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D3.1 – Pilot-A Progress report

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Project no. 621014

HBB4ALL

Hybrid Broadcast Broadband for All

CIP- Pilot actions

Competitiveness and innovation framework programme 2007-2013

D3.1 – Pilot-A Progress report

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Executive Summary

This document constitutes a report on the progress for the first year of Pilot-A, a 3 year sub-project of the HBB4ALL project, funded under the Competitiveness and Innovation framework Programme 2007-2013 (CIP). This project investigates accessibility in the new hybrid broadcast-broadband TV (HbbTV) environment, where a prominent challenge is to add access services, in a cost-efficient manner, that are consistent with the services available on traditional broadcasts. In addition, there is an opportunity to offer HbbTV viewers the ability to customise the access services they are using to best meet their personal preferences or needs. Pilot-A of the project investigates how broadcasters can provide subtitling access services to support viewers who are hard-of-hearing or do not understand the language of the content. Pilot-A also investigates the automated generation of subtitles from program audio using automatic speech recognition and the feasibility of automatic real-time generation of multilingual subtitles from program audio (for news programmes) will also be tested.

A principal objective of the Pilot-A is to implement operational pilots of HbbTV-based subtitling services in three countries that engage the complete chain of stakeholders. The first half of 2015 will see early implementations of non-customisable subtitle services followed in the second half of the year by the start of services with customized subtitles for a variety of devices including HbbTV, PC and Mobile. The original planned services are summarised below:

- **Customised HbbTV Subtitles for VOD in Germany**, starting March 2015 with customisation features from August 2015, with a potentially target of ~6 million households with HbbTV-enabled devices in Berlin-Brandenburg area and wider Germany.

- **Customised HbbTV Subtitles for VOD in Spain,** initially non-customizable with customization added late 2015.

- **Customised HbbTV Subtitles for VOD in Switzerland**, from the first quarter of 2015, with a desire to enhance the service later in the year. *The partner providing this service is not grant funded.*

- **Automated HbbTV multilingual news broadcast subtitles in Spain,** Real-time transcription and automated creation of "News" domain subtitles, with later addition of machine translation, operational from late 2015.

- **Automated HbbTV multilingual news broadcast subtitles in Switzerland**. *The partner providing this service is not grant funded.*

In addition to these services, two additional pilots are now planned to be implemented, thus exceeding the initial scope of the project:

- **Wide focus multi-platform Subtitles in Portugal**, extending the Hbb4All focus to other devices (e.g. PC and mobile). Initially VOD, subsequently adding customization options.

- **Customised Subtitles for Online learning (MOOC) in Germany and in Spain**, a cross-pilot showcase available for PCs and mobile devices, with user tests planned at the beginning of 2015. An advanced version is planned for the beginning of 2016; integrating personalized subtitle features using the GUIDE based UI adaptation service.

A number of challenges to the implementation of access services in an HbbTV environment have been identified by the pilot, including: the increased volume of the content that may need to be subtitled; the issue of the duplication / conversion of existing subtitles in the EBU STL (Tech 3264) format (for previously broadcast programmes made available later on broadband) into the appropriate format for HbbTV distribution; and the potential for necessary variations in that duplicated content to compensate for the different limitations of broadcast distribution compared to HbbTV distribution. Put simply, the largest challenge in implementing subtitle services on additional HbbTV platforms is seen as an economic challenge, largely as a result of anticipated increased manpower costs. The pilot will examine possible solutions to this challenge through optimization of workflow and identification of automation opportunities. It is also clear that the desire to support adaptation of the subtitle content to meet user's requirements may have significant implications for the subtitle production process.

Technical challenges to the implementation of new access services have also been identified, including a lack of support within the early HbbTV specifications for subtitling provision on broadband delivered video content. Later versions of the standard include support for subtitling broadband delivered services (both 'catch up' and live streaming) services by recommending the use of the EBU-TT-D subtitle data format. The provision of subtitles for live streaming broadband services is also a significant technical challenge as there is no standardized protocol to transport live subtitling information with different proprietary protocols currently in use. In addition, no end-to-end implementation of EBU-TT-D based subtitling on HbbTV has yet been trialled so it is not known what limitations may be present on the performance of the viewer's devices as there is no standard for the rendering of EBU-TT-D subtitles within an HbbTV device. Early 'lab tests' will allow these potential constraints to be identified, allowing the plans for service pilots to be refined.

The Description of Work (DoW) that forms part of the HBB4ALL Grant agreement breaks the activities of Pilot-A into 4 tasks. The core objectives of the initial task of Pilot-A, that of defining the test services and the initial plans for large scale tests, are largely completed. The current workflows and business models have been analysed, allowing optimisations and requirements for changes to those workflows to be identified. The results of previous relevant research projects have been evaluated and used to guide the design of the test services. An examination of the existing infrastructure for subtitling provision within the broadcasters has

been performed, and the plans for test service implementation have been designed accordingly. The partners of the project have also participated significantly in standardisation bodies to ensure that the proposed subtitle documents and strategies used in the test services are compliant and reflected within new standards.

Work to fulfil the objectives for the subsequent task of Pilot-A, which largely represents more practical adaptation and integration of existing technology, is in progress and on schedule. The components required to support the pilot services, which were identified in the initial definition task, are being implemented or are entering initial testing. In particular, the concepts and components created by the GUIDE project have been identified as fundamental to meeting the later objectives of providing a personalised access service to viewers and the experiences in the DTV4ALL project will be used to steer the customisation options implemented in Pilot A.

Throughout the activities of Pilot-A complementary user experience testing of related aspects of subtitling will be performed. This testing will research different aspects of subtitle personalisation and perception, such as subtitle usability across devices and in different languages/alphabets. In addition the reception of subtitles displayed in a second screen device (e.g. a smartphone) will be tested followed by a determination of which factors may need to be adapted in subtitles for small screen devices. The combination of this information and the reports will help us to understand different aspects of subtitle processing by viewers and inform decisions about the appropriate and desirable options that should be offered for subtitle customisation.

In summary, to date, Pilot-A (Work Package 3) has fulfilled and in some instances exceeded the objectives described in the Description of Work (DoW). Progress is as anticipated and according to the overall plan, with some minor deviations which were impossible to anticipate when the DoW was authored.

1. Introduction

The Hybrid Broadcast Broadband for All project (HBB4ALL) investigates accessibility in the new hybrid broadcast-broadband TV (HbbTV) environment. One of the most prominent challenges faced by broadcasters is the new requirement to add access services, in a cost-efficient manner, to Internet delivered audio-visual content while remaining consistent with the access services available on traditional broadcasts. An additional complication is the desire to offer viewers consuming Internet delivered audio-visual content a new opportunity to customise the access services they are using to best meet their personal preferences or needs.

The HBB4ALL project will test access services in four interlinked Pilots; Pilot-A: Multi-platform subtitle workflow chain; Pilot-B: Alternative audio production and distribution; Pilot-C: Automatic User Interface adaptation – accessible Smart TV applications; Pilot-D: Sign-language translation service.

The Operational phase of the HBB4ALL project (Task X.3 – Operation Phase for all Pilots A to D) will gather user feedback, assess the acceptance, and Quality of Service (QoS) in various delivery scenarios implemented using field user tests and also in complimentary qualitative lab tests performed by UAB. There will be a number of different large scale service pilots. In the specific case of Work Package 3 / Pilot-A, novel subtitle services will be rolled out in the different HBB4ALL countries in order to tackle the above challenges, but also to receive and evaluate user feedback for later improvement.

Pilot-A from the HBB4ALL project investigates how broadcasters can provide subtitling access services on multiple platforms to support viewers who are deaf and hard-of-hearing or do not have sufficient language skills to understand the content without textual support either in the original or foreign languages. The main challenge is to develop an economical subtitle production and distribution strategy for linear/live and Video On Demand (VOD) services that allows for the automatic repurposing of subtitles for multiple platforms, while maintaining quality access services. Experience gained during the development of the HbbTV based pilots has direct relevance to other distribution mechanisms (e.g. PC and mobile).

Pilot-A also investigates how the new technology options that arise from Internet delivered media and smart televisions may facilitate the customisation of the rendering of subtitles according to the user's preferences at the viewer's device. In addition, the pilot investigates the automated generation of subtitles from program audio using recently matured automatic speech recognition technology which may result in cost reductions and productivity increases and an increase in the quantity of subtitled programmes on offer. Machine translation technologies will also be used in a newsroom scenario where the feasibility of automatically generating multilingual subtitles of news relevant at international level in real-time will be tested. Recent years have seen a significant increase in VOD services supported by Connected TVs, however there is no standardised implementation of features for a synchronisation of video with other data streams, such as access services. In Pilot-A, new and updated mechanisms for synchronising video and subtitles will be analysed and chosen for integration.

1.1. Purpose / Scope of the Document

This document constitutes a report on the progress of Pilot-A, part of the HBB4ALL project, funded under the Competitiveness and Innovation framework Programme 2007-2013 (CIP). Pilot-A is a 3 year sub-project that is divided into 4 tasks. The first two tasks overlap, the final two tasks follow in sequence (see Section 1.2). Current progress in Pilot-A is reported in this document up to the end of month 11 of the project timeline, allowing a month for review before scheduled delivery at the end of month 12. This document includes an overview, the current sub-project status; a summary of relevant information generated, collected and assessed within the time period covered by this report; and a summary of decisions made during the first 11 months of Pilot-A.

1.2. Summary of Pilot-A Project Tasks

Task	Task description	Lead Beneficiary	Start Month	End Month
3.1	**Definition and Preparation of Operational Phase**	**SCREEN**	**1**	**20**
3.2	**Solution Integration and Trials**	**IRT**	**3**	**20**
3.3	Operational Phase	RBB	21	33
3.4	Evaluation and recommendations	RTP	34	36

Table 1. Summary of Pilot-A Project Tasks. Tasks in red are active during the period covered by this report.

1.3. Summary of Pilot-A Objectives

Work in year 1 of the HBB4ALL project has been performed in accordance with the objectives specified in the HBB4ALL Grant agreement for: CIP-Pilot actions Annex I -"Description of Work" [DoW].

	Objective (from Part B, section B1.1)	Partners by sub-pilot region			
		Germany	Portugal	Spain	Switzerland
A-1	A prototype of a complete subtitle production workflow chain for multi-platform purpose for broadcasters which enables basic (HbbTV1.1/1.5) and advanced (HbbTV2.0) customised HbbTV subtitling services aligned with existing subtitling services and integrates broadcast news transcription systems for automatic subtitling and subtitle translation provided by Screen, IRT and VIC and tested on feasibility in house with experts at RTP, RBB and TVC in Portugal, Germany and Spain, and in parts also in Switzerland at TXT.	IRT RBB Screen	RTP UPM (IRT[1])	TVC VIC (IRT[1])	TXT
A-2	HbbTV-based VOD services allowing users to add subtitles and also to customise them for large scale provision and testing in Portugal, Germany (Berlin-Brandenburg), and Spain (Catalonia), provided by RBB, IRT, RTP, TVC, UAB. Switzerland will be considered as an additional target region.	IRT RBB	RTP	TVC UAB UPM	TXT
A-3	An HbbTV-based news service allowing users to access live content automatically subtitled and translated to multiple languages, provided by VIC and UAB in Spain (Catalonia).			VIC UAB	
A-4	Complementary user experience testing of different end user related aspects of subtitling in the hybrid world involving users from the target groups which will deliver metrics for Quality of Service done by UAB.			UAB UPM VSX	

Table 2. Summary of Pilot-A Objectives.

For "Service Objectives" A2 and A3 there will be different "Service Sub-pilots" at different locations in Europe and **also** two additional services, compared to the single "HbbTV-VOD service pilot" and "News Service Pilot" outlined in the DoW, thus exceeding the initial objectives.

[1] Through the conversion framework and the analysis of the workflow IRT participates in the other regions.

1.4. Summary of Objectives for Task 3.1

The following subtasks are being tackled in Task 3.1 which runs from Month 1 to Month 20.

Workflow related:

- Recommend optimised workflows for the production of VOD HbbTV and multi-channel subtitles i.e. create plans for using existing infrastructure for provision of VOD HbbTV-Subtitles.
- Perform a detailed analysis of available subtitling delivery and integration options.
- Document changes required to current interfaces and processes (*machine and human*).
- Capture new requirements arising from proposed services from subtitling departments.
- Capture new requirements for the production subtitling software arising from customisable subtitles.
- Define requirements of the enhanced subtitle features of the subtitling preparation tool.
- Plan integration of components in order to translate the automatically generated news domain subtitles in both translation directions for English-Spanish and for Spanish-Catalan language pairs for the machine translation.
- Implement subtitle documents conforming to European Broadcasting Union – Timed Text (EBU-TT) standard for VOD HbbTV subtitles.
- Specify the information model of the subtitle interchange format as a profile of the standardised EBU-TT.

Service / Pilot related:

- Define which service components will be implemented, integrated and tested in Task 3.2. This shapes the strategy for Task 3.2.
- Produce a plan for user tests in sub-pilots across countries and testing sites to be performed in Task 3.3 / Operation Phase.
- Guarantee that at least one operational pilot of HbbTV-based subtitling services will be in place in three countries in M20 which will demonstrate significant impact potential and engages a complete value chain of stakeholders. The implementation of the services and applications as such for objective A2 (HbbTV-ST for VOD) and objective A3 (Multi-language ST for live news) will be performed in Task 3.2.
- Implementation of user recruitment from the target group in each country while a set of validation criteria will be specified, incorporating inputs from WP2 for the user experience and feasibility tests to cover both the professional and end user side foreseen for Operational Phase.
- Validate the results from past research projects.
- Specify the features for VOD customised subtitling services including the authoring perspective.
- Initiate and expand large scale field user tests.
- Early user tests on subtitle personalisation, user profile generation for personalized subtitles.
- Complementary user tests on different end user related aspects of subtitling with users from the

target group which will deliver metrics for Quality of Service, objective of WP2.6. *Note: This objective is only listed for the Operational Phase, Task 3.3 according to the DoW. However, UAB has not only planned their tests but already started executing preliminary tests in Task 3.1.*

1.5. Summary of Objectives for Task 3.2

The following subtasks are being tackled in Task 3.2:

- Create prototype of subtitle editor (*with preview, EBU-TT, export and transcoding features*).
- Test translation and automatic subtitle generation for live (*linear*) video and VOD-HbbTV ST-services.
- Prototype of subtitle editor independent transcoding and preview modules.
- Investigate the options for exposing produced content to delivery and distribution systems.
- Investigate file based transcoding services.
- Investigate transcoding services for live subtitles.
- Integrate automatic generation tool and translation component into the workflow.
- Perform expert tests, laboratory tests and 'friendly user' tests.
    - First user tests on integrated service for personalized subtitles on PC and mobile.
- Initiate and implement HbbTV subtitling services for objectives A2 and A3:.
    - Implement a VOD service with closed subtitles (not customisable) to provide a baseline which can be used for the evaluation of the customisable subtitles or the other ST-services on the various distribution platforms it uses.
    - Integrate HbbTV-based VOD services allowing users to add subtitles and also to customise them for large scale provision and testing in Portugal, Germany and Spain. Switzerland will be considered as additional target.
        - *It was decided to tackle the above service objective in two phases. The baseline service is to be available in March 2015 at RBB, TVC and TXT. The customisable services will be available in July 2015 to be available in time for the Operation Phase / large scale testing.*
    - Integrate a basic application to provide subtitles for VOD in PC browsers and other devices (e.g. handheld) by means of web technologies
        - *This relates to an additional service objective beyond the DoW that was shaped during our Definition Phase of Task 3.1: For the Portuguese user tests UPM and RTP decided to implement and test multi-channel subtitling for web-based content in PCs and mobile devices and tests of an HbbTV subtitling application. The background to this is that HbbTV is not yet adopted in Portugal and is at a very early test status. However, the results of the multi-channel PC based subtitles will be of great benefit for the other broadcasters as they are aiming at such services and*

the required workflow. In turn, RTP will benefit from the HbbTV subtitle pilots once they are ready to implement such services.

- Finalise the technology, infrastructure and services for task 3.3:
  - Validate and integrate options to expose the produced content to the delivery and distribution systems.
  - Implement options for multiple subtitle selection (different rendering and languages) so end-users can easily choose between different rendering and language options available.
  - Implement second screen features if applicable.
  - Implement live content and customization options (for PC, handheld devices, etc.).

1.6. Reference Documents

The following documents are relevant to Pilot-A:

TECH 3380 EBU-TT-D SUBTITLING DISTRIBUTION FORMAT, Version 1.0
TECH 3381 CARRIAGE OF EBU-TT-D IN ISOBMFF, Version 1.0
TECH 3350, EBU-TT Part 1 Subtitling format definition, Version 1.0
TECH 3360 MAPPING EBU STL (TECH 3264) TO EBU-TT SUBTITLE FILES, Draft for Comment, Version 0.9
Tech 3264-1991 EBU subtitling data exchange format
EN 300 472 - V1.3.1 - Digital Video Broadcasting (DVB); Specification for conveying ITU-R System B Teletext in DVB bitstreams
EN 300 743 - V1.5.1 - Digital Video Broadcasting (DVB); Subtitling systems
EN 301 775 - V1.2.1 - Digital Video Broadcasting (DVB); Specification for the carriage of Vertical Blanking Information (VBI) data in DVB bitstreams
TS 102 796 - V1.2.1 - Hybrid Broadcast Broadband TV
TS 102 796 - V1.1.1 - Hybrid Broadcast Broadband TV
ST 291: 2011 Ancillary Data Packet and Space Formatting, SMPTE Standards
SMPTE 2031-2007 - Carriage of DVB/SCTE VBI Data in VANC

World System Teletext Technical Specification
Timed Text Markup Language 1 (TTML1) (Second Edition), W3C Recommendation 24 September 2013
WebVTT: The Web Video Text Tracks Format, W3C First Public Working Draft 13 November 2014
NEWFOR[2] Protocol for Live Subtitles (various proprietary specifications)
ISO/IEC 23009-1:2012 Information technology - Dynamic adaptive streaming over HTTP (DASH) Part 1: Media presentation description and segment formats
MPEG-DASH Profile for Transport of ISO BMFF Based DVB Services over IP Based Networks
ISO/IEC 14496-30:2014 - Information technology -- Coding of audio-visual objects -- Part 30: Timed text and other visual overlays in ISO base media file format
HTTP Live Streaming - draft-pantos-http-live-streaming-13
Digital Television For All (DTV4All) D2.5 -Final Report on mature Pilot Services, Descriptions of the Mature Access Services and Guidelines for their Implementation throughout Europe
Digital Television For All (DTV4All) D3.7 / D4.7 - Joint Recommendations for Future Access Services, Devices and Platforms
Digital Television For All (DTV4All) D4.6 - Descriptions of the Mature Access Services and Guidelines for their Implementation throughout Europe
SUMAT (CIP-ICT-PSP-270919): An Online Service for Subtitling by Machine Translation, D 1.5 Final report.
SAVAS (SME-DCL) 3rd SAVAS End-User Panel, Paris, 29 April 2014
SAVAS (SME-DCL) Annual Public Report 2013, 15 November 2013
HBB-NEXT Next-Generation Hybrid Broadcast Broadband (FP7-ICT-2011-7) D 6.1.3 Final HBB-NEXT System Architecture
HBB-NEXT Next-Generation Hybrid Broadcast Broadband (FP7-ICT-2011-7) D 7.4.3 3rd Report on Standardization and IPR Protection Activities
HBB4ALL (CIP-IST-PSP-621014) D2.3.1 Common Technical Components (I) document

Table 3. Reference Documents.

