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PrismArch

Deliverable No D6.1

Define the architectural projects and usage scenarios for demonstration and evaluation

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Abstract	Report on usage scenarios for the PrismArch cross disciplinary design and collaboration platform, developed and authored by the three basic AEC disciplines namely Architects (Zaha Hadid Virtual Reality Group), Structural Engineers (AKT II) and Mechanical, Electrical, Public Health Engineers (Sweco). PrismArch's desired operation system and user experience design are included in the report. The developed case studies are based on residential and commercial case studies submitted with D1.1.
Keywords	Use scenarios, architecture, structural engineering, MEP engineering, cross disciplinary platform

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List of abbreviations and Acronyms

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CA	Client Approved
CD	Cross-disciplinary
CWS	Collective Work Sphere
CWS_AF	Collective Work Sphere_Agreement Form
D_A	Discipline Architecture
D_SE	Discipline Structural Engineering
IDS	Internal Discipline-specific
IH	Immersed Human
LD	Lead Designer
LD_A	Lead Designer_ Architecture
LD_MEP	BIM Manager/Project Coordinator
LD_S	Lead Designer - Structural
LID	Lead Interior Designer
LID_A	Lead Interior Designer_ Architecture
PA_PASS	PrismArch Passport and Identification
PAA	PrismArch Asset
PAAS	PrismArch Admin System
PACM	PrismArch Central Model
PADO	PrismArch Design Objects
PAM	PrismArch Matadata
PAMS	PrismArch Meeting Sphere
PAOBS	PrismArch On-boarding System
PAPS	PrismArch Project Sphere
PAPS_ID	PrismArch ProjectAccess Identification
PAS	PrismArch Sphere
PASD	PrismArch Singular Database
PAST	PrismArch Sphere Tag
PAT	PrismArch Tag
PAW	PrismArch World

PB	Public
PD	Project Director
PD_A	Project Director_Architecture
PD_MEP	Project Director
PD_S	Project Director - Structural
PPAA	Private PrismArch Asset
PR	Physical Reality
PUI	Personalisable User Interface
PVM	Presentation View Mode
PWS	Personal Work Sphere
QUI	Query User Interface
QUICM	Query User Interface Central Model
Recognisable	includes cultural and intellectual knowledge
SD	Senior Designer
SD_A	Senior Designer_Architecture
SE_MEP	Senior Engineer (Mechanical, Electrical & Public Health Engineers)
SE_S	Senior Engineer - Structural

Name	Meaning
Project Asset	an item of property inside the PrismArch Project Sphere generally relating to IP
Project Content	an item inside the PrismArch Singular Database
Project Data	analysable or referenceable set of project information
Project design objects	Immersivly produced project content inside the PAW
Project Information	Any non-design object; information related to the project. Recognisable as a PrismArch Project Sphere generally relating to contractual setup
Project Metadata	a set of project and system information that is referenceable to other set of project related data
Personalisable	means that the platform content can be tailored by the system for the individual user using prediction and services
Customisable	means that the content can be arranged by the user
Host	is a meeting sphere owner and has clear privileges that are persistent. The host will have the choice to lock certain aspects and functions to curate and limit the discussion prior to the meeting taking place.
Presenter	is able to translate the meeting (unless locked by the host), change QUI to interact with models to make their arguments. Meeting sphere has a singular navigation origin and the presenter will be the driver for the collective.

*Virtual Reality for the PrismArch project means a mixed reality simulated world. Our understanding of VR extends to all digital means of simulation and interfaces between machine logic and human perception, including all variations captured under the terms XR, AR, mixed reality, and augmented virtuality. Two-dimensional worlds are not an exception of this (i.e. access from desktop monitors, tablets, phones etc.)

Executive Summary

This deliverable explores a series of hypothetical usage scenarios for the PrismArch collaboration platform authored by the three basic AEC disciplines namely Architects (Zaha Hadid Virtual Reality Group), Structural Engineers (AKT II) and Mechanical, Electrical, Public Health Engineers (Sweco), and developed from internal discipline-specific and multi-disciplinary perspectives. While the deliverable D1.1 explores the limitations of current BIM workflow, this report aims to outline an ideal future workflow for an architectural project development with the integration of XR technology. The report introduces virtual work environments, user interface and navigation preferences, project information and data protection for multi-authored project content, and their management concept. What is described in this report thoroughly is a desired platform design collected from the three disciplines. It should be noted that the authored content is hypothetical and further prototype developments are required to analyse the detailed technical feasibility. The final outcomes are subject to the analysed technical feasibility, time-frame and resources of the PrismArch project.

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Introduction

The main purpose of T6.1 is to propose usage scenarios for the PrismArch design and collaboration platform. These are developed and authored by the three basic AEC disciplines namely Architects (Zaha Hadid Virtual Reality Group), Structural Engineers (AKT II) and Mechanical, Electrical, Public Health Engineers (Sweco). This deliverable intends to outline user demonstration and evaluations planned for T6.2 and T6.3. It is to be regarded as a recipe for our upcoming prototype development.

The goal of PrismArch is to design a cross-disciplinary work environment that functions for all architectural project stakeholders, including clients, architects, structural engineers, MEP engineers, project managers, quantity surveyors and contractors. The project outcomes are to enhance the collaboration inside immersed spaces by the platform providing a singular project database for all disciplines and each end user accessing the project information from his/her own customisable work environment with propriety, specialist and platform-embedded tool kits. PrismArch should be a guide to build an architecture in Physical Reality (PR) and we are required to be aware of the presence of physical human beings behind the immersed humans inside VR.

"*The insulation secret of the human sphere is that the cohabitants establish a shared inside in the shared outside through co-productive transference. It must be noted that trasfereces initially have a collective character and are only individualized later on, depending on the media, language games and living forms that support the privatization effect. "*
(Sloterdijk, 2016, p.366)

In the deliverable D1.1, we note that architectural project developments are historically collaborative efforts and these have a cross-disciplinary culture. Despite the facts, all architectural project stakeholders are presently siloed within their respective discipline-specific project spheres. This causes the entire architectural project ecosystem to be disconnected. The PrismArch platform proposes to weave the disconnected threads together by placing the collective and co-authored project information in a singular space powered by a unified database. The primary subject of this research is to design and organise the unified database that consists of diverse types and classes of architectural project assets, such as an immersed human as a digital representation of an individual project contributor and immersively accessible and immersively produced project content including information, project data and architectural design objects.

In order for an on-boarded immersed human to interact with the platform database from both individual (personal) and collective (as a discipline specific unit) perspectives, all data must be visualised first to become recognisable to the human. Additionally, there should be an organising methodology and functionality to carefully demarcate the data authorship and ownership. For this reason, immersed humans are not an exception of the visualised data, because each individual needs to be recognised by the collective in multipresence, co-authoring and cross-disciplinary situations.

In the first part of this report, we investigate the platform data management and organisational structure that would work for all architectural disciplines. The spatial construct of the PrismArch immersed world is also defined and described here being inspired by the concept of *Sphering*.

As clearly noted in the D1.1 report, architectural projects are never linear processes and require iterative design evaluations to reach the final outcomes and build results. We, therefore, aim to innovate a platform with the interface between all the architectural disciplines and the unified database sustaining the project information and content developed across the lifespan of an architectural project. We propose a dynamic project content navigation functionality to operate the interface that allows all disciplines to review, co-author

and manage the entire architectural project ecosystem collaboratively. The functionality should work before, during and after the construction of a building.

In Chapter 1, we first introduce the four root classifications inside the PrismArch world to unfold the unified database. We then propose a Sphereing functionality to demonstrate a data organisation system inside the PrimArch world. An ideal navigation methodology inside the PrismArch world and user-data interaction models are explored following the data on-boarding sequence.

In the second part of this report, observing the platform outline and framework developed in the first chapter, the three disciplines individually develop usage scenarios to illustrate examples of individual and collective interactions with the PrismArch ported data inside the PrismArch world. Using the residential and commercial case study projects explored in the deliverable D1.1, we develop the usage scenarios in both internal discipline-specific and cross disciplinary situations at different project phases, which then help to lay out the entire ecosystem of architectural project development.

In Chapter 2, each discipline looks at internal discipline-specific usage scenarios for residential projects, selected from the deliverable D1.1. Each usage scenario consists of several situations that take place during a selected architectural project phase and the proposed usage scenarios correspond to the tasks related to those situations. The main demonstration action for asset sharing and version controls in this chapter is a temporary increase in an asset access level to review and evaluate internal discipline-specific project content. Some of the highlights in the described user scenarios in this chapter are the platform's registration/ on-boarding process, administration setups, internal meeting arrangements and content creation using the PrismArch default and specialist tools.

In Chapter 3, each discipline investigates cross disciplinary usage scenarios for commercial projects, selected from D1.1. Each usage scenario consists of several situations at a later stage of architectural project development and corresponds to the situation related tasks. There are two central demonstration actions for asset sharing and version controls in this chapter. The first action is a permanent increase in an asset access level to review and evaluate cross disciplinary and co-authored project assets. These assets are to be reviewed and approved by the clients, project managers, quantity surveyors and contractors. The second action is an exceptional scenario where assets are approved and contractually agreed with the clients, however, some changes are introduced after the assets are submitted. This requires a permanent freeze of the asset and its replacement needs to be designed and resubmitted. Some of the highlights in the described usage scenarios in this chapter are more complex scenarios in comparison to the internal discipline-specific usage scenarios studied in Chapter 1. In this chapter, we intend to investigate a potential way of co-authoring assets from a cross disciplinary perspective and managing the asset version controls. We also look at advanced usage scenarios of the PrismArch platform and end user adaptations to the default, proprietary and specialist tools accessed from individual Personalise-able User Interface.

The expected outcome of this report is to outline and design the platform's infrastructure from an architectural project's multiple disciplinary perspectives; to illustrate the usage scenarios, specifying the research focus for the planned prototype; and to outline demonstration developments necessary for a technically functional, professionally usable and fully immersive collaboration platform that can be accessed from all architectural project disciplines.

The terminology explored in this report may change at a later stage of this research project, considering any changes in design scope due to the technical feasibility reported by the consortium. This report suggests an ideal-case outline and framework of the PrimArch platform and collaboration experience that would innovatively function for architectural, structural engineering and MEP engineering disciplines.

'*Every human being is an artist, a freedom being, called to participate in transforming and reshaping the conditions, thinking and structures that shape and inform our lives*'.
(Beuys, J. 1972. Every Man an Artist: Talks at Documenta 5)

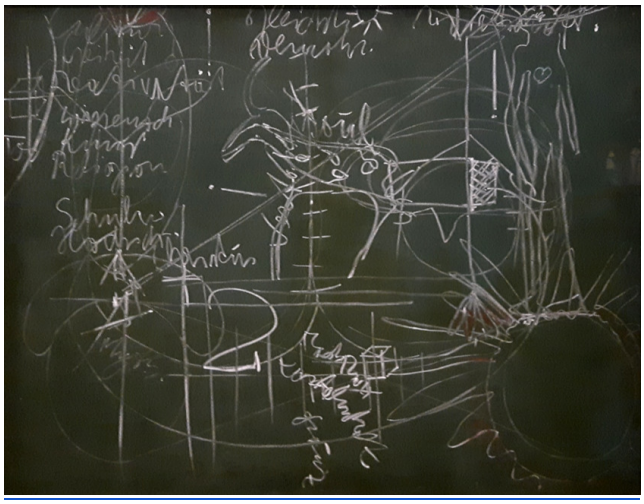


Figure 1: Joseph Beuys, For the lecture: The social organism - a work of art, Bochum, 2nd March 1974.

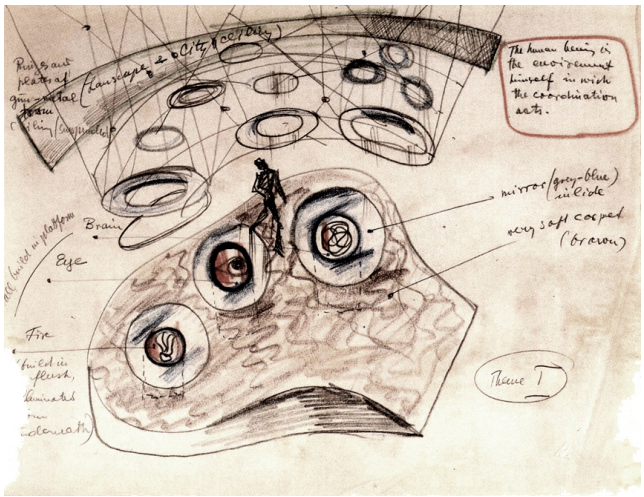


Figure 2: Frederick Kiesler, Vision Machine, 1937-1941.

Chapter 1: PrismArch Root Classifications and Sphereing Concept

1.1 The Four Root Classifications inside the PrismArch World

The PrismArch unified database stores various types and classes of AEC project data developed by all disciplines across project phases. The content includes data collected at the early stage of the project development such as hand sketches, project brief, initial proposed client requirements; the data analysed and produced during the design development stage such as structural stick models with deflection utilisation and maximum force; and the data coordinated at a later stage of the project development, such as MEP clash detection and Uniclass[1] information.

Considering the diversity in the data characteristics existing within the single database, the PrismArch platform requires an unformed classification style to treat all data as a PrismArch asset type. This data can then be visualised and interacted with inside the immersed sphere by all disciplines with their unique organisation style.

We introduce four fundamental data classifications inside the PrismArch platform.

(1) Immersed Humans (IH)
(2) User Interface (UI)
(3) PrismArch Design Objects (PADO)
(4) PrismArch Metadata (PAM)

(1) Immersed Humans (IH)
Immersed Human (IH) is a digital representation of an immersed individual who is on-boarded to work inside the PrismArch World (PAW). The digital representation is assigned a discipline-specific colour code such as orange for architects, green for structural engineers and blue for MEP engineers. Each individual can customise the digital representation and its settings. This includes the person's height, navigation sensitivities, and field of view. Each IH is contained within a dedicated Personal Work Sphere (PWS)

(2) User Interface (UI)
User Interface (UI) is a connection between IH and interactable project data visualised inside the PAW (via game engines). There are two classifications for the PrismArch UI; Personalisable User Interface (PUI) and Query User Interface (QUI).

[Terms of Personalisable and Customisable]
'Personalisable' means that the platform content can be tailored by the system for the individual user using prediction and services, while 'Customisable' means that the content can be arranged by the user.

[1] Uniclass is a unified classification structure for the UK construction industry.
Designing Buildings Wiki, 2020, *Uniclass*, viewed on 22 June 2021, <https://www.designingbuildings.co.uk/wiki/Uniclass>

Personalisable User Interface

Personalisable User Interface (PUI) is a scrollable UI that is anchored to Personal Work Sphere (PWS) (Figure 3). It contains tools and functionalities that can be personalised and classified as follows:

a. Task bar

Task bar is a minimised window that contains:

- Clock (calendar date and time, game/ simulation time)
- Performance settings (frame rate range)
- Sound settings (Muted/unmuted, current volume)
- User information (user name, user status, current sphere name etc)
- Notification alert
- Dashboard icon (see “b” below)
- Preferences icon (see “c” below)

b. Dashboard

Dashboard is a personal canvas with selected widgets, which is hidden by default and each IH maximises this from the taskbar. The arrangement of the widgets is customisable.

- Project Management widget (overall project calendar including deliverables, internal discipline-specific and cross disciplinary punch list)
- Contact widget (select project members to talk, send a meeting request to the selection from here by filling Meeting Sphere Agreement Form (MSAF))
- Recorded Actions widget (hyperlinks to recorded world coordinates of both the IH and design objects for easy access; recently visited time stamps, recently visited spheres, recent filtered tag names, recently used functions, locally saved sketches and screenshots, bookmarked spheres and tag names etc)
- New widget (each IH can build his/her own widget content to personalise the Dashboard)

c. Preferences

Preferences is a settings window, which is hidden by default and each IH maximises this from the taskbar.

- Display settings (dark and light menu modes, text size, dashboard size etc)
- Navigation sensitivities
- Audio settings
- Plug-ins settings (and installations)
- PrismArch Documentation and Best Practice

d. Tool kit

Tool kit is each IH’s plug-in/API/tool inventory. By default, the tool kit only includes PrismArch default functionalities and on-boarded users are individually asked to install his/her preferred tools to access the plug-in and/or APIs from the PUI. Once the tool kit content is installed and activated, these functionalities are persistent and should be accessible from all maps/levels.

d.1 PrimArch Default Functionalities

- Administration functionality
- Commenting and Markup functionality (keeping track of comments and quickly exchanging ideas inside the virtual environment)
- Clipping Plane functionality (providing ability to see and evaluate the cross-section of a 3D construction)
- Toggle Camera functionality (allowing user to view the project from several key perspectives repeatedly without having to travel to them each time)
- Toggle View Mode functionality (allowing different ways of viewing and evaluating 3D assets, each suitable for a distinct work activity. The visibility of the content can be driven by the user profile [e.g. IHs can only see approved or issued content and the scenes are set to the discipline suitable view mode by default.] The PrismArch credentials directly control what level of information is accessible and what view mode(s) can be used inside thePrismArch Project Sphere (PAPS) for the users.)

d.2 Specialist and Proprietary Tools

- Mindesk (as Rhino, Grasshopper and Revit connectors)
- Zoom, Skype and/or alternative Steam or other Voice Chat functionalities
- Outlook Email
- Specialist tool _ architect
- Specialist tool _ structural engineer
- Specialist tool _ MEP engineer

At a higher level of platform operation, the platform offers system embedded and persistent functionalities. These PrismArch CORE functionalities enable all the IHs to co-exist and work collaboratively inside the PAW.

d.3 PrismArch Core and System Embedded Functionalities

- Muli-presence on-boarding system (Managing interactions inside a multi-presence immersive space)
- Orientation and Navigation system (To assist the immersed users with wayfinding inside the project)
- Tagging functionality (Flexible data management system for tracking data inside PrismArch. The system assigns an asset tag to each PAA automatically. IHs can register a custom tag content.)
- Multi selection functionality (allows for highlighting, showing/hiding the selected objects)
- Sphering functionality (as a data organisation tool that enables IHs to take compound actions to the four root classifications existing inside the PAPS: Immersed Humans (IH), User Interface (UI), PrismArch Design Objects (PADO) and PrismArch Metadata (PAM). By creating a sphere compound, IHs can group PAAs, name the group, and assign a tag to the group. This logic also applies to arranging a meeting: sphering is used to create a group of individuals, name the meeting group, assign a tag to the meeting group (i.e. world coordinate of the meeting location, meeting time, meeting organiser and host, meeting sphere capacity and number of attendees). The sphering action is equivalent to picking apples and placing them in a basket. A very important functionality of sphering is to handle the access rights, either on a temporal/ad hoc, or a more permanent/systemic manner.

Query Users Interface (QUI)

Query User Interface (QUI) is an filterable and duplicable UI that is anchored to the project assets and data loaded at the project world coordinate (PrismArch Central Model). QUI is an equivalent to a three dimensional project folder structure with a time scale and it is a dynamic navigation functionality with spatial hyperlinks to project design objects. QUI resembles a three dimensional data-tree: each breakpoint has a node, which is a representation of an individual instance of the project information/metadata (Figures 4-5).

Each node would represent a project file, for instance, a site image (jpeg), diagrammatic floor plan (pdf), technical drawing (dwg), commentary (txt), structural data (txt). These nodes only appear as representations of project data with minimal information and a time-stamp that corresponds to the project timeline. Each node is a reference point within a project development process and it helps end users trace desired project-centred information and data in relation to Speckle loaded design objects. The action of tracing enables project disciplines to reference project topics dynamically throughout the project timeline. However, it must be emphasised that not all of project information and data are expected to be loaded or visualized persistently - these appear on demand of the platform end users. This is necessary to avoid overcomplicated work processes as well as due to the limitations of VR performance and technical capability of the platform. It should also be noted that the information level of details and their types differ based on each discipline's characteristics. The breakpoints are created when end users asynchronously or synchronously load or create an asset(s) in the PAPS (Figure. 26).

By highlighting and interacting with the nodes/using QUI, IHs can navigate themselves from one project location to another by following 'the golden thread' of the project development (Figure 6). All design objects have an automatically assigned and persistent PrismArch Tag (PAT) with a timestamp, which becomes filterble with the QUI functionality.

- Search function (equivalent to folder explorer search in three dimensional world coordinates and matched to the physical project world coordinates. IHs can filter design objects by searching sphere names, asset display names, and time)

- QUI has varying levels of detail in the project information/metadata visibility. The resolution depends on the filtered results and the IH's performance and networked speed. We expect to have async-loading time (technical constraints for the PrismArch World). QUI nodes' visibilities also would depend on the IH's user profiles, or if not, then there should be place folders for 'locked visibility of project information/metadata visualization' - such as nodes represented as a pale colour. The visibility content can be driven by the user profile (e.g. IHs can only see approved or issued content. The PrismArch credentials render PrismArch Project Sphere (PAPS) for the users).

- The visualised nodes are highlightable/ hoverable to view its content (rooted project design object information), selectable to visit the rooted design object and 'sphere-able' to select multiple nodes to assign a special and customisable sphere tag, which is added to the filterble naming list.

