ARCE – Augmented Reality for Concurrent Engineering Activities

June 01st , 2022

Agenda

What we do, is who we are.

- Introduction
- Development Summary
- Final Validation
- Lessons Learnt and Roadmap
- Q&A

Introduction

Introduction

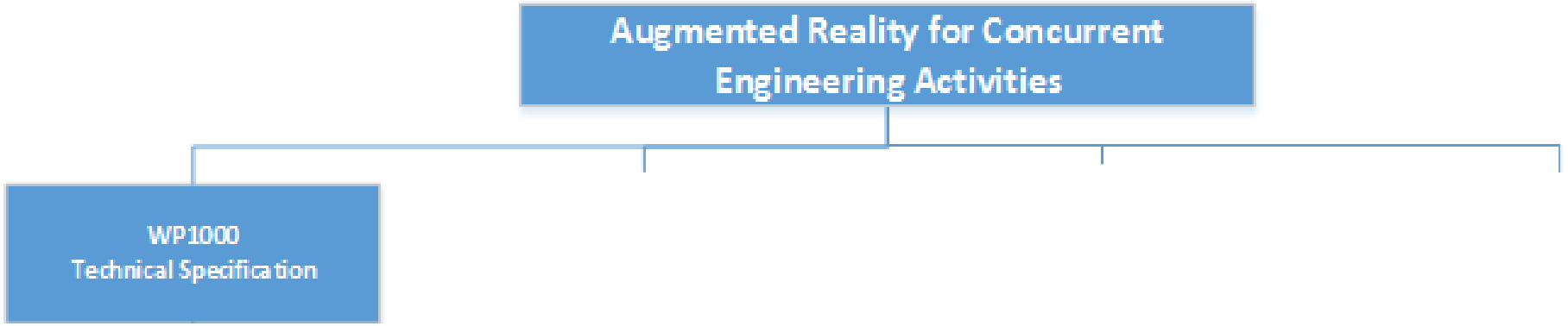
Project Objectives

- Kickoff **- 04 December 2019**
- **Consortium:** Lusospace (prime) and Critical Software (subco)
- **Objectives in the SoW**:
    1. Development of an interactive and collaborative Augmented Reality application for multidisciplinary and distributed design teams to enable visualization and editing of design models;
    2. Test the developed application in a concurrent engineering design exercise;
    3. TRL 2 ⇨ 4

Development Summary

Introduction

Consortium Contributions



WP1000 Technical Specification

Requirements Definition

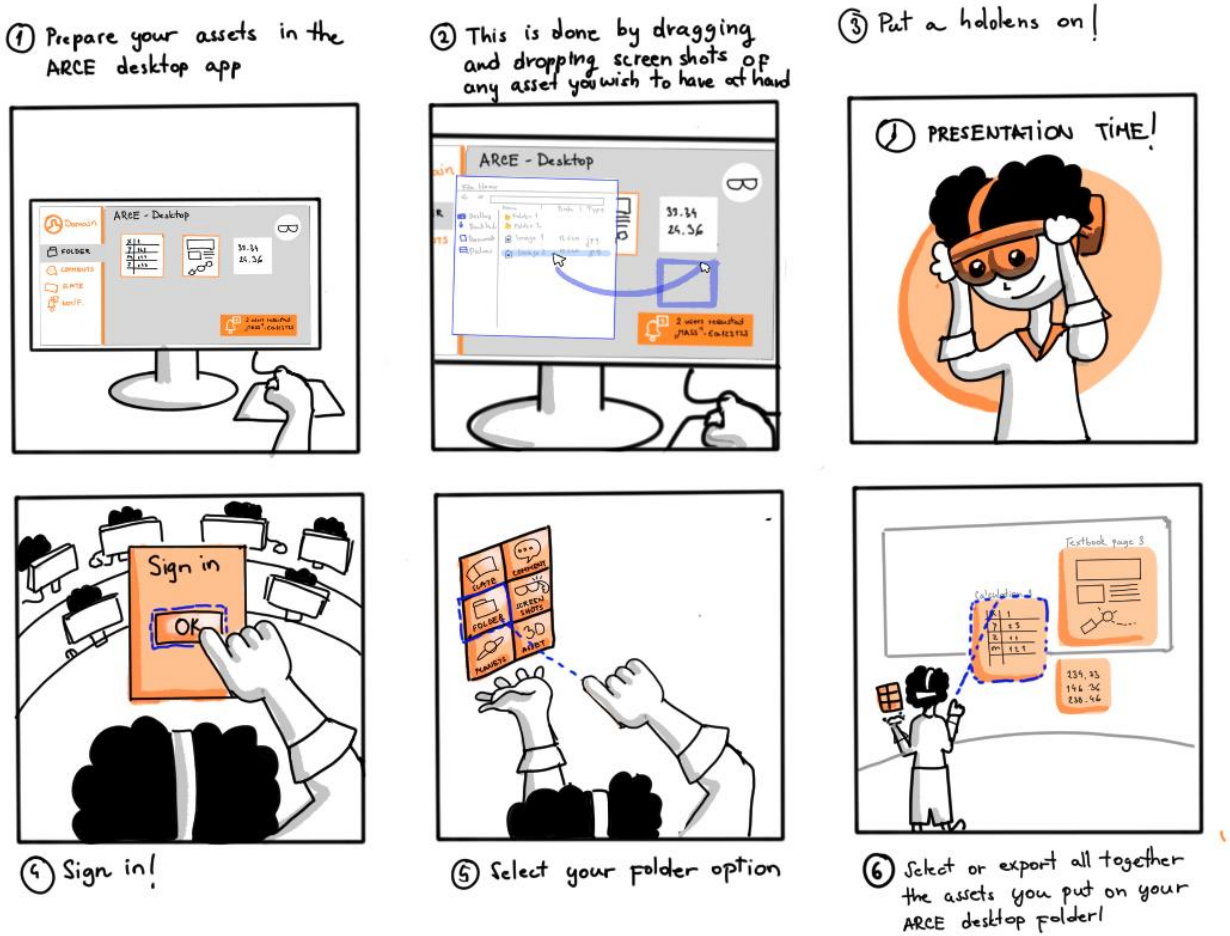
- Requirements Review:
- First, SOW requirements were analysed from the technical, usability and functionality points of view