[2] Different 'spellings' for this protocol are used: NEWFOR, NUFOR, NEW4

1.7. Acronyms and Abbreviations

In this document, when necessary, identified partners within the project are referred to using the abbreviated names initially defined within the Consortium Agreement for HBB4ALL and reproduced on the cover sheet of this document. Abbreviations and acronyms are introduced in brackets in the text after the corresponding full text version. The introduced abbreviation or acronym will then be used in subsequent prose in the document. For example:

Screen Subtitling Systems Ltd (SCREEN)
Hybrid Broadcast Broadband for All project (HBB4ALL)

1.8. Definitions and Glossary

This document draws upon the terminology and definitions established by previous research projects (in particular ICT PSP/2007/1.)

- **Access Service** [UK] = **Accessibility service** [US] The provision of additional services or enhancements that improve the accessibility of TV services for viewers with disabilities or special needs.
- **Accessibility** The degree to which a product, device, service, or environment is available to as many people as possible. Accessibility can be viewed as the "ability to access" and possible benefit of some system or entity. Accessibility is often used to focus on persons with disabilities or special needs and their right of access to entities, often through use of Assistive technology or Access Services.
- **Accessibility, Linguistic** The degree to which the language of an audio-visual work can be understood by as many persons as possible in the target audience.
- **Audio-visual Content** All kinds of time-based content consisting of images and sounds.
- **Business model** describes the rationale of how an organization creates, delivers, and captures value. This may be viewed in a narrow sense e.g. *economic value, what are the costs, and if there are revenue streams to pay for them*. Increasingly, a business model also includes social or other forms of value.
- **Captioning** (North America). See *Subtitling, Intra-lingual*. A form of subtitles primarily intended as an access service for viewers with hearing impairments. Captions not only display words as the textual equivalent of spoken dialogue or narration, but they may include speaker identification, sound effects, and music description. Captioning aims to include as much of the original language as possible. However, altering the original transcription may be necessary to provide time for the caption to be read and for it to be in synchronization with the audio.

- **Catch-up TV** A service that allows a viewer to see a TV program independent of when it was broadcast. This is usually a kind of on-demand service on the Internet, but may also be achieved via a Personal Video Recorder (PVR) on which the viewer has chosen to record the program, or through a push Video On Demand (VOD) subscription where the viewer receives the program via the Internet, his Set Top Box (STB) or his PVR.
- **Control, Remote** is also known as a remote, controller or sometimes channel changer. It is an electronic device used for the remote operation of a machine (*television set, set-top box or PVR*) often over very short distances within the home. The design of such devices needs to consider their usability and accessibility. Blind and partially sighted persons and those with other disabilities often encounter difficulties with remote controls that render them inaccessible.
- **DVB** Digital Video Broadcasting a set of technical guidelines, standards and specifications to benefit and advance digital media markets world-wide. It was originally European in origin but today is an alliance of 250-300 companies.
- **DVB subtitles** – bitmap or Teletext captions on digital television using DVB.
- **EBU** European Broadcasting Union.
- **HbbTV** Hybrid Broadcast Broadband TV is a major pan-European initiative building on work in the Open IPTV Forum aimed at harmonizing the broadcast and broadband delivery of entertainment to the end consumer through connected TVs and set-top boxes.
- **Impairment, age-related** is a collection of sensory and cognitive impairments. In the general sense, it covers matters such as the deterioration of sight and hearing, memory impairment or memory loss. In the report, we look not only at persons who are elderly but also at the challenges facing children whose intellectual maturity has an impact on their ability to read subtitles. In principle, there can be other impairments that are related to stages in the person‘s life.
- **Impairment, cognitive** affects the individual‘s ability to think, concentrate, formulate ideas, reason and remember.
- **Impairment, dexterity** is reduced function of arms and hands that makes activities related to moving, turning or pressing objects difficult or impossible. This does not influence speech communication itself but makes it hard to make a phone call or use a wide range of other equipment.
- **Impairment, hearing** is a generic term including both deaf and hard of hearing which refers to persons with any type or degree of hearing loss that causes difficulty working in a traditional way. It can affect the whole range or only part of the auditory spectrum which, for speech perception, the important region is between 250 and 4,000 Hz. The term deaf is used to describe people with profound hearing loss such that they cannot benefit from amplification, while hard of hearing is used for those with mild to severe hearing loss but who can benefit from amplification.
- **Impairment, visual**. Visual impairment (*or vision impairment*) is vision loss (*of a person*) to such a degree as to qualify as an additional support need through a significant limitation of visual capability resulting from either disease, trauma, or congenital or degenerative conditions that cannot be corrected by conventional means, such as refractive correction, medication, or surgery. The loss may cover visual acuity, significant central or peripheral field defects or reduced contrast sensitivity.

- **Internet Protocol Television, IPTV** is a system through which Internet television services are delivered using the architecture and networking methods of the Internet Protocol Suite over a packet-switched network infrastructure, e.g., the Internet and broadband Internet access networks.
- **Metadata** is supplementary data about data, in this case information about television programs. This can be in the form of program listings or guides, or technical data delivered with the program to accomplish an access service.
- **Metric** is a criterion or measure of success in reaching a particular objective or goal.
- **Metric, Quality** is a measure of the perceived quality of a television picture or sound or associated service.
- **Multiplex or mux** is also called a virtual sub-channel in the United States and Canada, and Bouquet in France. It is a group of TV channels that are mixed together (*multiplexed*) for broadcast over a digital TV channel and separated out again (*de-multiplexed*) by the receiver.
- **Personal video recorder, PVR** is a consumer electronics device or application software that records video in a digital format to a disk drive, USB flash drive, SD memory card or other local or networked mass storage device.
- **Re-speaking** is a means to provide real-time captioning for live events including television programs. It involves a captioner/subtitler re-speaking or dictating the captions that are transcribed using speech recognition trained to the specific re-speaker's voice and automatically formatted for display.
- **Set-top box** is a device that enables an analogue television set to receive and decode digital television broadcasts.
- **Simulcast** Simultaneous broadcast of a program on two or more distribution networks.
- **Smartphone** is a mobile phone that offers more advanced computing ability and connectivity than a contemporary feature phone.
- **SMPTE -** The Society of Motion Picture and Television Engineers, SMPTE is a technical society for the motion imaging industry.
- **Spotting -** The offline determination of subtitle timing (i.e. when subtitles need to appear) using a proxy or copy of the associated video content.
- **Stakeholder** is a person, group, organization, or system who affects or can be affected by an organization's actions. In the case of television accessibility, the stakeholders are all those who have an impact on, or are influenced by the planning, production, exchange, delivery, use and enjoyment of television.
- **Subtitling** is a generic term for the production of text as an alternative form of the audio content of Audio-visual Content. The term 'subtitling' is often interpreted as the process of translating the dialogue component of audio-visual content into text and displaying the text on the screen overlaid on the video image. [See also Captioning and Subtitling, Intra-lingual]. Translation subtitling [See also Subtitling, Inter-lingual] aims to convey as much of the meaning of the original language as possible.

- **Subtitling, Closed** or User-selected Subtitles. The user has to select the service, c.f. Open Subtitling which is seen by all and cannot be turned on and off.
- **Subtitling, In-vision** is a synonym for Open Subtitling.
- **Subtitling, Inter-lingual** is also known as translation subtitles. The dialogue in the original audio content is translated into a different language in the text output.
- **Subtitling, Intra-lingual** see Captions. Also known as same-language subtitles, or subtitles for the deaf and hard-of-hearing (SDH).
- **Subtitling, Live.** Intra-lingual [most commonly] subtitles prepared at the moment of program broadcast or distribution. Usually live subtitles are created using steganography or re-speaking.
- **Subtitling, Open** Subtitling where the user does not have to do anything in order to see the subtitles, as they are an integral part of the picture.
- **Subtitling, Pre-prepared.** Subtitles prepared before the program is broadcast or distributed.
- **Tablet or Tablet PC** is a device equipped with a touchscreen as the primary input device and designed for personal use.
- **Teletext** or broadcast Teletext is a television information retrieval service developed in the United Kingdom in the early 1970s. It offers a range of text-based information including closed subtitles and closed captioning. This service is typically available on page 888, but the actual page number depends on the broadcaster and country.
- **Transcription** is the representation of the sound track of a TV program in written form.
- **Transcription, Verbatim** is a word-for-word representation of the sound track of a TV program in written form.
- **Translation Subtitles** see Subtitling, Inter-lingual
- **Vertical Blanking Interval**, (VBI) also known as the vertical interval or VBLANK, is the time difference between the last line of one frame or field of a raster display, and the beginning of the first line of the next frame. It is present in analogue television and can be used for data casting (*to carry digital data*), since nothing sent during the VBI is displayed on the screen; various test signals, time codes, closed captioning, teletext, CGMS-A copy-protection indicators, and other digital data can be sent during this time period.
- **World Wide Web Consortium, (W3C)** is an international standardisation organisation that develops Web standards to ensure the long-term growth of the Web.

2. State of the Art and Results from Past Projects

The following projects are considered relevant to HBB4ALL Pilot-A by the partners. The public reports from these projects have been examined and relevant recommendations have been extracted. The recommendations have been used in task 3.1 of Pilot-A to develop the requirements for the solutions integrated and tested in tasks 3.2 and 3.3.

2.1. DTV4ALL

The reports generated as deliverables by the DTV4ALL project contain a significant resource of information regarding recent operational practise and provision of access services in Europe (D4.6 - Descriptions of the Mature Access Services and Guidelines for their Implementation throughout Europe). Although the recommendations made by the project are primarily oriented towards stimulating the provision of traditional access services there is coverage of Future Access Services. In particular D2.5, the final report on mature Pilot Services, Descriptions of the Mature Access Services and Guidelines for their Implementation throughout Europe report makes the following generic recommendations:

> *"The analogue switch-off provides two forms of opportunities to improve access to digital television for those with physical, mental or age-related impairments:*
> *1. To extend the provision of existing mature access services to European countries that do not currently provide them.*
> *2.* ***To provide new kinds of access services known as emerging access services*** *such as those described in this document.*
> ***3. To provide the capability to personalise access services to meet individual needs.****"*

The report D3.7 / D4.7 - Joint Recommendations for Future Access Services, Devices and Platforms makes the following recommendations for DVB-Subtitles which were the results of a comprehensive nine months test with 50 hearing impaired users: 'Tiresias Screenfont' in the output style of a normal box with a transparency factor of 60.

Figure 1. Ideal DVB Subtitle Presentation according to Tests.

These recommendations arising from DTV4ALL by RBB were adopted by ARD (Association of Public Broadcasting Corporations in the Federal Republic of Germany) which was a great success for RBB and the project. However, the users voiced at the time that even though they agreed with their majority decision on the design of DVB-subtitles they would prefer subtitles which they could customise themselves in order to meet the demands of this heterogeneous user group. This became possible with HbbTV and in the framework of HBB-NEXT this path was followed (please see below in section 2.4). The parameters used for customisation then were a basis for the customisation solution in HBB-NEXT.

Furthermore, the above document also lists recommendations on customisation options for HbbTV based text services, which although while clearly aimed at a Teletext style magazine service can also be considered to generally apply to an implementation of subtitling services within an HbbTV context. The recommendations (below) were derived in user tests by RBB and corresponding customisation options were implemented afterwards.

> *"**1. An HbbTV-text service should provide help for sight impaired users by offering options for considerable enlargement of the fonts, graphics and menus and also by offering a number of different contrast and colour variants for the text.***
> ***2. The access point to the barrier free settings must be obvious, well placed, of high contrast and large enough.***
> ***3. The barrier free personalisation page must be accessible in itself; the representation used and the language generally need to be clear and easy to understand.***
> ***4. At the personalisation page, every setting change must have a clear and logic feedback mechanism (for example by providing feedback by sound for the sight impaired).***
> ***5. A barrier-free configuration of the service should not disturb the navigation mechanisms.***
> *6. If the concept of using Teletext page numbers is kept the page number input windows should be enlarged.*
> *7. The screen representations of the text service colour buttons (Red, Green, Yellow and Blue) must be as clear as possible. Button labels must have clear contrast to the background colour.*
> ***8. The colours red and green should not overlap generally."***

2.2.SUMAT

One of the main results of SUMAT was that Statistical Machine Translation of Subtitles (SMTS) could speed up the translation of subtitles and provide around 38% productivity gain, corresponding to a significant reduction in translation time. Statistical Machine Translation systems were trained using a very large corpus of parallel (*4.4 million*) and monolingual (*14.5 million*) subtitles and sentences, and an extensive cross-evaluation of the resulting translation engines was performed. Different translation strategies were tested to explore possible improvements in performance but overall, none of the experiments performed using linguistic features provided significant improvement over the initial systems. The initial systems were subsequently refined by using larger language models and combinations of translation models.

In order to assess the quality and usefulness of the machine translation systems, two large-scale rounds of evaluation were executed. The first round focused on the quality of machine translated subtitles, while the second one measured productivity gain/loss when post-editing Machine Translated (MT) subtitles. The first round of evaluation of the SUMAT SMT systems showed positive results, with more than half (56.79%) of the machine translated output classified requiring little to no post-editing output, and more than 1 in 3 machine translated subtitles requiring less than 5 character-level corrections to reach 'professional quality'. The general feedback during this first evaluation round involved three main aspects:

- Surprise was expressed at the quality of machine translated output: when the translations were correct, they were fluent enough to meet the translators' quality standards.
- Secondly, it was reported that post-editing became easier over time, with practice helping to detect how to transform or discard MT output.
- Finally, it was indicated that there was a marked cognitive effort involved in evaluating poor Machine Translated output before post-editing, as it takes effort to evaluate incomprehensibly translated subtitles.

During the second round of evaluation to measure productivity gain/loss when post-editing machine translated subtitles, the average productivity for each translation pair, showed an average gain in productivity of 38.2%. This gain was viewed as a significant positive result, considering that machine translation was applied during the evaluation in the open subtitling domain, which covers a wide variety of language across the board. Another important conclusion determined during this evaluation round was that the post-editing effort, i.e. the amount of transformations performed on MT output, was not necessarily the most impactful indicator of productivity gain/loss, as other variables, such as post-editing workflow practice, had similar or greater impact.

SUMAT concluded that integrating machine translation in the subtitling workflow will probably need to occur gradually. As post-editing is not a part of the existing workflow and all work is currently done using various subtitling-specific software, a major step is the integration of these technologies into current workflows. New technology introduced into established workflows can be perceived as disruptive or inadequate, and an objective assessment of its potential, limitations and perception was thus critical. The quality of output of the systems was therefore evaluated by professional subtitlers. The large-scale evaluations brought precise results on these specific aspects and were quite positive when measuring quality in terms of objective metrics and rating by professional users, with significant portions of MT output deemed of sufficient quality to reach professional quality standards.

Overall, the SUMAT project enabled the development of statistical translation systems for a wide range of European translation pairs, and resulted in state-of-the art machine translation for the subtitling domain. The highest achievable quality with currently available mainstream MT techniques was reached and precise

evaluations of the potential and current limitations of the solutions developed to increase the efficiency of the subtitle translation workflow were performed.

However, SUMAT did not measure the impact of machine translated subtitles in making content understandable in other languages. State-of-the-art machine translation technology produces errors that need to be post-edited in order to achieve professional quality; however subtitle machine translation could be applied to improve cross-language comprehension in settings in which there is no room for post-editing (*e.g. live broadcast news*). This will be one of the user tests to be carried out within HBB4ALL.

2.3.SAVAS

The SAVAS project was intended to address the challenges involved in developing Large Vocabulary Continuous Speech Recognition (LVCSR) systems to specifically address the requirements of subtitling workflows. LVCSR is the most powerful technology for **speaker independent** automated speech recognition, but the high cost of its development has hindered its availability for many EU languages and language application domains. SAVAS aimed to acquire, share and reuse audio-visual resources so that European Automatic Speech Recognition (ASR) companies can use the shared data to develop domain-specific recognisers for automated subtitling. The accuracy achieved by LVCSR techniques can be good enough in bounded domains and systems of this kind are currently being employed by some broadcasters in the news domain.

SAVAS has:

- collected a considerably large corpus of spoken and textual resources, predominantly in the broadcast news domain, in six European languages (Basque, Spanish, Portuguese, Italian, French and German; plus the Swiss variants of the last three) from the broadcasters and subtitling companies;
- transcribed and annotated the collected corpora into a form suitable to train acoustic and language models of LVCSR systems;
- built a local repository containing the collected and annotated SAVAS language resources;
- adapted and trained dictation and transcription LVCSR systems with the SAVAS language resources;
- integrated and evaluated the developed systems into several automated subtitling application scenarios in order to show the impact of audio-visual data sharing for automated subtitling.

The SAVAS recognition systems have been evaluated by packaging them into different applications to test their suitability for automated subtitling, targeting Live Automatic Subtitling; Offline transcription and Re-speaking. Subtitle and transcription quality have been measured using Word Error Rates (WER) and an extended version of the NER[3] model that takes into account speaker changes, timing and subtitle

[3] The NER model is a method for determining the accuracy of live subtitles in television broadcasts and events that are

segmentation. In addition, a pilot experiment to test if post-editing automatic subtitles can help increase the efficiency and productivity of the intra-lingual subtitling task has also been carried out.

The SAVAS technology has achieved WER of 15% for Basque, Spanish and Italian; of 20% for French, Swiss Italian and Swiss German; between 20-25% for German and Swiss French; and of around 30% for Portuguese (*in the interview/debate domain*). Changes in speaker were detected with accuracy around 80% across languages. The average delay from the viewer's perspective of the SAVAS Live Automatic Subtitling application integrated at the premises of the consortium broadcasters was 7 seconds – which is in line with current live re-spoken output. Average capitalization and punctuation F-measures were around 85% and 50% respectively. Regarding productivity, results suggest that post-editing automatic subtitles is faster than creating them from scratch as four out of five subtitlers involved in the test managed to increase their efficiency that way. Although productivity gains were highly subtitler dependent, ranging from 33% to 2% across post-editors, training and practice are expected to increase them over time.