- IHs can hide/show a selection of nodes using the sphering tool to topologically create a sphere compound and the tagging tool to assign a tag (Figure 7). The tagging action confirms the action and creates a visibility setting for the selection. In a similar way, IH can zoom in

and out a selection of nodes. The magnifier effect functions to control the visibility level of details/ resolutions of project assets

- QUI is a spawnable, attachable, detachable, scalable UI that by default is loaded at the PrismArch Central Model location (PACM). QUI is a spawnable actor anchored to the project design objects and IHs can spawn a QUI near his/her PWS.

- QUI is also a duplicatable and instanceable UI. The duplicated or instanced QUIs are equivalent to tabs for search engines. For instance, duplicated QUI can also be aligned next to each other to compare different design versions such as massing models developed at an early project phase or a serieses of cutaway models developed at a design development stage. QUI would also function as a three dimensional tracing paper tool to overlay information by placing/ spawning each instance at the same location (Figures 8.1 and 8.2, for more info please see **No.13, Task A.ARCH.2: Redesigning the existing facade design**).

(3) PrimArch Asset (PAA) and PrismArch Design Objects (PADO)

PrismArch Design Objects (PADO) is a project-related object produced inside the PAW by on-boarded IHs. PADO is a subset of the PrismArch Assets (PAA) class. PAA is defined as a project specific item with properties inside the PrismArch Project Sphere that is tightly tied to authorship and ownership protection and disciplinary demarcations. Any individual PAA, therefore, is able to contain PrismArch Project Information and Metadata. The classification “PADO” specifically applies to its content being created by an individual IH inside the PAW, enabled by his/her UI.

(4) PrismArch Metadata (PAM)

PrismArch Metadata (PAM) is defined as a set of project information and data that is referenceable to other sets of project information and data with the condition when these exist within the PrismArch Singular Database (PASD). Project information in PrismArch is defined as physical reality project related information that is produced from an early stage of a design development.

a. *SD_A is using Mindesk inside PrismArch. She creates a cube in the PrismArch Central Model (PACM). SD_A would call this asset a PrismArch Design Object (PADO).*

b. *PrismArch Asset (PAA) is an asset that is unique to the PrismArch platform, that is successfully on-boarded to the PrismArch World (PAW), and that is routed at the PrismArch Singular Database. PAA is an item with properties that is placed inside the PAPS and it is generally relating to IP and contract particulars of the authoring party.*

c. *SD_A is now discussing the newly created PADO with PD_A. They review the PADO together and PD_A approves to upgrade the Sphereing Level from 1 to 2. They would now call the cube a PAA because upgrading from Level 1 to 2 requires a further administrative process, involving additional information about who made the last update and for what reason, and tracing the versioning.*

d. *SD_A imports a reference image in .PNG format from her desktop to the PASD and this appears at the PACM. This image is a PAA and not PADO, because the original data already contains metadata of who downloaded it at what time, etc.*

Example of definitions of PrimArch Design Objects (PADO) and PrismArch Assets (PAA)

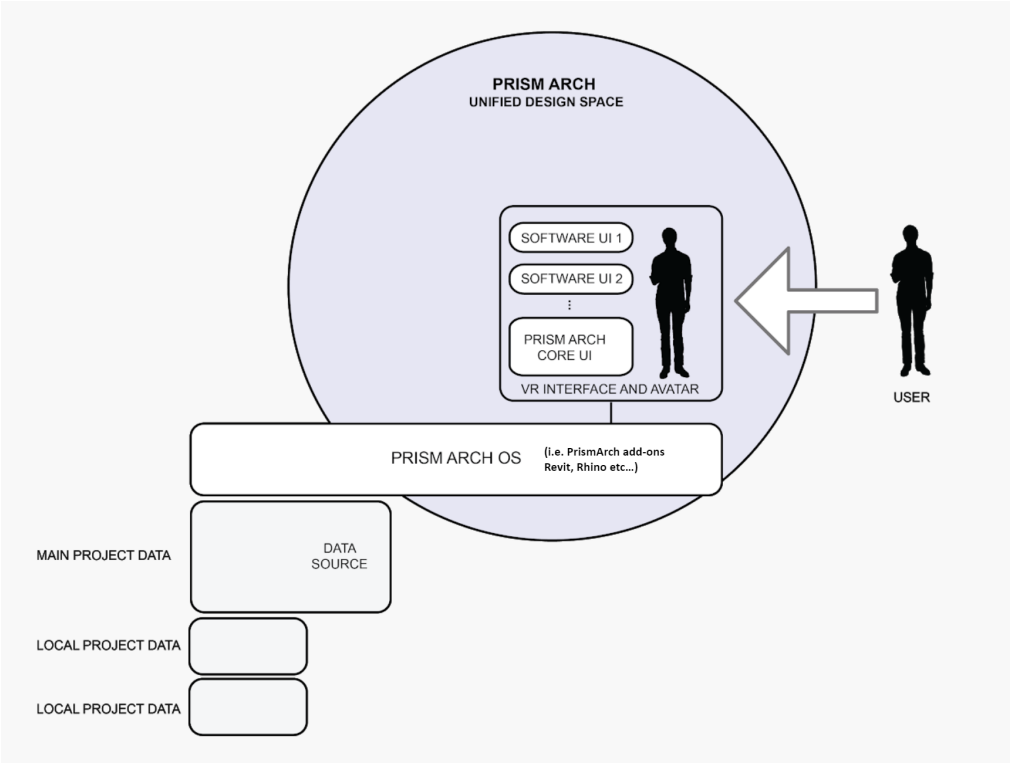


Figure 3: ZHVR Group, Diagram illustrating PrismArch end user, UI and the platform operating system, 2021.

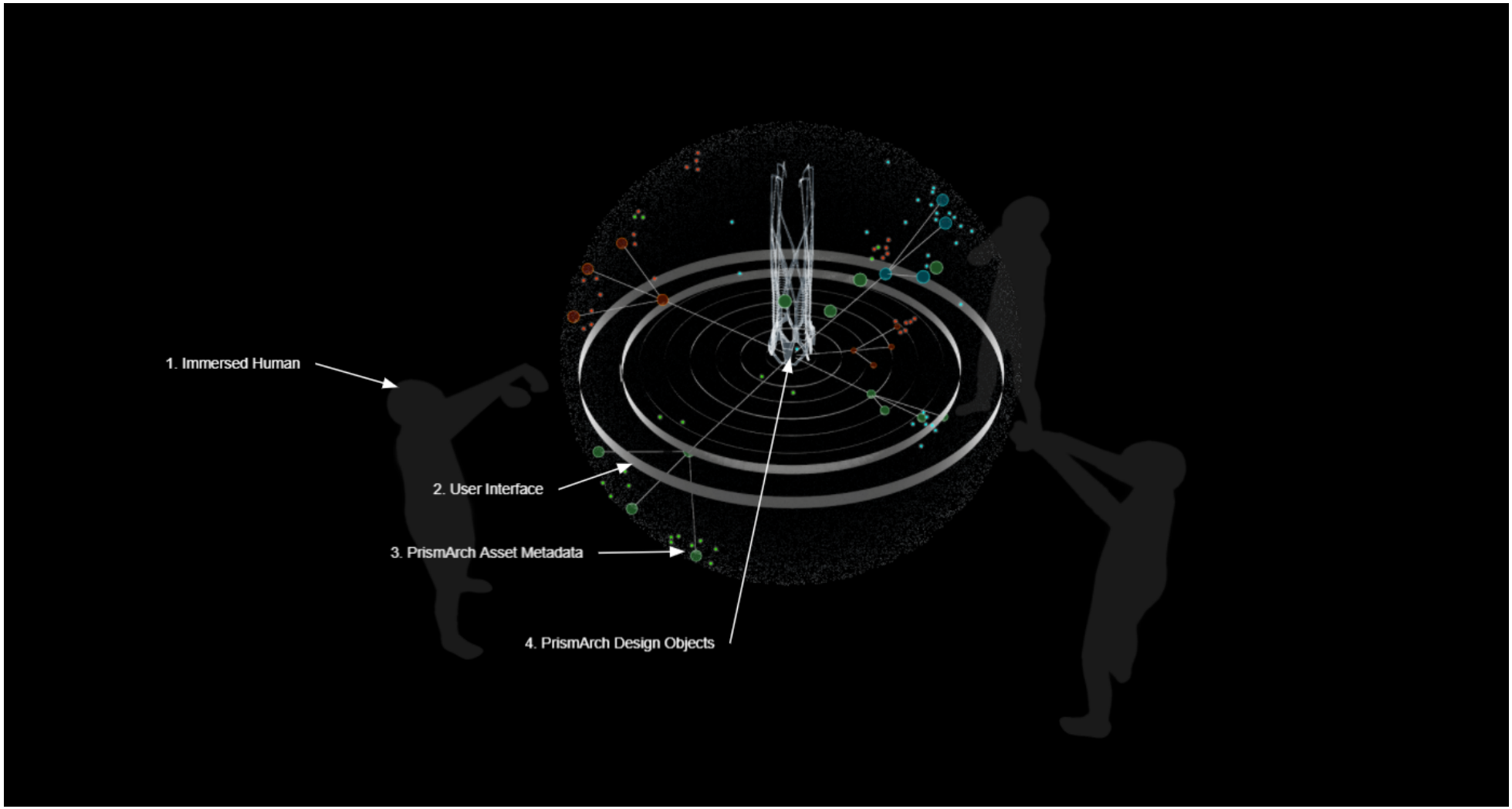


Figure 4: ZHVR Group, digital sketch illustrating the four classifications of the PrismArch platform, 2021.

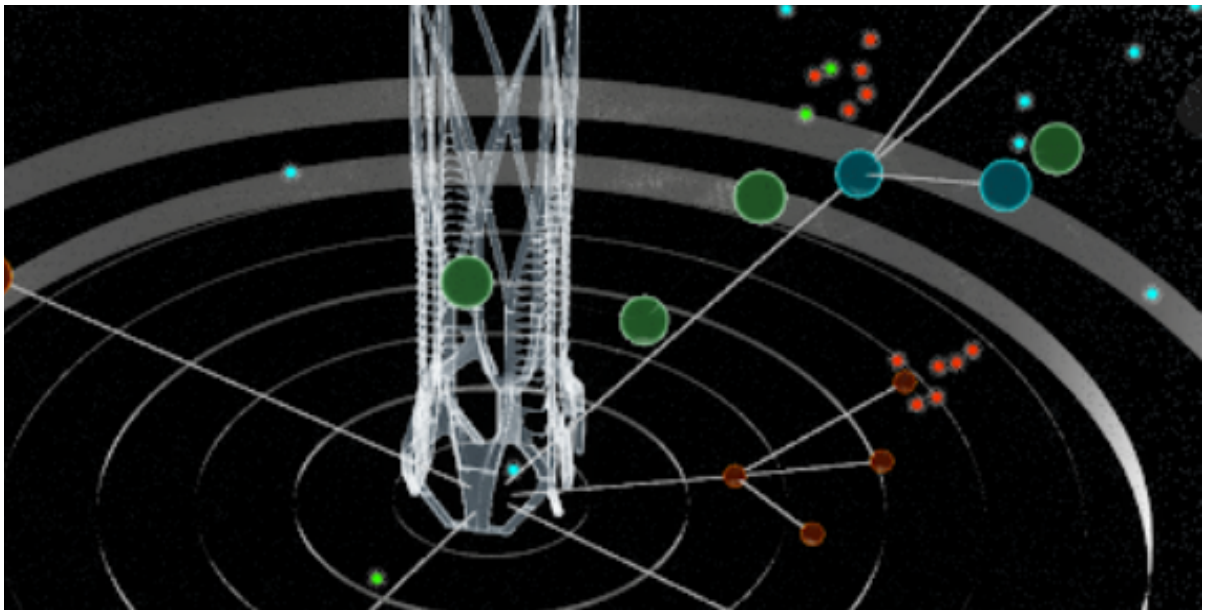
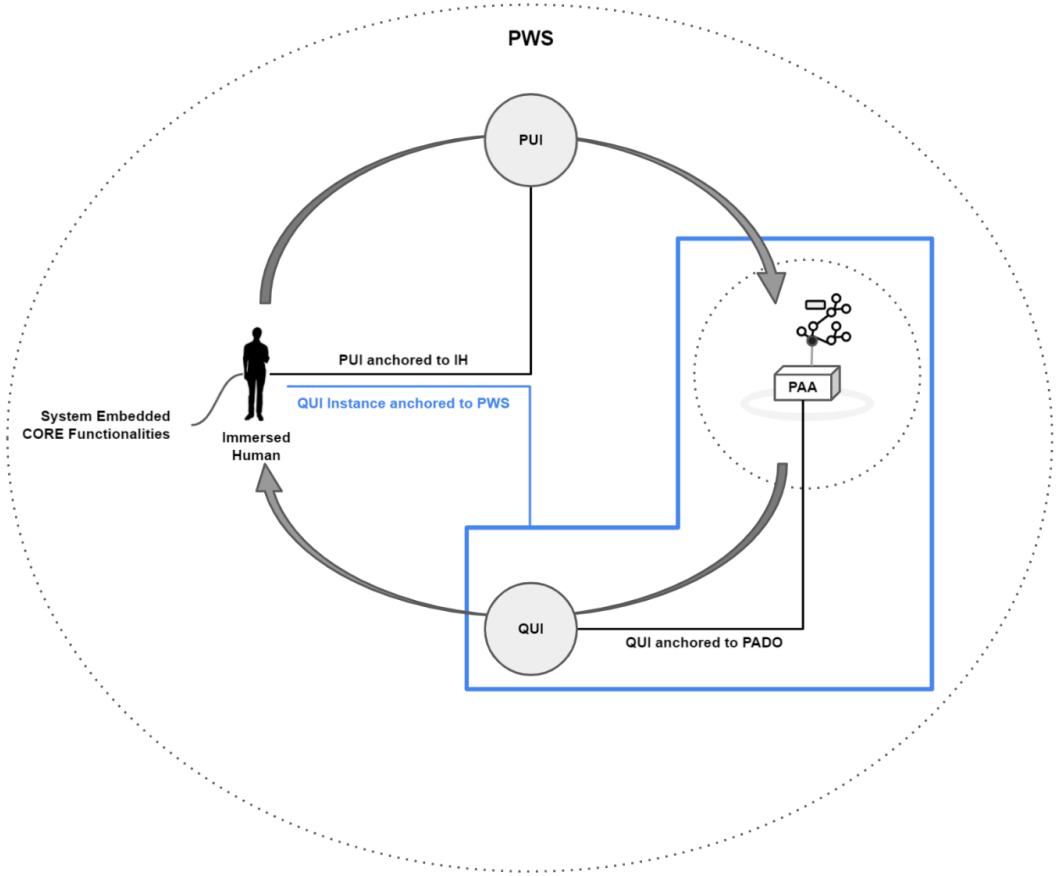
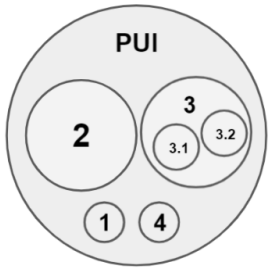


Figure 5: ZHVR Group, Close up view of PrismArch Design Object and Metadata Visualisation, 2021.





PrismArch User Interface Construct
1. Task Bar
2. Dashboard/ Widgets
3. Tool Kit
3.1 Proprietary and Specialist Application Programming Interfaces (API)
3.2 PrismArch Embedded Functionalities
4. Preferences

PWS: Personal Work Sphere
PUI: Personalisable User Interface
QUI: Query User Interface

Figure 6: ZHVR Group, Diagram illustrating Personalised User Interface and Query User Interface anchor points and user interaction, 2021.

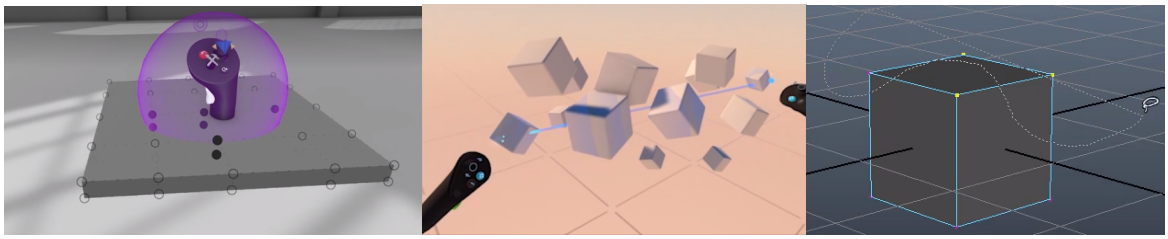


Figure 7.1: Left: Bootcamp, Selection system used in Gravity Sketch, 2021.
Figure 7.2: Middle: Bootcamp, One-handed, two-handed and multi-shape selection system in TVori, 2021.
Figure 7.3: Right: Truong CG Artist, Maya hotkey for lasso tool, 2018.

(IMPORTANT: The above can be good examples of how PrismArch Assets can be selected inside PrismArch Project Sphere, however, what PrismArch Sphereing tool should offer requires the ability to filter time-related and procedural PrismArch Content including Metadata.)

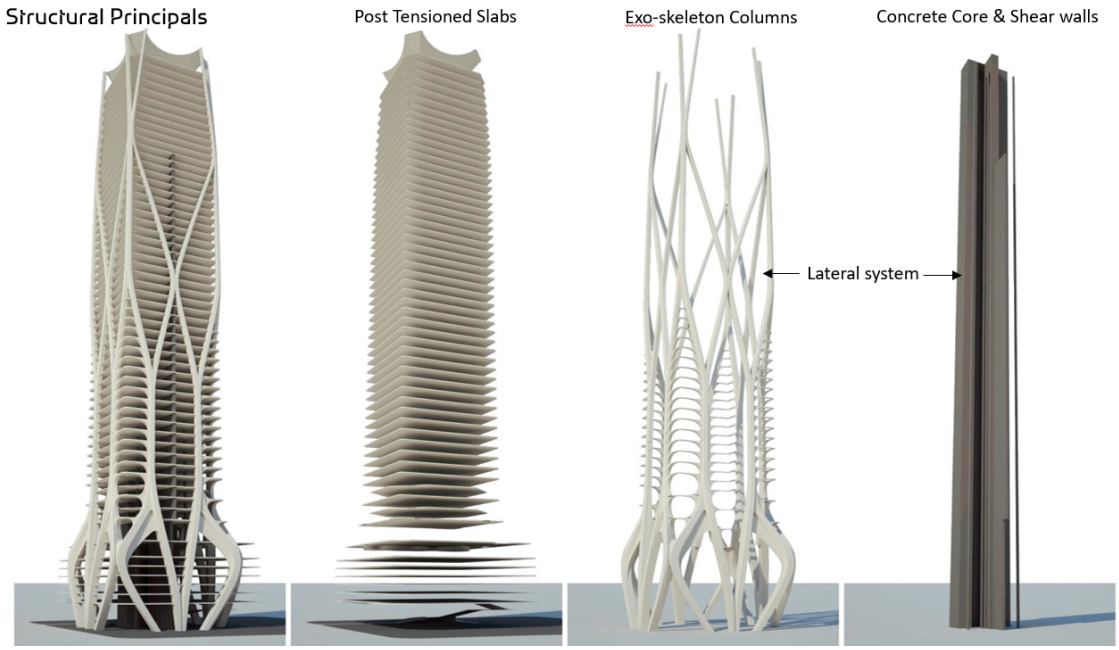


Figure 8.1: Image copyright Zaha Hadid Architects, One Thousand Museum, Examples of three-dimensional information layers, 2019.

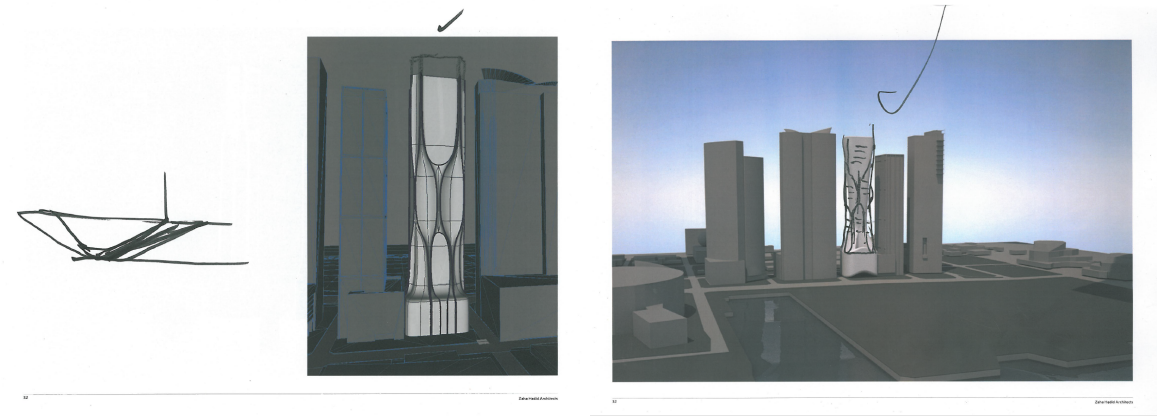


Figure 8.2: Image copyright Zaha Hadid Architects, Example of 3d asset being used as a base layer for overlaid hand sketches, 2012.