- For the definition of use cases, storyboarding was used and presented to CDF specialists for discussion

- Some of the main stories considered:
  - 3D Manipulation
  - Preparing my presentation
  - Remote and Desktop presentation

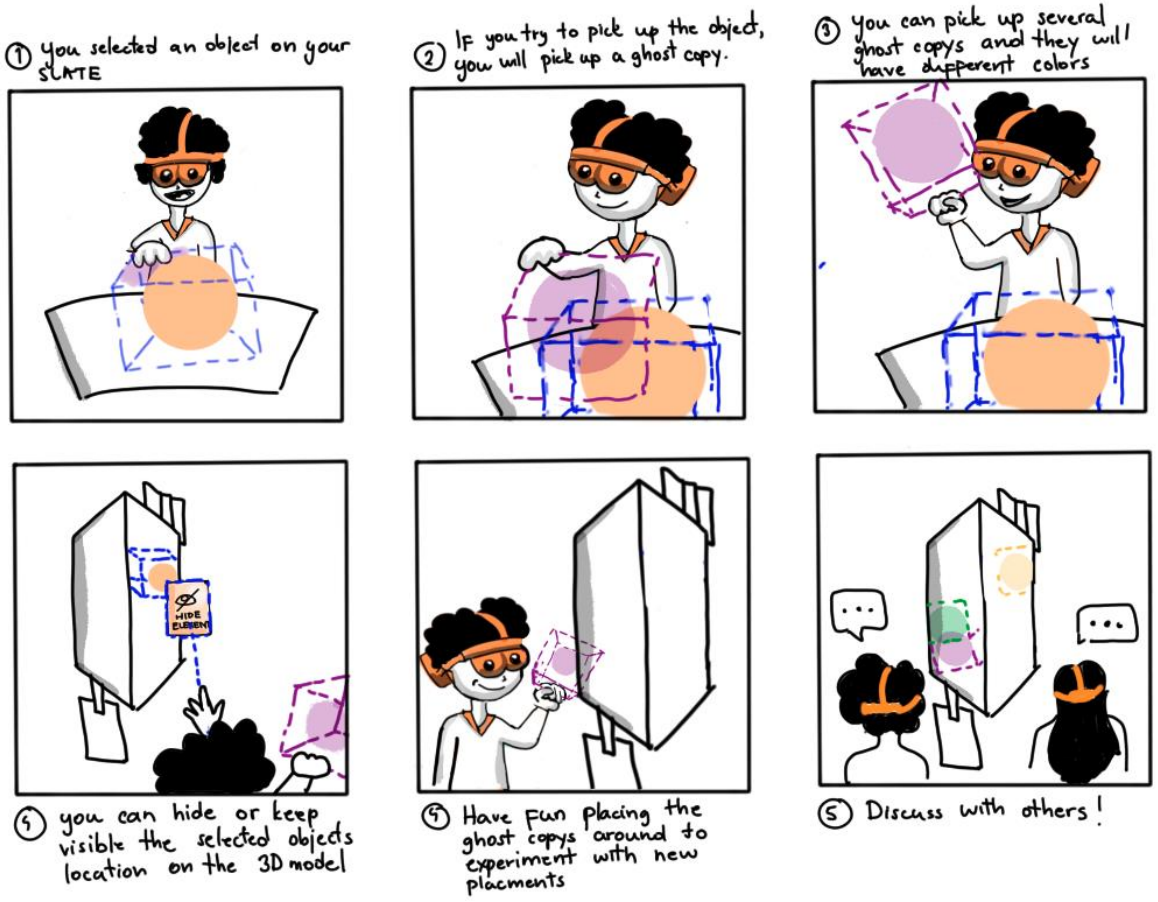
WP1000 Technical Specification

Requirements Definition



WP1000 Technical Specification

Requirements Definition



WP1000 Technical Specification

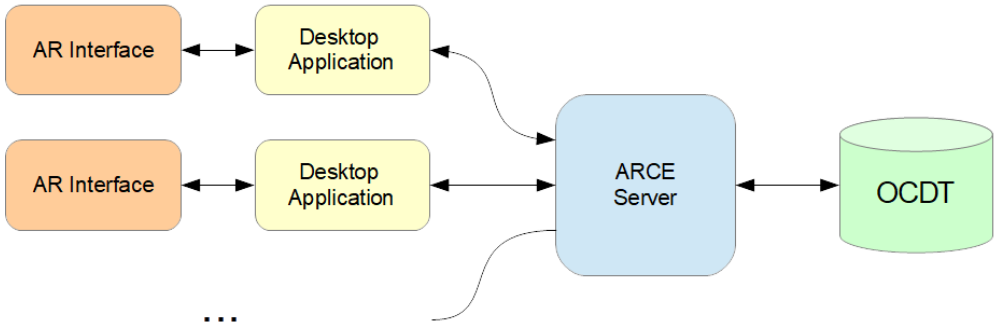
Application Definition

Three main applications were defined as part of the ARCE system:

- **Server Application**: the Server Application generates and manages the ARCE Design Session, guaranteeing the global concept of CE Model, CAD Model and synchronizing the connected Desktop Applications on the 'System's distributed features.

