. Highly recognized conferences gather academics, practitioners, and commercial partners: producers, broadcasters, and academics.

In particular, the project targets the following academic international conferences, independently of the continent in which they are hosted each year:

- ACM CHI, which it is the premier international technical and UX conference for computer interaction. The conference attracts yearly over 3000 participants from all over the world, including representatives from industry. For example, the course that was run by CWI in 2016 was attended by people working at YouTube, Facebook, and many other relevant companies and universities.
- ACM TVX, which it is the premier international conference on interactive experiences for online video and television. The conference attracts yearly over 100 participants from all over the world, particularly attracting representatives from the broadcast and online video world, for example Samsung, YouTube, Facebook and Nokia. For example, during TVX2016 CWI attended the TVX in Asia Forum, networking with companies such as NHK, NTT, and Samsung. Moreover, CWI is steering committee member of the conference.

3.6.2.1   Project Publications in year 2

Publication type	Event/ publication	Publication Title	Publication location or conference link	Lead Author
Book	Springer book	MediaSync: Handbook on Multimedia Synchronization	https://sites.google.com/site/mediasynchronization/book	Pablo Cesar, CWI
Book Chapter	Springer book	Social Interaction Design for Online Video and Television	http://www.springer.com/us/book/9789814560498	Pablo Cesar, CWI
Proceedings (peer reviewed)	TVX 2017	On time or not on time: A user study on delays in a synchronised companion-screen experience	https://tvx.acm.org/2017/	Chistoph Ziegler, IRT
Proceedings (peer reviewed)	TVX 2017	Multi-Screen Director: a New Role in the TV Production Workflow?	https://tvx.acm.org/2017/	Britta Meixner, CWI
Proceedings (peer reviewed)	TVX 2017	2-IMMERSE: A Platform for Orchestrated Multi-Screen Entertainment	https://tvx.acm.org/2017/	Ian Kegel, BT
Book Chapter	Springer book	MediaSync: Handbook on Multimedia Synchronization	http://www.springer.com/us/book/9789814560498	IRT/TNO
Exhibition demo	IFA 2017 exhibition	Presentation of HbbTV 2.0 companion screen and media synchronistation on prototype devices		IRT
Proceedings (peer reviewed)	NEM Summit 2017	Multi Screen Football Assessment	http://nem-initiative.org/	Doug Williams, BT
Proceedings (peer reviewed)	NEM Summit 2017	Theatre At Home Evaluation	http://nem-initiative.org/	Phil Stenton, BBC

3.6.2.2   Other dissemination activities in Year 2

Lead	Date/ Event	Dissemination type	Title	Audience
IRT	15. Mar 17	Project presentation	Workshop on joint HbbTV 2 developments/showcases	Samsung Head of HbbTV development HQ and SRUK
BT	5. May 17	Knowledge Share Call	Microservices - a Cisco research perspective	BT Researchers & TV Architects
BT	Jun-17	BT Innovations event 2017	Demonstrations of Football In a Pub and MotoGP and celebrity hosted inverview and video presentation of the project	Industry visitors

Lead	Date/ Event	Dissemination type	Title	Audience
IRT	IBC Sept 2017	Exhibition demo	Presentation of HbbTV 2.0 companion screen and media synchronistation on prototype devices	Media Industry
IRT	Münchener Medientage		Presentation of HbbTV 2.0 companion screen and media synchronistation on prototype devices	Media Industry
BT	Sept 2017	MotoGP Demo	New Scientist Live - BT stand: "Harnessing the power of Communications to make a better world." Object orientated Broadcasting demo based on MotoGP	General public (20,000 attendees)
Cisco	10 Oct 2017	Project presentation	2nd Annual Sport Summit Cisco CTO Presentation	Invited Cisco Customers & Partners from Sports Media
BT/BBC	17th October 2017	Project presentation	2-Immerse Delivering the right content, to the right screen, at the right time.	BBC staff
BT	7-8 November 2017	MotoGP Demo	Cisco - BT Technology & Innovation Showcase Event	BT Staff
BT	Nov-17	Masterclass (York university)	The Future of Television Experiences on Broadband	Undergraduates and post graduates in Theatre Film Television and Computer science
BT	13th Dec 2017	Project presentation and demo	BT Sport All Hands day	200 employees of BT Sport delivering the day to day BT Sport output and involved with its evolution
All	2017	Videos	2-IMMERSE YouTube channel	General Public
All	2017	Project website	2-IMMERSE Project website	General Public

3.6.3   Standardisation

Here we list our plans for standardisation.