1.2 PrismArch Sphering: System Guided and User Input Sphere productions

In PrismArch, Sphering is a functionality to organise and demarcate PrismArch Assets (PAA). Sphering is a topological data division which is not geometrically visible and only exists to envelop a collection of data. The sphering functionality works within three dimensional world coordinates with the PAW time aspect, and helps distinguish Immersed Humans from Project Content - both exist in the PrismArch Singular Database (PASD). Spheres are typically produced automatically by the PrismArch system (some with an agreement) and also can be produced by IHs inside the PrismArch World (PAW) on occasions when project assets require documentation level of description. Generally, the project description is automatically recognised and assigned as tag content by the system as soon as the target is ported to the PrismArch Singular Database (PASD). IHs should be able to manually assign or modify the tag content inside the PAW with a special administration and permission settings and/or approvals, however, the tagging action should ideally be minimal and limited considering the ease of use for the end users.

Types of System guided and produced Spheres (Figures 9-13)

- PrismArch World (PAW)
- PrismArch Project Sphere (PAPS) … agreement form must be submitted and approved by PAAS
- Collective Work Sphere (CWS) … agreement form must be submitted and approved by PAAS
- Personal Work Sphere (PWS)
- Meeting Sphere (MS)… agreement form must be submitted and approved by PAAS
- Sphering Level (SL)*… agreement form must be submitted and approved by PAAS

  *The Sphering Level indicates the state of a PrimsArch asset.

Types of Immersed Human Produced Spheres (Figure 14)

- PrismArch Spheres as exceptional entities and symbols (e.g. inaccessible and ghosted information can be represented as symbols or notifications such as player name and avatar presence accessed from a distance)

<u>System guided and produced Spheres</u>

Spheres can be produced automatically by the PrismArch system. Spheres form guided personal, internal discipline-specific and cross disciplinary project data and information constraints and these exist to sort all data existing inside the PrismArch singular database. By default, the PrismArch platform and the operating system produces a single type of sphere; PrismArch World (PAW). PAW is a singular immersed sphere that contains all project data visualised via game engines - this is equivalent to the immersed, experiential and four dimensional version of the PrismArch Singular Database that exists in the server.

In order for individual human beings to access the PrismArch platform and to become recognisable and identifiable within the system as an Immersed Human (IH) , every individual is first asked to pass the PrismArch Onboarding System (PAOBS). Each IH is a type of PrismArch Asset (PAA) with a PrismArch Passport/ Identification (PA_PASS). PA_PASS is project information relating to individual users. It contains personal registered information such as the person's name, discipline type, company name, company role, email, contact and any required additional information. Once the on-boarding and platform registration is completed, the system automatically produces a fundamental type of sphere for personal use; Personal Work Sphere (PWS). PWS is a customisable personal work environment that contains a digital representation of the immersed human and his/her Personalisable User Interface (PUI). PWS is an individual unit for each IH and this enables individual recognisable and interactable inside the PAW. With the registered personal information about discipline and role types, the system allocates each IH to one of the collective units (most likely a company name), Collective Work Sphere (CWS).

In order for IHs to start uploading and creating project specific PAA inside the PAW, a Project Director (PD) or Project Administrator first need to request the PrismArch Admin System (PAAS) to produce a project specific sphere called PrismArch Project Sphere (PAPS). This enables the PAW to create a project class that is capable of containing project specific data and information. Whether it is a potential or agreed project - the first date that the PAPS is created is considered as the start date of the actual project. The project activation date is when the PD or any registered project members upload the first project information to the PAPS.

If the discipline has not previously registered with the PrismArch platform, the discipline specific admin needs to fill in and submit the Collective Work Sphere Agreement Form (CWS_AF) and this needs to be approved by the PAAS. Once the CWS_AF is approved by the PAAS, registered project members are allowed to upload project data and information to the PAPS. PD can request to grow the sphere capacity at a later stage of the project development and this will allow the team to have more members as well as the content storage.

All project data and information that exist inside the PASD is demarcated with special administration and permission levels called Sphereing Levels (SL) (Figure 15). This demarcation system controls visibility, transparency and access privileges of all PAA inside the PAW and also manages version controls. SL is only editable by the PAAS, the registered discipline specific project admins. Individual IH is asked to notify one of the registered PAAS members to upgrade or downgrade their design objects; otherwise, they remain as personal production.

SL1 contains private and personal assets.These assets are visible and accessible from the PWS.
SL2 contains Internal Discipline Specific (IDS) approved assets. These assets are visible and accessible from the CWS.
SL3 contains Cross Disciplinary (CD) approved assets. These assets are visible and accessible from the PAPS and shared and visitable by selected disciplines with special agreement.
SL4 contains client approved assets. These assets are visible and accessible from the PAPS and shared and visitable by all disciplines with special agreement. These are typically polished assets that are prepared or being prepared for official or/and legal submissions.
SL5 contains public assets. This level will not be explored within this research project, however, these assets show potential opportunity to marketise PAAs (e.g. for exhibitions, company promotions etc. After the completion of a project with an agreement with project contributors, the PAPS owner can arrange to invite public domain users/visitors with SL5 special permissions to his site to share the cultural development of the project.)

Immersed Human produced Spheres

With the Sphereing tool, IHs can also immersively demarcate PAA inside the PAPS. For instance, an individual IH can select multiple PAA to create a sphere compound of the PAA. Each IH can assign a tag only to SL1 rated sphere compounds unless he or she requests access to the PAAS and the request is approved. In a similar way, IHs can coordinate a sphere containing meeting or presentation assets so that the content is filterable via QUI at any stage of the project development. Spheres in PrismArch are data organizational entities that help to organise and access Prismarch content including metadata. A meeting sphere can be arranged in a similar way by demarcating the PAAs that are prepared for the arranged meeting and immersed humans are also part of the PAAs that are compoundable within the sphere.

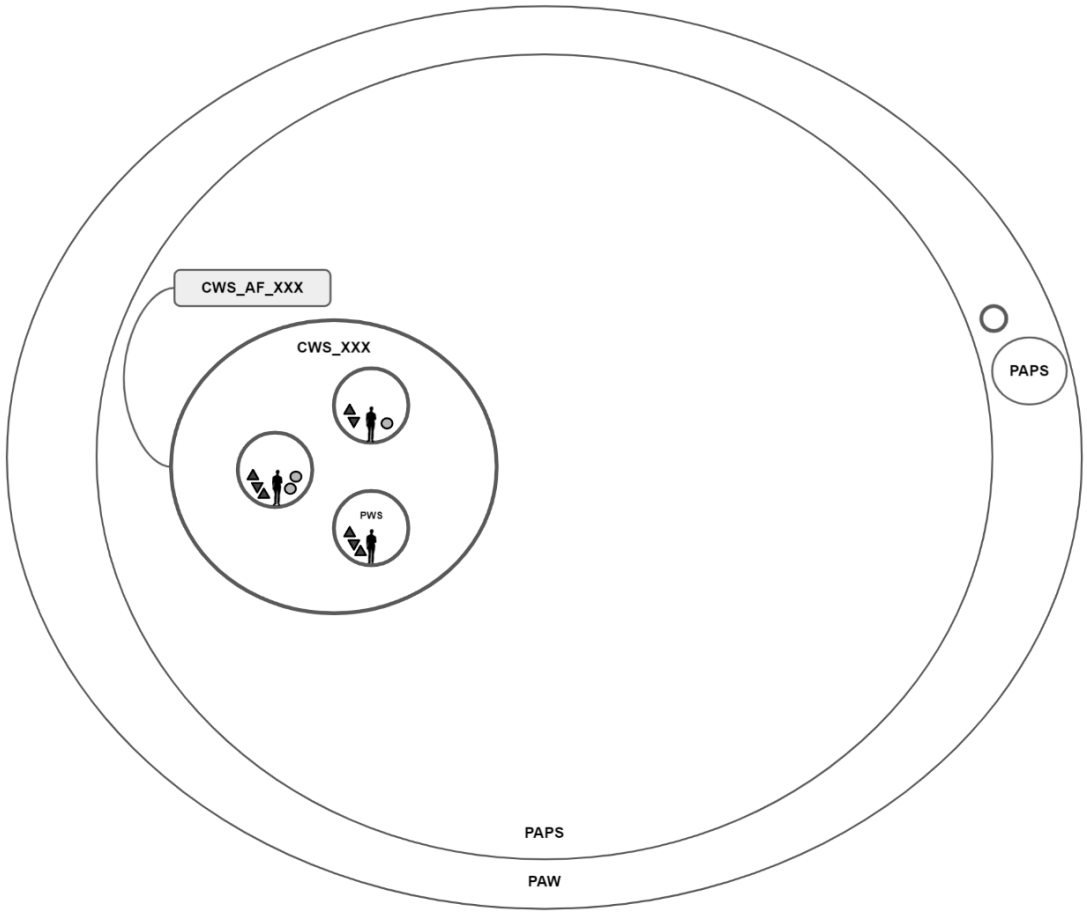


Figure 9: ZHVR Group, PrismArch Spheres as topological data divisions and demarcations (Single discipline example), 2021.

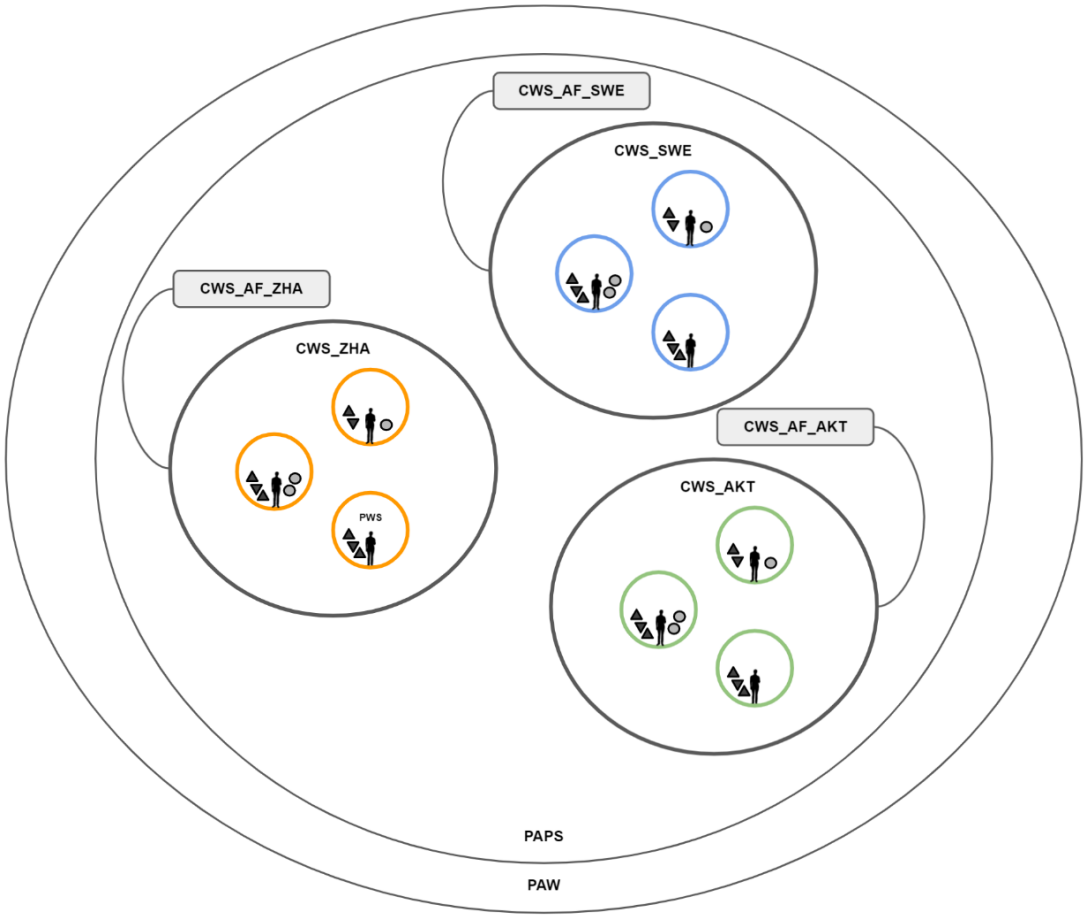


Figure 10: ZHVR Group, PrismArch Spheres as topological data divisions and demarcations (Multi disciplinary example), 2021.

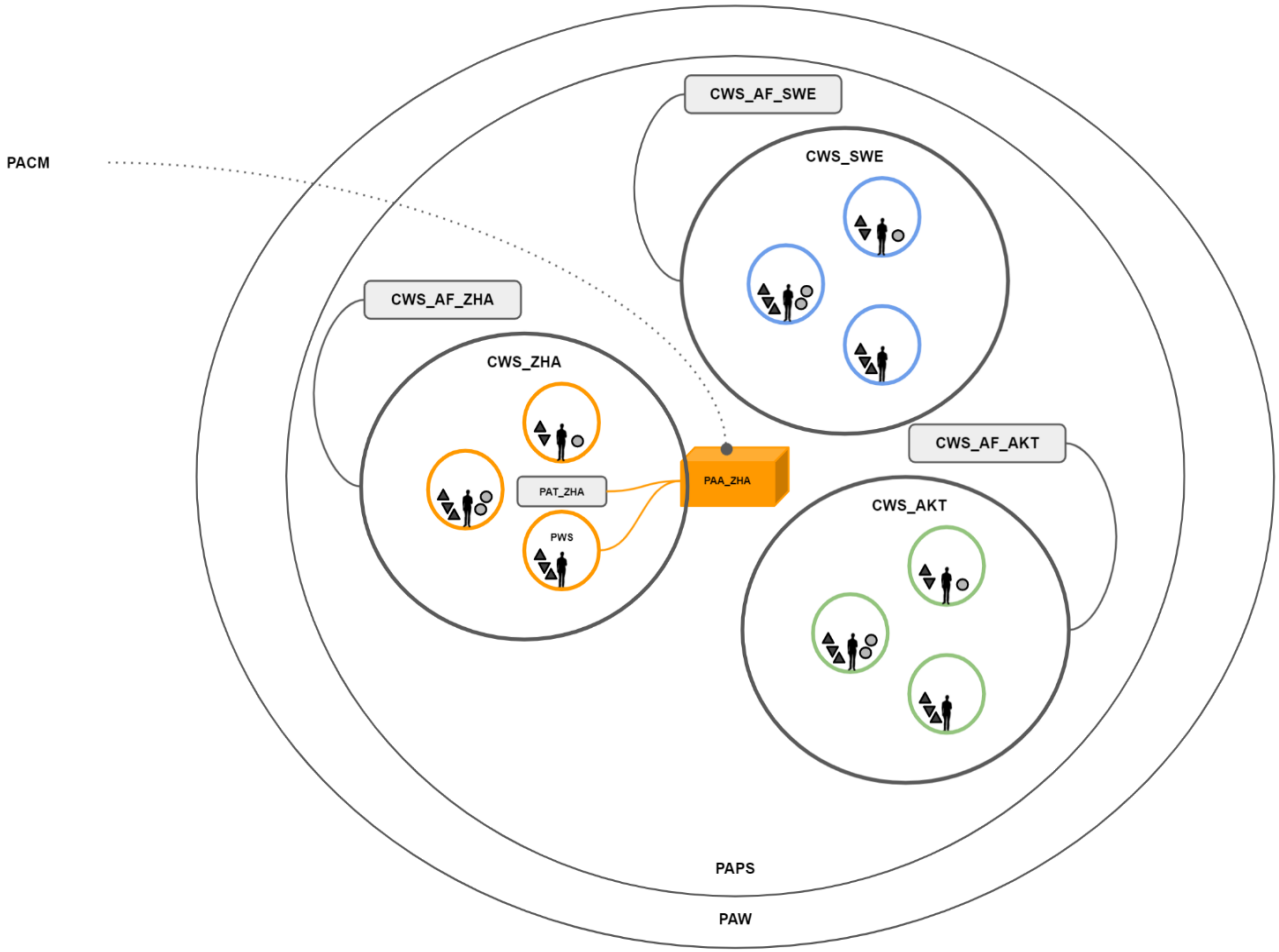


Figure 11: ZHVR Group, PrismArch Spheres and a PrismArch Asset loaded at the PrismArch Central Model location, 2021.

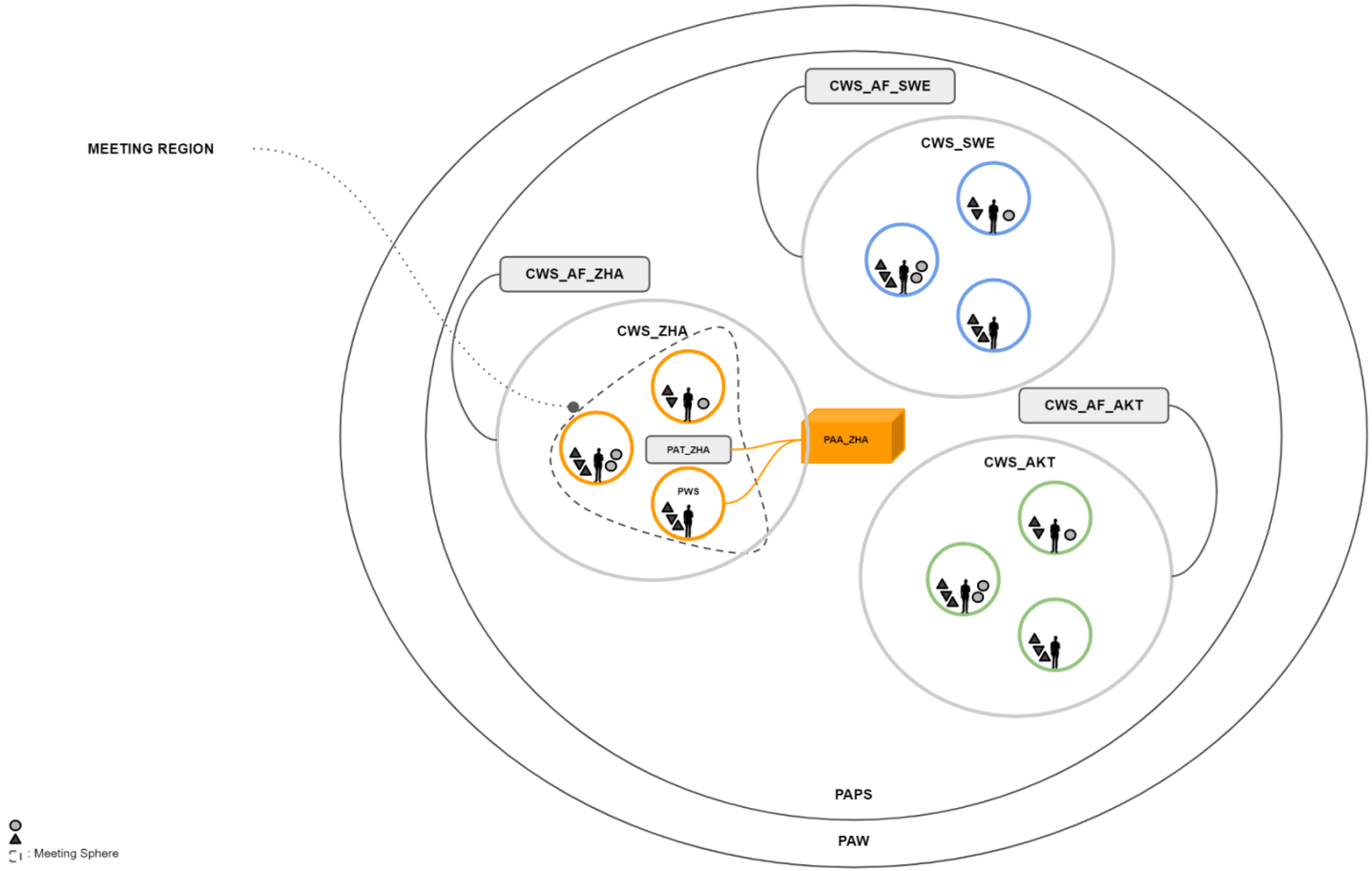


Figure 12: ZHVR Group, PrismArch Meeting Sphere (internal discipline-specific example), 2021.