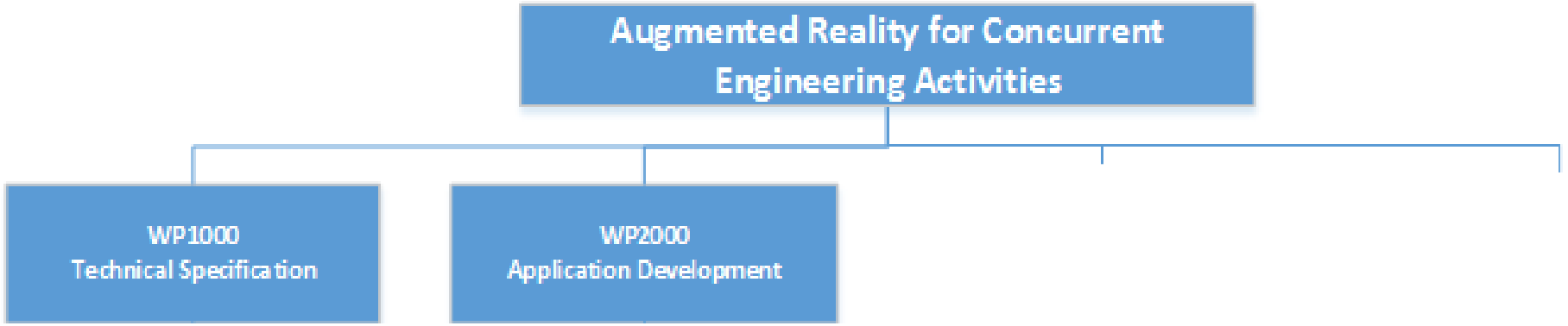
- **Desktop Application**: The Desktop Application is responsible for keeping the user logged in the session and is also the video stream client on features like Presentation Mode and User Point of View.

- **AR Interface**: the main means of interaction with the system. The user makes changes to the CE Model, CAD Model and other Session data through the AR Interface. CE Model changes requested by the AR Interface, are accepted by the Server only if the logged user has the right domain considering the change requested.



Introduction

Consortium Contributions



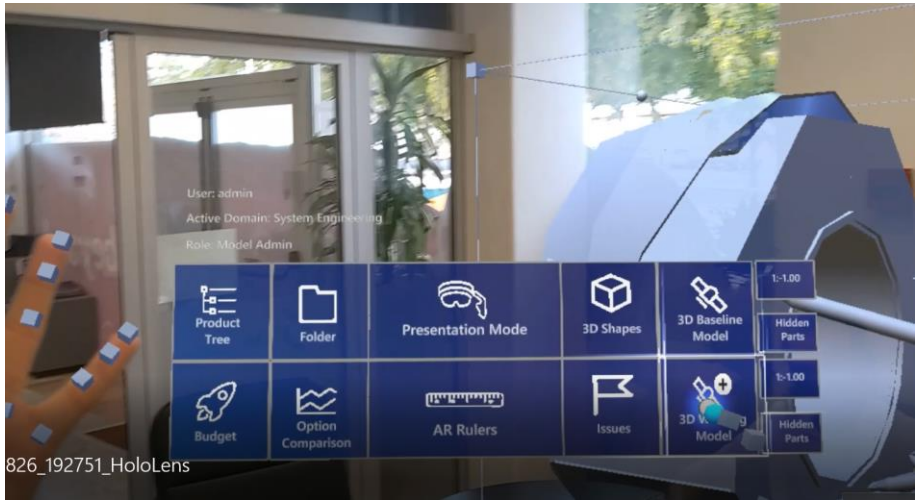
WP2000 Application Development

UX/UI Design

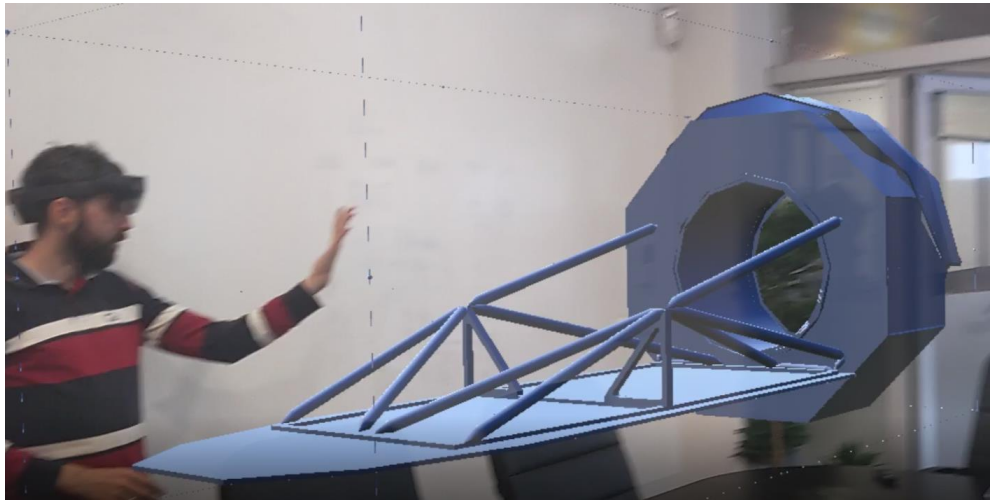
AR Interface

To comply with the established requirements, the UX/GUI design of the ARCE AR application was designed with two sets of main feature groups:

- 3D model visualization and interaction (3D information)
- CE parameter visualization and interaction (2D information)



