Deliverable 4.4

Supporting documents for tendering processes

AURA

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Project Information

"AURA - Auralisation of Acoustic Heritage Sites Using Augmented and Virtual Reality" (project no. 101008547)

Project Website: http://aura-project.eu

Auralisation – the technique of creating virtual soundscapes in 3D models to provide the same immersive sound experience as the music performed in the real venue. AURA will explore exciting new opportunities that auralisation opens up for music performing arts and their traditional and new audiences.

Publisher & Project Coordinator

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List of abbreviations and terms

3D model – a three-dimensional digital image of the required object, both real and fictional.

API – Application Programming Interface is a way for two or more computer programs to communicate with each other. It is a type of software interface, offering a service to other pieces of software.

AR – Augmented Reality is a supplement to the physical world with the help of digital data, which is provided by computer devices (smartphones, tablets or AR glasses) in real time.

Auralised model – a representation of sound in the place of real music in a virtual environment to learn how architecture affects sound.

BIM – Building Information Modelling is a process involving the generation and management of digital representations of physical and functional characteristics of places to support decision-making regarding a built asset

CMS – Content Management System is computer software used to manage the creation and modification of digital content (content management).

NURBS – a mathematical form used in computer graphics to generate and represent curves and surfaces.

SfM – Structure from Motion

SLAM – Simultaneous Localisation and Mapping

TLS – Terrestrial Laser Scanner

TWEB platform – a collection of technologies developed as open standards by the World Wide Web Consortium and other standardisation bodies: WHATWG, Unicode Consortium, IETF and Ecma International.

VR – Virtual Reality is a kind of reality, the form of the material and ideal identity, which is created and exists due to the existence of another reality.

1. Introduction

The goal of the AURA project is the promotion of immersive technology applications and related services to provide innovative opportunities of creative expression and new means of audience retention and acquisition.

As a demonstration and experimental testbed, the partners developed a prototype to build a case for multisensory models that are reliable and efficient both from the point of view of graphic rendering and virtual experience and acoustics, as well as the use of point cloud integration within the framework of game technologies. This enables to shorten the long processes of modelling complex virtual environments, modelling only those elements with which the user interacts in a multisensory way.

The purpose of this document is to provide heritage music venues (opera houses, music theatres, concert halls etc.) with the most salient parameters to be integrated into the technical specifications of a future tender. This takes into account the emerging regulations regarding sustainability and heritage protection, such as BIM or the protection of intangible heritage such as sound. Part of the current BIM requirements is the creation of a 3D model. In more and more European countries, legislation is catching up with the emerging practice of involving BIM in construction contracts. It is foreseeable that in the near future, BIM will become mandatory for public procurement for construction, hence 3D models will become a common asset. AURA aims to encourage European music heritage venue to act early, and procure 3D models of their venues and in particular of their main halls to benefit from them as an asset for multiple use.[3]

Within the framework of the AURA project, much attention was paid to exploring the relationship between architectural virtualisation and auralisation (acoustic virtualisation) through the development of digital laser scanners and SfM photogrammetric geodetic campaigns that enable the creation of highly reliable and descriptive 3D models. These models were tested by both ordinary users and expert users to verify the actual contribution of the virtual environment to auralisation.

To achieve the goal of the AURA project, three European case studies were considered - the Konzerthaus in Berlin (DE), Teatro del Maggio Musicale Fiorentino in Florence (IT) and the Opera and Ballet Theatre in Lviv (UA) – covering very different and distinct architectural, historical and acoustic characteristics. Each case served as a testbed for different methodologies of building the virtual twin which made it possible to implement auralisation processes and develop multisensory 3D models.

In support of the procurement of an auralised 3D model and its application, we outline the key specifications to be considered in the tender documents for following lots:

- **Lot 1 – Development of a new auralised 3D model:** analysis, design, development, support;
- **Lot 2 – Development of a WEB platform for the popularisation of classical music using an auralised 3D model:** analysis, design, development, support and assistance in the generation of a new content with adaptive versions (for different display sizes of a computer, laptop or smartphone devices);
- **Lot 3 – Development of VR/AR applications using an auralised 3D model:** analysis, design, development, maintenance and assistance in publishing applications based on VR and AR technologies.

2. Basic requirements for software development

The development technology proposed by the Contractor must be justified according to the specific demands of the specific project, formulated in the request for services/technical conditions and approved by the Customer.

Whenever possible, the technology selection should support the modular structure of the final product, allowing the reuse of modules. The approach to the development of mobile applications should be aimed at minimising the power and memory of the final product without losing performance. VR products are expected to be characterised by high accuracy and low communication latency to meet the user needs.

The Customer may specify more specific requirements/restrictions regarding the choice of technology and product compatibility in the request for services for specific projects, especially in the case of updates and customisation of existing products and products that require integration into a certain environment.

A basic requirement for the auralisation is a recording with no or little echo. Currently, the technology is still in development to become more manageable. We expect for tenders of the recording that in the near future, the procedures will have been simplified. There remains the question of individual track recording which is not comparable to the dynamics of a group recording of the whole orchestra. It remains to be seen if binaural recording technologies would be useful for auralisation of 3D models.

2.1 Standard services for Lots 1, 2 and 3

2.1.1 Project management

Each project must be agreed by the Contractor's project manager at all its stages: initiation, planning, execution, monitoring, control and closure. The Project Manager should be the main contact person during the project execution and take responsibility for all project deliveries. The project manager is also responsible for developing the agenda and minutes of the project meetings.

2.1.2 Product documentation

For software development products, the deliverables must include annotated complete product source code (delivered as specified in the specific tender) and product documentation, including:

The final result must include commented complete product source code and the following product documentation:

- User manual: How to use the product;
- Technical documentation (system operation manual), which includes:
    - Description of the solution:
        - Functional design;
        - System architecture;
        - Data architecture;
        - Integration (if applicable);
    - How to maintain or update the source code (e.g., fix major issues, updates);
    - How to store or update data (for example, updating content, adding a new language);
    - Deployment and installation/integration information;
    - Execution and adaptation of the construction process (if applicable).