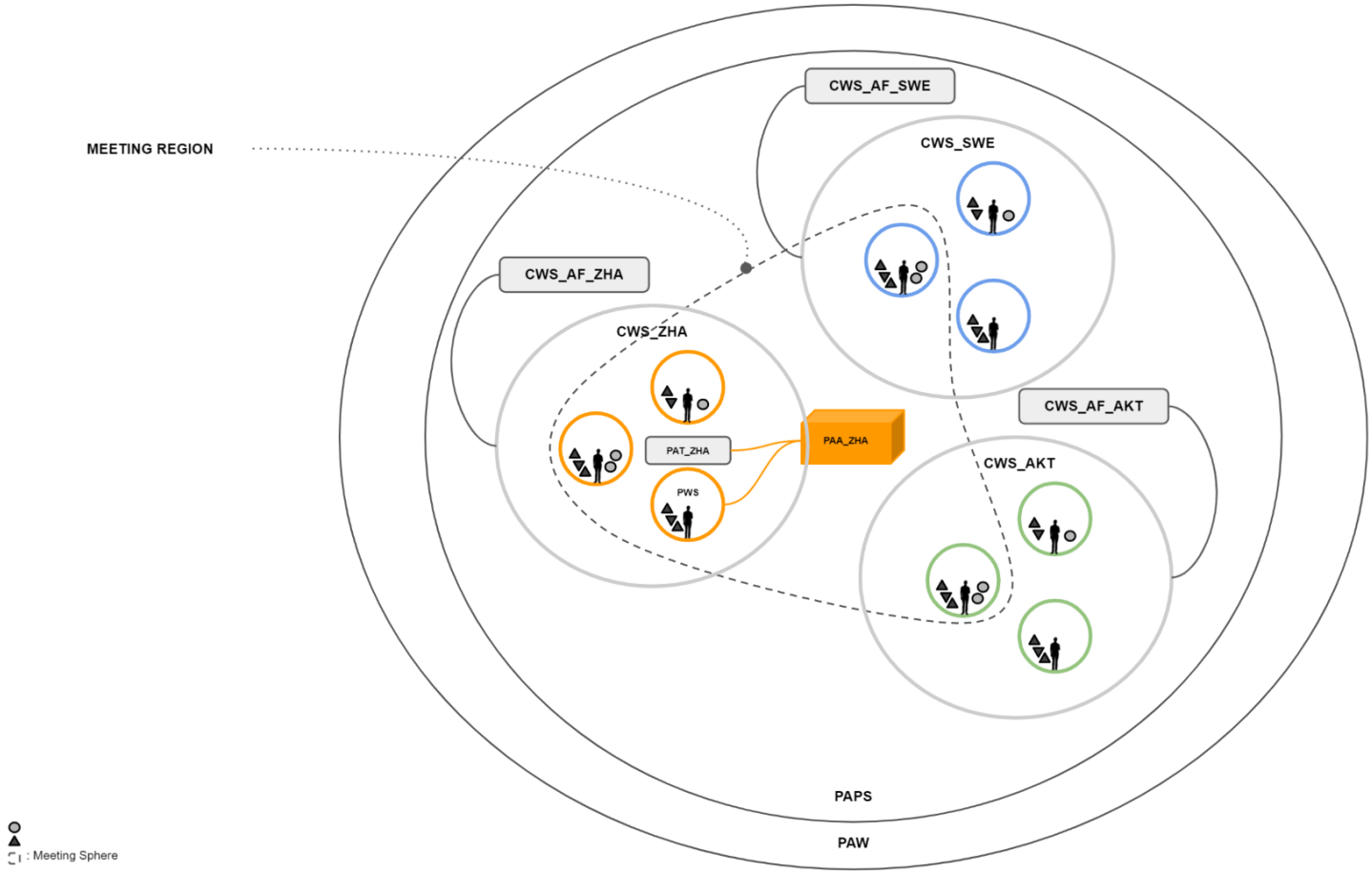


Figure 13: ZHVR Group, PrismArch Meeting Sphere (cross disciplinary example), 2021.

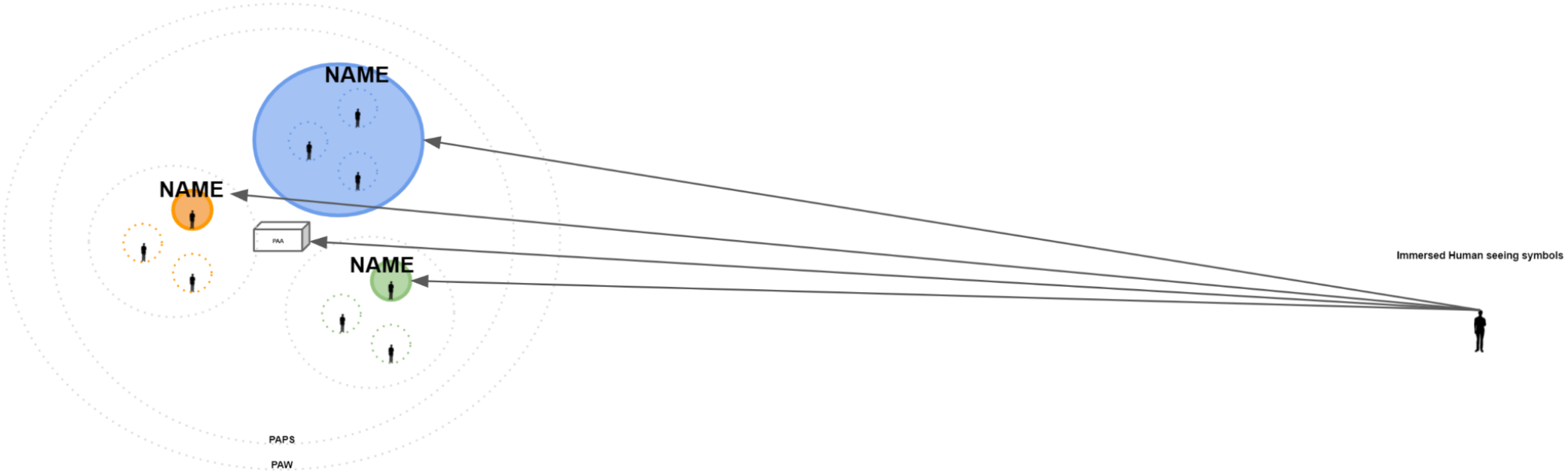
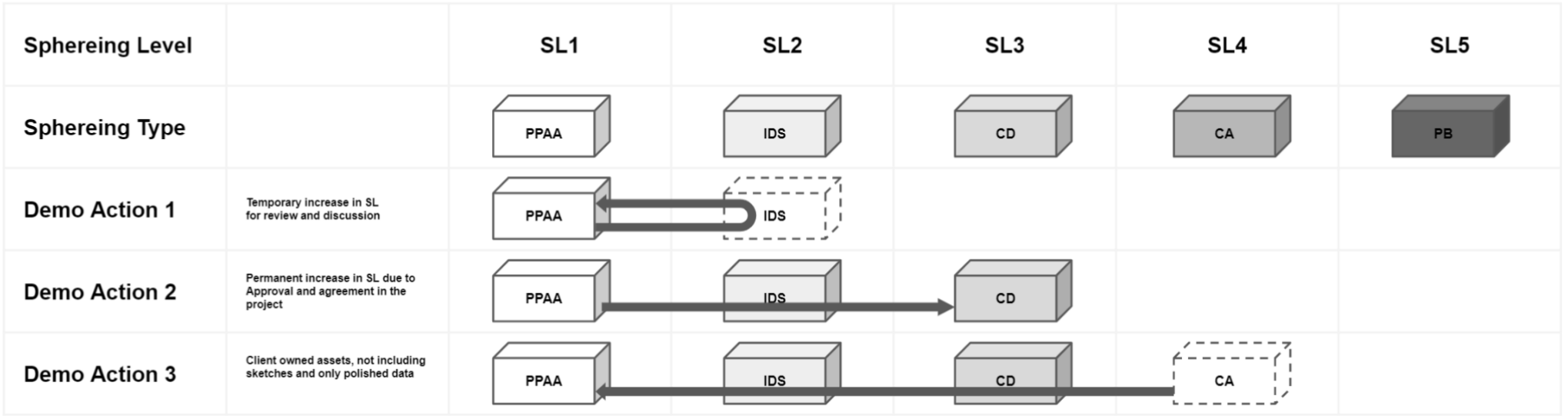


Figure 14: ZHVR Group,PrismArch Sphering exceptional entities as symbols, 2021.
(e.g. information such as player name and avatar presence when accessed from a far distance, or inaccessible and ghosted information can be represented as symbols or notification)



PPAA: Private PrimArch Asset
IDS: Internal Discipline-specific
CD: Cross Discipline
CA: Client Approved
PB: Public PrismArch Asset

Figure 15: ZHVR Group, PrismArch Sphering Level, 2021.

1.3 Prism Arch Onboarding Sequence Illustrated

On-boarding Sequence Illustrated (Figures 16-23)

1. User opens PrismArch application installed on his/her desktop PC
2. If the user is new to the platform/ first time user, register user information (on-boarding). If not, the enter username and password to log into the platform **(Sequence 1)**
3. Press 'Visit PWS' button in the app then choose VR or Desktop mode
4. Wears a headset with SteamVR apps opened if it is in VR mode
5. Immersed Human successfully on-boarded and arrives in the PrismArch World (PAW) compounded inside his/her Personal Work Sphere **(Sequence 2)**
6. From the PUI Taskbar, IH selects and visits a PAPS **(Sequence 3)**
7. Immersed Human successfully on-boarded and arrives at a last visited world coordinate compounded inside his/her disciplinary unit - Collective Work Sphere (CWS) **(Sequence 3)**
8. Immersed Human produces a design object inside the PrismArch platform at the PrismArch Central Model (PACM). Query User Interface (QUI) appears at the PACM **(Sequence 4)**
9. An immersed Human accesses the main Query User Interface loaded at the PACM to filter a tag name **(Sequence 5)**
10. Immersed Human highlights and selects one of the filtered result/node (spatial hyperlink) to review the project asset at a physical scale (1:1) **(Sequence 6)**
11. Immersed Human spawns an instance of QUI to filter new project information. IH highlights and selects one of the filtered result/node (spatial hyperlink) to review the project asset at a master plan scale **(Sequence 7)**
12. Immersed Human produces his/her work and completes assigned tasks using PUI and QUI
13. Immersed Human is ready to leave the PAPS and goes home to PWS. The production is automatically saved to PWS local directory
14. Immersed Human leaves the PWS by unloading his/her headset and logs off from the PrimArch app
15. Close the application on Desktop
16. User still receives notifications from the app on the desktop while he/she is logged off

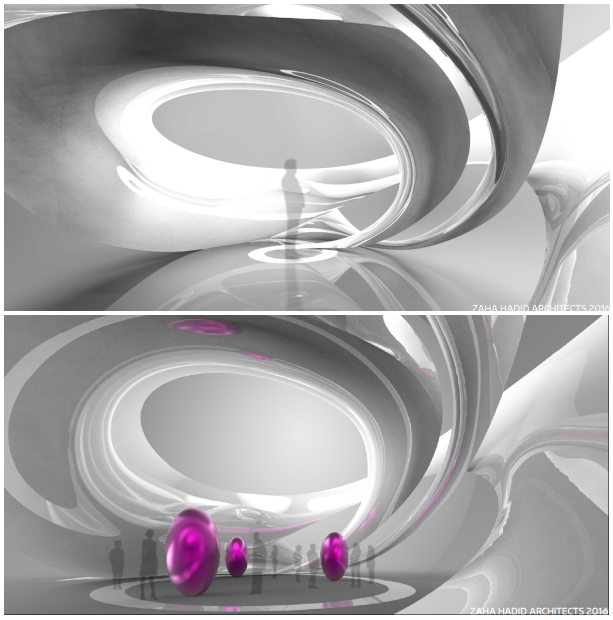


Figure 16: ZHVR Group, VR Home, 2016. As an example of Personal Work Sphere design.

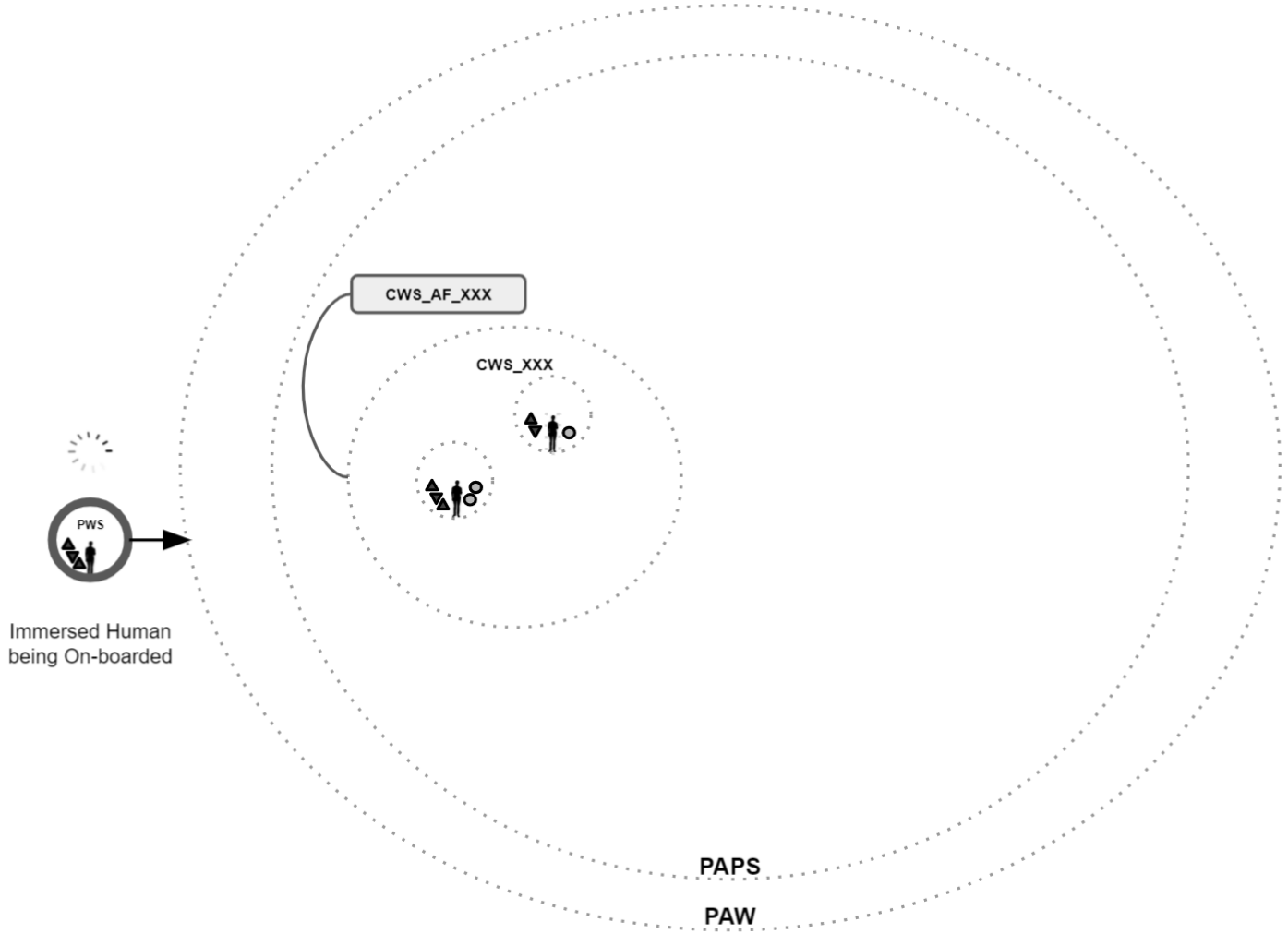


Figure 17: ZHVR Group, On-boarding Sequence 1/7: Immersed Human being on-boarded or logging in to the platform, 2021.

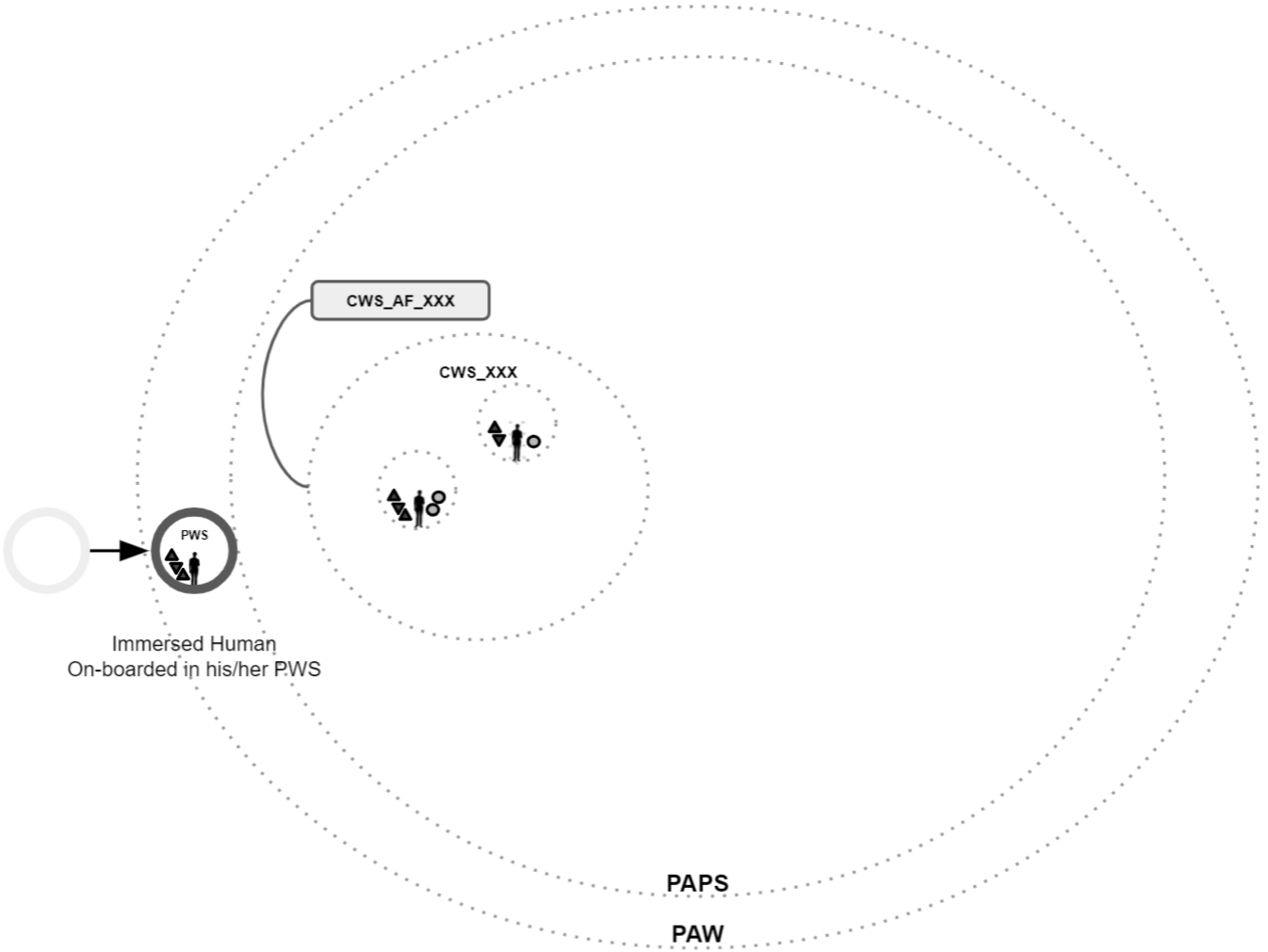


Figure 18: ZHVR Group, On-boarding Sequence 2/7: Immersed Human successfully on-boarded and arrives in the PrismArch World (PAW) compounded inside his/her Personal Work Sphere, 2021.

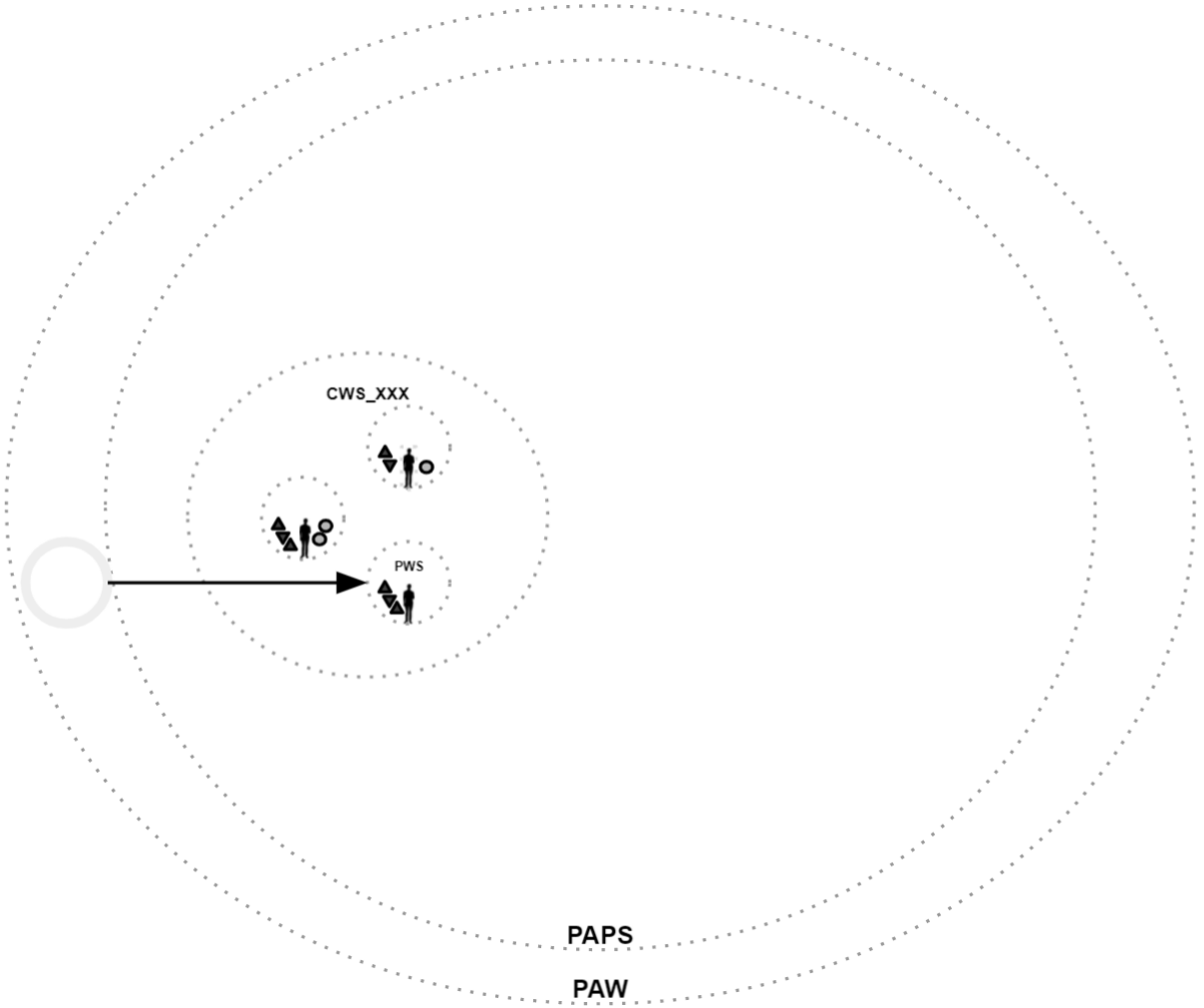


Figure 19: ZHVR Group, On-boarding Sequence 3/7: Immersed Human successfully on-boarded and arrives at the last visited world coordinates inside his/her disciplinary unit - Collective Work Sphere (CWS), 2021.