2D Information



3D Information

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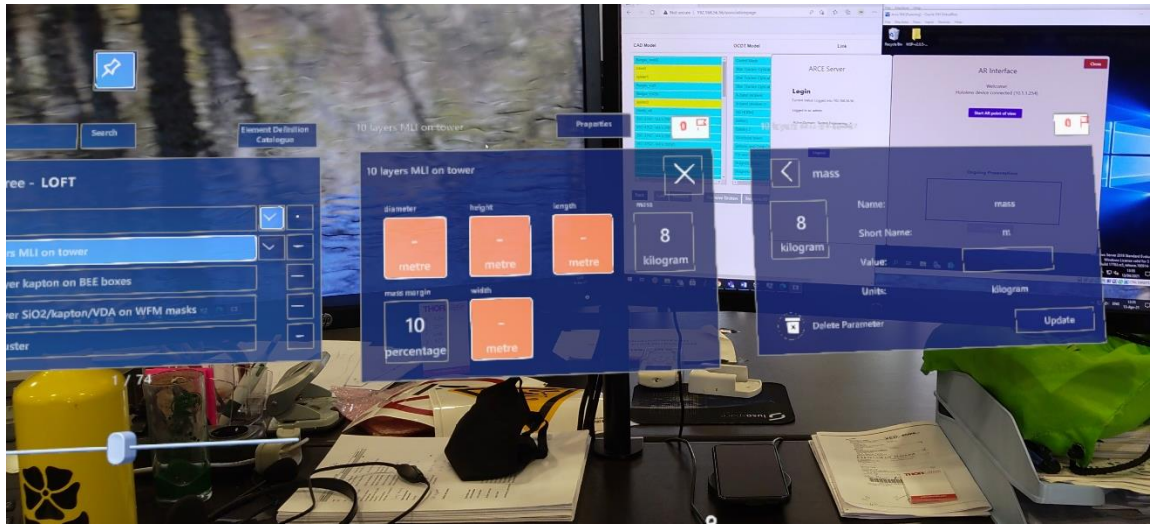
UX/UI Design

AR Interface

All the information from the OCDT server was divided into several views/panels, which are navigated according to the designed UI/UX flow. Main features: exploring the product tree, exploring/editing parameters, element definitions and design options, exploring budget and iterations, all in accordance to user profile/permissions



The user inspects a specific parameter for the selected equipment

Budget feature

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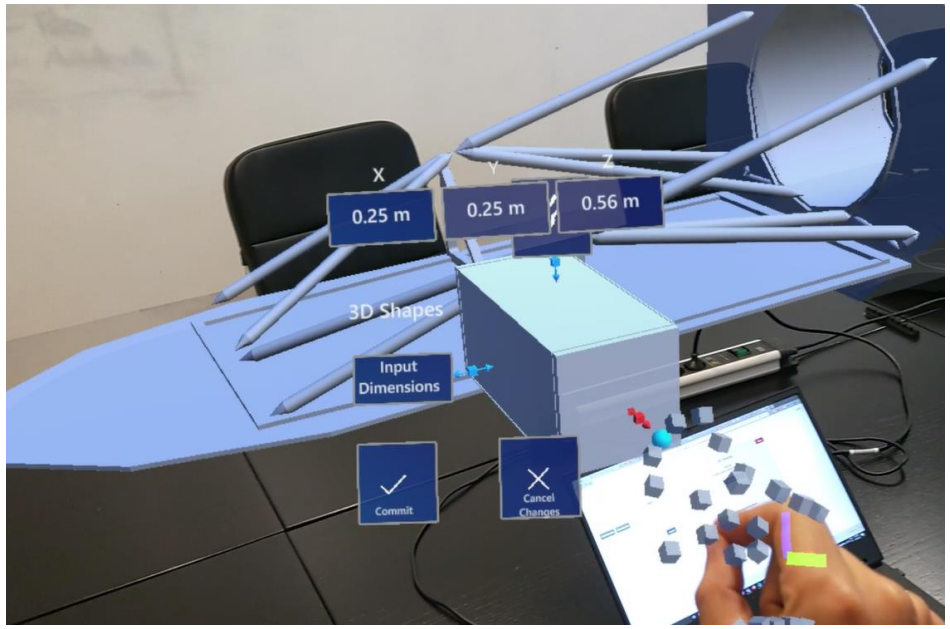
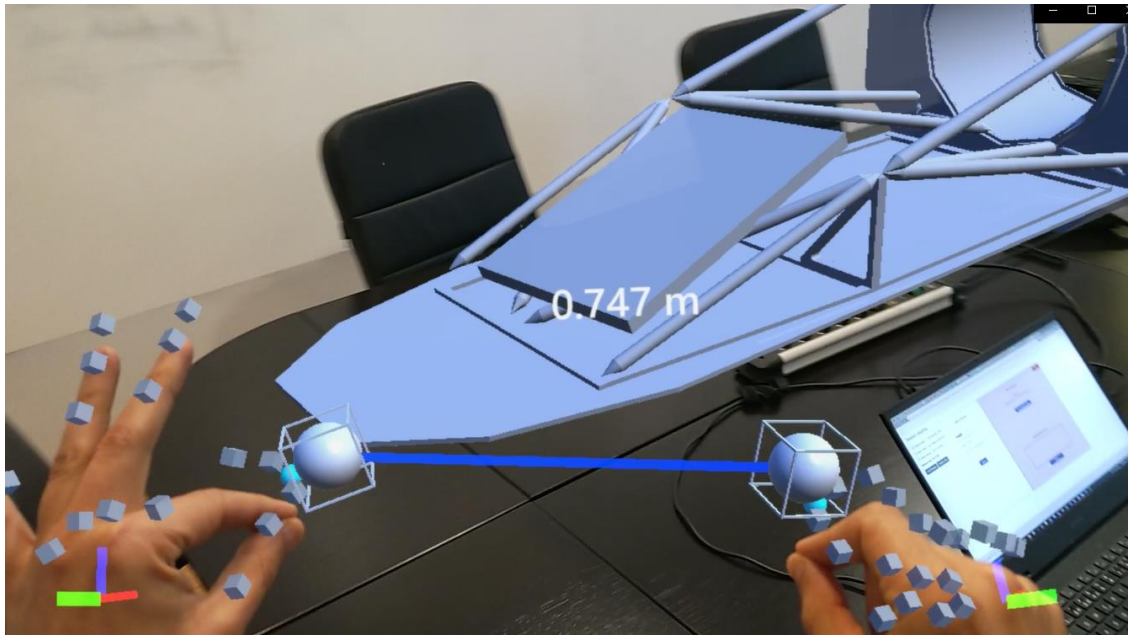
UX/UI Design