3.6.3.1   *HbbTV2/DVB-CSS – companion streams and screens*

2-IMMERSE plans to evaluate HbbTV 2 implementations, if they become available, by a dedicated HbbTV 2 showcase of its platform. As a result of the showcase, a gap analysis will identify the delta between the requirements of a "high-end" 2-IMMERSE TVset and an HbbTV 2 implementation. 2-IMMERSE will look into an opportunity to present these results to standards bodies, ideally to the HbbTV requirements group.

3.6.3.2   MPEG DASH

The DVB profile of MPEG DASH - DVB DASH - which is included in HbbTV 2, was created with substantial contributions from BBC and CISCO. DASH is used as the transport protocol for audio-visual content by the current implementation of the 2-IMMERSE platform.

3.6.3.3   MPEG MORE

MPEG media orchestration is a current work item within the MPEG-B specification suite. Requirements as well as the latest committee draft are available online. The work item came to attention of 2-IMMERSE after defining the initial architecture and starting the work for the first trial.

Recently 2-IMMERSE has analysed the committee draft in its version from end of March 2017. The status of the specification is not mature enough to consider an early adoption of individual aspects for 2-IMMERSE at this stage, except that both 2-IMMERSE and MPEG-MORE use the concepts of DVB CSS for media synchronisation. Nevertheless, there are useful aspects in MPEG MORE that may be considered in 2-IMMERSE once the specification reaches a stable draft.

3.6.3.4   W3C

Activities around the former Web and TV Interest Group within W3C, which will be re-chartered as the Media and Entertainment IG, will be monitored by 2-IMMERSE partners. There are no contributions related to 2-IMMERSE planned yet. However, partners see potential for contributions, e.g. in improving the community draft of Web Timing objects such that in can be integrated with the protocols defined in the DVB CSS specification.

3.6.3.5   Active membership of 2-IMMERSE partners in relevant standard bodies

Many of the project partners have active roles in a number of standards organisations. Partners can work with their colleagues who are members of the different standards groups to ensure relevant findings of 2-IMMERSE are represented appropriately. A summary of partner's membership in relevant standardization bodies can be found in the table below.

	BBC	BT	CISCO	IRT	CWI
W3C	Member		Member	Member	Member
HbbTV	Member	Member	Member	Founding member	
DASH industry forum			Member		
DVB	MemberChair of DVB TM CSS group amongst others	Member	Active, TM-AVC and TM	Member	
IETF	Membe	Member	Active		
DTG	Founding member and working group chairs	Member			
ETSI	Member		Member		
SMPTE	Member	Member	Member	Member	
MPEG	Member	Member	Member		Member

4 Project plans

Perhaps the simplest guide to the project plan is to consider the service prototype development schedule in Figure 3. Section 4.1 below explains the two key deviations to the project plan for service prototype development during the last reporting period which have led to the revision of this schedule.

However this is not the full story; it underplays our plans to offer software that will support developers beyond this project and it ignores our plans for dissemination at significant events during the final year like NAB, IBC TVX, and ICT 2018. A more complete view of the project plans for each workpackage is summarised in Figure 12 and is described in Sections 4.2-4.7 below.

4.1 Deviations from project plan for service prototype development

4.1.1 Re-partnering with Donmar Warehouse rather than RSC

For the Theatre in Schools service prototype, we have changed the associate partner (who are the rights holder for the content with which we will work) from Royal Shakespeare Company to Donmar Warehouse.

The prototype will be developed in close collaboration with, and take advantage of, the extensive education programme being created by the Donmar Warehouse to accompany the availability of *Julius Caesar* for use in schools from autumn 2018.

Having a working prototype of the domestic version is invaluable for introducing key ideas of second stream media production and use to potential collaborators at Donmar Warehouse and beyond. The central vision for the Theatre in Schools prototype is retained, but we are currently refining and developing this as workshop activities with the Donmar Warehouse and associated schools feed into the thinking and planning of the project.

4.1.2 Re-focusing of the Football demo (from 'in pubs' to 'at home')

This move was driven by the interest of BT Sport who we hope will adopt and take forward the multi-screen object based broadcasting ideas we are advocating, but we have found that their interest is heavily weighted towards the 'at home' scenario.

Though the project wasn't enthused with this change initially, it will allow us to address multi-screen opportunities relevant to a market that is measured in billions rather than tens of millions. That market is the market for bundles of services offered by TV, broadband and mobile companies (like, in the UK: BT, Sky, Virgin, TalkTalk, EE etc.). In terms of devices it means we will be targeting a large screen and companion devices (much more like MotoGP) and not addressing multiple large screens. This is not what we advocated originally, and we were 'attached' to the Watching Football in Pubs story, but this has not proved to tally with the commercial realities for BT.