Overall results regarding the usability and usefulness of the SAVAS applications in terms of their subtitling quality features were quite promising, with state-of-the-art delay and word error rates and relatively good speaker change detection that could be refined to be more robust with spontaneous speech. The adoption of automatic subtitles as a basis for more productive intra-lingual subtitling through post-editing still needs further testing, but seemed promising as well.

On the other hand, SAVAS identified several open issues that still need to be addressed in order to increase the overall quality of automatic subtitling:

- the need for an improved punctuation model, which is still considerably error-prone:
- a general open question related to timing: "*What is more important, the reading rate of the generated text or exact synchronisation with the audio?";*
- the need for an improved splitting algorithm, which shall look into making use of syntactic information to improve overall subtitle quality;
- operational questions about how to adapt to new domains and update the corresponding vocabularies.

As SUMAT, the SAVAS project did not measure the impact of automatic subtitles in making content understandable for people with limited knowledge of the original audio language. This will be tested in a live broadcast news setting within HBB4ALL as well.

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produced using speech recognition. The three letters stand for Number, Edition error and Recognition error.

2.4. HBB-NEXT

The HBB-NEXT project examined user-centred technologies for enriching the TV-viewing experience based on HbbTV: including dynamic tailoring content recommendations to individuals and groups of viewers; allowing seamless access to content via multiple devices; interactive services; data security and user privacy issues; multi-level user authentication, voice, face and gesture recognition and advanced synchronisation methods for content delivered across different networks.

A "TV Service Customisation Application" demonstrating the achievements of this hybrid inter-media synchronization was implemented. This app allows users to adjust HbbTV based TV services to suit their own needs. Demonstrating subtitles, supplementary audio-tracks and signer videos for barrier-free access to television, it not only bundles access to these services via a central HbbTV application, but also offers the user personalisation options such as adjustable font size, positioning and background settings for subtitles.

A first subset of this application, for customizable subtitles, has been piloted on air since 2012 –based on user demand and developed in DTV4ALL. Here, users can configure the HbbTV subtitles by choosing the font size, the background design and the position of subtitles on the TV screen via an application available from the red button application (HbbTV launcher bar) of the broadcaster. In HBB4ALL RBB enhances these customizable subtitles which are currently used for live programming to be used for HbbTV on demand services – this is the background to objective A-2 for RBB.

HBB-NEXT has been intimately involved with the development of the HbbTV 2.0 specification and has actively contributed to the subjects of media synchronisation and subtitle support for broadband content. This contribution has resulted in a recommendation to allow subtitling for broadband on demand and live content within HbbTV applications. This contribution proposes reusing the EBU TTML (EBU-TT-D) specification defined by an EBU working group within HbbTV 2.0. EBU-TT-D defines a distribution format for subtitles based on the W3C standard TTML. A key aspect of the proposal is to use HBB-NEXT synchronisation methods to enable access services (*including sign language interpreter, audio description and subtitles*) to be supported within a hybrid content delivery context as described above, where the video is distributed by broadcast networks and the access services by broadband.

2.5. GUIDE

The GUIDE ("Gentle user interfaces for elderly people") project researched the concept of multimodal user interfaces for applications that automatically adapt to the needs and preferences of elderly users with different kinds of mild ageing-related impairments (hearing, vision, motor, cognitive). The GUIDE project focussed on connected TVs and set top boxes and delivered a software framework and application design tools that allow developers to integrate advanced accessibility features into their applications with reduced development risk and costs, and without having to run comprehensive tests with real users. GUIDE was intended to support accessibility to applications throughout the entire lifetime of the application: by

publishing research into generic accessibility requirements; by supporting application design; by standardising the initialisation of the application when the user first interacts with the application and by continuously supporting adaptation of the application to meet changing user requirements. In order to increase application developer support further and make GUIDE available to HbbTV applications a public API was implemented. Access to core concepts, such as the user-specific impairment levels, is possible from purely web-based (and thus HbbTV compatible) applications with adequate authentication mechanisms in place to properly take care of privacy related issues known in web based applications and APIs.

GUIDE performed three phases of user trials to collect information about user's experiences with technology as well as to make a self-assessment of their impairments. Real interactive tests with a fully integrated user test application covering most of the UI technologies considered for GUIDE were used to collect preference feedback as well as raw data as a basis for user modelling. For the developer requirements, GUIDE performed a public web-based survey which addressed aspects of accessibility and collected data about current practice and features desired for run-time adaptation and design time simulation. Two dedicated developer focus group sessions allowed collection and analysis of requirements from a wide audience.

GUIDE finalised the specification of the GUIDE Framework and Tools, which includes approaches and schemes for performing multi-modal adaptation for web applications, as a software framework that can be installed on STBs and connected TVs. It integrates with web application environments (web browsers) and various types of UI technology. Also developed was a user model which forms the basis for user simulation at design-time and UI adaptation at run-time. This model represents knowledge about the user's impairments, his cognition, perception and motor capabilities and individual preferences. The open nature of the GUIDE API in HBB4ALL demands a more flexible user profile in terms of adaptation requirements. The existing user model from GUIDE is carefully adapted towards the needs of a more general and extensible user profile, so that new adaptation parameters may easily be introduced such as subtitle-specific settings (position, transparency).

A prototype application that integrates various forms of user interface technology (gesture recognition, speech recognition, remote control, avatars, etc.) was developed that can perform tests with the user in order to measure his capabilities, when he is using the system for the first time. This "User Initialisation Application" was intended to become an integral part of the GUIDE framework and to be usable by all GUIDE-enabled applications. The User Initialisation Application has to be slightly modified in order to respect the adapted user profile and will be rebranded "Access GUIDE" during this process. Access GUIDE will store collected user information through the GUIDE API in its online database storage. Furthermore, the existing accessibility features of the User Initialisation Application will be improved in accordance with existing accessibility standards such as W3C WAI recommendations.

A prototype of the GUIDE simulation tool was also developed. It takes as input user interface designs and allows developers to evaluate their designs with respect to various vision- and motor impairments. This means that the developer can perceive the user interface as if he had vision impairments, and he can assess

how an impaired person can interact with the user interface layout. The simulation is based on a virtual user, which exploits the GUIDE model.

3. Challenges, Workflows and Technologies

This section summarises the on-going evaluation during Pilot-A of the subtitling workflows in use by the partners (*identified as typical examples of broadcast subtitling practise*) and the technical infrastructure currently utilised for subtitle production and distribution. The workflows and infrastructure are being examined to identify where changes may be required to support the delivery of **additional new** HbbTV subtitle services with a specific focus on supporting the large scale pilots.

3.1. Challenges for Subtitle Production in a Multiplatform Environment

A multi-platform distribution of subtitles creates several challenges for subtitle production.

a) **Increased volume** - The most obvious challenge is a likely increase in the amount of content that is required to be subtitled - assuming that the multiple distribution platforms are not simply a simultaneous broadcast (a.k.a. *Simulcast*). Multiple distribution platforms are typically viewed by different viewer demographics, consequently issues like geopolitical sensitivity, content suitability and viewer preferences may result in a divergence of content between different distribution platforms. For example, *live subtitling on broadcast is often replaced by corrected or pre-prepared subtitles on catch-up or VOD platforms*.

b) **Duplication** – Multi-platform distribution of subtitles invariably implies duplication of subtitle content, the same text content must be reproduced in different formats for each distribution mechanism and systems have to be implemented that render these different formats.

c) **Variation** – Unfortunately different subtitle distribution mechanisms have different limitations, *e.g. number of characters per line of subtitle text, or colour restrictions*, which means that duplicated content in many cases currently requires manual alteration and *some of the alterations necessary are difficult to codify*.

These challenges are difficult to resolve using purely technical solutions; consequently this leads to the single largest challenge in implementing subtitle services on additional distribution platforms – the **economic challenge**. Put simply, the greatest challenge in adding a subtitling service for any new distribution platform into an existing infrastructure is an increase in (largely manpower) costs. It is an objective of the HBB4ALL project to examine possible solutions to this challenge through optimization of workflow and identification of automation opportunities.

3.2. Challenges for the production of HbbTV subtitles

The introduction of HbbTV subtitles to existing workflows and infrastructures has additional challenges to those listed in the previous section that arise from the nature of HbbTV distribution:

a) HbbTV subtitling is limited *in version 1.0 and 1.5 of the HbbTV specification* to only providing support for existing broadcast subtitle formats *i.e. DVB Teletext and DVB Bitmap subtitles delivered in band as part of the broadcast signal*. The EBU-TT-D format is not supported by current software and hardware solutions for subtitle production and distribution. The new HbbTV 2.0 standard adds support for subtitling services by recommending the use of the EBU-TT-D subtitle data format. EBU-TT-D is supported with out-of-band delivery for any broadband on-demand content, in-band delivery with MPEG-DASH for live services, and in conjunction with new synchronisation methods for broadcast services where the subtitles are delivered via broadband.

b) The limitations of subtitle provision using HbbTV 2.0 are unknown as there is no end to end implementation of EBU-TT-D based subtitling on a hybrid HbbTV distribution system. It is not known how accurately subtitles can be timed when delivered in a hybrid broadcast, or what limitations may be imposed on the frequency or complexity of the displayed text due to performance limits in the receiver devices. Consequently the producers of subtitles *-the subtitlers-* do not know what additional constraints they may need to take into account when producing subtitle content suitable for HbbTV distribution.

c) The desire to support adaptation of the subtitle content to meet user's requirements may have significant implications for the subtitle production process. For example, the user may choose to override the colours of the delivered subtitles in order to enhance legibility, but mapping of colours in the receiving device as a result of user preference may result in two different transmitted colours being mapped to the same colour. The mapping of colours at the receiver may be a result of specific unchangeable strategies related to visual impairments *e.g. colour blindness* and consequently various combinations of colours may need to be prohibited at the production stage.

These challenges need to be resolved using a combination of technical solutions and analysis; one of the principal rationales for this Pilot program. Examination of the technical limitations imposed by the HbbTV standard during the early Pilot stages will guide the development of the necessary constraints for subtitlers *as either 'rules of thumb' or templates within the software systems used for subtitle production*. User testing will allow the technical constraints identified in the early pilots (*due to HbbTV limitations*) to be further refined to anticipate and ameliorate the impacts of user customisation of subtitle content in the receiver.

The degree of user customisation that will be implemented in the planned implementations of Pilot-A is discussed in D2.3.1 – Common Technical Components (I) document (CIP-IST-PSP-621014). This section will summarise the two different customisation approaches that will be followed in Pilot-A:

- Customisation by user configuration within an individual HbbTV application.
- Profile based customisation, where an application can refer to a set of previously specified user preferences (a registered online profile).

The experiences in the DTV4ALL project will be used to steer the customisation options implemented in Pilot-A. The DTV4ALL project tested five different fonts in three different sizes, where 'medium' was equal to the subtitle size currently commonly used by broadcasters. A large number of subtitle background options, were also trialled and it was clear that individual demands need to be supported (and they may be context-dependent). An HbbTV subtitling application was developed that allowed users to configure the subtitles:

- The subtitles can be placed on top or bottom of the screen.
- There are four different font sizes available,
- There are three background options.
- There is built-in help and a preview option.

The experiences in the GUIDE project will be used to steer the customisation options implemented in Pilot-A. The GUIDE project established the concept of a User Initialization Application that creates a profile for a user based on a series of tests. The profiles can be accessed by Pilot-A applications to retrieve adaptation information relevant to subtitle display. Parameters related to subtitle adaptation in GUIDE include minimal font size, font and background colour combinations, opacity of the background (transparent, semi-transparent, opaque), and subtitle position (top, bottom).

3.3. Current Subtitle Production and Workflows

The workflows used for the current production of subtitles have been assessed in the first task (3.1) of Pilot-A. To establish cohesion between the partners when discussing workflows a business model for subtitle production has been developed. This business model diagrams the main business objects and relationships and aims to establish a core vocabulary for describing the production of subtitles for current linear television broadcasts. The business model identifies a number of tasks that may be performed during subtitle production, either by a human or an automated agent.

Some of the tasks currently performed only by human agents within current workflows may be performed by automatic agents during specific Pilot-A service sub-pilots e.g. *spotting, transcription and translation*[4]. Clearly, the automation of tasks can result in optimisation if the automation reduces the time and cost, or improves the quality of output of a workflow. The addition of new demands upon a workflow, such as new formats of deliverables or increased quantities of work may require optimisations of process and work processes. Comparing real world work practises with an idealised business model may assist in identifying practises or process steps that are unnecessary, inefficient or uneconomic to sustain.

[4] Some subtitling systems already perform some of these tasks automatically.

3.3.1. Spanish Existing Subtitling Workflow

The following figure shows the main processes in the TVC subtitle workflow. Note that for IP television only on-demand programme subtitling is supported.

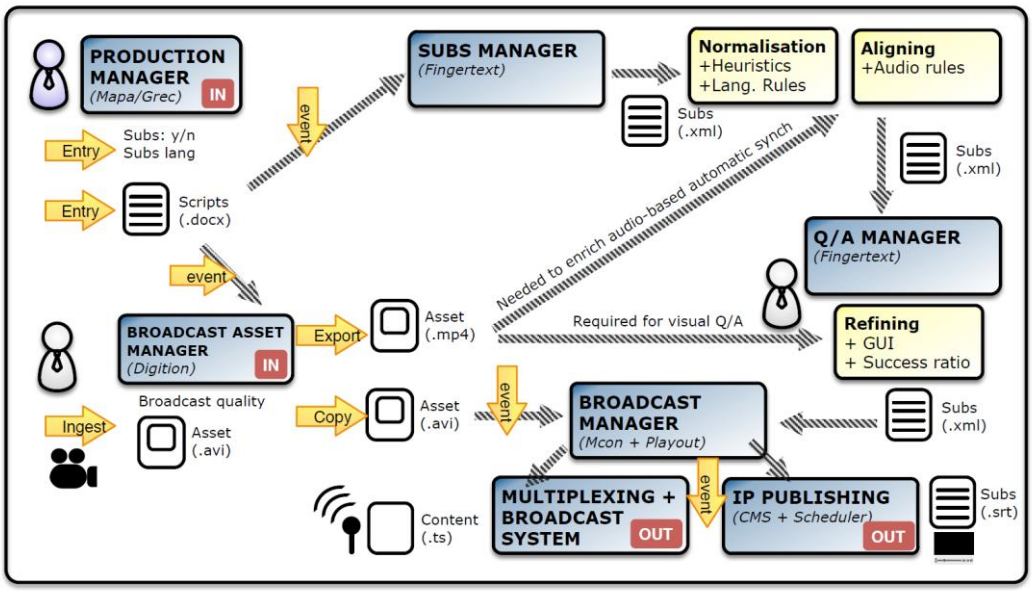

Figure 2. Existing Spanish Subtitling Workflow.

For on-demand production, the programmes are stored in the production platform of TVC. When the correspondent transcriptions are incorporated to the system; an instance of the pair asset-transcription is copied to the Fingertext subtitling repository. Once the subtitling manager (Fingertext) receives a new asset transcription pair, the subtitle segmentation and automatic alignment against the dialogue audio process is automatically done. This step is done automatically from an auto-learning Speech-to-Text system that includes the text recognition and text and subtitles formatting.

This process ends with scoring the average confidence at the recognition done. For each new processed asset, in function of its final score, the system gives advice about the level of human subtitle review needed. This score is directly related to the voices' intelligibility versus the ambient noise of the audio signal.

Depending on the score, a human revision may be done. This revision can be complete or partial. When the score has been lower than a specified value the revision will be complete. But in many cases only a partial revision is needed. A partial revision means that only the low scored subtitles will be revised.

When no human review is needed this process implies that 100% human time is saved. When a partial review is needed, the process saves more than 80% of time. On the other hand, when the score advises a complete revision, due to the initial dialogue alignment that is automated but with low confidence, the

reduction of time is only 25%. When the subtitles are accepted, the conversion to different publishing formats will start; for web it is TTML, for DVB-T the format is defined by the DVB standard and for VOD the format is also TTML. Finally, the subtitles are ready to be published at the different distribution platforms.

3.3.2. Spanish Existing Services

3.3.2.1. TV3 a la carta Application

The current TV3 a la carta application accessible via an online website offers subtitle services for some original programs made by TVC. There is only one language option of visualizing them: Catalan. For programs in foreign languages, there is neither a possibility of subtitle visualization, nor of switching to the original voice. No other personalized options are available, such as size, font or colour adjustments. Figure 3 shows a default view of the program watched through this application and initially, it has no subtitles shown.

The button which enables subtitles is situated in the bottom part of the menu bar between "comment" and "settings" buttons and it is denominated "subtitles" (see the yellow oval). After pressing this button, a list of available languages is shown in the upper part (see the blue oval). In this case only "Catalan" and "Deactivate" are available.

Figure 3. TV3 a la carta TV Programme without Subtitles.

The following image illustrates the view that is shown after enabling subtitles. The text is displayed in the bottom part of the screen, in white colour with black borders so that it can be visible with any background. As was mentioned before, no additional adjustments like colour, size, font or timing can be made.

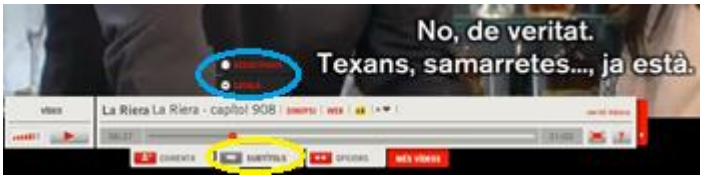

Figure 4. TV3 A la carta Menu Bar showing Subtitle Controls.

Figure 5. TV3 a la carta TV Programme with Subtitles.

3.3.2.2. TV Channel

In the case of TV channels accessible through Digital Terrestrial Television (DTT), the availability of subtitles is higher. Besides most of TVC's own production programs, almost all other programs, regardless of their original language, provide an option to display Catalan subtitles. Other options such as audio controls will be explained further in D4.2 "Pilot-B Solution Integration and Trials". The option to turn on the subtitles is situated in the main menu displayed after clicking "settings" or directly by pushing the "subtitle" button on the remote control, depending on the TV model.

After enabling the subtitle function, the captions are shown immediately on the bottom part of the screen. Normally they are displayed in different colours like white, yellow and blue, depending on the person that is speaking, so that for people with hearing disabilities it will be easier to differentiate characters. However, there is no possibility of choosing the colour personally, or of implementing any other adjustment like size or speed. As mentioned before, only the Catalan version of subtitles is available. The following illustrations visualise how the subtitles are shown for a Catalan program in a scene of a conversation between two characters, where the text is shown in two different colours (yellow and white).