AR Interface

The interaction with the 3D model designed includes moving/hiding components on the Working Model, adding shapes, ruler feature



Adding shapes



Ruler feature

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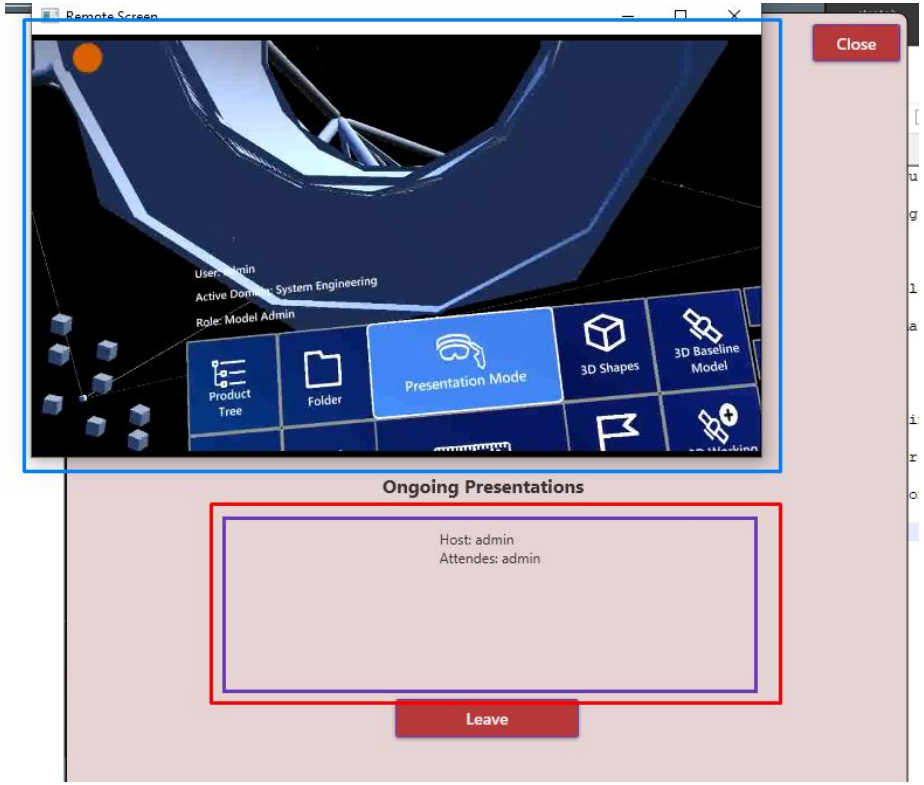
UX/UI Design

Desktop Interface

UI designed as to allow for login, viewing presentations and user point of view

Main desktop menu



Presentation mode

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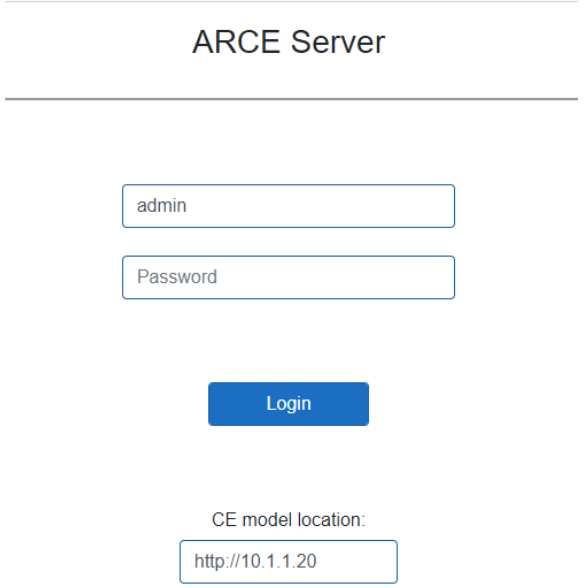
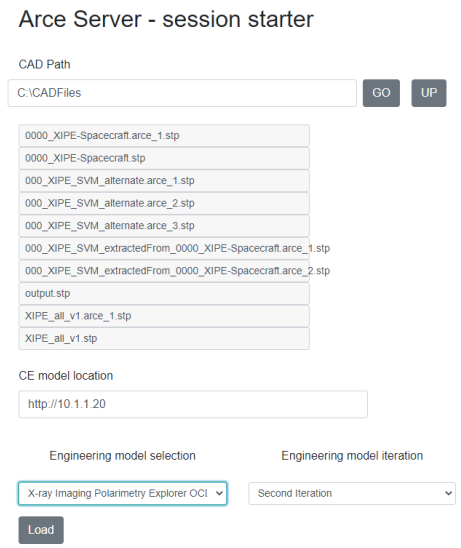
UX/UI Design

Server Interface

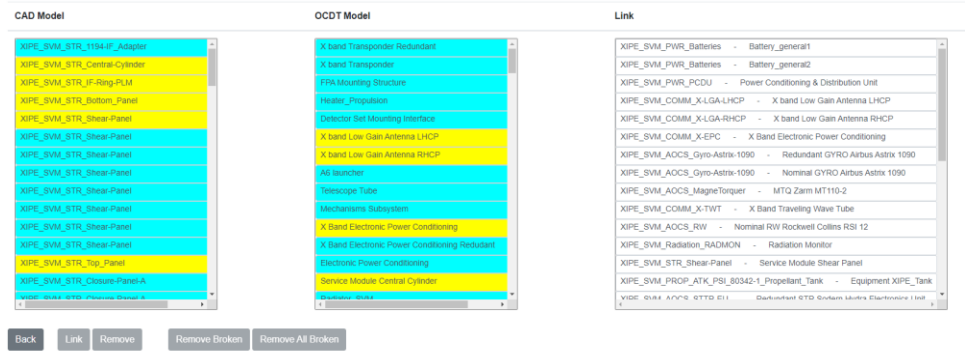
A frontend for the server was designed to allow for starting the session, selecting the necessary elements and mapping CAD to CE elements