2.1.3 Maintenance/Upgrade

For the delivered product, the Contractor must provide the following maintenance services:

- Correction (corrective maintenance, for example, error correction);
- Updating;
- Updating an existing product developed by a third party.

  Product upgrades will be covered by new orders. A product update may include (non-exhaustive list):

- Product adaptation to the changed requirements of the distribution platform and/or operating system;
- Ensuring product compatibility with a new operating system or distribution platform;
- Adding new functions;
- Adding language versions;
- Update of data integrated into the product.

In some cases, the Contractor may be asked to quote for upgrades covering a specified number and scope of changes (except for major upgrades) at a fixed rate over a period of time with the option to extend the applicable period. The requirements in this case will be defined in the request for services.

2.1.4 Testing/Quality Assurance

The Contractor must test, correct and verify each product deliverable in the current and requested systems to ensure compliance with the requirements specified in the project specification.

If any problem is identified during the testing/quality assurance process performed by either the Contractor or the Customer, the Contractor must correct and resolve it at no additional cost.

Quality testing for all software development products must consider:

- Functionality: The product behaves as expected on all relevant platforms and on all device types for which it was designed;
- Design: The interface is attractive and harmonious, and it follows any style guide or instructions provided by the author, the flow allows the user to navigate and explore the application, intuitively and effortlessly understand the main concepts;
- Usability: The product is easy to use in the intended context and it guarantees a satisfactory user experience. In addition:
  - for VR products: The application does not cause motion sickness or other adverse effects on the user's health;
- Interface testing: Menu options, buttons, user interactions and controls, input methods, bookmarks, history, settings, navigation flow are required. In addition:
  - for VR products: capabilities, functional control in the environment, use of visual effect to determine space and depth, etc. are necessary;
- Accessibility: accessibility criteria are met (accessibility testing will be included in the final test report upon request);
- Compatibility: The product is compatible with the required operating systems, devices, device types and screen sizes, developed in compliance with the technical requirements of the target platform(s);
- Performance: The product is stable and rationally uses resources (memory, battery, CPU, etc.). The backend must be scalable. In addition:

- for mobile applications: the application operates under certain conditions, such as low battery power, unstable network coverage, low available memory, simultaneous access to the application server by several users and other conditions;
- for a VR product: the application has a stable constant frame rendering rate, frame time;
- for an AR product: the application is reliable (it does not depend on environmental factors);

- Interruption testing (for applications running on mobile devices): the application can handle interruptions such as incoming and outgoing calls and SMS, incoming notifications, network outages, media player on/off, etc.;
- Security: The product shows no vulnerability to hacking policies, authentication and authorisation, data security, session management, and other security standards. Security testing on developed products can be conducted by third parties at the Customer's request. Correction of identified problems/vulnerabilities remains the responsibility of the Contractor;
- Data protection: the Guidelines of the European Data Supervisor [4] should be followed;
- Languages and localisation: accuracy of translations and aspects of localisation.

In addition to technical testing, the developed product must also show:

- Correct implementation of feedback provided by the Customer;
- Correct integration of the provided assets (text, icons, images, graphics, logos, data, etc.) into the product; complete integration of content and translations (in all language versions);
- Readability of tables;
- Correct display of special characters;
- Correct visualisation of images;
- Functioning of hyperlinks;
- Code quality control: cleaning of orphaned and redundant files;
- Possibility of moving the correct application from the test environment to the production server(s).

For products with adaptive design, the following issues should be taken into account:

- Checking the technical file (compliance with the established standards, page loading speed, file optimisation);
- Structural validation (website audit) and compliance with original source files;
- Verification of compliance with WebGuide, reuse of existing enterprise solutions (if applicable). The Contractor conducts tests and validations on various browsers running on MS Windows, Mac OS, Android and iOS, following the Europa WebGuide recommendations for minimum browser versions [5].

Applications (including VR and AR) should be tested on the devices most widely used at the time of performance testing.

Testing in emulators and virtual devices is carried out in the early stages of development, but the final version should also include some physical device testing.

A test plan (with description of the devices and platforms for testing) is submitted by the Contractor with a certain tender.

A document on use cases (test scenarios) is submitted at the beginning of each product project.

The Contractor is required to provide a test report with the final delivery. The report must document the quality control procedure, testing and validation performed by the Contractor on the results (including the accessibility test), and list the devices on which the product was tested.

For VR products, the ability of physical testing the final product at the Customer's site may limit. Then, the Contractor may be asked to provide a visual step-by-step guide that demonstrates navigation through the various virtual spaces.

2.2 Lot 1 – Development of a new auralised 3D model

The Contractor assists the Customer with all technical and communication tasks related to the planning, preparation, development, post-production and distribution of the auralised 3D model in common streaming media formats. The last ones should be suitable for use on websites, mobile applications, conferences or events, for informational and educational events, with electronic documents, on any electronic support at different bitrates (i.e., high, medium or low bandwidth).

The Contractor should also assist the Customer with certain services or tasks related to the development and post-production of the auralised 3D model.

2.2.1 Types of products using auralised 3D model according to Lot 1:

The following products may be requested for Lot 1 (the list is not exhaustive):

- Video clips of auralised 3D model: theatres, museums, interior design for acoustic rooms;
- Commercials, teasers, short clips intended for distribution in social networks;
- Screencasts (video recordings of the screen);
- 360° video;
- Narrated tours of websites;
- Slide show;
- Animations (including 2D, 2.5D and 3D);
- Podcasts and post-production;
- Still images;
- E-learning courses, virtual visits, etc. that involve creation and/or integration into a web interface for online distribution.