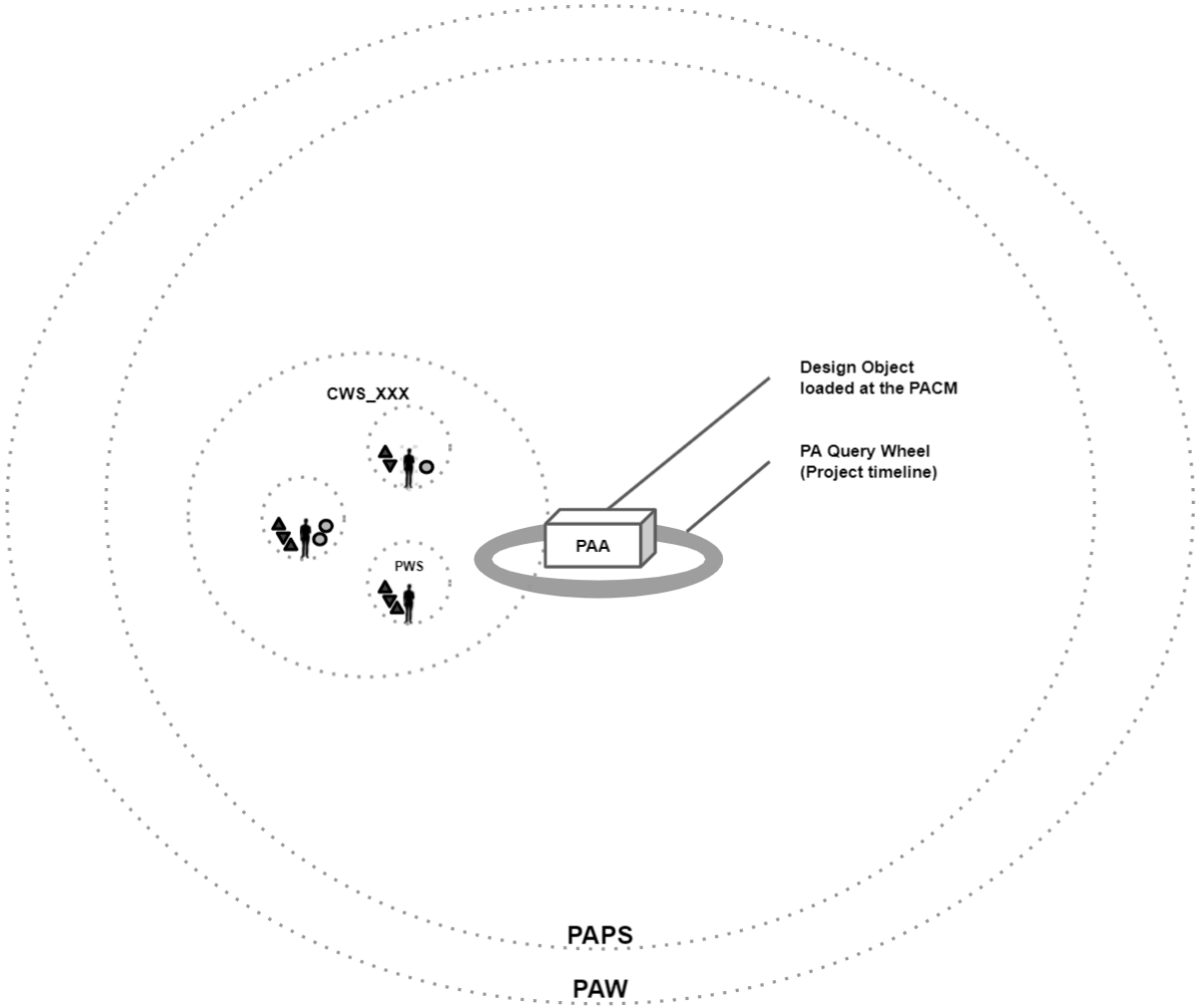


Figure 20: ZHVR Group, On-boarding Sequence 4/7: An immersed Human produces a design object inside the PrismArch platform at the PrismArch Central Model (PACM). Query User Interface (QUI) appears at the PACM, 2021.

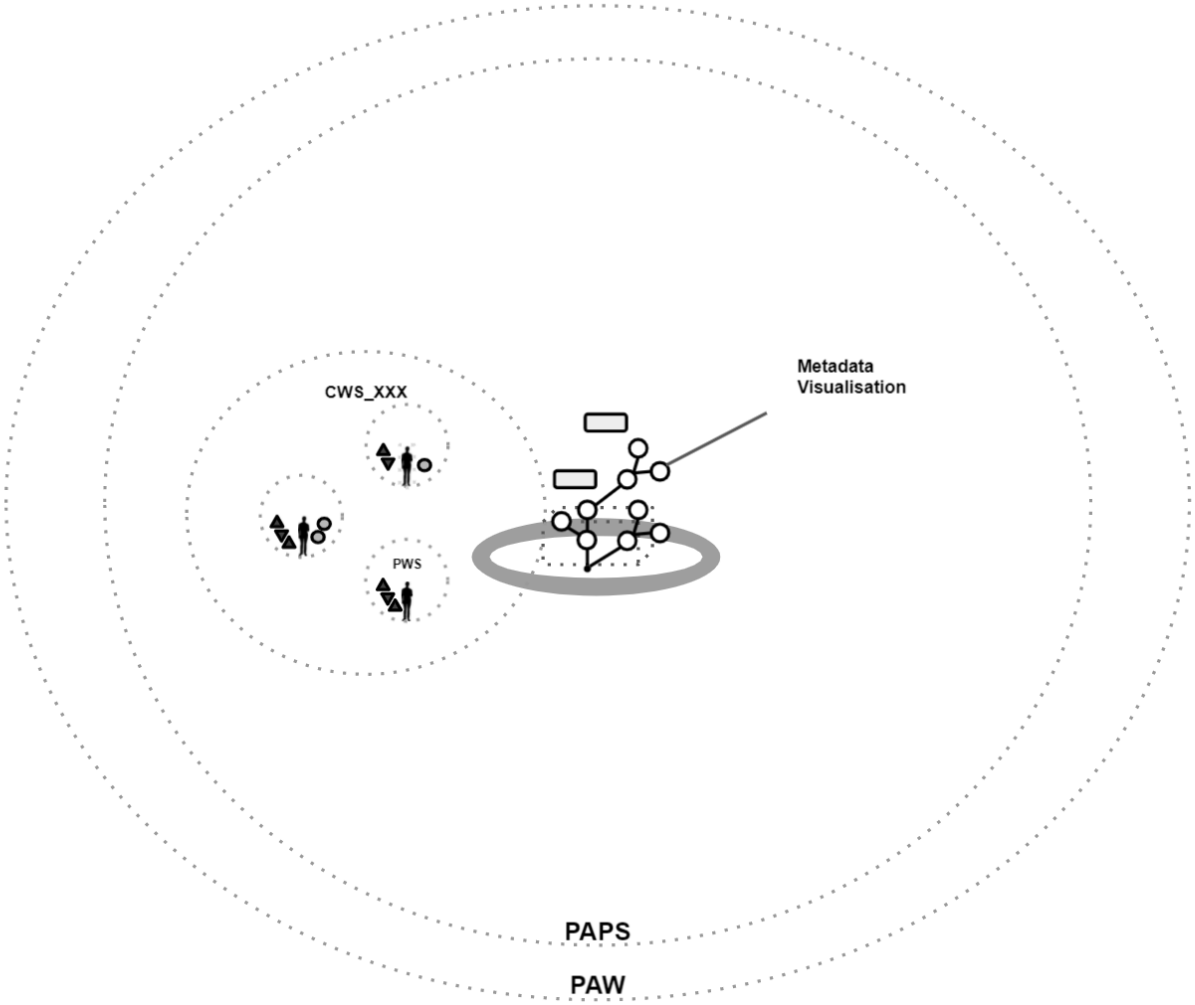


Figure 21: ZHVR Group, On-boarding Sequence 5/7: An immersed Human accesses the main Query User Interface loaded at the PACM to filter a tag name, 2021.

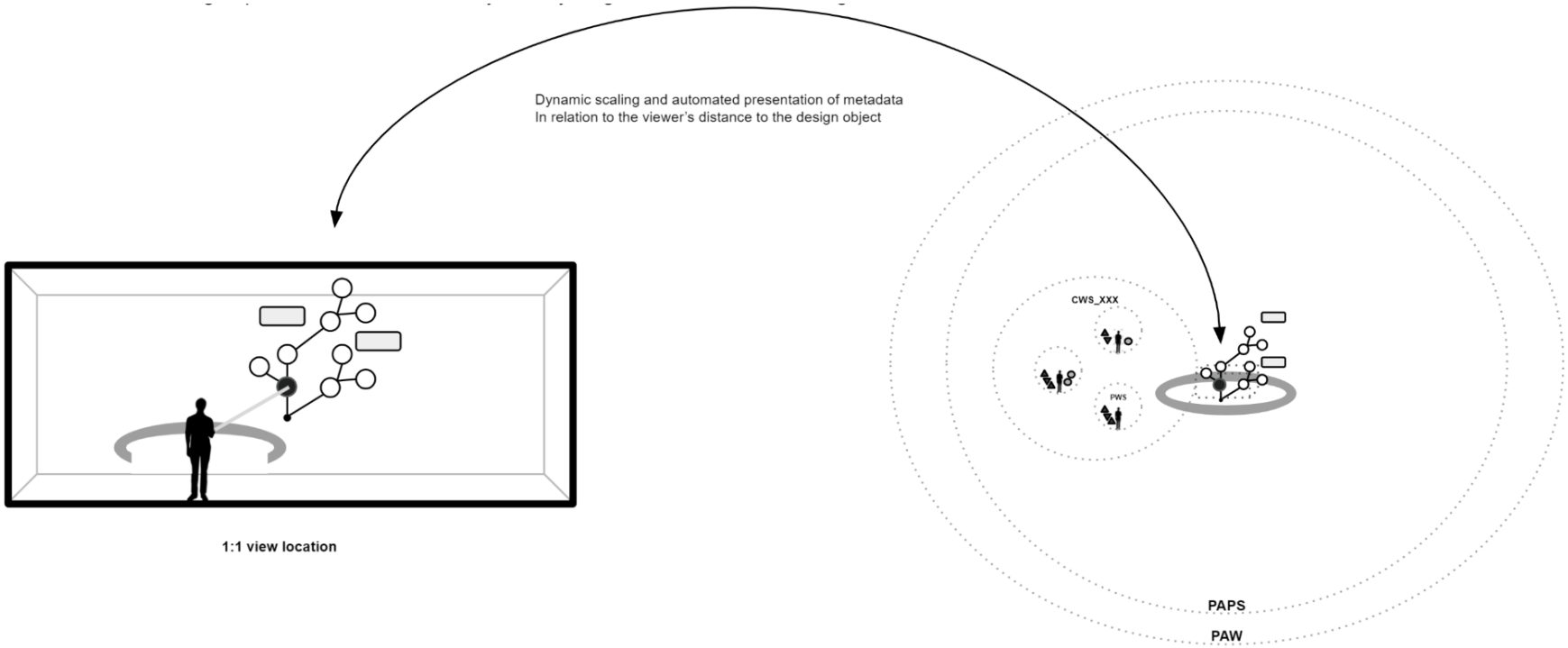


Figure 22: ZHVR Group, On-boarding Sequence 6/7: An immersed Human highlights and selects one of the filtered result/node (spatial hyperlink) to review the project asset at a physical scale (1:1), 2021.

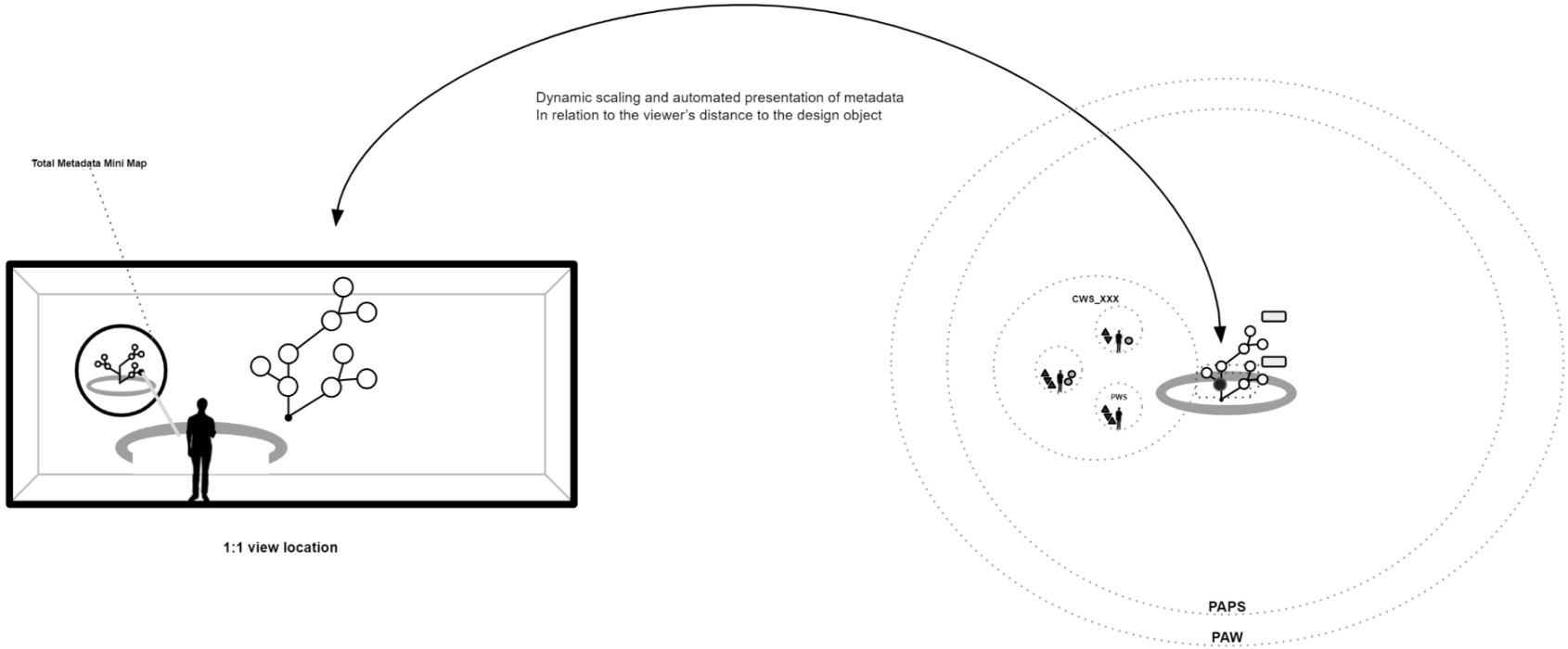


Figure 23: ZHVR Group, On-boarding Sequence 7/7: An immersed Human spawns an instance of QUI to filter new project information. IH highlights and selects one of the filtered results/nodes (spatial hyperlink) to review the project asset at a master plan scale, 2021.

Chapter 2: Residential Project User Scenario 1 (internal discipline-specific operations)

In this chapter, each discipline studies internal discipline-specific usage scenarios for a residential project explored in the deliverable D1.1. Each user scenario proposed by individual discipline includes several situations and its related tasks at a selected architectural project phase.

The demonstration action for this chapter thoroughly focuses on on-boarding, tool kit usage and asset sharing within disciplines, observing a temporary increase in an asset access level. Throughout the usage scenarios, we followed the Sphereing Level (SL) concept introduced in chapter 1. The objective of this chapter is to outline how end users review and evaluate internal discipline-specific project information, data and produced design objects inside the PrismArch Project Sphere (PAPS).

Keywords:
Platform registration/ on-boarding process/ administration setups/ internal meeting arrangements/ content creation /the PrismArch tool kit

2.1 Architectural Discipline

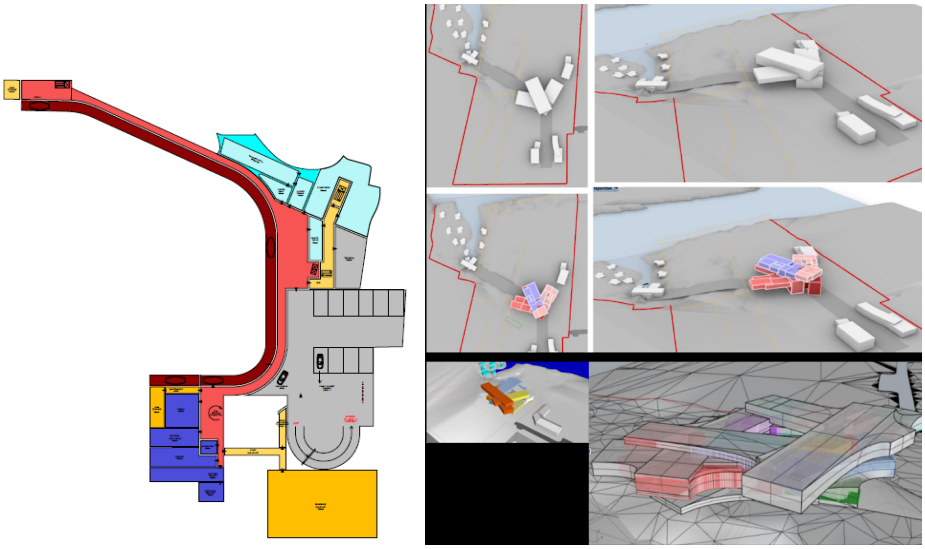


Figure 24: ZHVR Group, Examples of site investigation and volumetric studies conducted at an early stage of architectural project development, Case Study 01 submitted with the deliverable D1.1, 2021

To ensure clarity, the following abbreviations are used to identify the Architectural project participants' roles.

Abbreviation	Role
PD_A	Project Director_Architecture
LD_A	Lead Designer_ Architecture
LID_A	Lead Interior Designer_ Architecture
SD_A	Senior Designer_Architecture

Situation A: Incidents at the Concept Stage - Preparation of Project Data and Information

The PD_A has a potential architectural project at a specific global coordinate, Location A at (longitude, latitude). He visits the client on YY/MM/DD to discuss the project. The client shows him the site and he takes photos with his smartphone and makes sketches.

Task A.ARCH.1: Project Director_A visiting the site and requests PrismArch System Admin to create a PrismArch Project Sphere

1. A few days later, PD_A comes back to the office and receives an email from the client. The email includes a request for initial design proposal and cost with attachments (2D drawings -pdf, local regulations -doc, client checklist -pdf, cultural and architectural references -jpg and room programs -xls).

2. PD_A is not a first time PrismArch user. He logs into PrismArch, wears a headset and visits his Personal Work Sphere (PWS).

3. Inside his PWS, he does not see a Project Sphere for this potential project yet. He first requests the PrismArch System Admin (PAAS) to create a PrismArch Project Sphere (PAPS) then asks to add the discipline specific unit - Collective Work Sphere (CWS) to the PAPS.

4. The PAAS approves the request. By default, the PAPS has 5 GB capacity, which is a small distribution from the PrismArch singular database. The sphere capacity can be increased later. He is now allowed to load some of the project information and data inside the created Project Sphere.

5. PD_A first uploads the site photos and sketches he made during the site visit to the PAPS. As soon as the project data and information are ported to the PrismArch Singular Database (PASD), a PrimArch Tag (PAT) is automatically assigned to each project asset (each of the site photo and sketches). The tag content includes timestamps with his name, project role, content categories (e.g. photography, sketches) PAPS ID and SL classification. By default, all freshly ported PAA are rated as Sphere Level 1, and each project asset is loaded at the world coordinates of the original project asset (modeled location in Rhino and Revit, if it is a jpg, geo-coordinates taken from the GPS map on his smartphone).

6. PD_A now sees the site photos (jpeg) and scanned sketches (pdf) loaded at each geo-coordinate spawned within the PACM sphere. Next, he would like to upload the project information collected from the client. This includes 2D drawings (dwg, 3dm), local regulations (doc), client checklist (pdf), cultural and architectural references (jpg) and room programs (xls). These are SL1 rated assets by default but require further specification to protect confidential information with secondary SL settings - special permission. With the multi selection tool, he selects the confidential project data and information, then modifies the PATs and assigns a new project information ‘Confidential’.