Server login menu



Selecting necessary elements



OCDT/CAD element mapping interface

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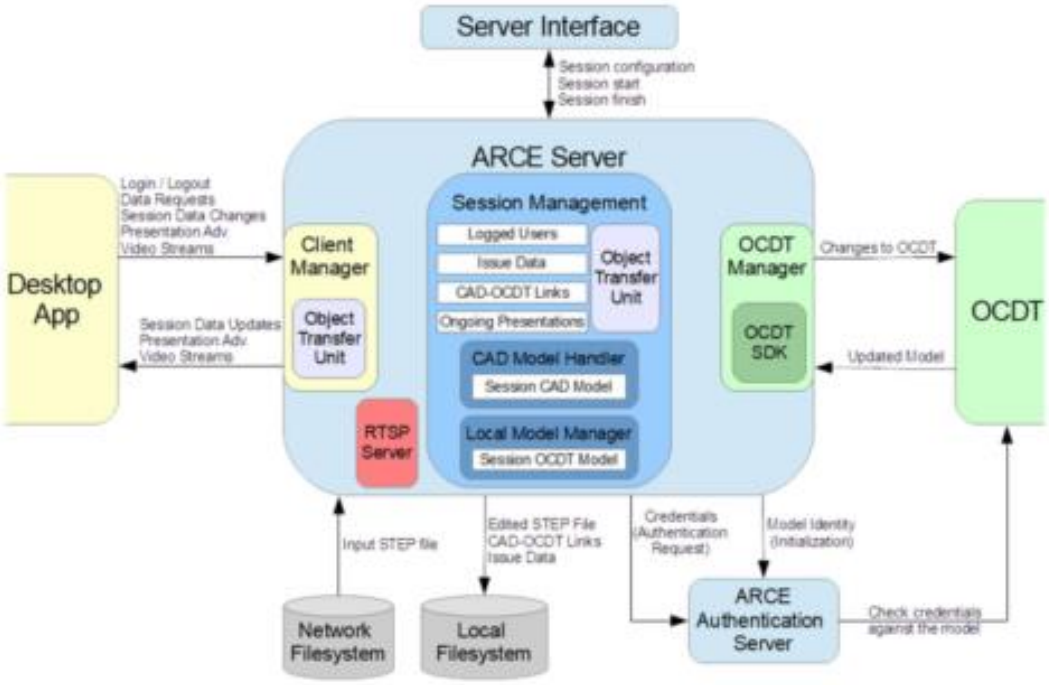
Application Development

ARCE Server

- **Integration with the OCDT** : Communication with the OCDT server, including reading and modifying the CE model.
- **Video streaming** : Implementation of the Real-Time Streami Protocol to relay the Presentations video streams to the clien attending to them.
- **CE Engineering Manager** : Manages a local state of the CE model, keeping it updated for all the connected clients.
- **CAD Model Handler** : Loads and saves from and to STEP fil Handles conversion of models to a mesh representation.
- **Authentication**: Manages authentication of clients using their OCDT server credentials;
- **Frontend** - UI/UX design and implementation of the server frontend.



ARCE Server Architecture implemented

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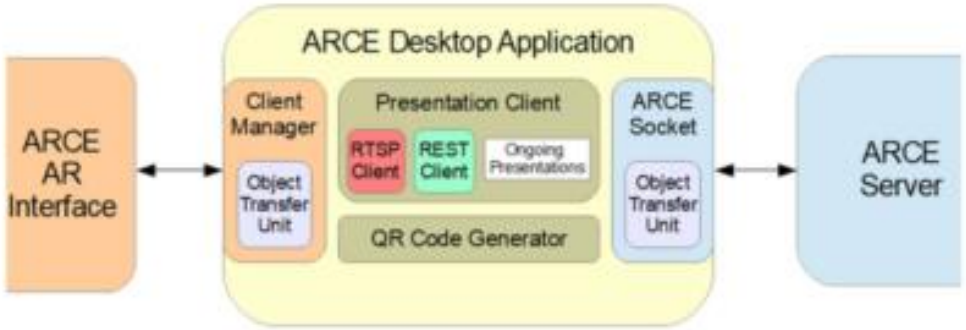
Application Development

ARCE Desktop

Presentation Module : Functionality related to displaying the status of ongoing AR presentations and rendering them to the screen.

Frontend : UI/UX design and implementation of the desktop application.

AR and Server Relaying : Handles all exchanges from the server to the AR application and vice-versa.



ARCE Desktop App Architecture implemented

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Application Development

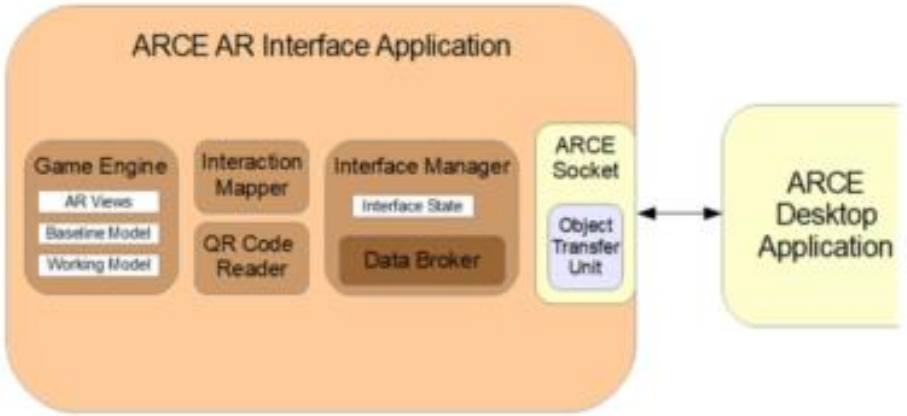
ARCE AR Application

Interaction Components: Definition and implementation of all common UI elements across all other functionalities and associated interactions

3D Model Interactions: Display and manipulation of 3D models in virtual space.