Figure 6. TV Channel showing Subtitles.

Moreover, if additional annotations of sounds are available (closed captions), they are integrated into the standard subtitles and shown along with them, but highlighted in a different colour and placed within brackets, as shown in Figure 7. There is no option of separating those two types of subtitles, i.e. choosing to display only standard subtitles without annotations.

Figure 8. TV Channel showing Closed Captions.

3.3.3. Spanish End user requirements

3.3.3.1. User Stories

In the subtitle pilot there are various user stories (US) that point out the issues to be considered while establishing the parameters of the service. Those user stories were gathered through brainstorming in one of the internal workshops. The complete list in estimated order of importance is shown in Table 4.

Number	User Story description
TVC01	As an end-user I would like to change the delay between the audio and the text of subtitles, depending if I prefer to hear the audio first, etc. Also I would like to be able to elect the time duration of subtitles' display.
TVC02	As an end-user I would like to adjust the size and colour of my subtitles regarding my own preferences or disabilities to have an enjoyable and personalized experience.
TVC03	As an end-user I would like to pause the video on-demand at any moment to get information about some difficult words from the subtitles text such as its significance or pronunciation, with aim to learn languages.
TVC04	As an end-user I would like to have an option to recall personalized adjustment of size or colour so that I do not need to re-establish them every time I enter the application
TVC05	As an end-user I would like to have a second-screen with difficult vocabulary that was or will be used in the subtitle text, all that to facilitate language learning.
TVC06	As an end-user I would like to be able to designate the level of detail of the subtitles (more or less

	complex) according to my preferences, needs and type of the content.
TVC07	As an end-user I would like to have subtitles easily accessible and available.
TVC08	As an end-user I would like to be able to switch the account with one click if I share a TV device with more people, so that all of us can have their own personalized subtitles without having to introduce them each time.
TVC09	As an end-user it is important for me to receive reliable subtitles while watching live program, so that the number of orthographic, typographic or lexical errors is minimized.
TVC10	As an end-user I would like a minimum subtitle delay while watching live program.
TVC11	As an end-user I would like to have a variety of subtitles languages to choose to enhance language skills.
TVC12	As an end-user I would like to choose between standard subtitles and closed captions depending on my preferences, to maximize the experience.
TVC13	As an end-user I would like to change the position of closed captions and its colour, size, etc. so it will be clearly separated from the standard subtitles.

Table 4. User Stories of Subtitling Pilot.

In the following, a more detailed description of the four most desired user stories is presented:

The first user story (TVC01) highlights the necessity of personalized experience. Each user has different preferences, one may prefer to see the text first to have more time for its understanding, while another goes for listening first to make sure no spoiler will be revealed in the subtitles. The personalized adjustment of the delay of the text would solve this particular issue.

The second user story (TVC02) concerns the customization issue. A user would like to see subtitles that are adjusted to its needs or limits, like sight problems or other disabilities and also to its general preferences, all that to maximize the pleasure and ease of watching a particular program. To help the user with that concern, a personalized menu will be provided where each user can select design aspects of the text like its size, font or colour.

The third one (TVC03) is related to language learning through subtitles. In this case the audio language is the native/known language and the one in the text the language that the user would like to learn. In the case that in the subtitles text appears with difficult or specific vocabulary like expressions, the user wants to have a possibility to pause the video (on-demand scenario) and get precise information on that particular word, like its pronunciation or definition.

The last of the chosen user stories (TVC04) is related directly to the TVC02. When the user has already established its visual preferences of the text shown in the subtitles, he also would like to be able to recall the same adjustment the next time he enters the application, without the need of re-establishing all election. For achieving that, it will be possible to save preferences for each TV.

It is noteworthy that not all of those user stories are doable and some of them need further investigation.

Thus, firstly we have created storyboards of ones that we know are feasible as of today. The first user story (TVC01) has to be initially investigated in terms of viability. On the other hand, user stories TVC03, TVC05 and TVC08 are not feasible at the moment and need to be reconsidered for their future deployment.

3.3.3.2. Storyboards

TVC07: As an end-user I would like to have subtitles easily accessible and available.

TVC07-1: As an end-user I would like to have subtitles easily accessible and available while watching live content through DTT channel.

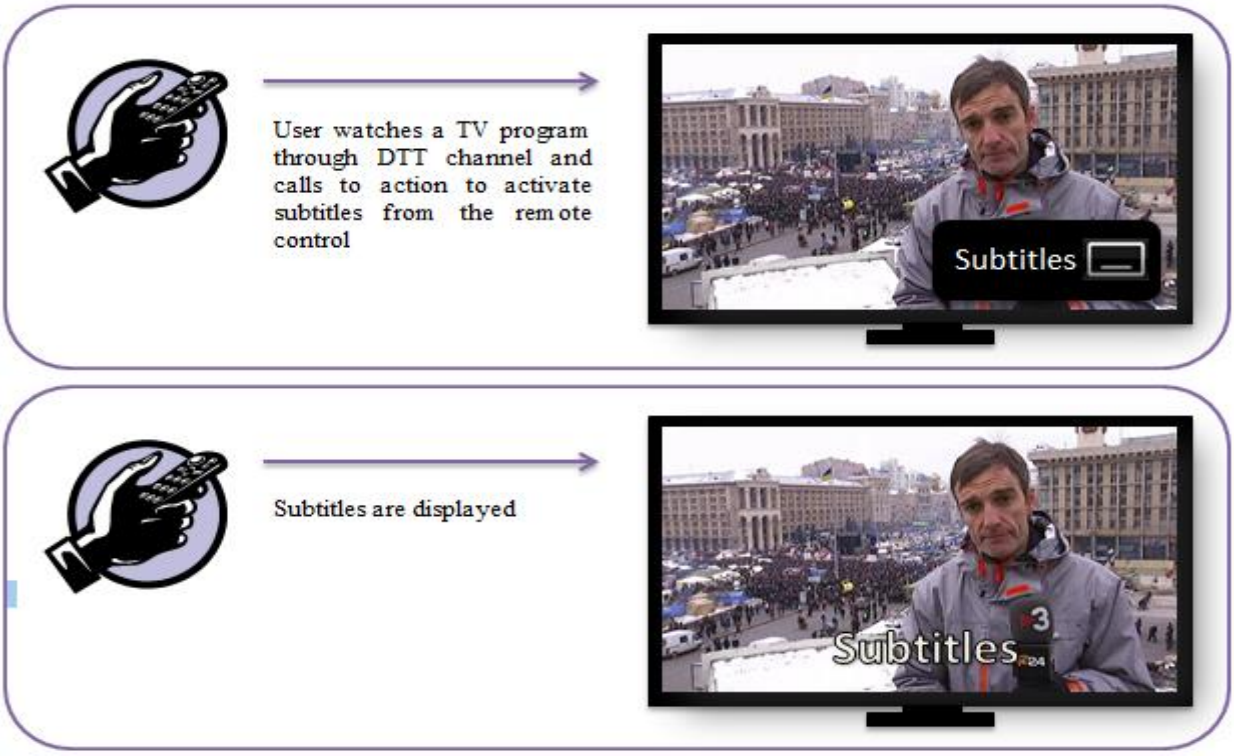

Figure 9. User story 7-1 story board.

TVC07-2: As an end-user I would like to have subtitles easily accessible and available while watching on-demand content through Connected TV application.

Figure 10. User story 7-2 story board.

Figure 11. User story 7-2 story board (continued).

TVC02: As an end-user I would like to adjust the size and colour of my subtitles regarding my own preferences or disabilities to have an enjoyable and personalized experience.

Figure 12. User Story 2 Story Board.

TVC04: As an end-user I would like to have an option to recall personalized adjustment of size or colour so that I do not need to re-establish them every time I enter the application.

Figure 13. User Story 4 Story Board.

TVC11: As an end-user I would like to have a variety of subtitle languages to choose to enhance language skills.

Figure 14. User Story 11 Storyboards.

TVC12. As an end-user I would like to choose between standard subtitles and closed captioning depending on my preferences, to maximize the experience.

Figure 15. User Story 12 story boards.

TVC13. As an end-user I would like to change the position of closed captions and its colour, size, etc. so it will be clearly separated from the standard subtitles.

Figure 16. User Story 13 story boards.

3.3.3.3. Mock-ups

For the Spanish Pilot-A first of all we have created various versions of paper mock-ups to see different alternatives for the user's interface. The next step was to carry out an internal workshop, where we discussed available options and chose one that is more suitable and doable at this point.

We have followed this methodology because paper mock-ups permit easy changes by cutting off the pieces or sticking and detaching buttons so it allows visualization of alternatives at the moment and creation even during the workshop. In the case of the digital mock-ups, it is much more difficult to alter any element and it requires a technical knowledge. Thus, we have decided to not elaborate any digital prototype as the interface is quite simple and the next step, after creating paper prototypes, will be direct creation of the real pilot.

3.3.3.3.1. Paper Prototypes

After listing most important user's requirements through user stories and storyboards, we were ready to represent them in a more tangible way, i.e. using physical prototypes. As it was explained before, first a couple of paper mock-ups have been created. For that, we have used paper sheets, pen and marker and also buttons and menu displays created on the computer and printed for easy handling. Because of this ease of creation and manipulation, we were able to create three different versions of the paper prototype presented in the following sections.

In the case of the paper versions of the prototype only one display will be provided, the one of the video in the full screen mode, as the rest of the interface is the same as the actual application *TV3 a la carta*, available via HbbTV enabled devices, in which new features will be integrated. The path to get to the mock-up display (video in the full screen mode) is the following for each prototype version:

- User starts watching DTT channel of TVC, when a pop-up window shows up as a call to action to enter the HbbTV application TV3 a la carta.
- When the user calls to action by pressing the red button, he accesses the initial page of the application. In the overhead menu bar there are buttons like: Home, Programs, Last Week, Most Viewed, TV3 Live and a search engine. They can choose to see content between highlighted videos and highlighted programs or go directly to the "Programs" section and choose content from an alphabetic list.
- When the user decides to see a specific content, the video is displayed straightway in the full screen mode. By pressing any button on the remote control, an overlaid control bar appears with the common buttons like: pausing, minimizing or scrolling the video. Moreover, specific additional buttons regarding the pilot services will be shown and explained for each case in the following sections.

At this stage, we have carried out two development sessions. First of all, we have described the interface and

delimited possible options and functions, resulting in three different mock-ups depicted in the following sections. Secondly, we have performed a workshop with the aim of choosing one of the options or create new one based on possible alternatives.

3.3.3.3.1.1. Paper Prototype Version 1

The first version of the paper prototype covers a scenario in which there are three separate buttons available in the overlaid control bar associated to the subtitling function. First on the left (CC) enables closed captioning, which are subtitles prepared especially for deaf people that includes descriptions of non-speech elements. The second one is the enabler of standard subtitles. Both, closed captions and standard subtitles, can be either activated or deactivated by clicking on the button (no more options are provided for these buttons). The last one, displayed as a settings button includes subtitle text personalization such as: Language, Position, Colour, Size and Background.

The mock-up and its flowchart are presented in the following illustration:

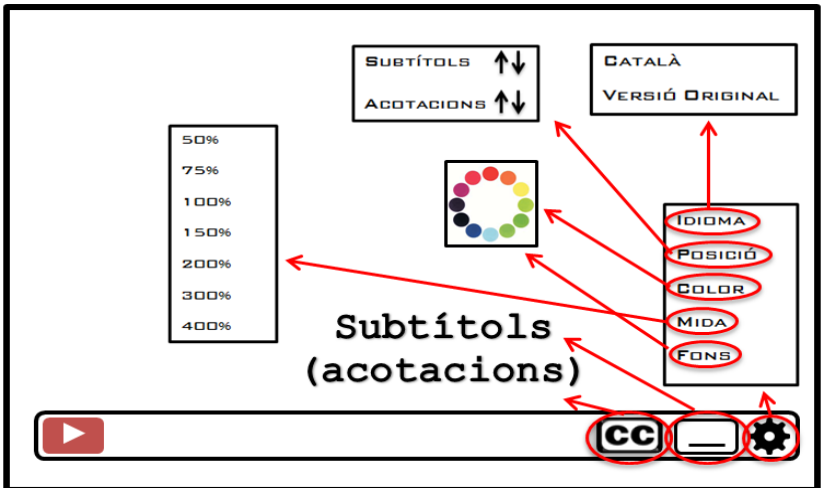

Figure 17. Paper Prototype version 1.

3.3.3.3.1.2. Paper Prototype Version 2

In the second version we have reduced the number of buttons in the control bar into one single button – a general subtitle button that enables the function and also permits personalize them. After clicking the button a menu window shows up where the user can activate/deactivate subtitles and also another button to personalize them. It doubles the steps to enable subtitles, but also encourages the user to personalize subtitles. In the case when the settings button is separated, like in the first and third version, the user may decide not to enter it or simply does not realize that there are subtitle personalization options.

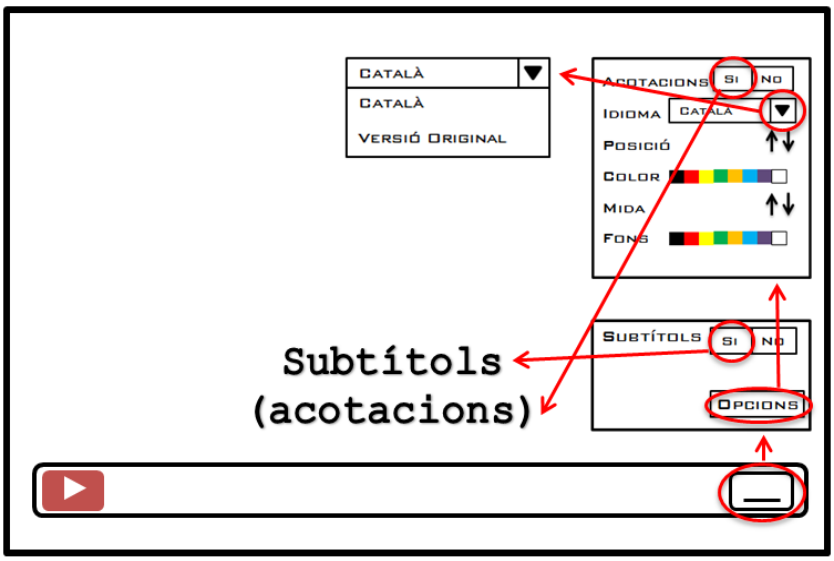

Figure 18. Paper Prototype Version 2.

When already placed in the personalization section, the user can activate/deactivate closed captioning, followed by language choice and text customization such as its colour, position and size.

3.3.3.3.1.3. Paper Prototype Version 3

In the third and last version of the paper mock-up there are two buttons in the control bar, incorporating closed captions enabler into settings. The button to enable subtitles remained separate as in the "Paper Prototype Version 1", but the settings button changed its design to emphasize that it is associated only to subtitles. This differentiation is very useful in the case of appearance of other settings like those linked to audio futures or general settings of the video.

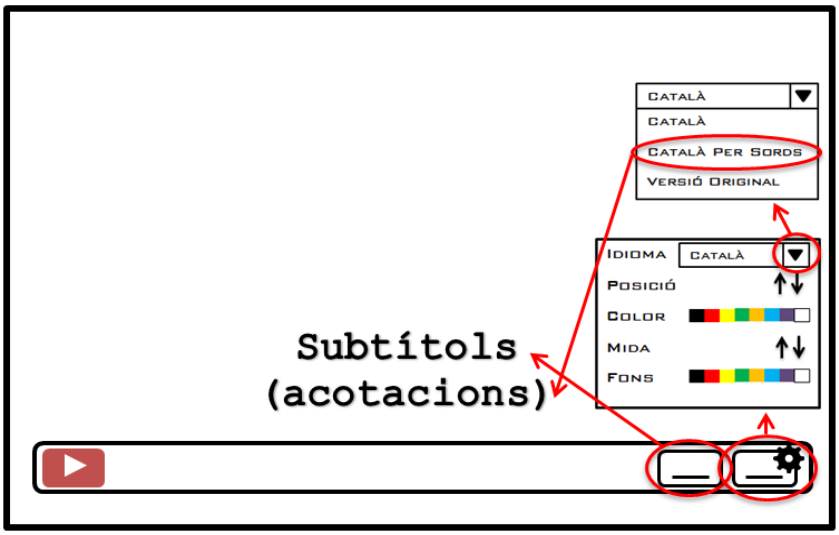

Figure 19. Paper Prototype Version 3.

In this scenario all configuration can be made directly from the first settings window, instead of having to open each element like in the first version. While choosing the language we can decide between standard subtitles or closed captions (both in Catalan) and the original version of audio.
As it was described before, in the second internal workshop regarding paper mock-ups, we have carried out a presentation of possible alternatives with the aim of choosing the one that is more suitable. The version chosen for the future service development is the "Paper Prototype Version 3", which will be used as a base for the future pilot.

We have selected this version as we think it is much more comfortable for the user to have a direct button of activating/deactivating subtitling, instead of having two steps, like in the "Paper Prototype Version 2". Also it has to be clear for the user that the settings button is associated only with subtitles, as while integrating other functions like audio, it has to be clearly differentiated. The menu display chosen should be easy to navigate as all options are visible and no other menu has to be displayed as it was presented in the ".
".

3.4. Requirements from Broadcast Subtitle Departments

The new requirements from broadcast subtitle departments for the production of HbbTV subtitles have been collected during the first task (3.1) of Pilot-A. The partners involved in subtitle production (Broadcasters) have contributed information to the Pilot in the form of 'Use cases'. These use cases have been used to develop a set of new requirements for HbbTV subtitle production. Many of the requirements for HbbTV subtitle production are naturally also common to linear broadcast TV subtitle production; although the following identified requirements have a clear impact on re-designing workflows to include HbbTV subtitle production.

- **Consistency of Coverage** - providing the same quantity of programmes subtitled as in traditional broadcast (often a legal obligation).
- **Consistency of Quality** - providing similar subtitle quality to traditional broadcast.
- **Customized Subtitles** - achieving content appropriately accessible[5] by 100% of the potential audience using customized subtitles on HbbTV.
- **Minimal Economic Impact** –delivering the same (or better) subtitling services as in traditional broadcast, with the lowest extra costs possible e.g. automatically handle generating the correct distribution format for different delivery platforms.
- **Efficient production -** delivering subtitle files on schedule and in the shortest time possible.
- **Minimal retraining** - Using (*upgraded*) existing subtitle production systems.
- **Re-use** - of archived subtitle files for previously subtitled programs.