2.2.2 Requirements for the quality of audiovisual publications

Video, audio and animation files must:

- Respect the European Web Guide for audiovisual content [6];
- Meet the requirements of the project (duration, languages, formats, etc.);
- Follow the principle of providing access to persons with disabilities on an equal footing with others and respect accessibility recommendations [7];
- Include appropriate metadata and copyright information where applicable;
- Comply with all applicable data protection regulations if the product contains or processes personal data;
- Be designed in such a way that they can be displayed on different devices, in different screen sizes (responsive design) and browsers;
- Comply with W3C [8] standards for content animation (note that the use of Flash is prohibited from 01.01.2020).

Videos and animations should:

- Be created in compliance with the approved scenario;

- Be in formats adapted for web distribution, including high-definition and low-definition streaming formats, suitable for viewing with widely available terminal software;
- Ensure compatibility (formats, permission, parameters) with the technical requirements of the target platform (author service website, AV Portal of the Commission [6] or the European Parliament, EUTube, YouTube, etc.).

E-learning, virtual visits or other products involving software coding and web design must comply with the most restrictive conditions applicable to web publications (accessibility, compatibility and usability testing, test reports).

2.2.3 Services provided under Lot 1

The following services, grouped at the main stages of the project workflow, can be requested for Lot 1 (the list is not exhaustive):

- Analysis of needs;
- Concept and design;
- Development;
- Post-production;
- Quality guarantee;
- Project management and coordination;
- Additional services for products that include a web interface;
- Consultations;
- Other audiovisual services.

  Services may be requested as a whole or as a subset.

Analysis of needs

The Customer may propose to define the scope of the project for the Contractor based on the needs analysis and provide advice on the communication strategy and distribution plan of the product using the auralised 3D model (e.g., target publication platforms, product type, output formats, publication and localisation strategy, etc.).

The Contractor is expected to ensure that all necessary information / user requirements for the project in the project definition provided by the Publications Office are sufficient before submitting a specific tender. The Contractor must have a good understanding of the product features, its functionality, as well as technical, time and budget constraints. In addition, the Contractor should clarify these aspects with the Customer to avoid misconceptions or incorrect product expectations at a later stage.

The Contractor must provide a project plan with timelines for interim and final results with the specific tender, keep it up-to-date during the project and share it with all parties in case of changes. Any timing risks should be addressed by the Contractor at the outset of the project and timing adjustments should be mutually agreed upon.

Concept and design

The Contractor must develop a product that meets the purpose and requirements of the Customer. The Contractor must provide a concept to create an auralised 3D model at the beginning of the project. The Publications Office may specify additional requirements in the request for services, such as for potential Contractors to submit a several concepts for selection. The solution concept document provided by the Contractor must be approved by the Customer and the authoring department before the Contractor proceeds to the next design steps.

At this stage the Contractor should clarify issues related to the overall "look and feel", and then make and edit drawings, buttons, photos, banners, thumbnails and other visual works.

The requirements for testing, accessibility and usability of WEB platforms applicable to Lot 2 are also applied to products with auralised 3D model. The Contractor must consider them at this stage. Delivered product must meet the requirements of the adaptive design unless otherwise is specified.

The Contractor must consider intellectual property rights for the content to be used for visualisation during the design phase. For audio productions, this service include the creation of a production concept/script with a consultative framework for the final product.

Development

The Contractor is expected to provide the following development services (the list is not exhaustive):

For 3D modelling:

- Location research, planning and logistical organisation of 3D modelling based on Customer information;
- Morphological transformations on existing assets or NURBS 3D modelling processes;
- Projecting photogrammetric data onto a 3D model;
- Conducting mapping and texturing processes;
- Determining the elements of the semantic division;
- Classifying materials;
- Determining acoustic parameters of the database.

For auralisation:

- Planning and logistical organisation of audio recording based on Customer information;
- Providing professional sound recording equipment;
- Import of musicians' avatars into Unity;
- Import of audio anechoic sources;
- Providing association of audio sources with avatars of musicians;
- Determining specific parameters of acoustic materials;
- Providing association of acoustic materials with the surfaces of 3D models;
- Conducting spatial and acoustic modelling;
- Conducting and remote monitoring of recordings according to a predetermined schedule;
- Creating a unique sound logo for the intro/outro podcast;

Services related to all kinds of products with auralised 3D model:

- Re-editing existing material, checking the right to copy and acquiring rights to reuse existing material.

Postproduction

The Contractor is expected to provide the following post-production services (the list is not exhaustive):

- Coding, recording, (re)editing, digitising, compression, conversion and optimisation of delivered audiovisual materials for online and electronic distribution, downloading or streaming, using several standard technologies;
- Incorporation of existing animated graphics into audiovisual material (animated charts and data visualisation, animated cartoon, 2D and 3D visual effects and animation);
- Sound design and sound mixing;

- Translation of AV content (script, storyboard, voice-over text and subtitles);
- Voiceover, dubbing and subtitling, including quality control, proofreading and delivery of scripts to the Customer for approval.

Quality assurance (testing)

The Contractor must ensure thorough quality control of each result, granted the following:

- Compliance with the Customer's requirements;
- Correct implementation of feedback provided by the Customer;
- Correct integration of provided assets (text, icons, banners, logos, etc.) into the audiovisual product.

  The results must also meet the Customer's technical requirements agreed in a specific tender.

Consultations

The Customer can send a request for consultation as a separate service or with a further request for the implementation of the product.