Task A.ARCH.2: Project Director_A creating a PrismArch meeting sphere to organise an internal meeting

7. PD_A now would like to invite the project members to review the loaded content together. In order to do so, he first needs to send a request to the PAAS to register his team with the PAPS. The PAAS approves the request and sends an invitation to LD_A and SD_A and LID_A - now the registered project members have access to the PAPS and they are able to create and share content from their PWS.

8. PD_A would like to organise an internal project kick-off meeting with the D_A team, to do so he needs to prepare for the project assets specifically for the meeting so that the project assets can be visually sharable and commentable within the arranged meeting sphere by all the meeting attendees.

9. To arrange a meeting sphere, he decides where the meeting happens first. He decides to start the meeting at the location and rotation where he can see the loaded project assets from the axonometric view at 1:500 equivalent distance from the PACM.

"Setting up views
'on a day to day basis with the team internally [...] one of the things we tend to do quite a lot is'

a. *'we set up views in the model'*
b. *'where you can test changes that were implicate implementing [implemented?]'*
c. *'for example [at the] top of the tower we have these [...] glazing [steels, steals?] again huge because of the wind load, which we have been discussing earlier'*
d. *'we designed something like this, very slender, thin and designed [draws a small sketch] - client couldn't afford that'*
e. *'they would then have to be thicker, so we did it like that [continues to sketch]'*
f. *'one of the processes is [...] setting up key views within the model'*
g. *'then designing different elements which we would place for these [steels, steals?] a simple [...?] clad or whatever it is [46:09]'*
h. *'and then testing the visual impact of those'*

'we have a fixed reference to compare'

i. *'say you have fide designs for a column'*
j. *'couple of people working on that'*
k. *'you need to compare them like for like'*
l. *'so you need that fixed view so you have an idea of - well - how much light do I see'*
m. *'that is the beauty of having the model'"*

From an interview conducted by ETH with a ZHA staff (PrismArch Deliverable 3.1, p.36)

10. He visits the location and rotation. He enables the sphereing tool from the PUI, then draws a compound sphere to include and contain the meeting assets. He then accesses the tagging tool to assign a tag 'internal kick-off' to the sphere. The timestamp, author information and world coordinate of the compound sphere are automatically added to the selection. When he confirms his action, he upgrates the project asset SL from 1 to 2 so that the rest of project members can see the content (special visibility replication settings). Because some of these project assets already have 'confidential' project information assigned previously, these cannot be upgraded to greater than SL2 without a permission from the PAAS.

11. PD_A finishes the meeting preparation, leaves the PAPS and comes back to his PWS. He opens the dashboard on his PUI and accesses the contact list widget. He selects all the current project members in the list, then filters the 'internal kick-off' tag to clipboard the spatial hyperlink (to the world coordinate of the arranged meeting sphere). He confirms the invite after filling in meeting information such as the meeting name, time, number of attendees/size.

12. Each attendee receives a meeting sphere link and visits the arranged location and rotation by entering the link from individual PWS at the arranged time. The event is automatically added to their calendars in the PUI dashboard.

13. All meeting attendees see each other's avatars inside the arranged meeting sphere with the curated project assets. The meeting sphere owner (PD_A) is the host of the meeting and he has persistent privileges for the duration of the meeting. The host will have the choice to lock certain aspects of the design objects and User Interface functionalities for other meeting attendees to curate and limit the

discussion prior to the meeting taking place. The meeting presenter can be one of the participants (by default this is the host), and this temporary privilege can be passed to other participants within the ongoing meeting. The presenter(s) will need to be able to transport the meeting (unless locked by the host) and make changes to the Query User Interface (QUI) to be able to interact with models and make their arguments. Meeting sphere has a singular navigation origin and the presenter will be the driver for the collective.

14. During the kick-off meeting, PD_A presents an overall project view and goes through the project information. At the end of the meeting, he assigns tasks for each project member. LD_A is responsible for site investigation and developing a site model. SD_A is responsible for assisting LD_A and adds volumetric studies on top of the site model. LID_A is responsible for material and interior mood boards.

15. PD_A closes the Meeting Sphere and the assigned tasks are distributed and appear in individual PUI.

Situation B: Incidents at the Concept Stage - Working on an Assigned Task in the Personal Work Sphere

Task B.ARCH.1: Lead Designer_A working on an assigned task relating to site investigation at her Personal Work Space

16. LD_A is assigned a site investigation task by PD_A. She is in her PWS. She creates an instance of the SL2 rated PAAs shared by PD_A and these project data and information are now loaded at the PACM. It contains site photos, sketches, 2D drawings and translated local regulations. Her plan is to mark the terrain on the 2D drawing to understand the landscape and ground features and constraints of the site. The designed result will be used as the base of volumetric study and it is to be shared within D_A.

17. In the PUI at her PWS, LD_A has the Mindesk API and PrismArch default tools installed (multi-presence on-boarding system, tagging, query, dashboard, admin, contact, multi selection, commenting and markup, punch list, spatial orientation and design support and evaluation tools).

18. Using the proprietary and PrimArch default tools, LD_A starts to markup the maximum allowed height, site offset, local regulation, vegetation/ trees and historical and any protected conditions on top of the 2D drawing loaded at the PACM. She has done so by placing lines and points using the Mindesk tool. Everytime she leaves an object, a new tag is assigned with timestamps with her name, project role, content categories, PAPS ID and SL classification. She selects multiple points by creating a compound of the site data and names the sphere compound as ‘contour heights’. The PAST includes a series of points with a contour height value.

19. Now LD_A would like to report the work progress to PD_A. She filters her last 5 hours worth of work using the QUI and creates a sphere compound called *‘PD_A_SiteModel_Review_v1*’. When she receives the project assets from PD_A, the initial view location and rotation for the compound sphere is set to the axonometric perspective at 1:500 scale. She decides to keep the sphere locations to meet with PD_A. She arranges a meeting sphere and enters the meeting title, purpose, time, location, scale, MS size and attendees. She only invites PD_A for this internal review.

20. LD_A and PD_A meet in the arranged PAMS at the arranged meeting sphere location and rotation. LD_A is the meeting organiser and host. The meeting assets loaded at the PACM include an instance version of her prepared assets with special visibility permission for PD_A.

21. LD_A loads a 2D drawing on the PACM on the horizontal plane then navigates the meeting sphere to the 1:200 world coordinate and sets the view angle to 'TOP'. The navigation is only enabled on the host so PD_A also navigates with the meeting sphere. Both PD_A and LD_A see the same objects from the same 'TOP' view. LD_A changes the opacity of the 2D drawings and the drawing now works as a tracing canvas. Both PD_A and LD_A access to their own tool kits in their PUI to make sketches together.

"Aligning the 2d information they provided with the 3d model… - it would be possible, 'also something I did'

a. take 2d plans and 'layer them up level by level in a 3d environment … did this in microstation'
b. 'then … open the 3d model which we also had in microstation'

'then, I could see if there's any areas where they weren't aligning or - [?] ...quite manual in many respects'"

From an interview conducted by ETH with a ZHA staff (PrismArch Deliverable 3.1, p.35)

22. The next day they meet at the same place and time and PD_A approves the design objects relating to the site. The assets are upgraded to SL2 with the PAAS approval and her task is resolved and disappears from her PUI dashboard. These design objects are now accessible for all D_A project members to load at the PACM to instance the content.

23. Two weeks later, PD_A invites a new starter (Architectural Assistant/AA) to the Project and the PAAS approved the PAPS access to the AA . The meeting sphere location and rotation at the axonometric perspective is still valid and SD_A has the spatial hyperlink in his PUI dashboard. SD_A visits the location and rotation and organises a meeting to brief the new starter.

24. With the QUI, he filters five latest versions of massing studies developed in the last two weeks. He creates a sphere compound of the filtered metadata nodes and includes his own avatar to assign a tag - 'Welcome_Meeting'. He sends the meeting invite to all D_A project members.

25. During the meeting, the pre-loaded five massing options are presented to update their current project progress. A timestamp is assigned to each massing option on creation of the sphere compound. By swiping the QUI disk horizontally, visibility information of the loaded sphere compound changes because the disk timeline is linked to the timestamp information (metadata connection) (Figures 25-26). The pre-loaded design objects appear in a time-collapsed manner following the asset production timeline. SD_A uses this functionality to show different design options - swiping the disk towards left to show version 1, right to show later versions by showing and hiding design objects using the timeline.

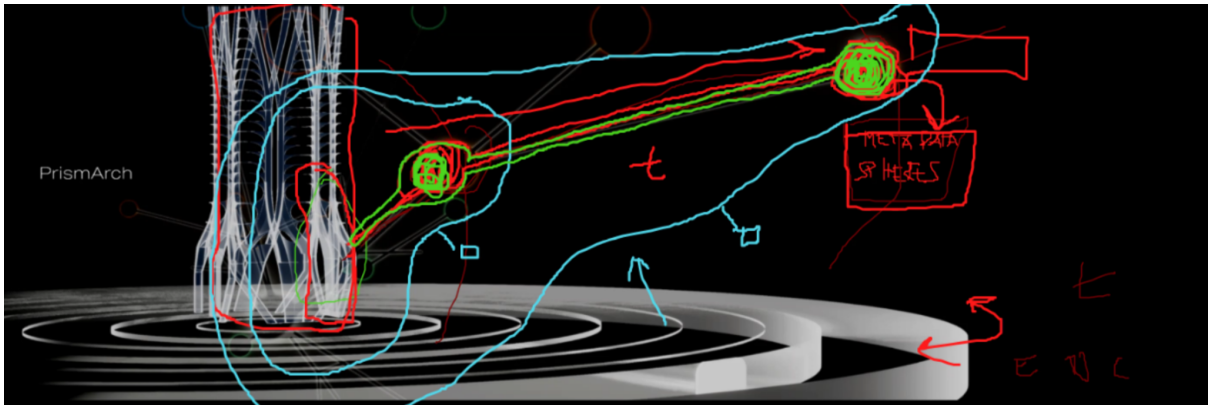


Figure 25: ZHVR Group,Digital sketch illustrating a Sphere Compound of metadata, 2021.

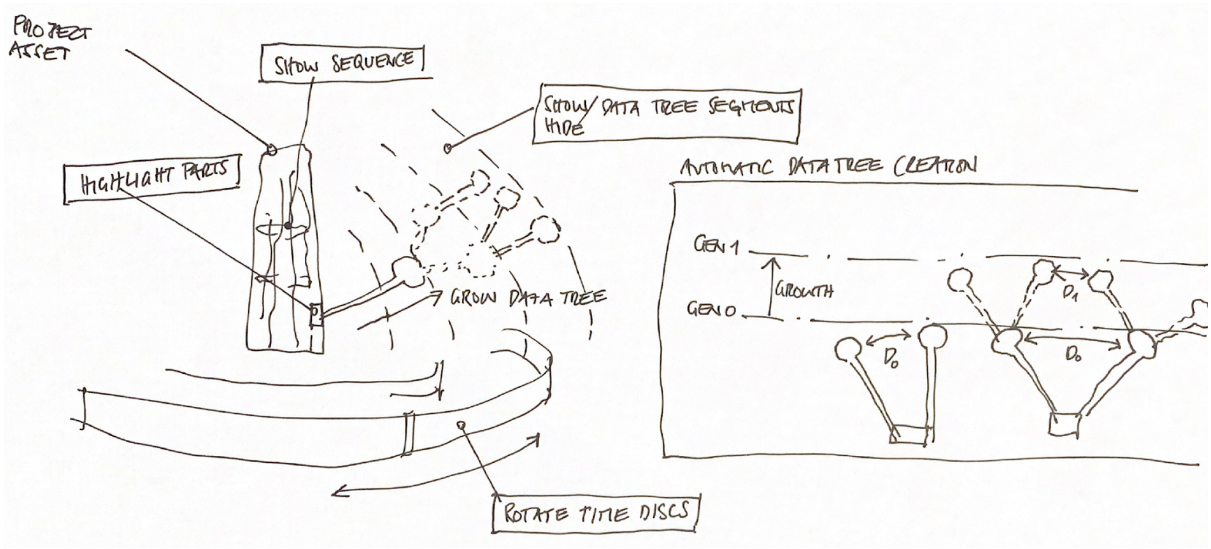


Figure 26: ZHVR Group, Hand sketch illustrating metadata growth over project time, 2021.

2.2: Structural Engineering Discipline

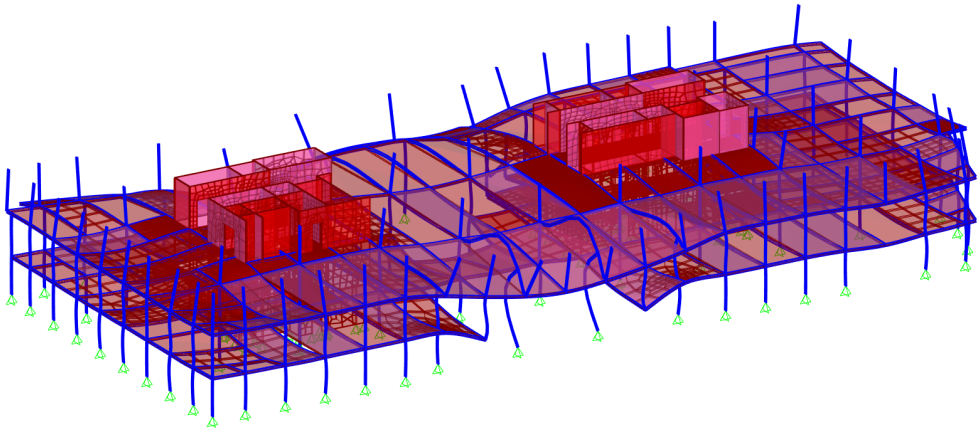


Figure 27.1: AKT II, Examples of global FEA structural models for floor slabs, columns and cores

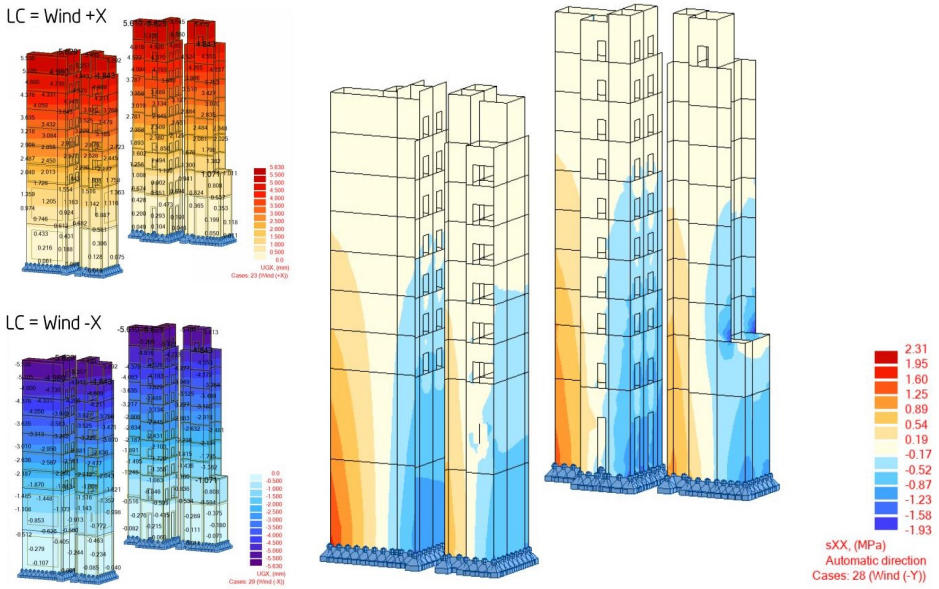


Figure 27.2: AKT II, Examples of global FEA structural models for element-specific models for core only.. These images show typical visual results from an analysis: false-coloured models denoting values such as deflections, utilisation, loadings, and so on.

To ensure clarity, the following abbreviations are used to identify the Structural project participants' roles.

Abbreviation	Role
PD_S	Project Director - Structural
LD_S	Lead Designer - Structural
SE_S	Senior Engineer - Structural

Situation A: Concept Stage Workflow - Kick off Meeting for Structural Design Work

Task A.SE.1: Internal review of Shared PrismArch Assets

1. PD_S receives confirmation that the project is going ahead and receives an invitation to the arranged PAMS.

2. Each attendee joins the arranged PAMS by visiting the arranged location, scale at the arranged time. He/she visits the PAMS with his/her own PWS with customised selections of software and tools in their GUI.

3. PD_A is the organiser of the PAMS. The organiser and the attendees see each other's avatar in the PAMS. The initial location and scale are set to the registered value. All the MS attendees including the organiser sees the model inside the MS. The organiser is the driver of the MS, and if he/she wishes, he/she can switch the host.

4. During the kick-off meeting, PD_A presents an overall project view and goes through the project information with the structural team. PD_S reviews the initial information and starts to assign tasks to the structural team. LD_S is assigned to review the site investigation and to prepare a site desk study, SE_S is assigned the task of contacting utilities providers and carrying out the necessary statutory searches. SE_S is also assigned the task of looking at initial structural solutions in terms of grid and material choices.

5. PD_A closes the PAMS and the assigned tasks are distributed and appear in the PrismArch dashboard.

Task A.SE.2: Senior Engineer_Structure working on an assigned task relating to site investigation at her Personal Work Space

6. 6LD_S is assigned a site investigation review task by PD_S. He instructs SE_S to produce a borehole log diagram to understand the description of the ground. SE_S is already wearing her headset and working at her PWS. She is looking at her forked PAAs loaded at the PACM. It contains site photos, sketches, and a geotechnical report provided by the client. Her plan is to review the information contained in the report and compare it to the proposed massing of the building to make sure enough detailed information is present in the report and to highlight eventual additional information to require. The review will serve as a step to prepare a Site desk study report to include in the deliverables to the client and to highlight potential risks and mitigations.

7. In the GUI at her PWS, LD_S has the Mindesk API and PrismArch default tools installed (multi-presence on-boarding system, tagging, query, dashboard, admin, contact, multi selection, commenting and markup, punch list, spatial orientation and design support and evaluation tools).

8. Using the tools, SE_S starts to markup the boreholes log information on top of the 2D drawing loaded at the PACM. She has done so by placing lines and points using the Mindesk tool. Everytime she

leaves an object, a new tag is assigned with timestamps with her name, project role, content categories, PAPS ID and SL classification. She selects multiple points she just added and assigns a new PAST. She names it 'borehole logs'. The PAST includes a series of points with a terrain specification value.

9. Now SE_S would like to report the work progress to LD_S. She filters her last 2 hours of work using the query tool and assigns a PAST. She names it 'PD_S_BoreholesLog_Review_v1'. The content is SL1 rated assets. She organises a PAMS and enters the meeting title, purpose, time, location, scale, MS size and attendees. She only invites LD_S for this internal review.

10. SE_S and LD_S meet in the arranged PAMS. SE_S's SL1 rated site investigation assets are reviewed by LD_S. He assigns a PAST and adds feedback using the PrismArch commentary and markup tool. They meet at the same location, scale and time the next day and LD_S_A approves the SE_S assigned SL1 content. The assets are upgraded to SL2 and her task is resolved and disappears from the PrimArch dashboard.

11. PD_S organises a PAMS and enters the meeting title, purpose, time, location, scale, MS size and attendees. He only invites PD_A for this review.

12. PD_S and PD_A meet in the arranged PAMS. PD_S reports the findings on the site review to PD_A.

2.3: MEP Engineering Discipline

To ensure clarity, the following abbreviations are used to identify the MEP project participants' roles.

Abbreviation	Role
PD_MEP	Project Director
LD_MEP	BIM Manager/Project Coordinator
SE_M, E, and P	Senior Engineer (Mechanical, Electrical & Public Health Engineers respectively)

Table 2.3.1 Residential project Situation A & B MEP project participants

Situation A: Concept Stage - Evaluation of the architectural information and making small amendments

The PD_A has a potential architectural project at a specific global coordinate, Location A at (longitude, latitude). He visits the client on YY/MM/DD to discuss the project. The client shows him the site and he takes photos with his smartphone and makes sketches.