The introduction of new technologies into existing workflows (e.g. speech recognition and automated

[5] E.g. Font size, colours and (translation) language appropriate to each viewer's abilities.

translation) may initiate the development of new workflows with improved efficiency:

- The automated production of reference transcriptions that can be used when translating or producing subtitles for the Hard of Hearing community.
- Automatic 'spotting' – the generation of empty subtitle files that mark where dialogue exists in the program. (N.B. time-codes generated by automatic speech recognition may not be directly usable for subtitle timing to an acceptable quality).
- Automatic translation subtitling – the generation of draft translation subtitle files. Note, that subtitles generated by automatic translation may require significant re-work to meet accepted quality standards.

3.5. Workflow Changes Required for Multiplatform Delivery

Specific technical requirements can be derived from the new production requirements for HbbTV derived during the first task (3.1) of Pilot-A.

- Conversion from archive subtitle files into multiplatform distribution formats (including HbbTV) – e.g. to meet the requirements of re-use and efficient production.
- Connection of existing subtitle production systems into multiplatform distribution systems – e.g. to meet the requirements of minimal retraining and efficient production. This is specifically relevant to the production of live subtitles as there is no opportunity to convert a complete subtitle file (since it does not exist).
- The ability to preview HbbTV subtitles in the production environment to meet the requirements of consistency of quality.

3.6. Technologies and System Infrastructure

3.6.1. Current system infrastructure

One part of the requirement analysis in WP3 was the evaluation of the system architecture for subtitle authoring, contribution and distribution. The goal of the evaluation was to define a representative cross section of the architecture landscape of HBB4ALL partners. From that definition the necessary change requirements have been deduced. These change requirements help to identify the implementation work needed for interfaces and systems used by HBB4ALL subtitling services, especially the new HBB4ALL subtitling services that are rolled out by a broadcaster that need to be aligned with the existing services. It was therefore important to take into account the existing system architecture of (Teletext and DVB Bitmap) broadcast subtitles.

The analysis was performed on information provided by the HBB4ALL partners RBB, VIC, TVC, UPM, RTP and IRT.

3.6.1.1. Authoring

HBB4ALL partners use different software for the manual preparation of broadcast subtitles. The authoring file format of the subtitles depends on the software manufacturer but there are commonalities in the interchange/contribution formats that are used for further processing. The main use case for the specification of these interchange formats is the transport of broadcast Teletext subtitle information. In general, the EBU STL (Tech 3264) format is used for file based subtitles that are used for the contribution of prepared content.

For the creation of live subtitles there is a greater variation. As there is no standardized protocol to transport live subtitling information, different proprietary protocols are used in practice. Most of them also have been designed specifically for the transport of Teletext subtitle information.

For the HBB4ALL broadcaster the authoring of subtitle information for HbbTV VOD services is closely linked to the authoring of broadcast subtitles for existing services. In most scenarios the system that is used for preparation of broadcast subtitles is used also for VOD subtitles and in general additional manual interaction is needed to export the subtitle information in the VOD subtitle formats.

The HBB4ALL partner RBB is the only partner that already operates a live subtitling service with broadband technology. An HbbTV Subtitle 'App' is provided for broadcast content. From the authoring perspective the same process and subtitle information exchange context applies as for broadcast subtitles.

A different scenario is the automated generation of subtitles. The HBB4ALL partner broadcaster RTP uses automatic translation tools for the distribution of live subtitles over the broadcast program. A system that automatically translates the audio emits the subtitle information in one of the proprietary live protocols.

3.6.1.2. Contribution

The systems involved in the further processing of the subtitle information depend on the targeted service. For broadcast Teletext and DVB Bitmap subtitles, the subtitle information has to be embedded in the MPEG 2 TS that is used for the different DVB services (DVB T/S/C).

For prepared content the information that is provided by the authoring part is mostly available in the EBU STL format. On this basis the subtitle information is inserted directly in the MPEG 2 TS or added first into the uncompressed video signal (SD-SDI or HD-SDI) using the VBI (Vertical Blank Interval) or the VANC (Vertical Ancillary Data).

For the provisioning of VOD subtitles in general, no further processing of the subtitle information as provided by the authoring process is needed. The subtitle information can be directly used by the rendering device. As the information is provided separately from the A/V content, some metadata has to be provided in the processing chain that link A/V content and subtitle information.

The processing steps to provide live broadcast subtitles are similar to the procedural steps needed for

prepared content subtitles. Instead of standardized EBU STL files the system has to deal with a variety of different proprietary live subtitling protocols as input formats. These are then used to insert the subtitle information into an SDI signal or the MPEG 2 TS.

The HbbTV Subtitle App for broadcast content has to deal with the same input formats as the subtitle services for broadcast content. The information for the HbbTV App is embedded in the MPEG 2 TS (in a special DMSCC section).

3.6.1.3. Rendering

The rendering device for DVB Bitmap and Teletext Subtitles for broadcast content is built into TV sets and set top boxes. If a user recorded program is played out on another device (e.g. a PC), software that is dependent on the operating system may be able to display the subtitles.

The TV manufacturers have the biggest responsibility for providing the rendering engines for these services. This is very different for the distributions of subtitles for VOD content. The software for rendering subtitles is dynamically downloaded by the user and provided most often by the content provider. As there are no standardized out of the box extensions for the rendering of subtitles all partners have their own customized version of a web player to render the subtitles.

The situation for the rendering of the HbbTV Subtitles (for HbbTV version 1.0 and 1.5) for broadcast content is similar to the rendering of VOD subtitles for PC. The rendering application is not provided by the TV Set or set top box but by the content provider. As the HbbTV device does not render the subtitles natively the HbbTV Subtitle rendering engine is transmitted in the MPEG 2 TS or downloaded from an HTTP server.

3.6.2. Change requirements for existing technologies

3.6.2.1. Authoring

For the roll-out of the HBB4ALL Subtitles the authoring process has to provide the subtitles in an adequate format. For the VOD subtitles most of the partners use the EBU-TT-D format. This improves the interoperable implementation of systems and interfaces.

HBB4ALL partners have been active in the standardisation activity of EBU-TT-D and made sure that HBB4ALL requirements have been incorporated into the standard.

Many of the subtitle preparation tools have no export feature that allows the lossless transformation of the characteristics of broadcast subtitles into EBU-TT-D. Some of the preparation tools support a strict subset of EBU-TT-D which is used by the ARD broadcaster. This format is called EBU-TT-D-Basic-DE. EBU-TT-D-Basic-DE will be used in the pilot services by RBB.

As the adoption by the vendors of the subtitling software may take longer than needed to implement

HBB4ALL services, the development of a subtitling conversion framework has been started as part of the HBB4ALL project. This framework will be made available to the public as open source and provides the ability to automatically transcode broadcast subtitles into a format required by the HBB4ALL pilots. The tool is tested and partially integrated in the workflows of TVC and RTP.

Discussions with editorial departments have shown that there is a difficulty from the editorial side to predict the influence of new services on the editorial process. In general, subtitlers have to deal with an increased workload and lack resources to control the additional subtitle characteristics that are used in new subtitle services. Because of this, establishing the change requirements for authoring tools has to be done in a prototypical way and by using examples to stimulate feedback from the authoring side. One planned new feature is to provide additional preview windows that show the rendering of subtitles for different services (e.g. for PC, HbbTV or Mobile).

From the current evaluation there is no strict requirement for editorial features of authoring software for the roll out of HbbTV Services. The implementation is possible with existing features. The tested advanced features are therefore an optional improvement of the new workflows.

For the further processing of live subtitle information there is an urgent need to use standardized technologies and update interfaces. The protocols that are currently used are all proprietary. This makes integration in new systems that are needed to distribute live subtitling services to broadband connected devices very difficult. Furthermore current technologies transport only very limited subtitle information which is often insufficient for the targeted quality for live subtitling services.

One problem that has to be faced is a missing published standard for the transmission of live subtitle information. Although EBU has standardization activities to define a format for transmitting live subtitle information this will only be available as a draft version by the end of 2014.

It is therefore likely that any changes to the subtitling authoring software in respect of the interfaces for live subtitling information would not be ready in time. Tools for automated subtitling as developed by VIC are more flexible in this respect and integration in the lab tests is currently evaluated.

3.6.2.2. Contribution

For VOD subtitles typically no change of the existing interfaces or systems is required, because from the authoring stage the subtitles are already provided in a format that can directly be used by a rendering device, and so no further processing is needed. However, updates to the Content Management Systems and Procedures that link A/V and subtitle assets are still necessary.

The technical infrastructure for streamed 24/7 programs or streamed live events is more challenging. From the standards perspective the most stable technical solution to use in this scenario is the DVB MPEG DASH profile for live content. By referencing other standards this profile defines how to embed subtitle information

into the ISOBMFF container using EBU-TT-D.

There is also a change requirement for live encoders of broadband content. They have to implement encoding features for streamed subtitles. The requirements gathering of which input formats must be supported by encoders is in process. Options that are currently under investigation are SD-SDI with Teletext subtitle information in the VBI, HD-SDI with Teletext subtitle information in the VANC, early implementation of EBU-TT Live over IP or MPEG 2 TS with embedded Teletext subtitle information.

The next release of HbbTV (2.0) will enable service providers to offer subtitling services for any kind of audio-visual service delivered to an HbbTV device. The new features include the support of rendering of EBU-TT-D subtitle documents for any type of on-demand A/V content. The subtitle documents are delivered out-of-band, i.e. they are not multiplexed or signalled within the A/V content but downloaded as separate files to the HbbTV terminal. The linkage between A/V content and subtitle documents is achieved via HTML.

HbbTV also updated its MPEG-DASH profile to support EBU-TT-D subtitles inline. With the new MPEG-DASH profile live services over broadband can also now include subtitles. The HbbTV profile is largely based on the DVB profile of MPEG DASH, which is available as a Blue Book from the DVB web site.

By adding support for EBU-TT-D, HbbTV closed a crucial gap of the first version of the specification. In addition, the multi-stream synchronisation feature of HbbTV V2.0 adds a new way to use the broadband connection for the delivery of supplementary streams like subtitles for broadcast services. Multi-stream synchronisation allows both classical DVB subtitles in MPEG-TS and EBU-TT-D delivered over broadband to be synchronized with the broadcast service. This new feature is quite sophisticated and it is partially optional for it to be implemented in HbbTV devices. Pre-produced subtitles in EBU-TT-D format have to be supported. Scenarios where the HbbTV device needs to buffer the broadcast service in order to achieve a synchronised presentation are optional.

3.6.2.3. Rendering

For all services either the new changed requirements have to be supported in the existing players already implemented or completely new players have to be developed. Most of the players will support the EBU-TT-D format.

The biggest challenge is the implementation of a player that renders subtitles from a 24/7 program or a live event program using the DVB MPEG DASH profile.

4. Service Sub-Pilots of Pilot-A

4.1. Introduction

During year one of Task 3.1, a number of different "Service Sub-pilots" at different locations in Europe for Subtitle Pilot-A were defined. In addition to the services tackled by Service objectives A2 "HbbTV-VOD service pilot" and A3 "News Service Pilot", two additional pilots are planned to be implemented, thus exceeding the initial scope of the project. This concerns "Customised subtitles for wide focus multi-platform" and "Customised subtitles for online learning".

Initial assessments were made of the requirements for implementation and workflows and integration of the required applications has started this autumn in the context of Task 3.2. These different "Sub-pilots" have been planned, taking into account the identified existing infrastructure technologies and the planned HBB4ALL service components. The scope and characteristics of the planned service "Sub-pilots" are detailed in the following sections.

4.2. Customised HbbTV Subtitles for VOD portal - Germany

4.2.1. General Set-up

In 2010 RBB carried out extensive DVB subtitle tests with 50 deaf and hearing impaired people within the DTV4ALL project (see section 2.1). As a result guidelines were defined on how subtitles should ideally be drawn on a TV screen. Deaf and hard-of-hearing users and their associations agreed on that approach of having a common subtitle representation based on a majority decision, and in parallel demanded an approach where users can change and customise subtitle graphics themselves, which was technically not yet possible in 2010.

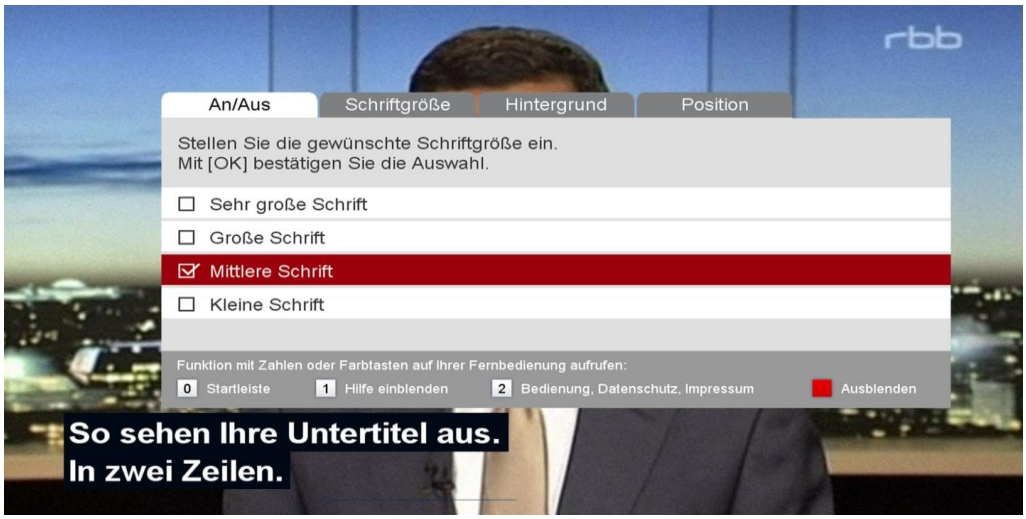

Figure 20. HbbTV application for customising subtitles, here adapting font size (RBB).

In the HBB-NEXT project (see section 2.4) a technical solution was developed and introduced in Berlin-Brandenburg area in 2012. This approach provided TV viewers with the functionality of adapting subtitles for their DVB-based programme with the help of an HbbTV application. Users can currently set-up four different font size classes and three different background settings, as well as the vertical position of the subtitle texts.

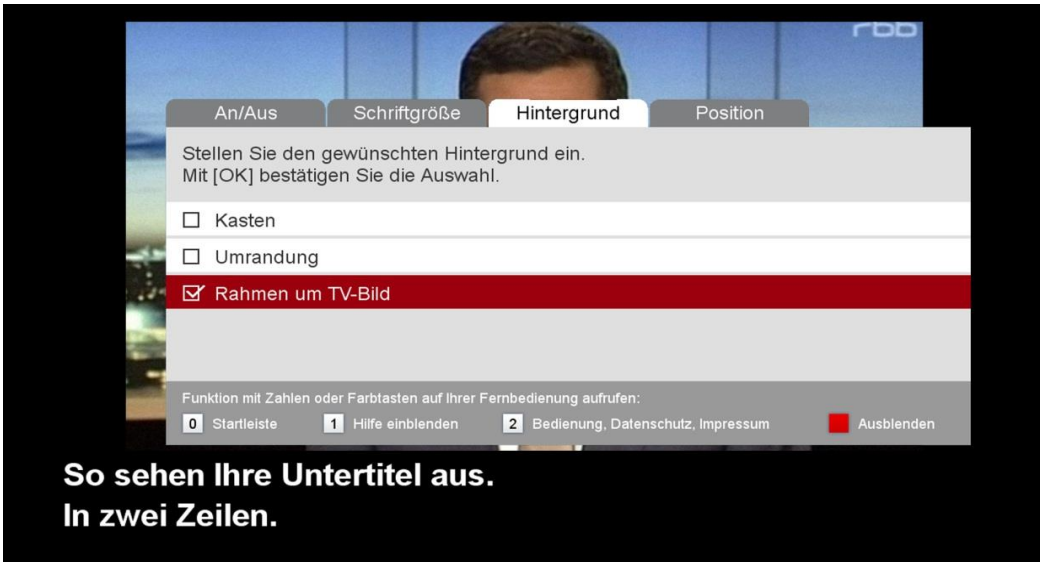

Figure 21. HbbTV application for customising subtitles, here adapting text background (RBB).

That solution is currently having a great acceptance in the region and RBB aims at integrating subtitle customisation in its HBB4ALL VOD pilot, based on the guidelines from DTV4ALL and the utilisation from HBB-NEXT. The set-up of the pilot is described as follows:

For the German service pilot RBB aims at adopting the current subtitling production process for on-demand media. As described in Chapter 3, this incorporates a proper post-processing of the needed subtitle data, done with the help of WINCAPS QU4NTUM software by Screen. The resulting subtitle data will then be exported in the format EBU-TT-D on a shared network directory. A subtitle editor can now import that subtitle file by simply assigning it to the corresponding video item in the GUI of the online CMS of RBB. The CMS will automatically take care of the subtitle export towards the actual, ARD-centralised VOD environment ("Mediathek") via an ARD-wide well defined TVAnytime interface. This will result in a proper availability of a video item with a dedicated subtitle file for a provision via IP.

RBB is planning to have the HbbTV-based VOD subtitling pilot ready in March 2015 as a level 1 baseline solution. In the level 2 phase to be started in August 2015, customisation features will be added, so that users can adjust the subtitle appearance regarding font size, text background and considerably the position of text.

4.2.2. Status of work

According to set-up above, the subtitling software is in the status of being updated with a new software version which is also capable of processing EBU-TT-D files. This task is ongoing at the moment and will end in M12 and is prerequisite for the complete RBB pilot here. Also a subtitle transcoding facility will be ready by end of M12, which can then be used for transcoding "old" STL files into EBU-TT-D versions, in order to process subtitles produced before the software and environment were adapted towards EBU-TT-D. Also the online CMS is currently being update so that it is able to process EBU-TT-D files on a permanent basis.

At present, the ARD-wide, centralised VOD environment (containing servers and databases for VOD essence and metadata) is also being adapted for processing EBU-TT-D data. In addition the adaptation of the file parsing and player modules for the HbbTV back- and front-end is currently being done.

4.2.3. Time frame

According to the internal planning the subtitling software, CMS and VOD environment will be ready by end of M13. The HbbTV parser and player modules will be available for level 1 by the end of M15. The additional subtitle customization feature in the HbbTV application will be ready at M20, so that M21 will mark the beginning of level 2, the operational phase, which will end in M32.

4.2.4. Test users

The German pilot can potentially target ~6 million households with HbbTV-enabled devices in Berlin-Brandenburg area and beyond in Germany for a quantitative analysis. For a qualitative validation RBB will again work closely with organisations for the deaf and hard-of-hearing in Berlin and Brandenburg. 30 users from the target group will be chosen for an evaluation of the pilot.

4.2.5. Validation method

Validation will be done with the help of interviews and questionnaires. It is required that all the 30 test users must have an HbbTV-enabled device ready for the pilot phase. RBB aims at organising a closing workshop at the end of the operational phase with all the involved users.