At the same time, the following services can be ordered (the list is not exhaustive):

- Needs analysis, audience research and editorial work on determining a product concept with an auralised 3D model (content organisation, message formulation, composition, graphic style, ergonomics, final features in the case of a user interface, etc.) in order to achieve the Customer's goals and reach the target audience;
- Advising on plan of the auralised 3D model product distribution and marketing strategy (target publishing platforms, output formats, distribution and localisation strategy (dubbing vs. subtitling), etc.);
- Determining the performance indicators;
- Consulting on issues and/or setting up performance monitoring and impact assessment (measurement of the effectiveness of AV content and its distribution plan), quantitative and qualitative data analysis, reporting.

2.2.4 Results for Lot 1

The list of final deliverables for an audiovisual project includes (the list is not exhaustive):

For all types of products:

- Specific tender;
- Project plan;
- Agenda and minutes of the meeting;
- Declaration of already existing rights.

  For a product with an auralised 3D model:

- The concept of creating a product with an auralised 3D model;
- 3D modelling of the object agreed with the Customer;
- Auralisation of the object agreed with the Customer;
- Spatiality and acoustic modelling;
- Final renderings of the auralised 3D model that meets the Customer's technical requirements;
- Final version of subtitle files, if applicable.

2.3 Lot 2 – Development of a WEB platform for classical music promotion using auralised 3D model

The Contractor provides assistance to the Customer with all technical tasks related to the analysis, definition, planning, preparation, production, publication and maintenance of the WEB-platform for the popularisation of the classical music with the use of auralised 3D model, which can be distributed on any electronic media.

2.3.1 Types of products developed under Lot 2

The following products may be requested for Lot 2 (the list is not exhaustive):

- Publications based on web technologies, for example, complex HTML versions, mobile websites, interactive publications, image and video galleries, slide shows, etc. for distribution on the network as stand-alone solutions or integrated into certain CMS platforms;
- Progressive web applications focused first on mobile devices;
- Complex, multi-page HTML templates (with navigation, presentation aspects, and placeholders for future content);
- Document templates for CMS integration;
- Animations controlled by HTML, CSS and JavaScript that can be integrated into electronic publications;
- Multimedia packages using an auralised 3D model.

2.3.2 Services provided under Lot 2

Due to the main stages of the project life cycle, the following services grouped may be requested for Lot 2 (the list is not exhaustive):

- Analysis of needs;
- Concept and design;
- Development/implementation;
- Implementation of additional opportunities;
- Testing/quality assurance;
- Project management and coordination
- Documentation of the electronic publication;
- Integration of the product into the target platform;
- Assistance in the publishing business;
- Service;
- Other services.

The Contractor may be asked to define product specifications based on needs analysis and provide advice on performance monitoring of data collection and its analysis, as well as advice on promotional activities.

The Contractor provides the Customer with a project plan with timelines for interim and final results along with the specific tender. He/she will keep it up-to-date during the project and share it with all parties in case of changes. Any timing risks should be addressed by the Contractor at the outset of the project and timing adjustments should be mutually agreed upon.

Concept and design

The Contractor designs a product that meets the purpose and requirements of the project.

This service includes all aspects of publication design such as (the list is not exhaustive):

- Functional design (including user interaction and navigation);
- Graphic design (development of original concepts, general "appearance", creation and editing of drawings, buttons, photos, banners, storyboards, thumbnails and other visual works);
- Data structure (front-end and, if the project requires it, back-end development);
- User interface/usability design;
- System architecture (tools, databases, data sources, libraries, integrations, etc.);
- Ergonomics;
- Accessibility (post structure, navigation, labels, color contrast, integration of alt text with visual elements, etc.);
- Selection of technology for development;
- Selection of appropriate APIs, etc.

In the event of a request for editorial work on the provided text content (any kind of transformation, adaptation, combination or deletion of information necessary to achieve the purpose of publication), the Contractor is obliged to provide the Customer with the revised text as an intermediate result for approval before insertion into the product.

In the case of multilingual publications, the multilingual aspect must be taken into account by the Contractor at the design stage to ensure that multiple language versions are handled correctly throughout the development process. Typographical rules applicable to the respective languages (e.g., spaces, hyphens, etc.) must be followed.

The Contractor provides a navigation scheme at the beginning of the project. It must include:

- Site map;
- Communication between different elements with links;
- Specification of the nature of various elements (pages, content, etc.);
- Clarifying the content of each page (content, menu, images, etc.).

The Contractor must take requirements for accessibility, ergonomics and ease of use into account at this stage. The platform must follow responsive design and adapt to different screen size capabilities, unless otherwise is specified. More specific product compatibility requirements may be specified in the service request.

The Contractor must consider intellectual property rights for the content to be used for visualisation during the design phase.

Development/Implementation

The Contractor provides the following development services to present a functional platform as specified in the request for services:

- Software coding in technologies selected for the project; creating dynamic websites using a programming language or development framework (in some cases, this may be a specific development framework approved by the Customer);
- Preparation of data (text, statistics, cartography, graphics, etc.) for integration into the publication;
- Development and establishment of promotion of the concert hall;
- Preparation/adaptation of all provided objects for use on the Internet in compliance with accessibility rules (for example, reworking of graphics, optimisation and resising the images, etc., integration of the replaced text into visual elements, etc.);
- Adaptation of the created pages for different devices (mobile phones, laptops), creation of adaptive design for mobile devices.

The Contractor should consistently develop a step-by-step approach in the development workflow in which one interim deliverable is approved by the Customer before the Contractor begins to develop the next one.

Product integration into the destination platform

The Contractor with the support of the website and/or system administrator must integrate each ticket that has a corresponding seat number attached to the auralised 3D model into the Content Management System (CMS).

It's expected the Contractor offers a better CMS, refines its functionality when needed, and assists to deploy it in a cloud environment.