Task A.MEP.1: Joining an arranged PrismArch Meeting Sphere and reviewing Shared PrismArch Assets

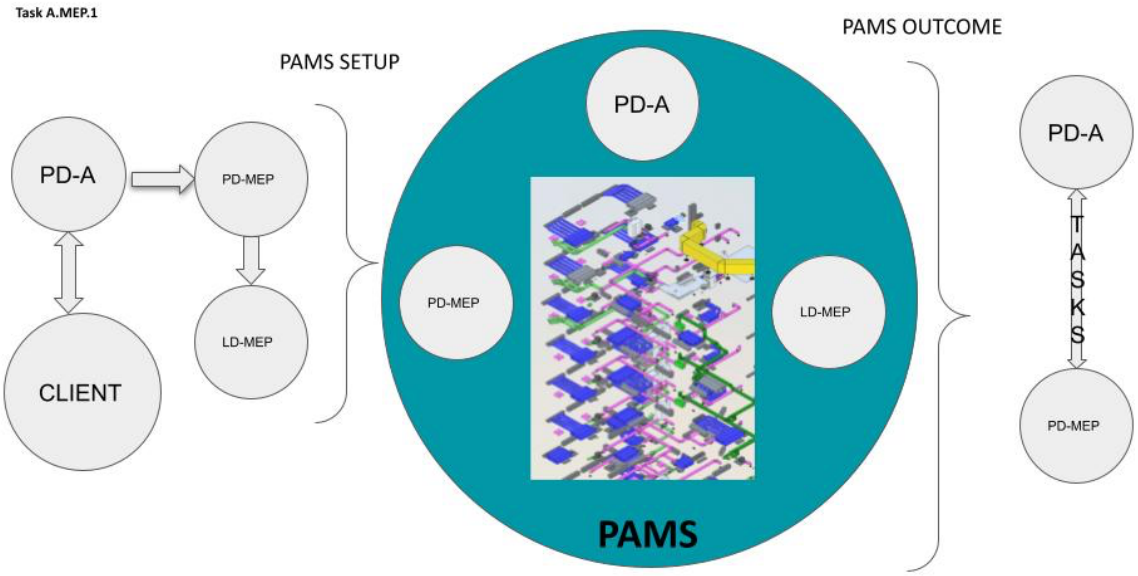


Figure 28: Sweco, Graphical representation of the Task A.MEP.1 workflow, Joining an arranged PrismArch Meeting Sphere and reviewing Shared PrismArch Assets.

1. PD_MEP receives an invitation to the arranged PAMS. PD_MEP extends the invitation to LD_MEP. Once the invitation is accepted the incident is automatically added to their calendars.

2. PD_MEP and LD_MEP are not first time PrismArch users. Both users log into PrismArch, wears a headset and visit his PWS.

2. Each attendee joins the arranged PAMS by visiting the arranged location, scale at the arranged time. He/she visits the PAMS with his/her own PWS with customised selections of software and tools in their GUI.

3. PD_A is the organiser of the PAMS. The organiser and the attendees see each other's avatar in the PAMS. The initial location and scale are set to the registered value. All the MS attendees including the organiser sees the model inside the MS. The organiser is the driver of the MS, and if he/she wishes, he/she can switch the host.

4. During the meeting, PD_A presents an overall project view and goes through the specific change. At the end of the meeting, he assigns tasks for each project member. PD_MEP is assigned with the task of reviewing the change and proposing alternative solutions.

5. PD_A closes the PAMS and the assigned tasks are distributed and appear in the PrismArch dashboard.

Task A.MEP.2: Lead Designer_MEP working on an assigned task relating to proposed change in his Personal Work Space.

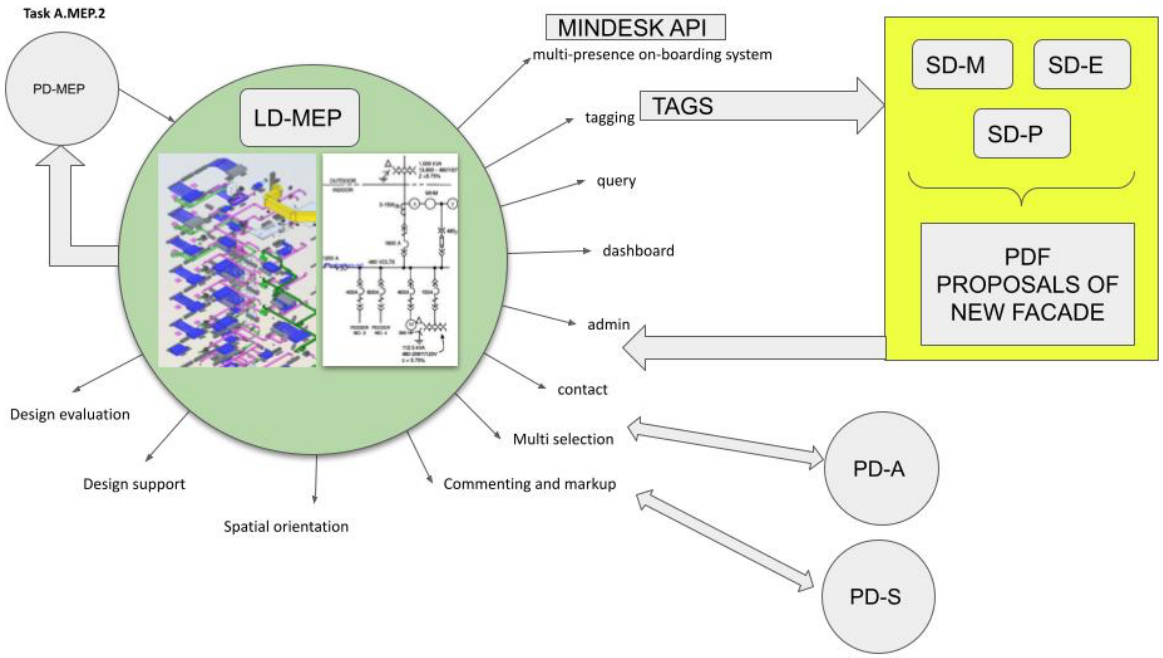


Figure 29: Sweco,Graphical representation of Task A.MEP.2, Lead Designer working on an assigned task relating to proposed change in his PWS.

6. PD_MEP arranges an internal meeting to present the overall project view and goes through the project information and changes. At the end of the meeting, he assigns tasks for each project member. LD_MEP is responsible for site investigation and developing a report detailing the impact of the changes. SD_M, SD_E, SD_P is responsible for developing conceptual single line schematics for services.

7. LD_MEP is assigned a site investigation task by PD_MEP. He is already wearing his headset and working in his PWS. He is looking at his forked PAAs loaded at the PACM. He reviews the 3D model with the proposed change and the translated local regulations. His plan is to adjust the existing Facade and thermade model to suit new changes and advise PD_A and PD_S of impacts. Alongside that, plan is to review conceptual single line schematics for all the services to advise PD_A and PD_S for plant room and riser sizes.

8. In the GUI at his PWS, LD_MEP has the Mindesk API and PrismArch default tools installed (multi-presence on-boarding system, tagging, query, dashboard, admin, contact, multi selection, commenting and markup, punch list, spatial orientation and design support and evaluation tools).

9. Using the tools, LD_MEP starts to markup ideas on the 3d model loaded at the PACM. Everytime he leaves an object, a new tag is assigned with timestamps with his name, project role, content categories, PAPS ID and SL classification. He selects multiple markups and objects he added and assigns a new PAST.

10. SD_AM, SD_E, SD_P produces a quick hand sketch and calculation showing various options of services distribution within the building. SD's scans their drawings to PDF and uploads the PDF to the PAS. Doing so automatically creates a tag for this new PAA.

11. LD_MEP reviews the scanned PDF produced by SD's. He also uploads a report with details of facade and thermal analysis assisting PD_A to develop proportions of wall and glazing to PAS.

12. Now LD_MEP would like to report the work progress to PD_MEP. He filters his last 3 hours worth work using the query tool and assigns a PAST. He names it 'PD_MEP_SiteModel_Review_v1'. The content is SL1 rated assets. He organises a PAMS and enters the meeting title, purpose, time, location, scale, MS size and attendees. He only invites PD_MEP for this internal review.

13. LD_MEP and PD_MEP meet in the arranged PAMS. LD_MEP & SD's SL2-rated site investigation assets and sketches are reviewed by PD_MEP.

14. PD_MEP approves the SL2 content created by LD_S, and these assets are upgraded to SL3. PD_MEP, LD_MEP's tasks are resolved and disappear from the PrimArch dashboard.

Situation B: Updates based on plinth raised

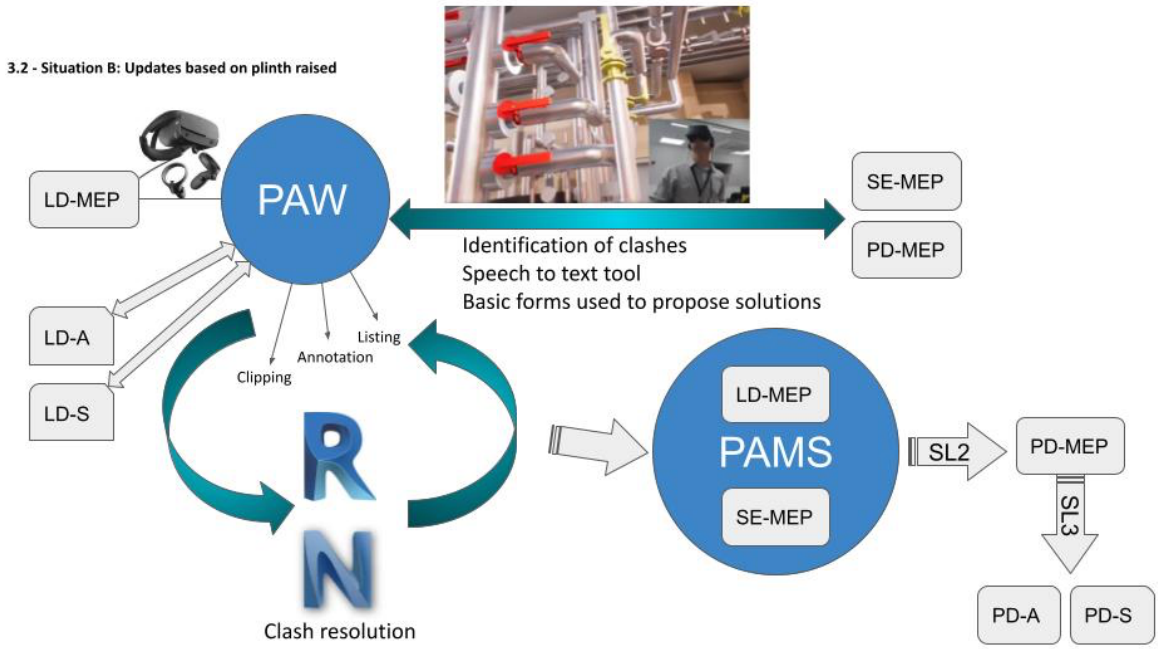


Figure 30: Sweco, Graphical representation of Situation B: Updates based on plinth raised workflow.

LD_MEP receives a notification of models changed by the LD_S and LD_A and reads the metadata.. The toggle camera tool contains relevant views highlighting the rises and changes in A and S services.. LD_MEP starts to investigate the model and identify potential clashes.

1. LD_MEP wears his headset and logs in the PWS. LD_MEP links the LD_A and LD_S models into his PWS and uses the camera toggle tool to quickly navigate to the relevant position and perform a visual check.

2. LD_MEP identifies clashes within the model due to the rise based on his visual inspection. To rapidly inform SE_MEP and PD_MEP the LD_MEP uses the speech to text tool to quickly brief the notification received and the actions taken up to this point. The file is distributed to PD_MEP and SE_MEP for information.

3. LD_MEP uses the Listing tool to describe the to-do actions regarding coordination and distributes to SE_MEP.

4. LD_MEP uses the Annotation tool to describe potential changes to services, specify distances, maintenance zones or voids.

5. LD_MEP uses the Clipping Tool in combination with the Camera Toggle View tool to highlight clashes and uses basic modeling forms when needed such as boxes and cylinders to propose alternative routes/ solutions.

6 LD_MEP through Mindesk/Speckle sends the updated model in Revit and Navisworks to perform in depth clash detection and resolution.

7 LD_MEP logs off the PWS and opens Revit and Navisworks. Clash detection and resolution are progressed to a point where the LD_MEP does not need feedback from SE_MEP. The clash detection report is loaded in PAPS to be presented in a future MS. Through Mindesk/ Speckle the file is updated in the PWS under a temporary revision (e.g. P01.01 based on ISO19650) until it gets approved (P.01).

8. After performing these actions, LD_MEP sets a PAMS and invites SE_MEP at a designated time and date to discuss the clashes caused by the other consultants' updates that cannot be resolved without the SE_MEP input.

9 SE_MEP and LD_MEP log in their PWS and join the PAMS. LD_MEP loads the models and discusses the issues. They both use the loaded tools to resolve the rest of the clashes.They log out of the session.

10 SE_MEP logs in the PWS and arranges a PAMS with PD_MEP to provide information about the changes. SE_MEP sends an invitation to PD_MEP for a designated date and time.

11 Both log in to their PWS under the arranged PAMS and they discuss the clashes and resolution. PD_MEP agrees and approves the actions. SE_MEP sends an approval note to LD_MEP. They both log out of the session

12 LD_MEP actions the agreed changes in Revit, the updated model is uploaded and assigned SL2 status. LD_MEP assigns the task to PD_MEP to review and approve the updated model. PD_MEP reviews the updated model and assigns SL3 status. SL3 model is issued to PAPS for Review and Approval by the rest of the appointed parties.

13 LD_MEP informs LD_S and LD_A for the update and any requests to be actioned by them such as BW holes, ceiling or wall transformations or increase/ decrease voids. These changes should be resolved in a future MS organised by LD_MEP.

Chapter 3: Commercial Project User Scenario 2 (multidisciplinary operations)

In this chapter, each discipline looks into cross disciplinary usage scenarios for a commercial project explored in the deliverable D1.1. Each user scenario proposed by individual discipline includes several situations and its related tasks at a selected architectural project phase.

We focus on two types of demonstration actions in this chapter. First demonstration action type is a permanent increase in an asset access level to review and evaluate cross disciplinary and co-authored project content. These assets are to be reviewed and approved by the clients, project managers, quantity surveyors and contractors. The second action type is an exceptional scenario of where the assets are approved and contractually agreed with the clients, however, some changes are introduced after the assets are being submitted. This requires a permanent freeze of the asset and a replacement asset is to be submitted after serious coordinations with the surrounding project assets. Throughout the usage scenarios, we followed the Sphereing Level (SL) concept introduced in chapter 1. The objective of this chapter is to outline how end users review and evaluate cross disciplinary project information, data and produced design objects inside the PrismArch Project Sphere (PAPS).

Keywords:
Project administration/ access privilege/ private/ public/ asset coordination/ co-authoring/ instances/ archivable/ project history

"- Something that also did help us a lot in understanding [...] the way the connections come together is - once that we did have the very detailed 3d model that was shared between all of us"

From an interview conducted by ETH with a ZHA staff (PrismArch Deliverable 3.1, p.37)

3.1 Architectural Discipline

FIGURE 31: Image copyright Zaha Hadid Architects, Photographs taken during installation of GRC panels, One Thousand Museum project.

To ensure clarity, the following abbreviations are used to identify the Architectural project participants' roles.

Abbreviation	Role
PD_A	Project Director_Architecture
LD_A	Lead Designer_ Architecture
SD_A	Senior Designer_Architecture

Situation A: Incidents at the Design Development Stage - Unforeseen Change Requiring Revisions of Approved Building Design

The planning application is submitted and approved. The project is now in the Design Development Stage (DD). All disciplines have SL4 assets loaded at the PACM.

"*1 month later, changes in local regulations are introduced and this requires the ground floor level to be moved to +10. A plinth has to be designed to negotiate between the existing grade and the ground floor. Further coordinations are required with all disciplines.*"
(PrismArch Deliverable 1.1, p.78)

Task A.ARCH.1: Adjusting the current design to a change in building regulations

1. LD_A is inside her PWS. She has SL4 rated design objects relating to the project site and floors loaded at the PACM. LD_A shared the sphere compound of project assets with D_SE and D_MEP two months ago, and since then, these are used as a base model for some of the cross disciplinary authored project assets inside a PAPS. Local regulations relating project data, information and metadata are already assigned to the loaded and shared assets, however, some of the information needs to be adjusted due to a change in building regulations.

2. LD_A is assigned a 'top priority' flagged task to implement the new building regulation information to some of the project assets to redesign several aspects of the project design objects. She now needs access to the specific sphere compound and asks one of the PAAS registered project administrators to lock and archive the sphere compound.

3. The approved request leaves notification tags to all project assets that are linked to the content of the sphere compound. When D_SE and D_MEP highlight any project assets within the SL3 sphere compound with the notification tag, it tells them that the project assets are currently in the process of archiving and to be replaced with newly created assets by LD_A. The archived and frozen project assets with the old building regulations are greyed out at the PACM from D_SE and D_MEP's view modes. In the LD_A's view mode, the sphere compound project assets are cleared out and she has a part of the PACM as a clean canvas.

4. LD_A is now ready to start working on top of the clean model loaded at the PACM. She first moves the minimum ground level to +10". She selects and moves the ground floor assets using the multi selection tool and a Mindesk functionality to move the floor level by 10".

5. While she moves the floor plane, the site constraint asset (collisions) designed 6 months ago gives her a warning that she is out of the project design region. She understands this because when she hits the collision, the collision becomes visible and its materials blink in red. From the iteration, she understands that the level 8 and 9 require more height. 1" or 2" needs to be removed from a series of levels and these need to be redistributed to the podium levels.

6. LD_A finishes adjusting floor levels. PD_A asks her to share her work with D_SE and D_MEP for a cross disciplinary review to check if the updates are SL3 equivalent project data and information. After a few cross disciplinary discussions in arranged meeting spheres, PD_SE and PD_MEP approve the assets.

7. LD_A requests one of the PAAS registered project admins to upgrade the SL2 rated assets to SL3. Her task to re-investigate the project assets affected by the change of building regulations is resolved now. At the PACM, the updated project assets are loaded and become visible to all disciplines. D_SE is ready to proceed with further investigations in structural analysis of the updated design objects, D_MEP is ready to proceed with studying clash detections further using the shared assets.

8. A week later, all project members receive a SL4 rated notification and email from the PD_A. The message says that 'the client requested to redesign the facade'. The new request introduces further evaluations in the exoskeleton model and adjustments with glazing lines on all section drawings.

Task A.ARCH.2: Redesigning the existing façade design

9. A few weeks later, the client requests the project team to propose a new feasibility plan; the cost difference from the original facade design components.

10. The D_A prepares for three new facade options and the options now require further evaluations from a technical point of view. PA_D assigns a task to SD_A to prepare for a CDMS to present their current design options - as of SL2 to SL3 asset upgrade process.

11. SD_A curates a few cutaway models because he would like to discuss the GRC panel joints with the D_SE (Figure 32). He navigates himself to a 1:20 distance from the PACM and sets the view mode to an axonometric view. With the lasso-like selection and clipping tool (Figure 7.3), he creates three different types of cutaway models. For each version, with the sphereing tool he creates a sphere compound of the design objects he would like to present, then assigns a tag 'D_SE_meeting_CutawayModel_v1'. For the other two design objects he added tags 'D_SE_meeting_CutawayModel_v2' and 'D_SE_meeting_CutawayModel_v3', respectively.

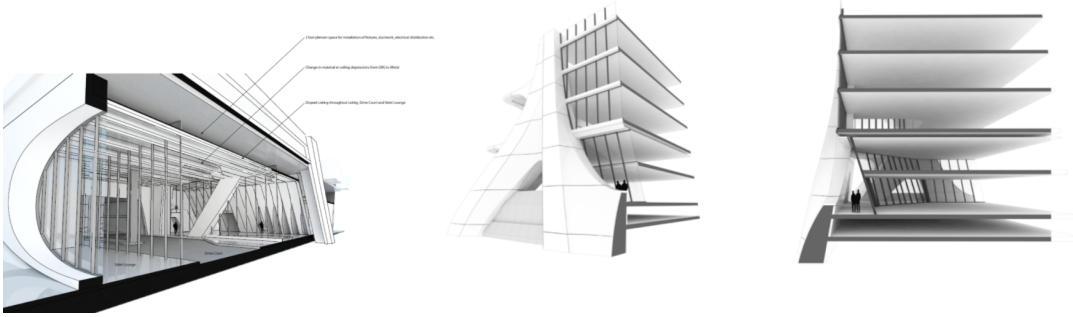


Figure 32: Image copyright Zaha Hadid Architects, Example of Cutaway models, One Thousand Museum, 2018-19.

'We would supply to the facade engineer with … both 2d and 3d drawings'

'they take the rhino model'

'chop it into … where they would have their joint lines - how big that panels can be [32:36] … ten, eleven feet '

'then they release packaging information'

which is described as a 'pack of 2d drawings which they then generated from their model or from the model they [have] taken from us'

'and we check'

'any instances which we feel that would be [?]'

'it was a two-stage process … combined process'

'looking at the aesthetics'

'but also - assisting with the detailing some of these features of - '

'it is their detailing … how those panels fit together'

'we could, say, propose alternatives … cleaner details … less joints, that kind of thing'

(PrismArch Deliverable 3.1, p.35)

12. SD_A then curates three plinths at his preferred world coordinate. The plinths are authored and owned by D_A. These are SL4 rated assets with special visibility only permission. Other PA members can only see and interact with the assets but cannot load the assets at their arranged MS. SD_A sets each plinth's origin location as the pivot location for each design option.

13. Now he spawns three instances of QUI at each plinth location. Each instance of QUI is equivalent to a tab on a browser. Inside each instanced QUI, he searched the tag name
'D_SE_meeting_CutawayModel_v1',
'D_SE_meeting_CutawayModel_v2', and
'D_SE_meeting_CutawayModel_v3'

    to load the scaled cutaway models at the QUI Central Model (QUICM). He alights the QUI instances next to each other to compare the joint options.