CE Product Tree:

- Display and interaction with data derived from the OCDT CE model.
- Supporting Features
- Functionalities such as budgets and virtual rulers that relate to both the 3D models and the CE design model.

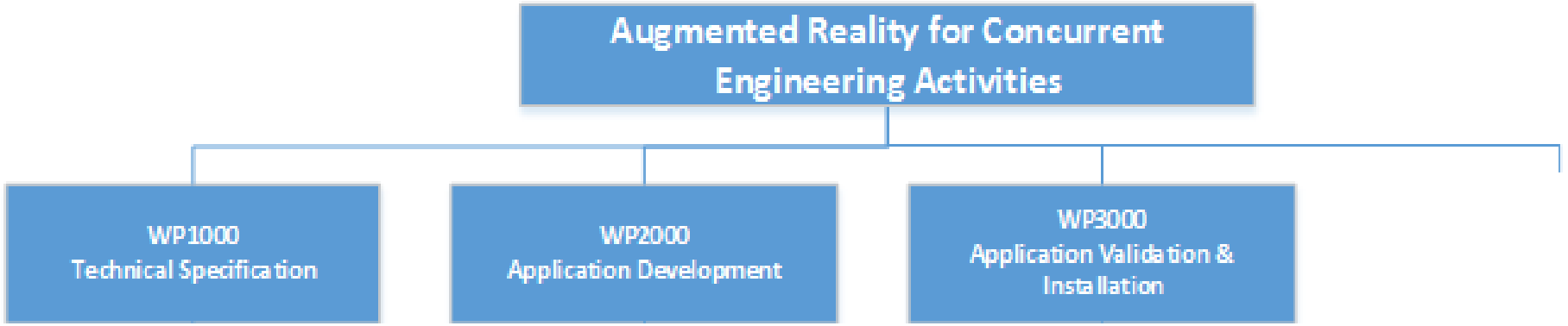


ARCE AR App Architecture implemented

Final Validation

Introduction

Consortium Contributions



Design Exercise

Validation

- A design exercise was executed on the **4th and 5th of March 2022 at the CDF, ESA ESTEC**. Two concurrent users were involved in the design exercise using the AR application. Other users were verifying from their respective desktop stations.
- The exercise followed a script that was agreed upon prior to the design exercise.

Design Exercise

Validation

- **Main ARCE features used during design exercise**:
- Interaction with the 3D model (positioning, changing orientation, pointing)
- Ruler feature
- Adding shapes
- Consulting the budget

The interaction between the ARCE system and OCDT was also validated during the exercise

Design Exercise

Validation

Two users running a design exercise and moving pieces of the 3D model while the presentation mode is active and visible on the projector canvas

One user manipulating the Product tree and properties of a object while the presentation mode is active and visable on the projector canvas and desktops of other users.

Objectives met

Conclusions

- The consortium successfully implemented a software suite that allows for **interacting with satellite 3D models** (modifying absolute/relative positions and orientation of the model/components, evaluating dimensions) **and engineering data** (consulting and altering parameters, design options, budgets and issues, amongst others) in an AR environment.

- The developed environment is considered to be interactive as the **3D model's position and orientation is shared amongst all users in the session**, **engineering data is synchronized between all AR users and OCDT**, and a **presentation mode** is available for those users not wearing AR headsets.

- **Several users from different disciplines** can participate in the session (dully authorized and with corresponding permissions), and visualisation and editing of design models was **proven at the CDF during the final design exercise.**

Objective 1 Achieved!

Objectives met

Conclusions

Let’s take a look…

Conclusions

Validation

- At the end of the exercise, feedback was gathered though a survey with both quantitative and qualitative questions
- Results provide a valuable insight into the potential of the ARCE system
- Most useful features noted were the interaction with the 3D model shared by all users, presentation mode and budget feature
- Key improvements desired: undo/reset function, connectivity issues, shared panel view
- As previously mentioned, the SW developed was deployed at ESA ESTEC and tested during a design exercise at the CDF, with positive responses from the CDF experts participating (4.5 out of 5 answer when questioned “I found that the ARCE application could add value to a concurrent engineering session”).

- **Objective 2 Achieved!**

Conclusions

Validation

Question	Average
I was able to enter the application with ease	4.5
I found the menu to be easy to use	4.5
The menu only opened when I wanted it to open	5
I found it hard to open the menu when I wanted to open it	1.5
I was able to open the product tree of the 3D part I was interested in	4.5
The 3D part I was interested in and opened the product tree for is easily identifiable using the color difference and the tether	4.5
Two users could discuss the same object with ease using pointing and product tree search	4
I was able to see the different parts in different colors based on the budget weight and understand what they mean	3.5
I was able to create and place a new 3D shape with ease	4.5
For second user: It was clear which new 3D part was made by the other user	5
I was able to use the ruler feature with ease	4
I was able to use the budget feature with ease	4.5
I was able to create and place a new 3D shape with ease	4.5
I found that the ARCE application could add value to a concurrent engineering session	4.5