On the other hand, considering the 'at home' case, the vast majority of our BT Sport customers will have a broadband service (usually from BT). We want the best experience possible to come from them accessing our TV service over our broadband – this allows us to create a clear point of difference i.e. our bundled services offer more immersive multi-screen experiences than our competitors we offer better ways of engaging with sport (and drama).

As an innovation action where impact is the key measure, we thought that moving to a revenue monster in the billions rather than in the high tens of millions is an attempt to ensure the project has greater impact.

For these reasons we argue that it is sensible to switch the football work to address the 'at home' market.

We sense real excitement for using the object based broadcasting approach to better present football in homes and since adopting this switch of focus we have been able to have monthly catch ups with the COO and Chief engineer of BT Sport who continue to show interest in the object based approach. Prior to this switch, getting access like this was almost impossible.
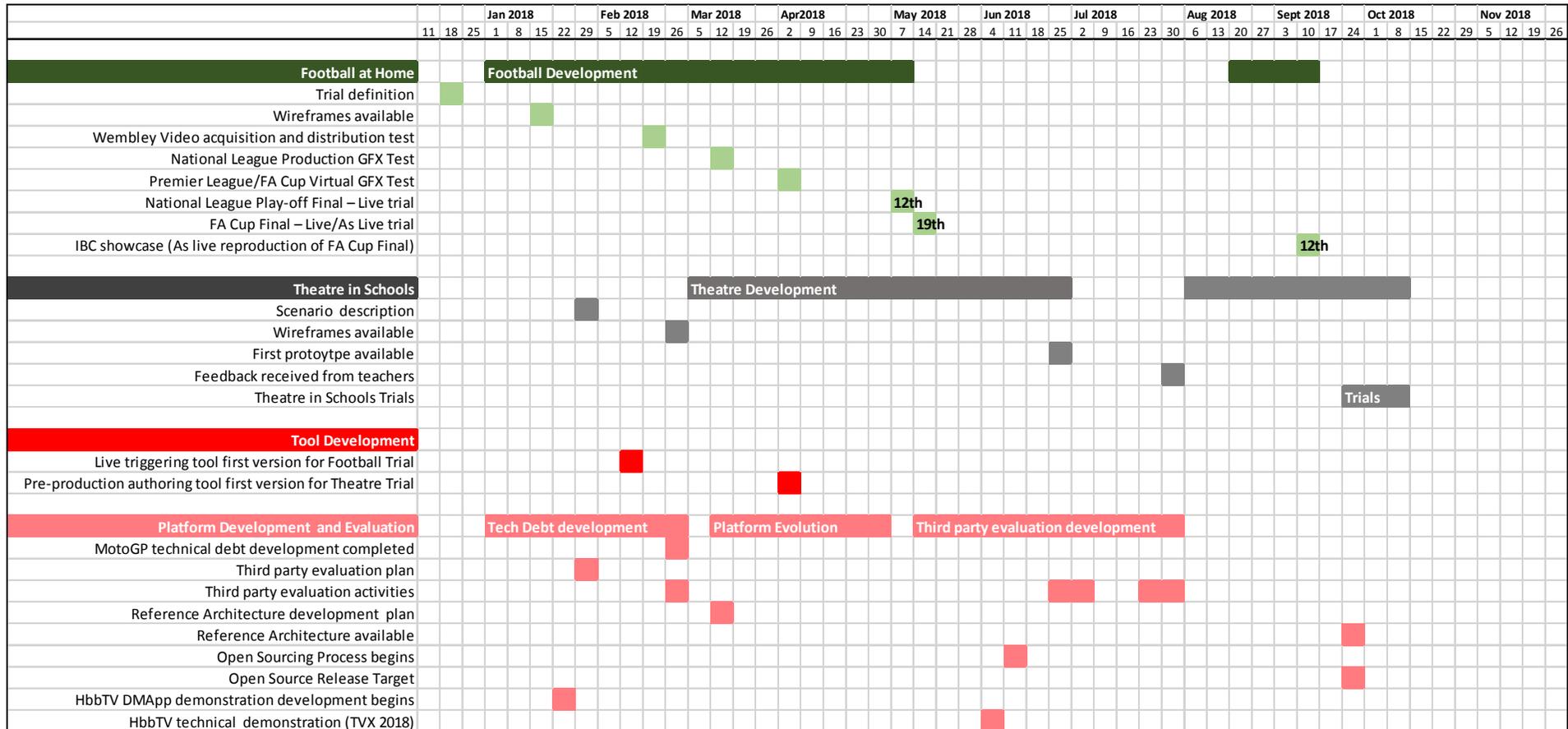
Figure 12 Chart of 2-IMMERSE project milestones for the final project year

4.2 WP1 – Coordination and Management

WP1 is the coordination and management workpackage. It is responsible for ensuring the project makes progress against goals. BBC, BT, Cisco and ChyronHego all contribute to the project management under WP1.