4.3. Customised HbbTV Subtitles for VOD portal - Spain

4.3.1. General Set-Up

TVC is aiming to provide the services live and open to all users before the end of the project. This includes non-customizable baseline HbbTV subtitles on a 1st phase and on a 2nd phase TVC will add customization, following up on RBB's HBB-NEXT work on this. HbbTV subtitles are to be considered for non-live broadcast, for live broadcast, for on-demand IP content streams and /or for live IP content streams.

4.3.2. Status of work at M12

TVC has analyzed the own existing workflow and service, others partners services (for instance, RBB). TVC has tested and provided detailed technical feedback to IRT about their subtitle transcoding tools, which TVC has used for transcoding TVC's STL working format into EBU-TT and EBU-TT-D.

At the present time TVC is analyzing the playback of the EBU-TT-D subtitle format in the TVC HbbTV video player. TVC is also working on the EBU-TT-D generation and integration in our automated subtitling workflow. As described in section 3.4 TVC has done requirements analysis and mockup construction. In addition, TVC has been defining a quantitative validation method with in-app event markup using the Adobe Omniture engine.

4.3.3. Timeframe

M21-M32 (August 2015 - July2016)

4.3.4. Test Users

30 test users from the target group of the deaf and hard-of-hearing in the case of lab tests by UAB. In the case of the open pilot deployment, any interested users in Catalonia having a capable HbbTV TV device.

4.3.5. Validation Method

Validation will be achieved by end-user questionnaires, interviews and HbbTV application javascript event-based audience monitoring (using Adobe Omniture).

4.4. Customised HbbTV Subtitles for VOD portal - Switzerland

This is only a short summary for TXT's activitities in this area – TXT is performing a lot of work but as a non-funded partner does not document its work intensively. Roll out of an HbbTV-based subtitling service is planned from the end of 2014, exclusively for VOD, including possibility to customise the subtitles (size, positioning, colours, etc.).

TXT has installed a server which grabs all broadcast subtitles and stores them as an XML file in a database with the real-time time code. Video files on HbbTV will contain the same time code. Thus subtitles will automatically be available for almost any video content on HbbTV. As long as TXT is obliged to subtitle only broadcast content (until 2017) we will maintain this procedure.

The HbbTV-ST for VOD app will be ready by the end of the year 2014, but subtitles won't be accessible yet as the television channels (in German, French and Italian) are delayed with their video supply. VOD with subtitles will then be accessible by the first quarter 2015. In a second run next year we will aim to enhance the application. For the first version of the app the following criteria apply:

- as simple as possible
- no configuration possibilities for the user
- use of cookies
- use of automatically stored subtitles
- conversion from TTAF to JSON

4.5. Customised Subtitles for VOD on Wide focus multi-platform – Portugal

RTP as a public broadcaster is an organization committed to the needs and requirements of all citizens, including people with disabilities. For this reason, RTP has traditionally provided a variety of access services, including subtitles, audio description and signing. In fact, RTP is one of the leading Portuguese broadcasters in access service provision.

Subtitles are currently included in RTP linear/broadcast emissions by means of Teletext, which is one of the technical tools considered in the DVB norms to provide the services. The formats used in the RTP premises to manage the subtitle authoring and exploitation are STL and SRT.

The deployment of HbbTV is not being considered by RTP as a priority, inside the HBB4ALL project, the current RTP strategy concerning broadband distribution of multimedia programmes is focused on PC or similar devices. In this way, RTP strategy allows to extend the HBB4ALL focus to other devices and mechanisms for the delivery of contents.

UPM is collaborating with RTP to carry out the required activities to deploy this user test, centred on the following characteristics:

- Exploitation of subtitles for audio-visual content delivered by means of a broadband network (i.e., Internet) to be presented on a variety of devices, including PC, tablets and smartphones.
- Use of web-browsers and web technologies for the creation of a subtitling presentation tool.
- Use of the EBU-TT-D format for subtitle distribution.
- Reaching an implementation as compatible as possible with HbbTV, since HbbTV applications consist of HTML content which is interpreted by a browser embedded in the hybrid TV receiver.

- Considering video-on-demand applications (similar to catch-up portals).
- Adding customization options in a second phase to provide a fully satisfying service.
- Testing the service from RTP servers, according to the current RTPplay model.

UPM has a wide experience on the implementation of solutions for audio-visual accessibility, using the available technologies in each moment (e.g., interactive TV or connected TV based on HbbTV). For the customization features, this pilot counts on the collaboration of VSX, which can provide the required personalization technology.

As STL is the format traditionally used by the industry, a tool is needed to generate the EBU-TT-D file, which will be interpreted by the web-based application implemented in the pilot. For this purpose, this pilot uses the technical component provided by IRT named "Subtitling format conversion framework".

4.5.1. Status of work at M12

The implementation of the subtitling tool to be used on this pilot has completed several steps for the first year of the project. Currently, the implemented application is able to interpret EBU-TT-D subtitle files, converted by means of the subtitling format conversion framework.

The application uses web technologies such as JavaScript and HTML to be successfully interpreted in web browsers. Moreover, one important requirement has been the compatibility with HbbTV receivers. For this reason, the implementation and integration activities are using the Firefox plugin for HbbTV applications (named Fire TV) to check the compatibility.

At this moment (M12) the application is able to:

- play the audio-visual content;
- interpret and depict the subtitles in a synchronous manner, according to the EBU-TT-D format. The start of the audio-visual file is interpreted as time reference;
- interpret and depict the associated format information, such as fonts, size and position on the screen;
- interpret additional features in the playing timeline, such as forward, backwards and pause.

The preliminary implementation has been prepared for a certain audio-visual content, as shown in Figure 21. The ongoing work aims to play the subtitles of any RTP programme. For this purpose, RTP has created a REST API able to provide metadata about the available programmes in its servers, detailed information about programmes and episodes, the URL where contents are located to be streaming and the URL where the EBU-TT-D subtitle files are located. To create these files, the mentioned conversion framework is used.

Figure 22. Subtitling application based on web technologies in an HbbTV-compatible PC browser.

The basic workflow used in this process starts inside RTP's Accessibility Unit, with the production of STL subtitles file for broadcasting teletext accessibility subtitle service. Then, the file is uploaded into GMediaTX, in the episode program database, with the same media id of the program. The publication system, based on AsRun log file detects the programs to publish and records them in database.

To manage all format conversions several worker tasks were defined (jpg, mp4, mp3...). Each format corresponds to one worker task, which works independently and searches for a new job each minute. For the subtitle conversion of the EBU-TT-D format, a new worker task was defined. The EBU-TT-D worker task searches the STL file in GMedia and starts the workflow described in the framework conversion, converting STL -> XML -> EBU-TT -> EBU-TT-D.

After all steps have concluded, the EBU-TT-D worker task signals the format is converted and ready for upload. The upload worker task finishes the process, uploading and recording the subtitle file in the RTPPlay database. After this, the subtitle file, video and other metadata are available via the RTPPlay API.

4.5.2. Timeframe

This service pilot is considering the following timeframe:

- January - August 2014. First version of the multi-platform subtitling tool. Interpretation of EBU-TT-D files for VOD content, including format options.
- September - December 2014. Integration with RTPPlay API to admit any RTP piece of content.
- January - July 2015. Addition of customisation.
- August 2015. The operational phase begins.

4.5.3. Test Users and Validation Method

The laboratory validation of the subtitling tool has been performed by means of the use of HbbTV hybrid terminals, TV transmission equipment and HbbTV-compatible web browsers. User validation will involve viewers who enable the subtitling tool in the RTP site. In this way, the tool will be massively tested. Moreover, preliminary versions of the tool will be available before the beginning of operational phase in order to validate partial functionalities.

4.6. Automated HbbTV multilingual news broadcast subtitles- Spain

4.6.1. General set-up

The following two automated subtitling modules will be integrated within the HbbTV workflow:

- Real-time transcription and automated creation of subtitles.
- Machine translation of the generated subtitles.

The service will focus on the "News" domain, for which the automated subtitling modules are trained. The use case scenario will be that of "shocking news" (e.g. Boston marathon) being broadcast at international level but only produced in the source language. The real-time transcription service will be used to generate subtitles of the broadcasted event while the machine translation service will make those comprehensible in other languages. Although the quality of the output subtitles will not be professional, HBB4ALL expects them to be useful to enhance comprehension at newsroom level. The real-time transcription technology developed in SAVAS and a version of the subtitle machine translation technology developed in SUMAT adapted to the news case scenario will be integrated in the HbbTV workflow – which will be modified as necessary to include the above two modules. UAB will evaluate the impact of automatically generated subtitles in content comprehension.

4.6.2. Status of work at M12

During the first year of the project, we have:

- Adapted the machine translation technology to the broadcast news domain.
- Defined the workflow and architecture required to integrate the automatic subtitling modules in a live HbbTV scenario.
- Defined the qualitative evaluation methodology.
- Generated a first batch of automatically subtitled and translated material for the first evaluation round.

TVC has sent sample content with English language audio with English transcription for VIC service testing.

4.6.3. Timeframe

Adaptation and integration from M1 to M20. In operational phase from M21 to M32. Evaluation from M1 to M36.

4.6.4. Test users

Qualitative test users will be journalism students with little English language skills. They will be shown English contents with and without automatically generated subtitles and differences in their comprehension

level will be measured.

4.6.5. Validation method

Validation will be done at two different levels: qualitatively and in terms of quality. **Qualitatively**, the feasibility of employing automatically generated subtitles to improve the comprehension of journalists regarding "shocking news" will be tested. **In terms of quality**, the delay, recognition and punctuation errors, timing, splitting and speaker colour features of automatic subtitles will be evaluated using metrics such as WER, precision, recall and F-measures. Translation errors will be evaluated using standard machine translation metrics such as BLEU (BiLingual Evaluation Understudy) and TER (Translation Error Rate).

4.7. Automated HbbTV multilingual news broadcast subtitles- Switzerland

TXT plans to also test this service in a service sub-pilot.

4.8. Customised Subtitles for Online learning (MOOC) - Germany + Spain (VSX)

4.8.1. General setup

Vsonix is working on a video based learning application ("MOOC"), which is planned to be provided as webcast (online) service for Spain as well as for Germany. The MOOC will act as a cross-pilot showcase addressing Pilot-C and Pilot-A, whereas the online UI adaptation service targeted in Pilot-C based on GUIDE (see chapter 2.5) will be extended in WP3 to also support user profiles for personalized subtitle rendering. The MOOC service will be available for PCs and mobile devices. It integrates a variety of functions including lecture content playback, user access and profiles, functions for social communication including messaging boards and chat as well as functions for learning assessment.

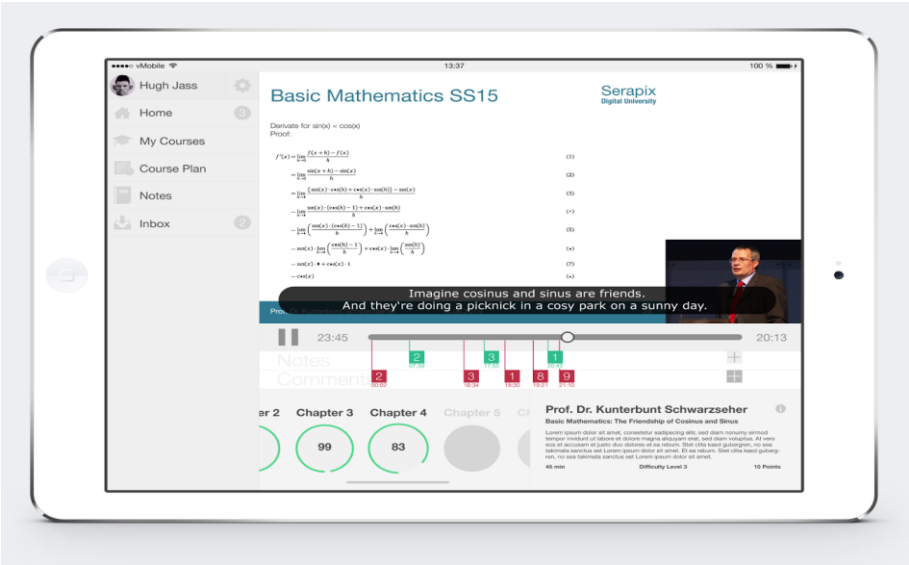

Figure 23. UI design for the MOOC application.

The content of the MOOC showcase for Spain will be developed by UAB. The goal is to provide an online course for media accessibility. The course will consist of a number of lectures addressing different aspects of media accessibility and interactive functions for learning assessment and feedback provision. For Germany, Vsonix has started a collaboration with the Jacobs University of Bremen to provide a series of lectures in Mathematics. As an alternative, Vsonix will provide a German version of UAB's media accessibility course.

The MOOC service is actually integrated using software components developed by Vsonix including vPlayer, a Flash and HTML5-based webcast player that is capable of playback of lecture and presentation content as well as vInteract, a software component that provides functions for social interaction including messaging, chat and voting functions. The MOOC will be hosted via Vsonix' content delivery network (CDN). The subtitle implementation for the vPlayer is based on common standards such as EBU-TT-D using the W3C Standard TTML for implementation.

For the subtitle adaptation/personalisation mechanisms, the MOOC implementation will use the UI adaptation framework based on GUIDE that is targeted in Pilot-C. The framework will include an application called AccessGUIDE. This application provides a number of standard-tests to determine the user's preferences/needs related to personalized subtitle rendering including parameters like subtitle speed, font size, position, font type contrast and colour.

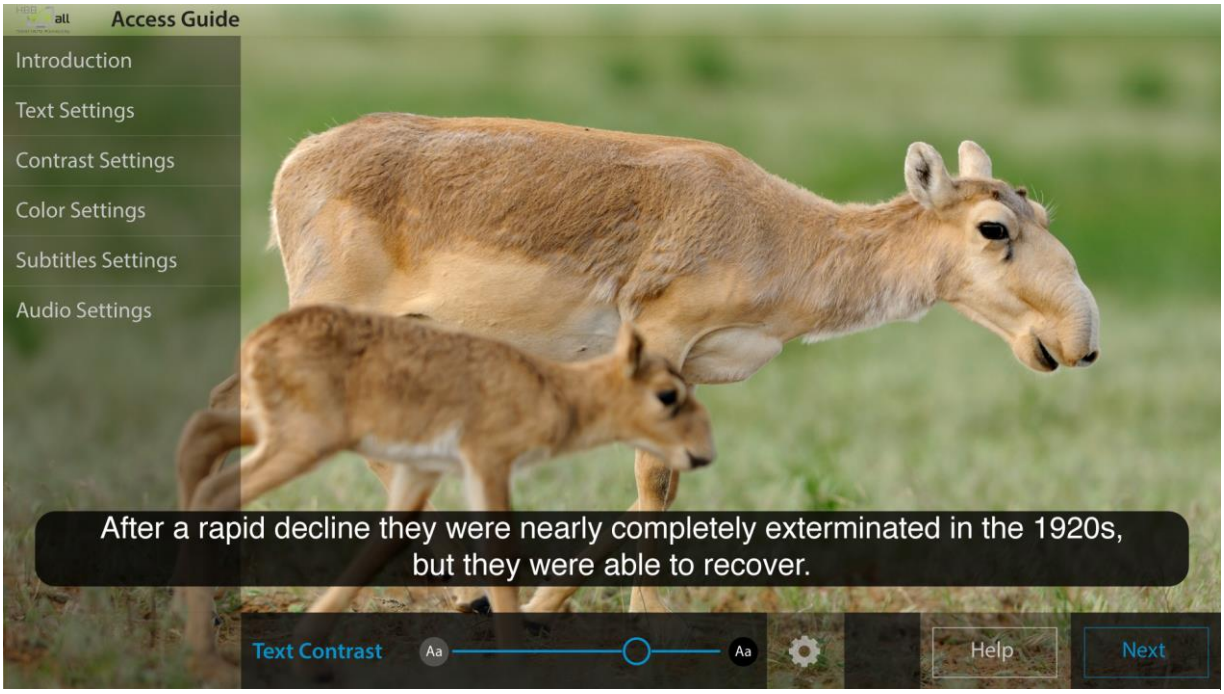

Figure 24. UI for Access Guide.

Besides the MOOC, the AccessGUIDE will be itself an important component to be tested by users from the target groups in terms of accessibility and usability. The AccessGUIDE as part of the UI adaptation framework is intended to be a standard application for accessible UI personalisation. It can be used by

software developers of PC, mobile and HbbTV applications as part of the UI adaption service in order to determine the accessibility needs / preferences of the individual users for the user interface (as in Pilot-C) and for subtitles (as targeted in Pilot-A), but also for other modalities such as personalized audio rendering and signing.

4.8.2. Status of work

During the first 12 months of the project Vsonis has worked on a variety of aspects for the MOOC showcase, the UI adaptation framework that will be used for subtitle personalisation, including an online text to speech service that e.g. can be used for spoken subtitles, as well as the AccessGUIDE application to determine the user preferences stored in a profile.

Vsonix has worked on the MOOC concept including its different aspects for lecture playback, interaction and assessment. A first integrated prototype of the MOOC is actually implemented that will be used in the upcoming user tests planned at the beginning of 2015. Regarding the integration of the subtitle features for the MOOC showcase Vsonix already has worked on different aspects of the technical implementation: This includes the preparation of Vsonix' vPlayer software for the integration of a subtitle rendering engine. Further we have started to integrate subtitle rendering based on common web technologies using XHTML, javascript as well as CSS. Vsonix will collaborate / exchange ideas with UPM on the further realization of the subtitle rendering engine, with Vsonix concentrating on the customization part.

First implementation and integration work has been done on the GUIDE UI adaptation / personalization framework to become an online based service for personalized accessibility. This includes the provision of the UI adaptation API, which has been completely defined, as well as the implementation of the necessary backend services, which we already have started to integrate. Moreover Vsonix has worked on the definition of subtitle customization aspects to be tested during the user tests. Regarding the AccessGUIDE, Vsonix has worked on a first clickable prototype, which will be tested in early user tests at the End of November.

4.8.3. Timeframe

The integration, adaptation work on the MOOC, AccessGUIDE and UI adaptation framework has already started in the first 12 months of the project, whereas a first prototype of e.g. the AccessGUIDE is already available for early user tests (at the end of November). An integrated version of the MOOC application for PC and mobile, with integrated subtitling using EBU-TT-D as well as TTML, is planned to be tested in the first half of 2015. An advanced version of the MOOC application is planned for the second half of 2015 / beginning of 2016, integrating personalized subtitle features using the GUIDE based UI adaptation service.