Objectives met

Conclusions

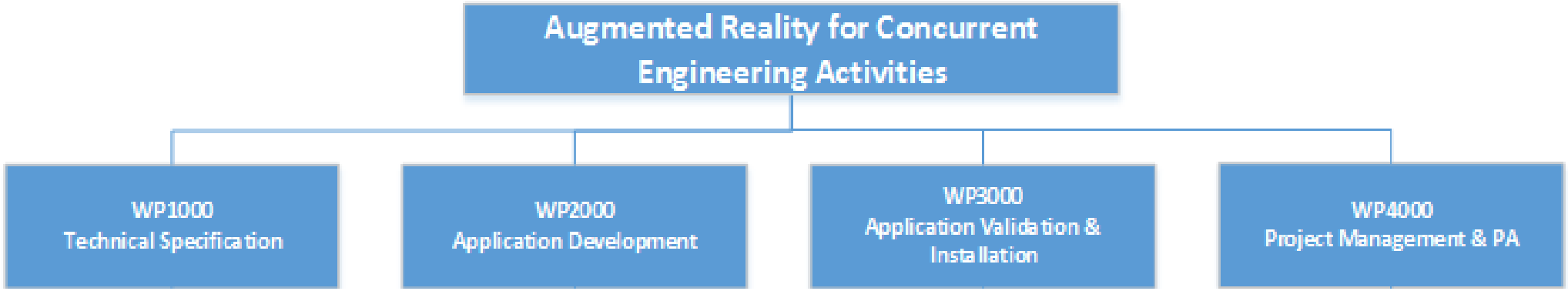
The definition of TRL4 according to ECSS-E-HB-11A is “Component and/or breadboard functional verification in laboratory environment”. In [REF], the ESA TRL recommendation for SW projects is as follows: “The first 4 levels are used to increase the level of functionality of the tool, from the mathematical formulation and through prototyping and incremental enhancement up to the level of an “alpha” version”. It is considered that the ARCE application fulfilled the objective to reach TRL4, as a comprehensive set of features was developed and the software suite successfully tested in its final environment, the ESA ESTEC CDF facility.

Objective 3 Achieved!

Lessons Learnt and Roadmap

Introduction

Consortium Contributions



Lessons Learnt

Validation

UX/UI considerations:

- 3D model interaction in AR has room for improvement
- Main menu and side menu interaction has room for improvement
- Budget color heat map has room for improvement
- Extra features recommended during the design exercise by the experts are advised to be implemented

Lessons Learnt

Validation

Technical considerations:

- Network configurations – it needs to be tested and improved to support more users and different network configurations.
- 3D model complexity – the CAD to 3D model mesh conversion is not appropriate for complex geometries, which is often the case in design exercises. This should be tackled in next iterations

Roadmap

Validation

The natural evolution of the ARCE system is three-fold:

• **Overall raise of the TRL, from TRL 4 to TRL5/6**. The current is system is considered to be at TRL4. A raise of the TRL will encompass the improvement of system robustness and the implementation of improvements detected during the implementation of the current project and described in the lessons learned, together with extensive verification and user testing. Further iteration with the experts at the Concurrent Design Facility is also needed to ensure the software is delivered with maximum added value.

Roadmap

Validation

The natural evolution of the ARCE system is three-fold:

• **Integration and harmonization with third-party ESA developments**. As the ARCE project was developed, a new version of OCDT (V3) was deployed at the CDF. It was then announced that COMET would substitute OCDT and Concorde. On the other hand, the STEP – ECSS 10-25A mapping was implemented in parallel developments by ESA, which would be benefit ARCE. It is the natural step to integrate with such systems to ensure compatibility with ESA's IT infrastructure and raise the added value of the involved systems through integration.

Roadmap

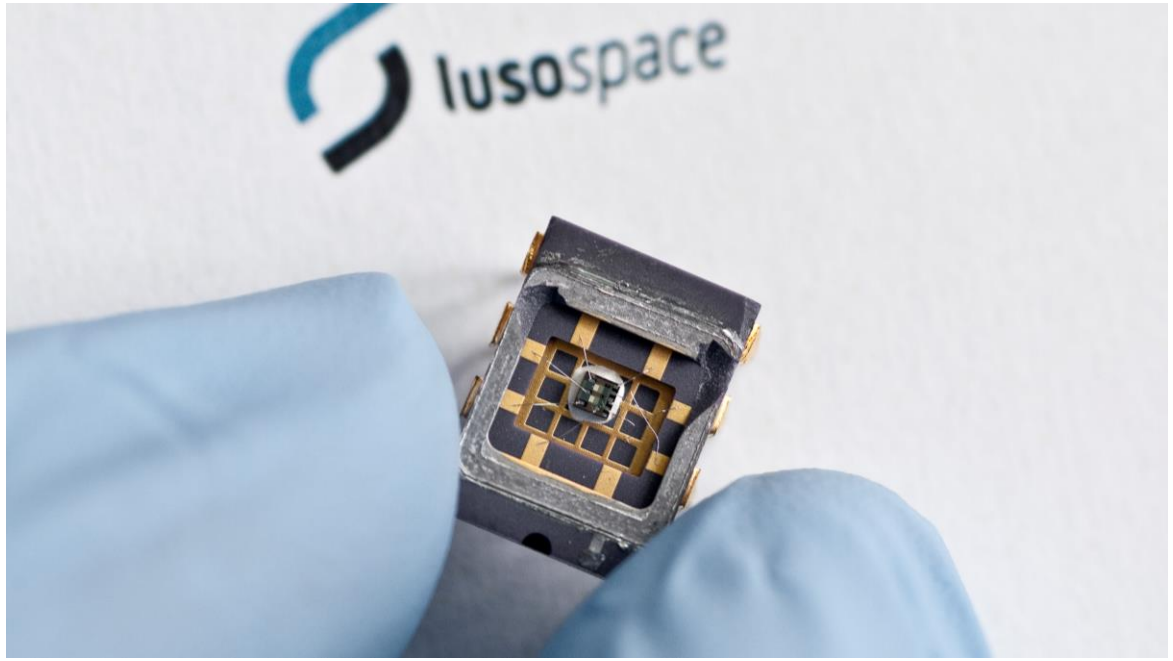
Validation

The natural evolution of the ARCE system is three-fold:

- **Adapt the ARCE system to newer, improved AR headsets**. The AR hardware market is in constant evolution and more advanced headsets, namely at the level of processing power, field-of-view, weight, and autonomy are under development. The ARCE system was developed to be as agnostic as possible, but alterations are still needed if the Microsoft Hololens 2 is not the selected AR hardware.

Get In Touch

We will be pleased to help you.



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Questions?