Planned activities for the final year include:

- Weekly calls: Plan, agendas, minutes, on a project wide basis.
- (BBC-specific) Recruitment of Project Manager to replace Phil and Hélène.
- Coordination of delivery of WP specific deliverables D1.1, D1.2, D1.3.
- Organising and attendance at quarterly meetings.
- Organising and attendance project review and final report.

4.3 WP2 – Distributed Media Application Platform

The platform that supports the delivery of our multi-screen applications is, in many ways, more important than the more visible service prototypes that are developed in WP4. But WP2 needs WP4 as a source of requirements and to prove that the media application platform is fit for purpose.

In the final year WP2 has the following ambitions:

- Address technical debt and support the development of the Football at Home and Theatre in Schools service prototypes.
- Further develop the Timeline service to fulfil the requirements of the upcoming trials, and to provide further technical support when needed.
- Develop the layout service, in terms of feature development for the Football at Home and Theatre in Schools service prototypes.
- Ensuring that Layout service capabilities model reflects HbbTV2.0 device capabilities.
- Develop interactive layout control for the Football at Home service prototype.
- Deliver a reference architecture document that captures the high-level building blocks, dependencies, protocols and flows of the 2-IMMERSE architecture which is independent of implementation choices such as which cloud platform provider is chosen or which message queue implementation is used.
- Develop a rights-free 'Hello World' technical sample to accompany the final platform release. This sample will be used by the platform evaluation lab experiments to enable external developers to take part in the creation of their own DMApps and 2-IMMERSE system deployments.
- Develop a reference implementation of Client API for the reference architecture.
- Definition of platform evaluation activities and development tasks to meet these e.g. Documentation of reference architecture, improved developer-facing platform and service documentation, scalability testing.
- Investigate the feasibility of HbbTV 2.0 as a supported platform and if possible modify the Client API and other platform components as necessary to enable a DMApp to be tested on HbbTV 2.0 devices.
- Build an on-boarding implementation (similar to that used in the MotoGP service prototype) that can be supported under HbbTV2.0.

- Adapt the platform to use an Authoritative State architecture. This should simplify the service architecture as a whole by allowing us to consolidate distributed state, enable service resiliency and facilitate horizontal scalability.
- Design a solution for correlation timestamp generation in production and integration into cloud-based synchronisation service for all data types, video and audio. This may involve some implementation work too. This is to support live use cases.
- An evaluation of the synchronisation performance of the Python-based cloud-sync service with respect to different network delay patterns. Optimisation of the synchronisation functionality via measurement of and accounting for presentation/rendering delays in common browser environments.
- Supporting a developer from another consortium partner as they use the Client API to develop the Theatre in Schools DMApp.
- Rancher platform support for ongoing and future trials
- Refinement and iteration of the Bandwidth Orchestration Service

4.4 WP3 – User Interaction Design

WP3 is where much of the design thinking and experimentation takes place. Broadly, design ideas that lead to the definition of the service prototypes and of certain common platform components are developed in WP3. Final implementation and some iteration of the design may take place in WP4 but WP3 will be the home for more of the experimental work including many ideas that do not move forward to trial stage in WP4.

This period the focus for WP3 will be:

- Develop and test the user experience for the Theatre in Schools service prototype through workshops with schools and Donmar Warehouse.
- Develop and test the user experience for the Football at Home service prototype. We anticipate that there will be user issues to be unpicked in the production process.
- Agree the trial design for the Theatre in Schools and Football at Home trials.
- Continue the user-centric work behind the design and definition of the Production Tools. Some initial evaluations will happen in January 2018, and at least two other iterations (anticipated for April and September 2018) will happen before the end of the project.
- Update the Production Tools based the evaluations mentioned above, and submit a paper for CHI2018.
- Conduct supplementary trials that may provide further generic design insights that may be of value for the deployment of multi-screen experiences. This may include an evaluation of augmented reality.