2.3.3 Results for Lot 2

The requested list of deliverables for the development of a WEB-platform for the popularisation of classical music using an auralised 3D model includes (the list is not exhaustive):

- Specific tender;
- Project plan;
- Exact technical characteristics;
- Agenda and minutes of the meeting;
- Revised text (if any);
- Navigation scheme;
- Frames;
- Layouts;
- Functional prototypes created in HTML/CSS;
- The first version of the publication;
- The final version of the publication (including linguistic versions) as a separate package or integrated into the target platform, including:
    - Commented source code;
    - Source files and assets;
    - Integration guide;
- Media embedded/used in the final product: for example, images, video, audio;
- Source files for developed illustrations and diagrams;
- User manual;
- Instructions for operating the system;
- Test protocols;
- Declaration of the already existing rights.

2.4 Lot 3 – Development of VR/AR applications using auralised 3D model

2.4.1 Types of products developed under Lot 3

The following products may be requested for Lot 3 (the list is not exhaustive):

- Virtual reality products such as simulated experience / activities / learning, three-dimensional (3D) visualisation of environments and places, virtual visits or tours in 3D, photorealistic 3D worlds, VR process

simulations, fully immersive learning / educational experiences, VR game environments, etc., which can be distributed through one or more of the following channels:

- As mobile applications published in mobile application stores (e.g., Apple App Store, Google Play Store, Oculus store or on dedicated VR stores/gaming platforms;
    - As mobile applications published in mobile application stores (e.g., Apple App Store, Google Play Store, Oculus store or on dedicated VR stores/gaming platforms;
        - As a browser-based VR experience for desktop and mobile operating systems (e.g., WebVR, WebX R, etc. [9]);

- Augmented reality products or experience (displaying an additional layer of information on top of the camera display) can be released through the following channels, including:
    - As mobile applications published in mobile application stores (e.g., Apple App Store, Google Play Store, Oculus store);
    - In the browser via, for example, WebXR (when there are no physical touch points to activate), etc.;
- Backend solutions for VR or AR products, if they are ordered together with these products (not stand-alone server solutions);
- Sites included in complex projects based on VR or AR technologies.

This batch of products is technology oriented, based on hardware, applications and methods that include some degree of spatial tracking.

2.4.2 Requirements for the quality of applications based on virtual and augmented reality technologies

The developed final product must:

- Meet the specific requirements of the project;
- Be fully operational/functional on the relevant platform(s) and/or device for which it was designed;
- Ensure ergonomics and physiological and environmental comfort of the user (prevention of motion sickness, nausea, claustrophobia, agoraphobia, dizziness or other adverse health effects);
- Respect the technical requirements of the platform(s);
- Adhere to common development standards and software development best practices;
- Integrate correctly data content into all relevant language versions;
- Comply with all applicable data protection regulations (including new regulations published after this call for tenders);
- Include appropriate metadata, identifiers, and copyright information where applicable;
- Be designed, if possible, inclusively to facilitate access for persons with disabilities (VR content accessibility, interaction method accessibility, device/equipment accessibility, inclusive user representation in VR environments), etc.

Products developed and distributed as mobile apps in mobile app stores must:

- Meet the accessibility requirements of target platforms:

  For iOS, see the latest version of the iOS Accessibility Programming Guide:
  https://developer.apple.com/accessibility/ios/

  For Android, see the latest version of the Accessibility UI API Guides:
  https://developer.android.com/guide/topics/ui/accessibility/index.html

For Oculus, see the latest Designing Accessible Virtual Reality guidelines: https://developer.oculus.com/learn/design-accessible-vr/

- Comply with applicable legislation and institutional security standards and guidelines.

2.4.3 Services provided under Lot 3

Due to the main stages of the project life cycle, the following services may be requested for the Lot 3 (the list is not exhaustive):

- Analysis of needs;
- Concept and design;
- Development/implementation;
- Testing/quality assurance;
- Project management;
- Documentation of goods;
- Help in publishing the product;
- Service;
- Consultations;
- Other services.

  Services may be requested as a whole or as a subset.

Analysis of needs

Based on information from the Customer (project definition or less structured/comprehensive input), the Contractor is expected to think creatively as well as analyse needs.

Given the complexity of VR and AR projects, a pre-meeting can help clarify relevant aspects and allow the Contractor to develop a concept for the implementation. The Contractor must have a good understanding of the existing or new features, functionality, target audience and its equipment requirements / limitations, information security risk aspects, as well as technical, time and budget constraints to avoid any misconceptions or incorrect product expectations at a later stage.

The Contractor must provide a project plan with timelines for intermediate and final results with the specific tender, keep it up-to-date during the project and share it with all parties in case of changes and recalculation of deadlines. The Contractor at the beginning of the project implementation must highlight any risks related to the implementation period.

Concept and design

The Contractor must develop a solution that meets the purpose and requirements of the project.

This activity includes all aspects of VR/AR product design such as:

- Functional design (including precedents, navigation scheme, conceptual flows and interaction models: user interaction and control, input methods, auralised 3D model, functional controls in the environment instead of menus, etc.);
- Visual (3D graphics) design and modelling: development of original concepts based on a 3D model;
- Motion design;
- Data structure (front-end and, if the project requires it, back-end development);
- System/software architecture (tools, databases, data sources, libraries, integrations, etc.);
- Ergonomics and ensuring the user's physiological and environmental comfort (prevention of nausea, claustrophobia, agoraphobia, dizziness, etc.), taking into account the Goldilocks zone;

- Selection of product development technology, as well as stereoscopic display, motion tracking devices and user input (in the case of VR);
- Accessibility (on request in addition to features typically applied to mobile apps, such as in-app ads, audio descriptions, text and image magnification features, transcripts and closed captions for audio elements, adjustable volume and caption controls, and keyboard-based features, screen reader, etc.).