4.8.4. Test users

All user tests will be made with 20 users from the target group, which will be mainly elderly users (50+) with an interest in online video applications, and with mild to moderate visual and hearing impairments. In addition we will include users of all generations from the deaf and hard of hearing group.

4.8.5. Validation method

Within the tests Vsonix will focus on usability and accessibility aspects of the MOOC as well as of the AccessGUIDE application. The customisation aspects of subtitling to be tested will include subtitle position, font size, colour, background, timing, etc. The validation will be made based on questionnaires and interviews.

5. Roadmap

5.1. Main Timeline

Period	Activity
2014 - 1st half of year	Integration of VOD Subtitles for PC begins. The preferred format for subtitle content will be EBU-TT-D.
2014 – 2nd half of year	Subtitles for HbbTV VOD integration work begins
2015 – 1st half of year	Subtitles for 24/7 Streaming and live events for PC.
2015 – 2nd half of year	Roll-out for services with customized subtitles for a variety of devices including HbbTV VOD
2016	Roll-out of advanced services: Customized VOD HbbTV; Live HbbTV subtitles

Table 5. Roadmap - Main Timeline.

5.2. December 2013 – May 2014

- VOD Subtitles for PC-based VOD Portal are being prepared at RBB. This is the technical pre-requisite for providing HbbTV-Subtitles for VOD-TV Portal. Cooperation between all involved professionals at RBB and ARD for improved workflow and VOD application issues initiated (Kick-off / workshop with IRT, regular phone conferences with WDR).
- RTP / UPM have a VOD subtitling tool for PC / mobiles based on web browser capabilities. The tool will interpret EBU-TT-D subtitles (conversion from STL format if needed).
- TVC have non-personalised VOD subtitles on HbbTV and TVC begin testing interoperability of EBU-TT-D with TVC internal formats.
- VIC Initial planning of the integration of automatic subtitling and machine translation components in the hybrid broadcast broadband workflow.

5.3. June 2014 – December 2014

- VOD Subtitles for PC-based service made available at RBB through HBB4ALL from November 2014 (selected programmes only / test). At the same time “Level 1 Application Development” of “baseline app” mentioned in the objectives for Task 3.1 is begun: Non-customised Subtitles for Video on Demand HbbTV for HbbTV V1 and V1.5).
- RTP/UPM Integration subtitles in RTP Play (catch-up TV for Web). The tool will be ready for preliminary test in RTP Play at the end of the year for VOD content.

- TVC begin, like RBB, Level 1 development of internal HbbTV non-personalised VOD subtitles prototype.
- VIC Define the user tests and collect the necessary material. Final integration plan.

5.4. January 2015 – May 2015

- RBB baseline application for non-customised subtitles for HbbTV 1.0 and 1.5 available March 2015 for internal testing In parallel "Level 2" Application development starts (to support customised subtitles, for HbbTV V1 and 1.5) available July 2015.
- RTP/UPM Subtitling will be integrated in RTP Play. Customization features will be added in cooperation with Vsonix.
- TVC Non-customised HbbTV subtitles for v.1.5 rollout, **on-air pilot deployed in Catalonia.** Work on customisation of VOD subtitles (HbbTV) (Level 2 application work) begins (PC stays non customised on VOD.) Customisation internal prototyping begins.
- VSX First integrated version of Massive Open Online Course (MOOC) application for PC and mobile, integrating subtitling using EBU-TT-D as well as TTML.
- VIC Pilot integration, preparation of the operational phase and first round of user tests (without integration).

5.5. June 2015 – December 2015

- From August 2015 to January 2016 Application for HbbTV VOD Portals is brought on air either regionally or nationwide and tested in operational phase (RBB Field User Tests),
- RTP/UPM Field User Tests from August 15 for at least 6 months. The subtitling tool will be available in RTP Play for PC / mobile devices and will work for VOD content. It will include customization.
- TVC Recommendation work starts for customised subtitles on HbbTV, on-air rollout if internal tests are successful and feedback is positive.
- VSX Advanced version of MOOC application planned for the second half of 2015 / beginning of 2016 integrating personalized subtitle features using the GUIDE based user profiling service.
- VIC Operational phase. Lab tests and optimizing component integration. Second round of user tests if integration has an impact on results

5.6. 2016

- RBB small scale user tests for subtitling of live streams with support of IRT are planned for early 2016 if a technically feasible solution can be found. Could also be tested nationwide through ARD, depends on Showcase (possibly Olympics 2016, Rio de Janeiro).
- RTP/UPM Field user tests continue during the first months of the year.
- TVC Live support internal user tests and on-air rollout if user tests are successful.
- VIC Lab tests and optimizing component integration continues.
- Final recommendations

6. Service Components to be Adapted, Integrated and Tested

The technologies and standards used for the planned implementation of Pilot-A have been detailed in the D2.3.1 – Common Technical Components (I) document (CIP-IST-PSP-621014). This section will summarise these components.

6.1. Subtitle Authoring Components

Information model - An information model used for subtitling is an essential reference for generic, vendor independent strategies for the adoption of multiplatform workflows. In HBB4ALL the EBU-TT format will be used in prototypical implementations. During the HBB4ALL project guidelines may be developed on how to use EBU-TT in the authoring context.

EBU-TT export – Subtitle preparation tools may be extended to support EBU-TT as an export format.

HbbTV preview - Subtitle preparation tools may be extended to include a prototypical preview feature to verify the presentation of created subtitles on HbbTV devices.

6.2. Subtitle Contribution Components

Adaptation, integration and testing of these components will be performed by SCREEN, IRT and RBB.

EBU-TT transport in VBI and VANC - Subtitle information may be carried 'in-band' (i.e. within a video signal, e.g. as VBI in SDTV or VANC in HDTV). The transport of EBU-TT documents in the VANC may be tested.

Integration with HbbTV transmission systems - subtitle synchronisation information must be contributed to MPEG2-TS multiplexers. Subtitle content (for broadband delivery) for VOD must be delivered to a CDN or Internet server.

Live Subtitle Conversion - subtitle content in proprietary formats must be transcoded into EBU-TT-D format for delivery to HbbTV Distribution systems.

6.3. Subtitle Distribution Components

EBU-TT to EBU-TT-D transcoder - To obtain subtitles in the EBU-TT-D format, a transcoder will need to be implemented.

Live EBU-TT-D subtitle distribution - Solutions for live subtitling based on current technologies such as HDS (Adobe), HLS (Apple) or MPEG DASH can be implemented in a test environment.

MPEG DASH EBU-TT-D Segmenter – a module needs to be implemented that creates the necessary DASH segments from incoming subtitle information assuming DASH is natively supported by HbbTV 2.0.

IRT has actively collaborated with the EBU and the GPAC project to provide the requirements for the adoption of the open source tool MP4Box. A first release of MP4 Box with this this feature has been published in August 2014.

6.4.Automatic subtitling component

This component will allow the automatic generation of EBU-TT format subtitles from audio (*English language for testing*) within the HbbTV workflow, and limited to the broadcast news domain.

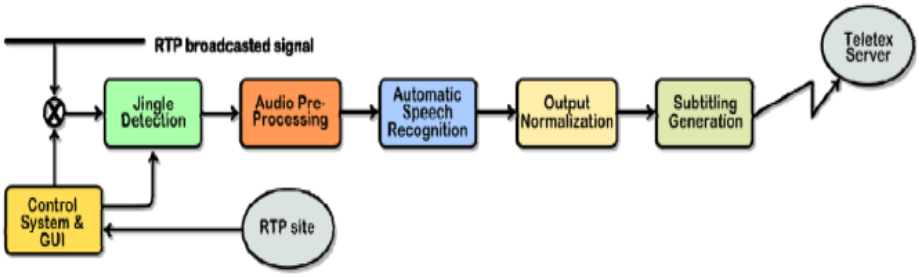

Figure 25. Automatic subtitling pipeline.

As shown, this module is composed of a pipeline of processing blocks, each providing a set of the operational capabilities needed to automatically transcribe and subtitle live audio-visual material.

- A jingle detection block searches and filters jingles and commercials based on audio feature extraction and pattern classification.

- An audio pre-processing block discriminates between speech and non-speech based on acoustic change detection technology. Additionally, it can also classify audio segments in terms of background conditions (clean, noise, music), gender (male/female) or speaker clusters – using the Bayesian Information Criteria to detect speaker turns through a generalized likelihood ratio modelled with Gaussians with full covariance matrices and hierarchical clustering.

- The automatic large vocabulary continuous speech recognition (LVCSR) block transcribes the audio input stream according to a vocabulary and a language model. The engine is based on a hybrid speech recognition structure combining the temporal modeling capabilities of Hidden Markov Models (HMMs), with the pattern discriminative classification capabilities of Multilayer Perceptrons (MLPs).

  The system uses and combines phone probabilities generated by several MLPs trained on distinct feature sets, resulting from different feature extraction processes in order to better model the acoustic diversity. This is relevant in the recognition of TV programs and multimedia contents, which contain a high diversity of speakers and environments. These probabilities are taken at the output of each

MLP classifier and combined using an appropriate algorithm.

The decoder is based on the Weighted Finite-State Transducer (WFST) approach. Besides the recognized words, the decoder outputs a series of values describing the confidence level of the recognition process.

The MLP/HMM acoustic diphone model combines posterior phone probabilities generated by three phonetic classication branches. Different feature extraction and classication branches effectively perform a better modelling of the acoustic diversity, in terms of speakers and environments, commonly present in multimedia content.

The language model is a statistical backed-off 4-gram model, which results from the interpolation of several specific language models trained from diverse data sources. With the aim of having a reasonable coverage of the language, while maintaining performance, the vocabulary is composed of 100K words.

- An output normalization block converts sequences of words representing digits, connected digits, and numerals into numbers. It also capitalizes the names and introduces the punctuation marks. The most common acronyms are included in the vocabularies and techniques based on maximum entropy models are used for the automatic punctuation and capitalization of named entities, based on the information provided by the preceding audio pre-processing and LVCSR blocks – such as pauses, speaker changes, Part-Of-Speech (POS) information of the present, previous and following words, and the confidence measure associated to each word.

- Finally, a subtitling generation block formats subtitles according to the most common layout features related to subtitling: the position of subtitles on screen, the number of lines per subtitle, the amount of characters per line, the typeface, the distribution and alignment of the text, the transmission modes (i.e. blocks or scrolling), or the colors linked to different speakers.

For English, it has been trained on the Linguistic Data Consortium's Hub4 corpora[6] composed by about 200 hours of transcribed news from American broadcasts of ABC and CNN and text crawls from the Internet.

[6] https://catalog.ldc.upenn.edu/LDC97S44, https://catalog.ldc.upenn.edu/LDC98S71

6.5. Machine Translation Component

This component will allow the automatic translation of broadcast news subtitles (*from English into Spanish for testing*) within the HbbTV workflow. EBU-TT will be used as input/output subtitling format.

It is based on Moses[7], one of the most widely used implementations of the statistical approach to machine translation (MT) – the dominant approach in the field at the moment. In statistical machine translation (SMT), translation systems are trained on large quantities of parallel data (from which the systems learn how to translate small segments), as well as even larger quantities of monolingual data (from which the systems learn what the target language should look like). The training process in Moses takes in the parallel data and uses co-occurrences of words and segments (known as phrases) to infer translation correspondences between the two languages of interest. The key to creating a good system is lots of good quality data. In general, the closer the training data used is to the type of data that needs to be translated, the better the results will be.

The two main component blocks in Moses are the training pipeline and the decoder:

- The training pipeline prepares the data before it is used in training, tokenising the text and converting tokens to a standard case. Heuristics are used to remove sentence pairs which look to be misaligned, and long sentences are removed. The parallel sentences are then word-aligned. These word alignments are used to extract phrase-phrase translations and corpus-wide statistics on these rules are used to estimate probabilities. Another important part of the translation system is the language model, a statistical model built using monolingual data in the target language and used by the decoder to try to ensure the fluency of the output. The final step in the creation of the machine translation system is tuning, where the different statistical models are weighted against each other to produce the best possible translations.

- The job of the decoder is to find the highest scoring sentence in the target language corresponding to a given source sentence. Includes configuration features that allow different input types (i.e. plain text, xml, lattices); translation models (i.e. phrase-based, hierarchical); decoding algorithms (i.e. stack-based, cube-pruning, chart parsing) or language models (i.e. SRLIM, KenLM, IRSTLM). It also supports multi-threaded decoding and also has scripts to enable multi-process decoding.

The core of the HBB4ALL MT component consists in the newswire corpora in which Moses is being trained: a combination of the parallel ES-EN News Commentary and monolingual News Commentary and News Crawl data, made available as part of the 2013 ACL Shared Task on Machine Translation[8].

[7] http://www.statmt.org/moses/

[8] http://www.statmt.org/wmt13/translation-task.html

A major source of improvement for SMT systems comes from increasing the amount of both bilingual and monolingual data on which the systems can be trained. This reduces the number of out of vocabulary items, increases the number of translation phrases and extends the amount of information available on the target language side through larger language models. As a general rule, the coverage and quality of SMT systems is expected to increase with the size of the training data, assuming data of appropriate quality for the domain at hand. In order to take into account possible discrepancies in the quality and quantity of the available newswire data, data selection based and combination approaches will be applied.

6.6. Live Hybrid Broadcast-Internet subtitle viewer and synchroniser

This component will create specific timestamp mechanisms to match the broadcasted video with Internet-based subtitle delivery and include a JavaScript library to be used in an HbbTV application to display subtitles for live TV.

The aim of this component is to create an HTTP media stream contributing a live broadcasted content with subtitles generated automatically. This way, the generated stream can be then played on a player embedded in a Web browser, such as an HbbTV application. In order to have a clear idea about the focus of this component, it meets the media contribution with subtitles and the stream packaging for the distribution, keeping the delivery of the content out of focus.

This component is responsible of creating a synchronised Internet multimedia stream, in a MPEG-DASH format that comprises the broadcast video and the automatically generated subtitles, all aligned to a common time basis. The automatic subtitling component is formed by the integration of the Automatic subtitling component (see section 6.4) and the Machine Translation Component (see section 6.5) providing real-time automatically generated subtitles in different languages. On the other hand, the Live Hybrid Broadcast-Internet subtitle viewer and synchroniser will enable the client player to consume a MPEG-DASH stream that includes the aggregated subtitles.

Regarding the formats, the data source will contain a MPEG-2 TS with H.264 encoded video and MPEG audio layer 3. While the generated MPEG-DASH MPD will manifest synchronised ISO BMFF fragments containing MP4 fragments that include H.264 encoded video, MPEG audio layer 3 and EBU-TT-D subtitles. This way, no transcoding or quality loss is introduced at all at the dataflow. However, the transcoding is not a discarded option, and the component design could include this feature with minor modifications.

This component does not consider the processing of the subtitles potentially present in the MPEG-2 TS stream. They will not be employed, being excluded from the final MPEG-DASH stream.

The next diagram summarises the component functionality and formats:

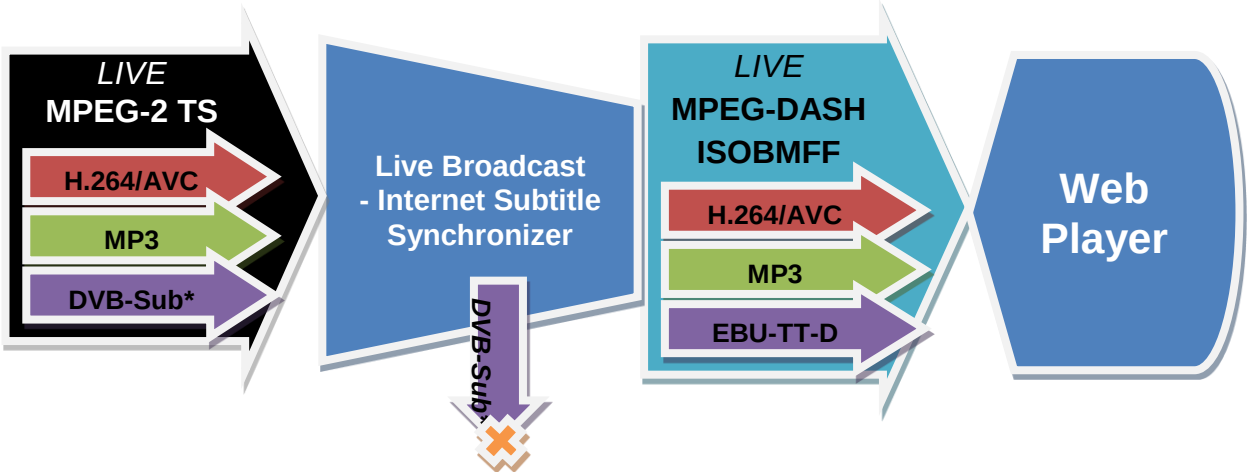

Figure 26. Live Hybrid Broadcast-Internet subtitle viewer and synchroniser.

It is important to highlight the delay introduced by the intrinsic processing tasks for creation of the fragments of the MPEG-DASH and the necessary buffering of the audio to generate the subtitles. In the case of the Internet stream generation, the lag compared with the broadcast stream is close related to the size of the fragments and the window size, setup in the manifest MPD, to enable the player buffering that mitigate networking fluctuations. For the automatic subtitle generation, it is also required to have a buffer that contains the past and future audio speech context to provide a consistent transcription, meaning a real time processing that pulls bursts of subtitles with a variable delay.

Concerning the synchronisation of the video and audio with the subtitles, two different scenarios are being considered:

a) Subtitles generated automatically by this component invoking the automatic subtitling component. Thus, the timestamps embedded in the MPEG-2 TS are used to signalling the audio buffers injected to the automatic subtitling generator to have a common timeline with the video and audio streams and synchronise them properly.
b) Subtitles provided by a third party Internet service. In this case, the different data sources, the live broadcasted content and the live subtitles contributed from the Internet, do not share a time basis, being necessary the use of a NTP protocol to create a common timeline.