4.5 WP4 – Prototype Services Development and Trial

This workpackage manages the development and evaluation of each of the service prototypes. The workpackage works closely with WP3, receiving user experience designs that are then implemented and finessed in this workpackage. It also provides requirements for the technical workpackages, particularly WP5.

- **MotoGP Service Prototype:**
    - Completing the MotoGP trial. This looks to be going well but we should react to issues as they arise and try and keep on top of the development of D4.5 (MotoGP results deliverable.)
- **Football at Home Service Prototype:**
    - Finalising the design and build for the Football at Home service prototype. The most critical area will be the engagement with BT Sport around the Football at Home use case as this will dictate the shape and ambition of the prototype and live production trial.
    - Building graphics for Football, including client rendering capabilities for virtual graphics and TV-graphics.
    - Working with BT technical and production colleagues and third party suppliers to arrange access to live camera feeds and recorded assets, plus encoding and distribution facilities.
    - Organising several rehearsals and tests using elements of the live production environment.
    - Managing technical delivery of the Football at Home DMApp through a schedule of development milestones, frequent QA testing and progressive sign-off of delivered features.
    - Delivering the Football at Home trials in May 2018, including one or two live production trials at Wembley stadium.
- **Theatre in Schools Service Prototype:**
    - Developing and managing the relationship with Donmar Warehouse, including acquiring assets and rights.
    - Finalising the design and build for the Theatre in Schools service prototype.
    - Managing technical delivery of the Theatre in Schools DMApp through a schedule of development milestones, frequent QA testing and progressive sign-off of delivered features.
    - Delivering the Theatre in Schools trials in September 2018.
- External/internal platform evaluations involving the design/running of lab experiments to test facets of the platform not covered by the service trials. Evaluation criteria given by the software sustainability institute will be used to capture some of the result
- Provide support in gathering requirements for the field trials (primarily in terms of production tools and documents), in implementation needs of the project, and in their evaluation.
- Define modifications to existing DMAPPs required or desired for the HbbTV showcase of a 2-IMMERSE scenario.

4.6 WP5 – Components for Multi-Screen Entertainment Experiences

This workpackage works closely with WP4; WP4 provides requirements for WP5. It works closely with WP2; the components developed in WP5 run on (and sometimes constitute) the platform defined in WP2. Key activities this period include:

- Focus on final development of the production tools, their integration in the 2-IMMERSE platform, and of the document formats.
    - Design and develop the production tools for the Football at Home trial, including a new lightweight triggering tool.
- Develop the Football at Home DMApp Components, including user interaction and media playback.
- Support the use of analytics tools in preparation of the results for the MotoGP trial.
- Implement logging enhancements to enable better monitoring of live production trials.
- Tailor DMApp instrumentation to meet requirements of Theatre in Schools trial.
- Implement HbbTV showcases based on existing trial applications and platform and test with existing HbbTV devices in cooperation with manufacturers if possible. Feedback to manufacturers regarding interoperability issues.
- Improvement of existing software/libraries used in HbbTV showcases. Further alignment with BBC iOS implementation.

4.7   WP6 – Innovation and Exploitation Management

This workpackage coordinates and reports what the project does to disseminate and exploit the results of the project. In the coming period, the workpackage will focus on:

- Contributions to the web site including blogs, presentations and development of short promotional video.
- Sharing 2-IMMERSE results with target organisations and individuals, often on an ad hoc basis.
- Open sourcing and dissemination activities.
- Preparing a submission for IBC and (assuming the submission is received well) planning, developing and presenting the exhibit.
- Preparing a submission for ICT 2018 and (assuming the submission is received well) planning, developing and presenting the exhibit.
- Preparing a submission for NAB and (assuming the submission is received well) planning, developing and presenting the exhibit.
- Disseminate the novel contribution of the Timeline Service through an ACM Document Engineering paper.
- Disseminate the novel contribution of the Production Tools through two papers, at ACM TVX and ACM CHI.
- Showcase the production tools in relevant events such as ACM TVX (demonstration) and the Innovation Days from VRT (4) in Brussels on December 5th 2017. The latter will give us as well the possibility of interacting with a number of related projects like ImmersiaTV, MOS2S, and FLAME. We will as well showcase project results at IBC in September 2018.
- Present an HbbTV 2 showcase of 2-IMMERSE at several events (depending whether or not demo spaces are granted or demos are approved at conferences) such as TVX2018 in Seoul, or the IBC 2018 Future Zone.
- Exploitation of knowhow and reuse of software modules for HbbTV 2 showcases and services with broadcasters (no commitments yet, but in contact with SRG, arte, rbb, ZDF, RTL, pro7). Two 2-day HbbTV 2 seminars are planned in German and English language.
- Continue discussion with Samsung arte on 360 HbbTV.
- Lead discussion for potential feedback to HbbTV.