The Contractor must take into account the main specifics and limitations of the display technology (latency, CPU, memory capacity, battery life, accuracy of gyroscopes and motion sensors, security, network bandwidth, etc.) at this stage. In the case of multilingual products, the multilingual aspect must be taken into account already at the design stage to ensure that multiple language versions are handled correctly throughout the development process. Typographic rules applicable to the respective languages must be followed (e.g., spaces, hyphens, etc.).

The Contractor must provide the Customer with a draft of system architecture map at the beginning of the project and a final complete architecture map with the application of data integration and results.

A data architecture map is required from the Contractor where data integration is applied.

Before starting development, the Contractor provides the Customer with the following intermediate results:

- Story flow and interaction model;
- Clear frameworks that illustrate each option of using the product;
- Layouts and 3D models;
- Asset placeholders.

The Customer approves these results before development begins. Multiple iterations are possible which are considered as refinements.

The Contractor must create and submit a VR/AR prototype that shows the product concept (expected visual components, user interaction model) as well as its functioning on the target devices. The Customer before the Contractor proceeds to the development phase approves the prototype.

The Contractor must consider accessibility, ergonomics and usability requirements at this stage. VR/AR web applications must follow responsive design and adapt to different screen size capabilities, unless otherwise is specified. According to the service request more specific requirements to compatibility of product may be specified.

The Contractor must consider intellectual property rights for the content to be used for visualisation during the design phase.

Development/Implementation

The Contractor provides the following development services to deliver a functional VR/AR product as specified in the request for services (the list is not exhaustive):

- Software coding in technologies selected for the project;
- Preparation/adaptation of data (text, statistics, cartography, graphics, etc.) for integration into the application;
- Integration of streaming data sources (if available);
- Integration of tools or services already available on the market (e.g., geolocation, social media tools, API);
- In some cases, the product may require binding or use of enterprise solutions and building blocks, for example, those provided by the European Commission [10].

The Contractor provides the first test version of the program, properly tested and compatible with all requirements of usability and functionality, for the approval by the Customer. It must be fully functional and demonstrate the usability and functionality of the final product. In the case of multilingual applications, the test version includes content in the piLot language to be implemented in all language versions.

Assistance with publishing of VR/AR applications

The Contractor must help the Customer create accounts in major mobile application stores and in the Oculus store, as well as publish the developed applications on these accounts by default and provide the support for them.

Consultations

The Publications Department may request a consultation as a separate service or as one included into a separate request for product implementation.

The following services/consultations can be requested (the list is not exhaustive):

- Analysis of needs in order to define the concept of the VR/AR application (organisation, composition, selection of functions, technical design, graphics, ergonomics, usability, marketing, etc.) and coverage of the target audience;
- Selection of technologies to be used for product implementation, as well as time limits and cost implications;
- Hardware for implementation of the application distribution plan;
- Distribution plan (choice of platforms to ensure the availability of the program), compatibility, etc.;
- Usability testing of the existing application;
- Provision/organisation of user testing (play-testing);
- Analysis of analytics on the performance of the existing product and recommendations for further measures to improve its performance, and/or a conceptual proposal for the creation and/or publication and marketing strategy of any subsequent product (for example, a series of VR/AR applications);
- Benchmarking analysis: setting parameters for benchmarking of the existing or new VR/AR program against the parameters of the existing counterparts. This may include detecting problematic features, identifying organisations with similar processes, researching best practices, and etc.;
- Branding and strategic consulting on the use of colours, type of illustrations, layout styles, etc.

2.4.4 Results for Lot 3

The list of results for the development of VR/AR applications using an auralised 3D model includes (the list is not exhaustive):

- Specific tender;
- Project plan;
- Exact technical characteristics;
- Agenda and minutes of the meeting;
- Draft system architecture map;
- Data architecture map where it is possible;
- Story flow and interaction model;
- Frames;
- Layouts;
- 3D models;
- Asset fillers;
- Options for use (test scenarios);
- Testing plan;
- Program prototype;

- The first version of the program;
- The final version of the program, which includes:
    - Commented source code;
    - Source files and assets;
- Declaration of the already existing rights.

  If the product is a mobile app:
    - Application binaries for target platforms (for example, for Android);
    - All complete project files in the appropriate environment required to run the project, with all necessary libraries, if not proprietary (e.g., for iOS);
- Media embedded/used in the final product, e.g., images, video, audio;
- Source files for developed illustrations and diagrams, if applicable;
- User manual;
- Instructions for operating the system;
- The final complete map of the system architecture;
- Test protocols;
- Declaration of the already existing rights.

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Annex

TECHNICAL GUIDELINES TO SUPPORT THE DRAFTING OF TENDER DOCUMENTS FOR PROJECTS FOCUSED ON THEATRE AURALISATION

Based on the experience conducted within the AURA project and in expectation of future scenarios in which "auralised models" of theatres may be commissioned by theatrical institutions for projects of three-dimensional reconstruction and acoustic simulation of their environments, punctual guidelines are drafted below that may be of support, from a technical-operational and timing point of view, for the drafting of tender documents intended for projects with this type of purpose.

The elements to be taken into account (software, instrumentation, methodologies, etc.) for these types of projects are strictly related to the processing steps, which can be articulated according to two macro-phases related to data acquisition and processing, discussed below.

1. Data acquisition

The data acquisition phase is extremely important within a project of three-dimensional reconstruction of a study object, as it allows to obtain a solid metric-morphological basis on which all the subsequent processes of modelling, auralisation and creation of virtually exploitable environments can be developed in a way that is completely reliable and equivalent to reality.

The following points list the main methodologies to be considered for such data acquisition operations.

1.1 Finding internal technical documentation

The first activity regarding data acquisition involves researching and obtaining all or part of the technical documentation related to the theatre environment to be digitised.