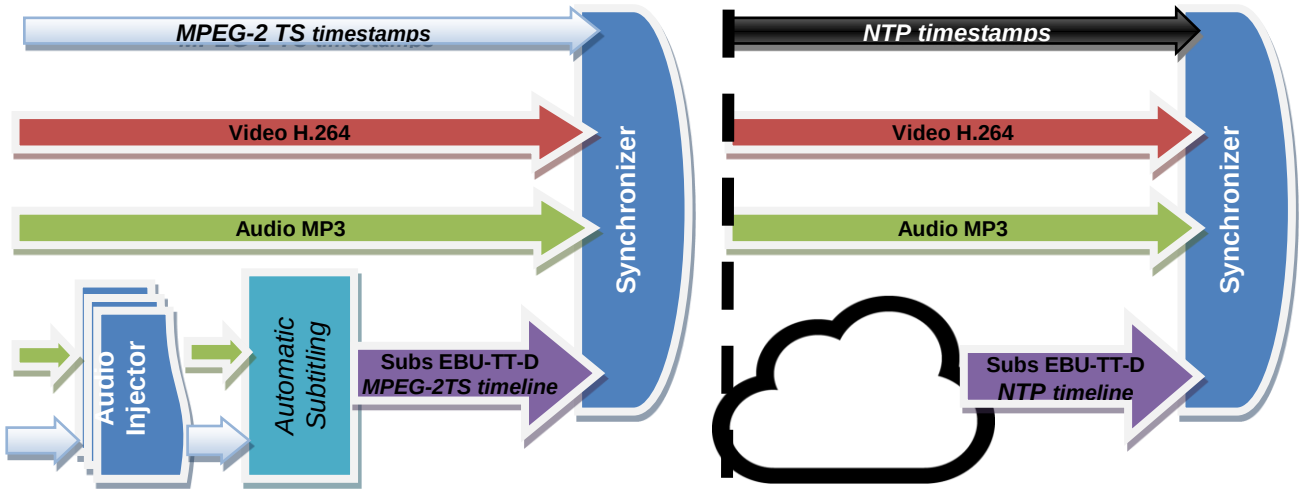

Figure 27. Synchronisation of video / audio with subtitles scenarios.

To overcome these scenarios the component design would comprise:

1. a parser of the broadcast video format to extract the media timestamps;
2. a demuxer of the live broadcast videos, splitting the encapsulated video and audios and dropping the embedded subtitles;
3. a timestamped audio injector to the automatic subtitling component;
4. a parser of the automatically generated EBU-TT-D formatted subtitles;
5. a synchroniser that align the timestamps of the different media streams;
6. a MPEG-DASH video and audio fragment generator;
7. a MPEG-DASH subtitles formatter and fragment generator;
8. a MPEG-DASH live manifest generator and fragment manager;
9. and a Web browser integrated MPEG-DASH player.

The general scheme and workflow of this component is depicted below:

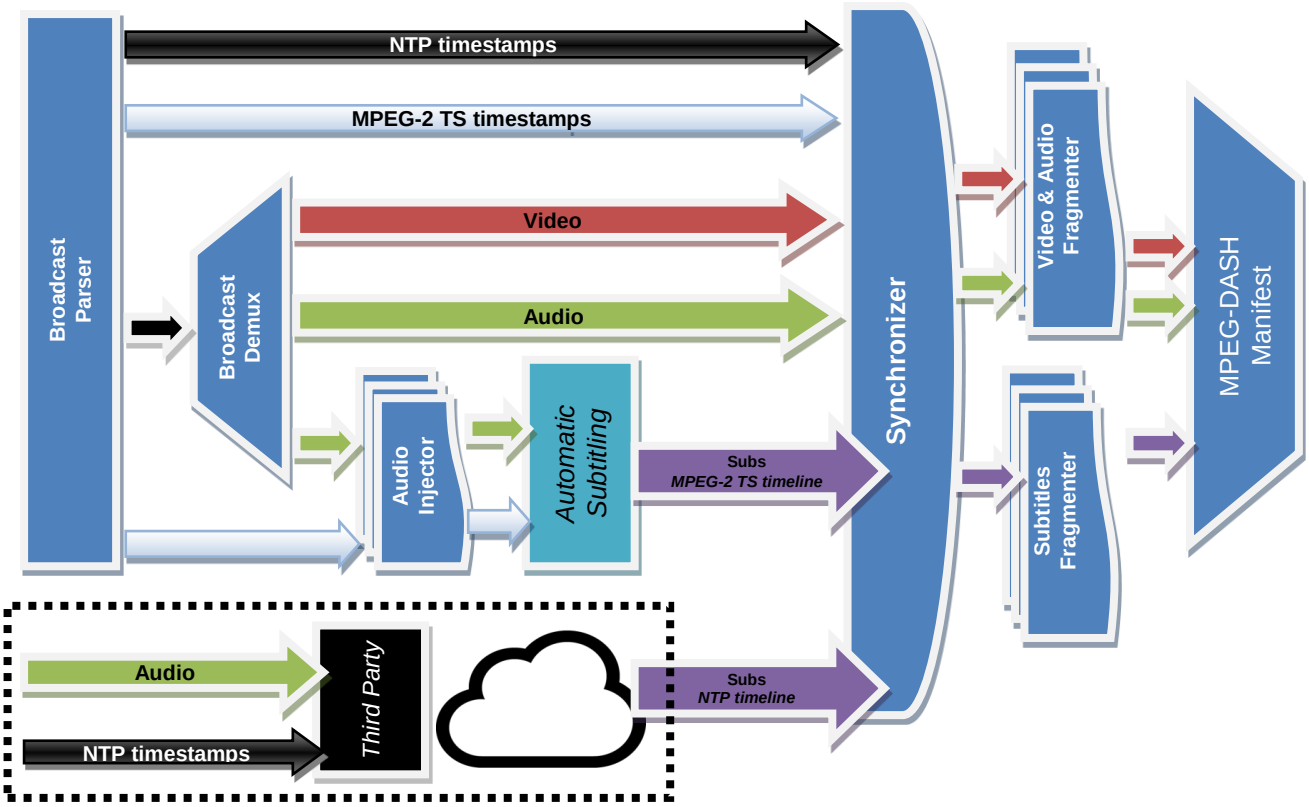

Figure 28. Live Hybrid Broadcast-Internet subtitle viewer and synchroniser.

The broadcast parser will retrieve the MPEG-TS timestamps and the NTP clock to build a time basis that can be attached to the incoming video and audio signals. Thereby, this block gets the timestamps from the live broadcasted content or from a NTP server and provides it to the synchroniser in order to signal each media with a common timeline.

The demuxer of the broadcast signal MPEG-2 TS takes the embedded video (H.264) and audio (MPEG audio layer 3) streams dropping the DVB subtitles, if any.

The audio injector ingests the audio samples with the MPEG-2 TS timestamps to assure a correct alignment of the EBU-TT-D subtitles with the timeline of the video and audio streams.

A parser of the subtitles will capture the live generated results coming from the automatic subtitling component or from a third party internet provider, and it will deliver them to the synchronization component. The format accepted by the subtitles parser is EBU-TT-D for live subtitling and TTML.

The synchronisation of the different media is needed because of the latency added in the automatic generation of subtitles which requires a buffer of sound containing enough data, and time, to create a

transcription. Therefore, the synchroniser is responsible of creating the buffers to queue the different incoming signals, the live broadcast video in MPEG-DASH format and the subtitle stream from the internet subtitling service. Then, the synchroniser has to absorb the latency and the jitter from the subtitles employing the different timestamps to match the timing delays.

The different fragmenters must include the proper time segments that create a synchronised subtitled experience. The fragmentation mechanism must be triggered by the business models and under terms of Quality of Experience according to some previously defined patterns.

The manifest generator must manage all the data and the fragments to create a fully standard compliant manifest MPD ISOBMFF.

Last but not least, a web browser player will request the MPD manifest and the correspondent fragments and updates in order to visualise synchronous subtitles, video and audio internet stream.

Going into implementation details, some Open Source technologies are being considered:

- Gstreamer eases the live broadcast signals management, the parsing and de-multiplexing tasks, the buffer timing and synchronisation.
- GPAC brings a more advanced compliance with the MPEG-DASH and EBU-TT-D standards.
- DASH-IF player due to its support by the DASH community. It has an up-to-date player that support different configurations to validate generated streams.
- VLC player because it is widely available for different OS and web browsers.

6.7. Subtitle interpretation tool for browsers

This component will interpret EBU-TT-D subtitles and provide synchronized subtitles for VOD in the browser. Fast forward, fast rewind and style information will be supported.

6.8. HbbTV-based customisable subtitles for VOD playback

This component will interpret EBU-TT-D subtitles and provide synchronised subtitles for VOD and live video in the HbbTV device. Fast forward/rewind will be supported and will ultimately support end-user customisation of the subtitles.

6.9. Subtitling Format Conversion Framework

The subtitle conversion framework (SCF) is a set of different modules that allows a user to convert between different file based subtitle formats. The original driver and still the main purpose of the SCF is to convert a subtitle file that conforms to the binary subtitle format EBU STL (Tech 3264) in one XML document that conforms to one of the EBU-TT profiles (EBU-TT Part 1 - Tech 3350 or EBU-TT-D Tech 3380).

The main design idea is to keep the different conversion module as separate as possible so that in a processing chain one module implementation can be replaced by an alternative implementation. In addition the SCF follows clearly defined and documented requirements. The documentation of the requirements are published together with the source code. Where possible the requirements that are implemented are covered by automated software tests.

Although there is no reason to not use the SCF in operation its goal is primarily to provide a reference framework that shows in a transparent way how to implement new subtitle standards (especially EBU-TT) and how to integrate them in an existing work flows. The source code can be used by other tool providers to implement their own conversion methods. They can just take it as a reference or they could just reuse some of the SCF code.

The current state of the SCF is an early beta release. The idea is to release early and to get feedback from the community in an early development stage.

Overview of the processing chain

The main conversion chain follows these processing steps:

- The start point is a binary STL which is decoded and serialized in an XML representation of the STL file. This has the following advantages: XML processing tools can be used from that point onwards the XML representation of the STL file is human readable standard XML validation technologies can be used.
- The STL XML representation is then transformed into an EBU-TT file that conforms to EBU-TT Part 1. The guidance for the transformation is the EBU document TECH 3360. Like an EBU-STL file the purpose of an EBU-TT Part 1 document that was created from an STL file based on the Tech 3360 guideline is thought to be used in exchange and production but not for distribution.
- To get an EBU-TT file that can be used for distribution over IP based networks a transformation to EBU-TT-D (TECH 3380) is necessary. The module for this conversion step expects an EBU-TT file that follows the Tech 3360 guideline and creates one possible form for an EBU-TT-D file.

6.10. IPTV subtitle publishing system

Subtitle publishing system that exposes subtitles to IPTV systems using the EBU-TT-D format.

6.11. HbbTV device and version detection

A JavaScript component to detect the device capabilities, specifically its HbbTV standard version to ensure any features used are compatible with the viewing device.

6.12. EBU-TT HbbTV personalised subtitle playback

Subtitle playback system on HbbTV devices using the EBU-TT-D format, synchronisation dependent on transport mechanism. This component will support user personalisation.

6.13. vSubtitle: Adaptive subtitle rendering

The vSubtitle component is a sub-component of Vsonix's vPlayer. It handles the synchronisation, rendering and adaptation of subtitles. vSubtitle exists as integrated part of vPlayer and communicates with it through suitable means such as API functions exposed by vPlayer and callbacks provided by vSubtitle. Periodic events and interval-based timers make sure that both vPlayer and vSubtitle stay synchronized in order to make sure that each subtitle is shown for the correct duration without time shifts between subtitles and media playback. Especially, events such as buffers underruns or stream switches (cf. adaptive bitrate streaming) that require vPlayer to interrupt media playback, need to be handled gracefully by the vSubtitle component by extending or delaying the display of subtitles accordingly.

6.14. Access GUIDE: User profile generation for personalized subtitling

The Access GUIDE component is a separate component that originates from the previous GUIDE project. Access GUIDE establishes based on both the current user and the current device a profile which measures the user's impairments and preferences and communicates them to the GUIDE API. This is a one-time initialization process needs to be done only on the first time the user works with a device; afterwards the profile will be readily available directly through the GUIDE API (of course it is the user's choice to recreate or update or extend their profile at any time). Access GUIDE uses modern input controls and measurement methods to establish the optimal user settings and is extensible to include tests for preferences that are defined by individual applications.

7. User Tests

Complementary User Experience Testing of different end user related aspects of subtitling within Pilot – A.

7.1. General Set up

UAB is developing several research lines addressing different aspects of subtitle personalisation and perception. The current lines under development are:

- Subtitle usability across devices. In this experiment we will get to know if there are differences in the perception of subtitles when they are presented in mobile devices vs. TV sets. The experiment is being developed in coordination with the Warsaw University in Poland and the Autonomous University of Barcelona in Spain.
- Subtitle usability in different languages/alphabets. In this experiment, we are going to be testing different Chinese fonts in order to determine which one is the best in terms of readability. This experiment is being developed by Vienna University in Austria, and Valladolid University and Autonomous University of Barcelona in Spain.
- Automatic subtitle utility. This experiment is being developed as part of the Objective A3. For more information please address to Objective A3 section.
- Second screen subtitling utility. The aim is to test subtitles displayed in a second screen device (a smartphone) across the application Artaccés provided by the Department for Culture of Generalitat de Catalunya. The experiment will be carried out with participants with hearing difficulties. The test takes place during Sitges International Fantastic Film Festival of Catalonia.

Subsequently to the research lines specified above, we are planning the following:

- Subtitle adaptation to mobile devices. Determine which factors need to be adapted in the subtitles for mobile devices in order to achieve better understanding of the content. Different formal aspects of subtitles will be tested individually to achieve our objective.
- 6 seconds rule verification. The six seconds rule is an industry standard that is never been tested. We will be testing it in different universities across Europe to establish if it is a good practice standard or it should be changed.
- Frame synchronisation. Current subtitling practices recommend to set subtitle time-in/outs a fixed number of frames after/before the shot change. The number of frames varies among countries and/or companies. The aim of the experiment is to study which number of frames would the most adequate in terms of readability.
- Pyramidal subtitling presentation. The normal subtitle presentation nowadays consists of two rows in an inverted pyramidal form. The goal is to test if by changing this implementation it is possible to achieve better reading and comprehension ratios.

7.2. Timeframe

M1-M24

7.3. Test Users

The user tests will be done with the appropriated target group depending on the experiment setup. The sample will vary depending on the nature of the experiment, but it will never be less than 30 participants. In all the experiments demographic data and information about uncontrolled variable data is going to be gathered.

7.4. Validation Methods

The validation methods differ depending on the experiment setup. Besides that, a general pattern will be applied. In the majority of our experiments there will be three main questionnaires that will help to establish the suitability of subtitles and the degree of efficiency they offer. In order to do so, a liking questionnaire, a comprehension questionnaire and a visual recall questionnaire will be presented.

Moreover, to have more objective data, we are going to gather information from our eye-tracker system to obtain more objective data. This will help us to determine the number of fixations users do in the subtitle area and their duration. The combination of this information and the reports will help us to understand different aspects of subtitle processing.

8. Results

8.1. Task 3.1 Objectives Progress

Objective	Progress
Define which services will be implemented, integrated and tested (in Operational phase).	100%
Develop the plan for large scale user tests across countries.	40%
Initiate an operational pilot service for HbbTV subtitles in three countries.	100%
Analyse and recommend optimised workflows for the production of VOD HbbTV subtitles.	75%
Validate the results from past research.	100%
Capture new requirements arising from proposed services from subtitling departments.	70%
Perform a detailed analysis of subtitling delivery and integration options.	65%
Implement subtitle documents conforming to (EBU-TT) standard for VOD HbbTV subtitles.	70%
Capture new requirements for the subtitling software arising from customisable subtitles.	50%
Document the requirements for current interfaces and processes (machine and human).	75%
Develop the plan for automatic subtitles and translated subtitles.	60%
Specify the features for VOD customised subtitling services.	50%
Initiate and expand large scale field user tests.	30%
Recruit viewers for the large field user tests.	0%

Table 6. Task 3.1 Objectives progress. (*) Potential viewers for user tests have been identified.

8.2. Task 3.2 Objectives Progress

Objective	Progress
Create prototype of subtitle editor (with preview, EBU-TT, export + transcoding features)	20%
Prototype of subtitle editor independent transcoding and preview modules	40%
Test translation + automatic subtitle generation for live (linear) video and VOD.	
Investigate the options for exposing produced content to delivery and distribution systems.	15%
Perform expert user tests, laboratory tests and ‘friendly user’ tests.	
Initiate HbbTV subtitling services at RTP, TVC, RBB, UPM and TXT	
Finalise the technology, infrastructure and services for Task 3.3	

Table 7. Task 3.2 Objectives Progress.

8.3. Component Progress

Component	1st Prototype	Final version
Authoring Information model (SCREEN/IRT)	Q2 2014	Q2 2015
Authoring EBU-TT export (SCREEN)	Q3 2014	Q2 2015
Authoring HbbTV preview (SCREEN)	Q1 2015	Q4 2015
Contribution EBU-TT transport in VBI and VANC (SCREEN)	Q2 2015	Q3 2015
Contribution Integration with HbbTV transmission systems (SCREEN)	Q1 2015	Q3 2015
Distribution EBU-TT to EBU-TT-D transcoder (SCREEN / IRT)	Q2 2015	Q4 2015
Distribution Live EBU-TT-D subtitle distribution (SCREEN / IRT)	Q3 2015	Q4 2015
Distribution MPEG DASH EBU-TT-D Segmenter (SCREEN / IRT)	Q3 2015	Q4 2015
Automatic subtitling component (VIC)	Sept 2014	July 2015
Machine Translation Component (VIC)	Sept 2014	July 2015
Live Broadcast-Internet subtitle viewer and synchroniser (VIC)	March 2015	July 2015
Subtitle interpretation tool for browsers (UPM)	August 2014	August 2015
HbbTV-based customisable subtitles for VOD playback (RBB)	November 2014	September 2015
Subtitling Format Conversion Framework (IRT)	August 2014	December 2015
IPTV subtitle publishing system (TVC)	n/a	Q4 2014
HbbTV device and version detection (TVC)	n/a	Q4 2014
EBU-TT HbbTV personalised subtitle playback (TVC)	Q1 2015	Q2 2015
Adaptive subtitle rendering MOOC (VSX)	Q2 2015	Q4 2015
Access GUIDE: user profile generation for personalized subtitling (VSX)	November 2014	Q3 2015

Table 8. Service Component Progress.

9. Impact / Knowledge Transfer / Resilience

The D2.4.2 deliverable due in M12, is where consolidated Knowledge Transfer / Resilience for all pilots will be reported.

10. Conclusions

Work Package 3 looks back on a very successful first project year and has fulfilled and in some instances (like the type and number of targeted service sub-pilots) even exceeded the objectives laid down in the DoW. The degree of accomplishment of the objectives for the initial two tasks of Pilot-A are summarised documented in great detail in the previous sections of in this document. In general, and with respect to the plan detailed in the HBB4ALL "Description of Work" document:

- **Progress is as anticipated** and according to the overall plan.
- At present there is **no perceived impact on subsequent tasks or deliverables**
- There are small deviations from the original work plan which were impossible to anticipate when the DoW was authored.

  The DoW was incorrect in identifying which languages will be supported in the automated subtitle translation service sub-pilots.

  There is more emphasis on transcoding components than was originally planned.
- No specific measures, actions or contingency plans are considered necessary at this stage.