5   References

1. 2-IMMERSE. *2-IMMERSE.* **[Online] 2015. www.2immerse.eu.**

2. 2-IMMERSE. 2-IMMERSE YouTube Channel. [Online] https://www.youtube.com/channel/UCpGa5NU1Bbj8Nkz0vZi7IwA.

3. OpenAIRE . [Online] https://www.openaire.eu/.

4. Media Fast Forward. [Online] https://www.mediafastforward.be.

Annex A   End of Period 2 Partner Reporting (Dec 2017 Update)

The following Annex reproduces an example of the per-partner reporting proforma which was completed by all partners at the end of Period 2.

2-IMMERSE Reporting Template for BBC

Year to 30th Nov 2017 - reporting of effort and tasks

WP1 Project coordination and overall Management 1.50 PM	
WP1.1 Overall project coordination and management	**Jeff/Peter:** Project coordination including weekly conference calls, planning of quarterly meetings (Agendas and minutes). Monitoring deliverable progress, gaining agreement on project priorities. **Phil**/**Helene**: preparation and attendance of 1st project review in January and interim technical review in June (BT Adastral Park) **Phil**: Management deliverables D1.1, D1.2 and D1.3 first updates
WP1.2 Quality assurance, reviews and audits	**Jeff/Peter:** D1.2 updates
WP2 – Distributed Media Application Platform 19.54 PM	
WP2.1 Management	**Mark:** attend consortium meetings, weekly telcos and EC reviews; 2-Immerse recruitment interviews; MotoGP demo and testing
WP2.2 Platform (Server/clients) and API	**Mark:** MPEG-MORE / MPEG-SAND investigation, write up and identification of bandwidth orchestration requirement **Mark/Tim:** Contributions to platform architecture including shared/authoritative state, production synchronisation and scalability. **Rajiv:** Cordova DVB-CSS sync library development, Cordova device discovery library for iOS **Rajiv:** User trial equipment testing
WP2.3 Determine device environment	**Mark:** Hardware investigation and specification of trial equipment **Mark:** NUC firmware implementation including operating system and installer for MotoGP trial **Mark/Aidan:** Companion and communal device on-boarding, experience launching, sign-in/out, device pairing and authentication implementations **Mark:** 4K UHD and audio support **Mark:** Design and implementation of networking solution for home trials, including captive portal, WiFi access point and router implementation. **Mark:** Implementation of tools for configuring server environment

	Mark: Mac mini firmware implementation for Theatre In Schools trial, system image creation, update and testing **Mark:** Video stats logging **Mark**: ODroid troubleshooting for friends and family trial
WP2.4 Orchestration and mediation	**Mark:** Video/audio chat DMApp implementation; text chat implementation and supporting lobby/call service **Mark/Tim:** Component switcher implementation and supplementary content selection and preparation **Tim:** Article DMApp component **Mark/Tim:** Distributed text chat controls, video chat controls and article control DMApp components utilising shared state service.
WP2.5 Delivery, presentation and synchronisation	**Mark/Aidan:** On-boarding functionality improvements; firmware improvements **Rajiv:** Cloud-based synchronisation architecture and implementation **Mark**: trial preparations and creation of setup instructions **Tim**: 2-Immerse app design; Theatre at home development work; **Tim:** Moto GP requirements workshop **Tim:** 2-Immerse architecture overview
WP3 User interaction Design 8.68 PM	
WP3.1 Management	**Maxine/Jenny/Tim/Mark** : D3.3 **Maxine**: D3.1 and D3.2 updates **Maxine: Introduction to role of UX in 2Immerse; Concepts and Challenges** (Areas of engagement with users); **Maxine: Prototyping and lab experiments** - Wireframes prototypes of content and control surface layout, Synchronisation tolerance studies (BBC/IRT reported in TVX'17 paper), Audio configuration testing for video chat, Lab testing, Audio Chat Conclusion; Notes on production craft.
WP3.2 Experiments with interaction scenarios	**Jenny**: Onboarding; MotoGP trial preps **Andy:** MotoGP trial design and preparation **Maxine: Theatre in Home context** –planning, Schedule for User Experience & Trial design, Drivers and Initial Assumptions behind the Theatre in the Home Service-Drivers & Hypotheses); **Maxine: Designing the Theatre at Home User Experience (BBC /Illuminations)**- Defining context -Rituals of Going to the Theatre, mapping Trajectories Through the Experience, Wire Frames: Defining the Visual Design & Interaction Design -Mapping key services against multiple screens/devices, Detailed Sketching of the Components of the Interaction, User Interface Design: Component Layout - Watching the performance, Being social -Communication, Accessing theatre programme material, Responding to the performance; **Defining the final Composition of the Theatre in the Home Experience (Illuminations/BBC).** (NEM'17 paper) **Vinoba/Rajiv:** User experiments to determine the effects of asynchrony on the QoE for (1) interactive companion-screen applications, (with IRT) and (2) genre/content-