Indeed, often the technical departments of theatres archive – digitally or on paper – many assets in the form of:

- 2D graphic drawings (floor plans, sections, elevations, construction details, etc.),
- technical reports (architectural, engineering, acoustic, etc.),
- 3D As-built models (in the case of newly constructed buildings)

Such technical documentation, if present, can offer primarily an economically free product-being internal and already in the possession of the property-on which the data processing phase can be developed, or it can be the preliminary basis on which to plan subsequent digital survey activities.

In the case of contemporary theatres such documentation is often easily accessible since it has already been digitised and is in the possession of the administration.

On the contrary, for historic theatres – which have not, however, recently undergone restoration operations, and in that case, digital technical drawings can be requested from the architectural or engineering firms that developed the projects – it would be appropriate that the technical documentation, if present, should first be digitised and then be combined with digital surveying activities, in order to verify its metric-morphological reliability and, if necessary integrate it with additional data before proceeding to 3D reconstructions and auralisation and virtualisation processes.

1.2 Laser-scanner digital survey

In the case of historic theatres, or in the total or partial absence of reliable technical documentation for a correct 3-D reconstruction of the environments, it would be appropriate during data acquisition to rely on the digital surveying potential offered by laser-scanner instrumentation.

The result of the acquisition using these devices, which is done automatically and independently of the morphology of the object to be surveyed, is a 3D digital asset composed of a set of points scattered in space, each endowed with metric coordinates, which is commonly called "point cloud."

The latter makes it possible to obtain a digital copy of any type of environment endowed with highly reliable metric-morphological characteristics.

To date, there are numerous laser-scanner models on the market that could be used in projects dedicated to virtual theatre reconstruction, each of which has the following main technical parameters to be taken into account:

- *range*: maximum distance the instrument can measure;
- *accuracy*: degree to which a measured quantity conforms to the true value
- *precision*: ability of the instrument to return the same value in several consecutive measurements;
- *resolution*: indicates the smallest geometric detail that can be measured by the instrument;
- *integrated devices*: ability to integrate other devices such as cameras or GNSS

In addition to the definition of these technical parameters, it is appropriate to distinguish the types of laser-scanner instruments on the market according to their operational mode of data acquisition, which are:

- Terrestrial Laser Scanner (TLS)
- Mobile Laser Scanner with SLAM technology (Simultaneous Localisation and Mapping)

Specifically, based on these two types of laser scanners, the minimum requirements of the main technical parameters are listed below in relation to different types of theatres.

	typology of theatre	**range max**	**measurement accuracy**	**scanning resolution**	**timelines**	**integrated devices**
TLS	main-halls of any size	at least up to 70 m	at least ±3 mm	high	medium	camera
SLAM	small halls	at least up to 25 m	at least ±10 mm	low	fast	camera

1.3 Photogrammetric digital survey

In some cases, it seems appropriate to complement the digital surveys carried out by laser-scanner with Structure from Motion (SfM) photogrammetric acquisitions, in order to integrate the metric-morphological data derived from FM TLS or SLAM point cloud with a product that can both represent, through mapped 3D models, information on the appearance of the various architectural elements present in the theatre halls, and can be used to extract photographic textures useful for the eventual mapping of 3D models.

In fact, digital photogrammetry bases its operating principle on the method called "Structure from Motion" (SfM), by which it is possible to reconstruct the three-dimensional shape of objects or environments through the automatic collimation of points from a set of photos taken from different positions.

Therefore, this image-based survey methodology appears to be very advantageous for the three-dimensional reconstruction of objects belonging to Architectural Heritage, especially in terms of acquisition speed, instrument economy and measurement range.

In any case, when acquiring data, the only element to be considered is the camera with which the photos will be taken, so photogrammetric operations should be planned according to the technical capabilities and settings of the camera.

In choosing the latter, there are basically two main technical features to be considered:

- *sensor size*: the larger the sensor, the more sensitive the camera will be to light and will allow it to capture larger images in terms of pixels, and consequently more detail (a full-frame camera will allow it to capture wider quality photos than one with a small sensor)

- *lens focal length size*: to capture objects of architectural size, it is advisable to refer to lenses with fixed focal lengths of about 25-28 mm, avoiding ultra-wide lenses (below 22mm) as they can cause distortions that can bother photogrammetric processes.

1.4 Study of the acoustic properties of the materials present

For projects intended for the auralisation of theatres, in addition to the virtual reconstruction of the rooms, the study of the materials with which they are made, and in particular their construction properties from the acoustic point of view, is of fundamental importance.

For such projects, it is advisable to rely on professionals in this field, such as acoustic engineers or architects, who will be able to work in different ways depending on the level of in-depth study required:

- Visual examination supported by existing acoustic reports (lower level of reliability and detail, faster, cheaper)

- Instrumental examination and acoustic report drafting (higher level of reliability and details, slower, expansive)

Each of these options will result in assigning specific values to the absorption and acoustic diffusion coefficients of the various materials in the theatre's main hall and, once associated with the respective surfaces of the 3-D model, will allow subsequent auralisation and environmental acoustic simulation processes to be developed.

2. Data processing

Once the metric-morphological data of architectural environments have been acquired and the acoustic properties of various materials have been identified, it is necessary to process this "raw" data in order to create qualitatively reliable assets for the development of the processes of modelling, auralisation and creation of virtually exploitable environments.

The following points list the main methodologies to be considered for such processing operations of the acquired data.

2.1 3D model processing in the form of a point cloud

Once the data have been acquired by laser-scanning instrumentation (TLS or SLAM mobile laser-scanner), it is necessary to work on the scans processed by the device, which may sometimes amount to a very high number (on the order of hundreds) in case the venue is large.

Bearing in mind that each scan represents in the form of a point cloud a three-dimensional portion of the surveyed environment, in order to have a global cloud that digitally reproduces the entire room without missing data, it is necessary for the various scans to be somehow joined together.

This process is called "registration" and is based on a procedure of aligning adjacent scans having at least 50 percent points in common.