	specific companion-screen applications (Results for (1) published at ACM TVX '17 paper "*On Time or Not on Time: A User Study on Delays in a Synchronised Companion-Screen Experience*")
WP3.3 Interaction in the moment	**Maxine: Review** (BBC) Context & Recap (an overview of new capabilities and components, review on the evaluation of service prototypes);
	Maxine: Set-Up & Onboarding (BBC) -Rationale and position, Background Research and Competitor Analysis -state of the art review, End to End User Journey, exploring how will we evaluate;
	Maxine: Features and Components developed for MotoGP User Experience Design & Trial Plan (BT / BBC / Cisco)-defining MotoGP at Home Trial aims, Background Research & UX design development, Screen Layouts, Key Capabilities, Components and Features, MotoGP: Trial Plans;
	Maxine: New Production Tools (CWI/BBC) -Phase 1: Collecting Requirements, Phase 2: Initial wireframe concepts based on the requirements, Phase 3: Evaluation of the four concepts, Phase 4: Validation and detail design suggestions, Phase 5: Development and pilots. (TVX'17 paper)
	Maxine: Supplementary trial (BT) -Assessing the relative affect of design-choices relating to the presentation of Football in Pubs at British Science Week. Test designed, technology and content created and test conducted with 200+ children. (NEM'17 paper)
WP3.4 Configuration and personalisation	**Mark/Tim/Aidan/Maxine/Jimmy:** On-boarding interaction design and wireframes
	Maxine: Concepts translation from interviews
	Jenny: Initial Theatre in Schools planning
	Maxine: Theatre in Schools (BBC/Illuminations) - Observations & Interviews with schools & education practitioners (Spring/Summer'17); 2x Internal workshops (BBC) to create first list of ideas, documented in Slide-deck (Summer'17); Donmar – introductions meeting (BT/Illuminations/BBC); Observations & Interviews of Donmar workshops in 2x Schools (BBC); Donmar workshop Presentation Day (BBC); 3x requirements gathering & knowledge share meetings with Donmar Education Dept (BBC); 2nd phase idea generation based on Donmar workshops–added to slide deck (BBC); Meeting to collate information gathered to date (BBC /Illuminations)
	Maxine: Football (BT) - Departure from Football in Pubs leading to new environment choice (home); Requirements gathering; Background Research & UX-design; New features for the Football Experience -development of the Football at Home in the home experience;
	Maxine: Capture Tools (BT/CWI) -liasing with Production tools.
	Maxine: Defining Live Football Experience User & Production Trial/s. (BT)
WP4 Prototype Services – Development and trial **1.67 PM**	
WP4.1 Management	
WP4.2 Requirements	**Maxine:** D4.2 contribution
WP4.3 Theatre	**Mark:** DASH encoding of Theatre -At-Home supplementary content

	Jenny: Theatre At Home trials planning and execution **Maxine: Theatre At Home trials** • Final UX design & build (All) • Managing trial (schedules, recruitment, visiting homes delivering recovering kit) (BBC/BT) • Trial evaluation design (BBC/BT) • Facilitating trial (collecting online data, interviewing participants) (BBC/BT) • data analysis & write-up (BBC) • NEM paper'17 (BBC)
WP4.4 MotoGP	**Mark:** Tools for video encoding, encryption and DASH/HLS stream creation for MotoGP content **Mark:** Preparation of MotoGP assets for CDN delivery **Maxine/Jenny/Rajiv:** Theatre and home demo setup & run-through; theatre at home trials set up; MotoGP trials **Maxine: MotoGP Trial (BT/BBC)** • Trial planning & management -relationship with Acumen, organising training workshop, • Trial design - developing questionnaire and defining data analytics • Data analysis • Write-up -drafting D4.5 'as we go'.
WP4.5 Football	
WP5 Components for Multiscreen Entertainment Experiences **0PM**	
WP5.1 Management	
WP5.2 Tools for production	
WP5.3 User experience engine	
WP5.4 Media app components	
WP5.5 Tools for review and monitoring analytics	
WP6 Innovation Management **3.68PM**	
WP6.1 Dissemination	**Mark:** Contributions to 2Immerse TVX demo paper **Max**ine: TVX paper review **Maxine:** Recruitment of Caroline for website **Caroline:** Website and blog updates **Jenny:** 2-Immerse project website **Phil/Maxine:** NEM Summit 2017 paper