Through a series of rigid rototranslations between adjacent point clouds, their homologous points are identified and, through visual alignment processes, their matching is determined. This cloud-to-cloud registration thus makes it possible to obtain a single global point cloud of the theatre complex that includes all the data acquired in the instrumental survey phase.

The next phase after the scan registration phase, instead, concerns the reliability check of the developed survey: during this phase, any misalignment errors present in the registered point cloud are verified.

It should be underlined that, given the high accuracy of these instruments, it is necessary to set a tolerance limit for which to consider the survey reliable, usually based on the scale of representation and the level of detail to be desired. For example, if the scale of representation of the graphical drawings to be developed on the basis of a point cloud is defined as 1:50, accuracy limits between aligned clouds with a tolerance of ±12 mm are expected.

This check is implemented through sections performed on the global point cloud, either by means of horizontal or vertical slice planes, verifying that the distance between the section wires of the different aligned point clouds is less than the tolerance set by the representation scale. If the results of this verification yield positive results, with maximum errors lower than the tolerance, the clear reliability of the developed TLS survey is established, thus making it a trusted morphometric support for the digital drawings and analyses to be carried out on the theatre complex.

The development of such processes requires reliance on specific point cloud management software, which can be widely found on the market (including open-source versions). Such programs, once the global point cloud is developed, allow not only to manage it and work on it "internally," but also to export its data into various formats that can be used by other software's.

To ensure that the workflow of the job is not exclusively internal to one program, it should be checked that the point cloud management software chosen allows the export of the final data in at least one of the standard formats that can eventually be reimported again.

Often, in fact, the technical requirements within tenders aimed at the digital reconstruction of architectural assets explicitly demand the use of so-called "open" formats for point clouds (such as .E57, .PTS, .PTX, .LAS), so that they can be employed by any type of software, possibly even open-source.

2.2 3D photogrammetric model processing

Once the data have been acquired through photographic instrumentation, it is necessary to work on the images taken by the device through SfM photomodelling software (also widely available on the market, both licensed and open-source).

Once the images have been imported, the software through image-matching processes identifies homologous points between the shots and reconstructs their position and orientation for each. These procedures make it possible to process an alignment between the acquired images and, through further specific DSM algorithms, to develop a point cloud that explicit the morphology of the detected object. Through subsequent processes, its points are then triangulated and polygonised, thus creating a 3D mesh model that perfectly represents the object. Finally, this latter is mapped with the texture of the photographs, obtaining a digitally mapped 3D model of the surfaces.

For better use of these high-poly textured 3D models, in order to also make them a reliable support for virtual elaborations, they need to be referenced and calibrated according to homologous point coordinates extracted from laser-scanner surveys.

This procedure in fact makes it possible to integrate the two digital surveying methodologies, obtaining mapped 3D models with a high level of reliability both from the metric-morphological point of view and from the visual-virtual representation and simulation of reality.

Again, given the large presence of SfM photomodelling softwares in the market, the technical requirements present within tenders aimed at digital reconstruction of architectural assets, explicitly require the use of so-called "open" formats for photogrammetric point clouds (again, such as . E57, .PTS, .PTX, .LAS) or photogrammetric 3D models (such as .OBJ, .FBX, .PLY, .DXF), so that they can be employed by any type of program, possibly even open-source.

Additional data that can be obtained from the processing of photogrammetric data calibrated according to laser-scanner survey coordinates are 2D graphical outputs such as orthophotoplans.

In fact, every photomodelling software allows to export any view of the photogrammetric model with quality in terms of sharpness equal to that of the photos with which it was developed (that is why in the acquisition phase

the choice of instrumentation and optics is very important). If exported parallel to a surface, such view makes it possible to obtain a representative image of the state of preservation of that object at a graphic scale, by assigning to the single pixel a user-defined size (such as 2 mm, 1 mm, 0.5 mm, etc.) depending on the level of detail required.

Such outputs are very useful both for possible restoration or documentation activities of the existing, and for obtaining realistically reliable planar textures for mapping and material creation of non-photogrammetric 3D models.

2.3 3D model processing intended for auralisation and visualisation

The 2D and 3D assets processed by digital surveys (laser-scanner or photogrammetric) and acoustic analyses conducted provide a highly reliable basis from the point of view of measurement, acoustics and visual representation of architectural environment such as a theatre hall. That base thus becomes a fundamental support for the creation of a 3D model intended as much for auralisation processes as for immersive virtual experiences.

Each of these purposes is based on the creation of a 3D model from morphological data extracted from the point cloud developed from a laser-scanner survey. Within three-dimensional modelling software (also widely available on the market), virtual metric assets (portions of point clouds, photogrammetric models, CAD drawings, etc.) must first be imported and, on the basis of these, 3D modelling processes based on NURBS geometries are carried forward, so that there is greater support from the point of view of accuracy and management of the elements to be modelled.

In order to develop a 3D model that can be used for auralisation processes, it needs to be developed while maintaining a subdivision based as much on the semantics and function of the elements (wall, chair, floor) as on the materials of which the surfaces of these are made, so that these can be associated with the corresponding results of the acoustic studies preliminarily carried out.

In this way, it will be possible to create a kind of acoustic database in which each element will be associated with the values of acoustic parameters related to the absorption and acoustic diffusion of the material of which it is made and, consequently, facilitate the processing of auralisation processes.

At the same time, such subdivision by elements and materials will also simplify the texturing processes of the 3D model in order to make it visually accurate for immersive virtual experiences (such as VR, AR, etc.).

In order to be used for different purposes, it is necessary, again, that the chosen modelling software allows for an export of the file to so-called "open" formats (such as .OBJ, .FBX, .PLY, .DXF), so that they can be employed by any type of platform for auralisation and ArchViz graphics simulation.

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