	Vino/Rajiv: ACM TVX '17 paper ("*On Time or Not on Time: A User Study on Delays in a Synchronised Companion-Screen Experience*") **Matt:** Open sourced dvbcss-clocks and dvbcss-protocols library on GitHub
WP6.2 Exploitation	**Mark/Tim/Phil:** Meetings with BBC Sport for awareness.
WP6.3 Standardisation	

Planned work for next period to Nov 30th 2018

Partner Input

Partner Name	*BBC*
WP1 Project coordination and overall Management	*TOTAL Effort in PM 2*

Weekly calls on a project wide scale (and for WP4) will continue to be conducted, agendas developed and notes written up.

Jeff/Peter : Weekly project calls and coordination of deliverables D1.1, D1.2, D1.3; **Helene/Mark**: attend project review in Brussels on 25 January

Jenny/Mark/Helene : recruitment of Project manager to replace Phil & Helene

WP2 – Distributed Media Application Platform	*TOTAL Effort in PM 3.75*

Mark: Rights-free 'Hello World' technical sample to accompany the final platform release. This sample will be used by the platform evaluation lab experiments to enable external developers to take part in the creation of their own DMAPPs and 2-Immerse system deployments. **(estimated 0.5 PM)**

Mark: On-boarding user experience and implementation for HbbTV2.0 device support **(estimated 0.5 PM)**

Mark: Authoritative State architecture/design to simplify service architecture as a whole; consolidate distributed state, enable service resiliency, facilitate horizontal scalability **(estimated 0.25 PM).**

Mark/Rajiv: Design of a solution for correlation timestamp generation in production and integration into cloud-based synchronisation service for all data types, video and audio. This may involve some implementation work too. This is to support live use cases. **(estimated 1 PM)**

Mark/Rajiv/Aidan: Addressing technical debt and providing consultancy and assistance in the development of the live football prototype and Theatre-in-Schools trial implementations. **(estimate 0.5 PM)**

Mark: Providing design and consultation input into the delivery of a reference architecture document that captures the high-level building blocks, dependencies, protocols and flows of the 2-Immerse architecture that's independent of implementation choices such as which cloud platform provider is chosen or which message queue implementation is used. **(estimate 0.5 PM)**

Rajiv: Cloud sync client accessible in Python. An evaluation of the synchronisation performance of the cloud-sync service with respect to different network delay patterns. Optimisation of the synchronisation functionality via measurement of and accounting for presentation/rendering delays in common browser environments (estimate 0.5 PM)

WP3 User interaction Design	*TOTAL Effort in PM 5.5*

Theatre in Schools (BBC/Illuminations) - User experience design, informed by workshops with schools & Donmar; Trial design & planning. **(BBC effort for WP3 & WP4 Max 4months & placement student 3months)** **Production Tools** –redesigns based on evaluation (Jan'18) (CWI &BBC?); paper for CHI'18 **Supplementary trials** –AR Signing Evaluation trial (BBC/ IRT) -paper for TVX or IBC **(BBC effort-20days-max & vino)**	

WP4 Prototype Services – Development and trial	*TOTAL Effort in PM 6*
Maxine: Theatre in Schools (Illuminations / BBC) –final UX design & build; trials in schools (Sept'18) **Mark:** External/internal platform evaluations involving the design/running of lab experiments to test facets of the platform not covered by the service trials. Evaluation criteria given by the software sustainability institute will be used to capture some of the results **(estimated 5 months effort)**	

WP5 Components for Multiscreen Entertainment Experiences	*TOTAL Effort in PM 0*

WP6 Innovation Management	*TOTAL Effort in PM 4*
Mark/Maxine/Aidan/Rajiv: We expect to continue contributing to the web site with blogs presentations and to the development of short promotional videos as well as to sharing 2_immerse results on an ad hoc basis as and when opportunity arises **(estimated 2 months effort)** **Mark**: Open sourcing and dissemination activities **(estimated 2 months effort)**	