14. By spawning the instance QUI at the same world coordinate, these can also work as a three dimensional layer (i.e SD_A makes only slabs visible in the D_SE_meeting_CutawayModel_v1, and only facade structure visible in the D_SE_meeting_CutawayModel_v2)

15. Depending on the number of project assets querying, it may take some time to load the content inside each instanced QUI. He checks the clock on the task bar in his PUI and it is 6pm. He decides to let the querying process load overnight.

    (Alternatively, SD_A downloads the sphere compound as a fbx. The PAST meta data is assigned to the asset root. SD_A imports the downloaded asset at the plinth's location.)

16. Next day, SD_A sees the three cutaway models loaded on each plinth. He adds an annotation for each plinth describing the main topic to discuss with D_SE. With the sphereing tool, he draws a sphere compound to include the three plinths and the QUI load results and assign a tag 'D_A_SE_meeting assets'. The world coordinate of the sphere compound with the meeting title becomes filterble as soon as he confirms the sphere compound selection.

17. From the contact list in his PUI dashboard, he selects attendees in different CWS (CWS_SE and CWS_MEP) and shares the 'D_A_SE_meeting assets' with an arranged time and date.

18. D_SE and D_MEP visit the meeting sphere location and rotation at an arranged date and time by accessing the shared invitation/ spatial hyperlink. SD_A is the host and the organiser of the meeting sphere and he presents the three cutaway models filtered with QUI with a customised presentation space.

19. SD_A has a few questions to SD_E, to answer the question, SD_A hides some of unrelated design objects using each instanced QUI. D_SE and SD_A make sketches on top of the QUI. The meeting sphere host is the driver of the navigation. D_SE asks SD_A to zoom in the instance QUI so that the content is shown on a larger scale. The sketches made on top are attached to the QUICM so as SD_A zooms in the content, the sketches appear to be larger, too.

20. After a few meetings like above, the project team ends up with two design options with feasibility calculation that is ready to share with the client (SL3 rated assets).

21. LD_A is at her PWS and loads an instance of the assets collected from D_SE and D_ME at the PACM. The information includes analysis data to report their simulation results. D_SE discipline specific data is such as structural data including material properties, maximum permissible loading, max module sizes due to transportation or fabrication constraints - and general properties of the facade systems such as overall fire rating, or material reuse/ recyclability rates. Where relevant, specification documents from manufacturers regarding the material and construction system are appended to the facade elements. D_MEP specific data can be noise level, glare index and daylight factor.

22. SD_A then filters and merges the internal discipline-specific project assets to present and report the total project development inside the D_A designed presentation sphere. These project assets are SL3 rated project assets with special visibility access for the clients, project manager and quantity surveyor.

23. This time the meeting is a client presentation and photo-realistic materials are loaded to the carefully merged and curated assets. He loads a D_A authored and owned branded meeting room asset with plinths and dedicated lighting scenes. He loads poster frames to present drawings and diagrams with curated cutaway models. He also prepares for sphere references for polished cutaway models with annotations to navigate the arranged MS in the presentation.

3.2 Structural Engineering Discipline

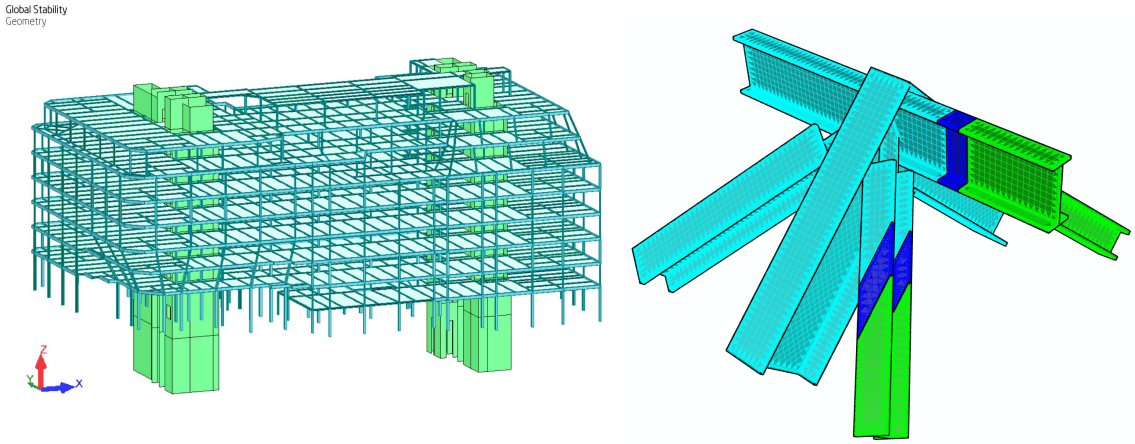
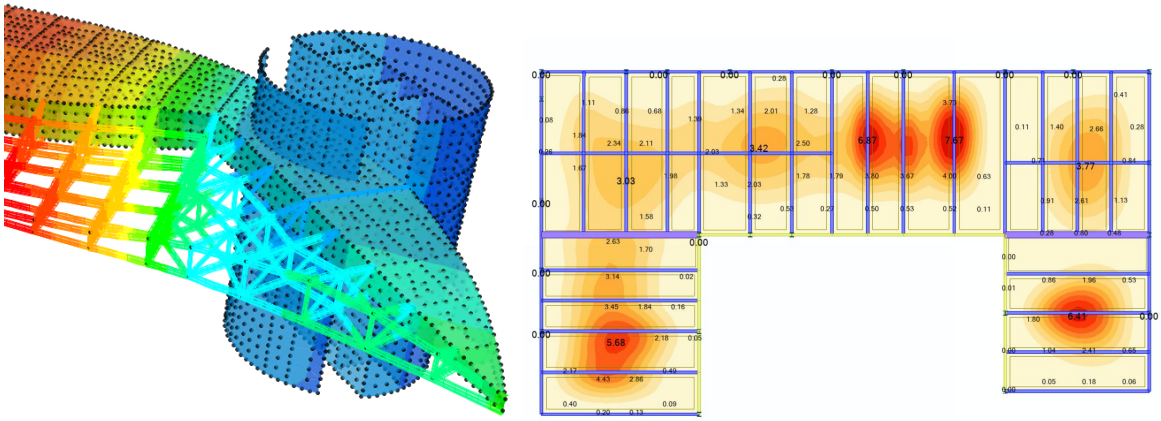


Figure 33.1: Left: AKT II, Example of input geometry for a global FEA model.
Figure 33.2: Right: Example of input geometry for a localised connection analysis model.



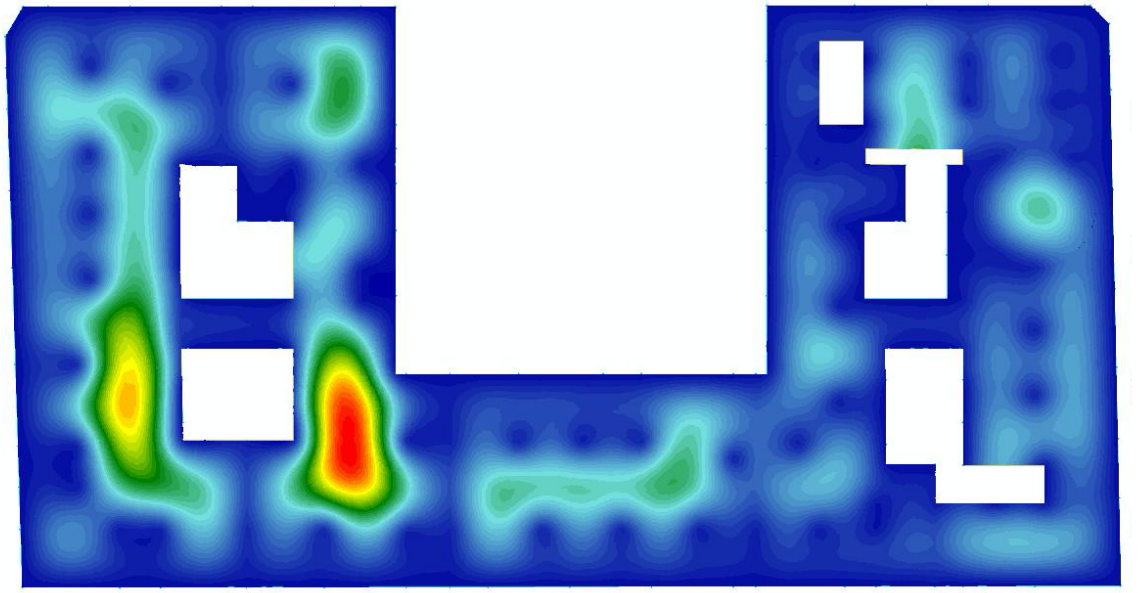


Figure 33.3: AKT II, Examples of visual results from the analysis: false-coloured models denoting values such as deflections, utilisation, loadings.

To ensure clarity, the following abbreviations are used to identify the Structural project participants' roles.

Abbreviation	Role
PD_S	Project Director - Structural
LD_S	Lead Designer - Structural
SE_S	Senior Engineer - Structural

Situation A: an incident at the Design Development Stage

The PD_S attends an arranged PrismArch Meeting Sphere, reviews Shared PrismArch Assets and acknowledges that due to a change in local regulations the ground floor level of the developments needs to be changed.

"1 month later, changes in local regulations are introduced and this requires the ground floor level to be moved to +10. A plinth has to be designed to negotiate between the existing grade and the ground floor. Further coordinations are required with all disciplines." D1.1 p.78

Task A.S.1: Joining an arranged PrismArch Meeting Sphere and reviewing Shared PrismArch Assets

1. Each attendee receives an invitation to the arranged PAMS. Once the invitation is accepted the incident is automatically added to their calendars.

2. Each attendee joins the arranged PAMS by visiting the arranged location, scale at the arranged time. He/she visits the PAMS with his/her own PWS with customised selections of software and tools in their GUI.

3. PD_A is the organiser of the PAMS. The organiser and the attendees see each other's avatar in the PAMS. The initial location and scale are set to the registered value. All the MS attendees including the organiser sees the model inside the MS. The organiser is the driver of the MS, and if he/she wishes, he/she can switch the host.

4. During the meeting, PD_A presents an overall project view and goes through the specific change. At the end of the meeting, he assigns tasks for each project member. PD_S is assigned with the task of reviewing the change and proposing alternative solutions.

5. PD_A closes the PAMS and the assigned tasks are distributed and appear in the PrismArch dashboard.

Task A.Struct.2: Lead Designer_Structure working on an assigned task relating to proposed change in his Personal Work Space.

6. LD_S is assigned a site investigation task by PD_S. He is already wearing his headset and working in his PWS. He is looking at his forked PAAs loaded at the PACM. He reviews the 3D model with the proposed change and the translated local regulations. His plan is to sketch an alternative proposal with a plinth designed to negotiate between the existing grade and the ground floor.

7. In the GUI at his PWS, LD_S has the Mindesk API and PrismArch default tools installed (multi-presence on-boarding system, tagging, query, dashboard, admin, contact, multi selection, commenting and markup, punch list, spatial orientation and design support and evaluation tools).

8. Using the tools, LD_S starts to markup plinth on top of the 3D model loaded at the PACM. He has done so by placing surfaces using the Mindesk tool. Everytime he leaves an object, a new tag is assigned with timestamps with his name, project role, content categories, PAPS ID and SL classification. He selects multiple surfaces she just added and assigns a new PAST.

9. Moving this plinth creates a change in the connecting columns. They are now different lengths to the previous iterations, and so the SE_S must reconsider the optimum material and construction system for them. This is only early stage development, so the SE_S produces a quick hand sketch and calcs showing two different options for the column. The SE_S scans this drawing to PDF, and uploads the PDF to the PAS. Doing so automatically creates a tag for this new PAA.

9. Now LD_S would like to report the work progress to PD_S. He filters his last 4 hours worth work using the query tool and assigns a PAST. He names it 'PD_S_SiteModel_Review_v1'. The content is SL2 rated assets. He organises a PAMS and enters the meeting title, purpose, time, location, scale, MS size and attendees. He only invites PD_S for this internal review.

10. LD_S and PD_S meet in the arranged PAMS. LD_S's SL2-rated site investigation assets and sketches are reviewed by PD_S. PD_S reviews the hand sketched column designs by LD_S, and decides on one preferred scheme. However, PD_S decides that to be certain about the structural performance of the columns, they require a digital FEA model of the building. PD_S writes a comment on this subject and assigns a task to LD_S, and appends both to the sketch.

Task A.Struct.3: Lead Designer_Structure creates a basic structural model in their Personal Work Space.

11. LD_S makes a copy of the current architectural 3D model. In this new model, they create an abstracted global FEA model of the building: manually building mesh and line elements that represent columns, beams, walls and floor slabs. LD_S assigns a new PAST and names it 'StructuralModel_v1_GeomInputs'. This new model is assigned SL2, and saved inside the PAW. Please see PrismArch_D3.1, "Sphereing and GIT" (p.49) for more detail on how this is done.

12. Using a software connector, LD_S exports this geometric model to a structural analysis package. Inside this package, LD_S applies cross sections, materials, supports, loads and load cases to create a complete FEA model. LD_S assigns a new PAST and names it 'StructuralModel_v1_FEAinputs'. This new model is assigned SL2, and saved inside the PAW.

13. LD_S runs a structural analysis on the FEA model. The results are directly exported to a PA-compatible data file, and uploaded into the PAW. LD_S assigns a new PAST and names it 'StructuralModel_v1_Outputs'. This new model is assigned SL2, and saved inside the PAW. LD_S creates a PAMS to discuss the results with PD_S.

14. PD_S and LD_S meet in the arranged PAMS. The results from the structural analysis are presented as a series of structural stick models, with various structural analysis datasets (deflection, utilisation, max force, etc) overlaid on them via colour-coding and labelling. PD_S reviews the model and is happy with the chosen design variant.

15. The structural engineer must now present their preferred engineering solution to the other Architectural and MEP partners, as the changes size of these columns will affect the architectural room layout, and this in turn could affect the MEP layouts. PD_S approves all of the SL2 content created by LD_S, and upgrades these assets to SL3.

16. PD_S organises a PAMS and invites PD_A and PD_MEP as attendees. Having reviewed the updated column sizings, the other two parties are in agreement. The outstanding tasks by PD_S and LD_S are resolved and disappear from their PrimArch dashboards.

Situation B: an incident at the Construction Stage

The PD_S attends an arranged PrismArch Meeting Sphere and reviewing Shared PrismArch Assets and acknowledges that having worked to optimise the geometry for a more commonplace cast-in-situ concrete formwork solution, there was a change of directive: one of the main financial backers made a strong case for accepting the risk, and it was decided to proceed with the innovative GFRC precast formwork for the building..

Task B.Struct.1: Joining an arranged PrismArch Meeting Sphere and reviewing Shared PrismArch Assets

1. Each attendee receives an invitation to the arranged PAMS. Once the invitation is accepted the incident is automatically added to their calendars.

2. Each attendee joins the arranged PAMS by visiting the arranged location, scale at the arranged time. He/she visits the PAMS with his/her own PWS with customised selections of software and tools in their GUI.

3. PD_A is the organiser of the PAMS. The organiser and the attendees see each other's avatar in the PAMS. The initial location and scale are set to the registered value. All the MS attendees including the organiser sees the model inside the MS. The organiser is the driver of the MS, and if he/she wishes, he/she can switch the host.

4. During the meeting, PD_A presents an overall project view and goes through the specific change. At the end of the meeting, he assigns tasks for each project member. PD_S is assigned with the task of reviewing the change and proposing alternative solutions.

5. PD_A closes the PAMS and the assigned tasks are distributed and appear in the PrismArch dashboard.

Task B.Struct.2: Lead Designer_Structure working on an assigned task relating to proposed change in his Personal Work Space

6. LD_S is assigned a contractor's change task by PD_S. He is already wearing his headset and working in his PWS. He is looking at his forked PAAs loaded at the PACM. He reviews the 3D model with the proposed change and the subsequent facade contractors comments on the construction sequence. His task requires re-checking the columns against the change in construction methodology and review the typical and non typical details.

7. In the GUI at his PWS, LD_S has the Mindesk API and PrismArch default tools installed (multi-presence on-boarding system, tagging, query, dashboard, admin, contact, multi selection, commenting and markup, punch list, spatial orientation and design support and evaluation tools).

Task B.Struct.3: Lead Designer_Structure updates the structural model in their Personal Work Space

8. LD_S makes a copy of the current architectural 3D model. In this new model, they update the abstracted global FEA model of the building:updating the lines and the meshes that represent the new column system.. LD_S assigns a new PAST and names it 'StructuralModel_vxx_Updated beams GRC'. This new model is assigned SL1, and saved inside the PAW. Please see PrismArch_D3.1, "Sphereing and GIT" (p.49) for more detail.

9. Using a software connector, LD_S exports this geometric model to a structural analysis package. Inside this package, LD_S applies cross sections, materials, supports, loads and load cases to create a complete FEA model. LD_S assigns a new PAST and names it 'StructuralModel_v1_FEAinputs'. This new model is assigned SL2, and saved inside the PAW.

10. LD_S runs a structural analysis on the FEA model. The results are directly exported to a PA-compatible data file, and uploaded into the PAW. LD_S assigns a new PAST and names it 'StructuralModel_vxx_Outputs'. This new model is assigned SL2, and saved inside the PAW. LD_S creates a PAMS to discuss the results with PD_S.

11. PD_S and LD_S meet in the arranged PAMS. The results from the structural analysis are presented as a series of structural stick models, with various structural analysis datasets (deflection, utilisation, max force, etc) overlaid on them via colour-coding and labelling. PD_S reviews the model and is happy with the chosen design variant. They approve all of the SL2 content created by LD_S, and these assets are upgraded to SL3. LD_S's tasks are resolved and disappear from the PrimArch dashboard.

12. Changing the columns construction system propagates a change in the rebar detailing. SE_S updates the details in the production model and the changes to the PAS. Doing so automatically creates a tag for this new PAA.

13. Now LD_S would like to report the work progress to PD_S. He filters his last 4 hours worth work using the query tool and assigns a PAST. He names it 'PD_S_SiteModel_Review_vxx'. The content is SL2 rated assets. He organises a PAMS and enters the meeting title, purpose, time, location, scale, MS size and attendees. He only invites PD_S for this internal review.

14.. LD_S and PD_S meet in the arranged PAMS. LD_S's SL2-rated site investigation assets and sketch are reviewed by PD_S. PD_S reviews the changes LD_S, and approves the scheme.

3.3: MEP Engineering Discipline

To ensure clarity, the following abbreviations are used to identify the MEP project participants' roles.

Abbreviation	Role
PD_MEP	Project Director
LD_MEP	BIM Manager/ Project Coordinator
SE_M, E, and P	Senior Engineer (Mechanical, Electrical & Public Health Engineers respectively)

Table 3.3.1 Commercial project Situation A & B MEP project participants

Situation A: Clash analysis based on the changes described in Chapter 3.1

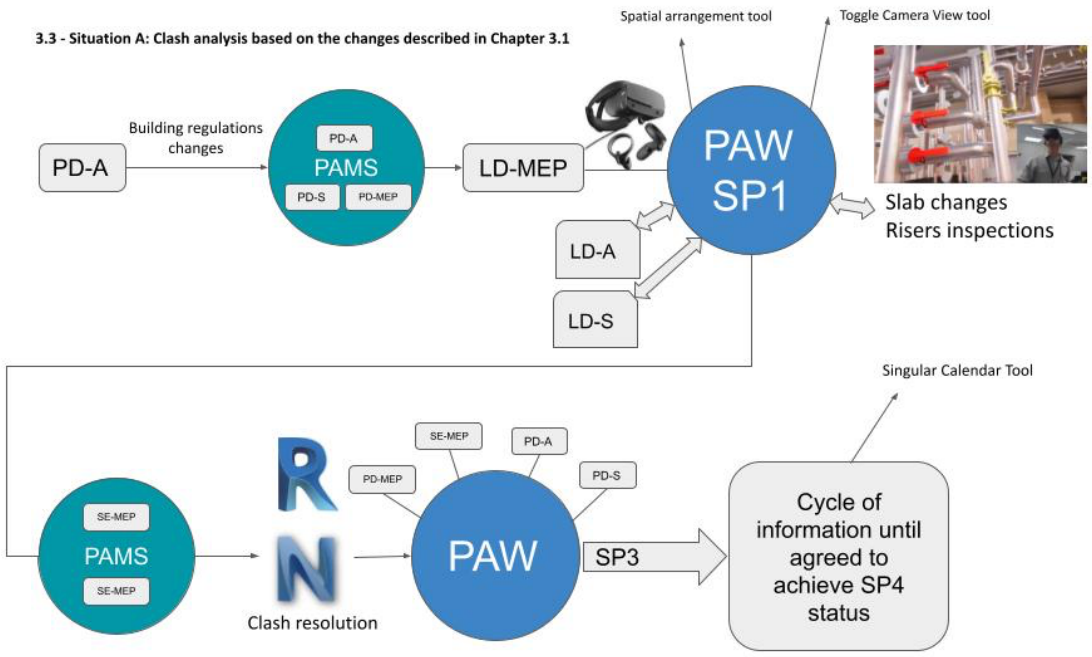


Figure 34: Sweco, Graphical representation of Situation A: Clash analysis based on the changes described in Chapter 3.1 workflow.

1. A notification email about the building regulation changes and the chain reaction these have to the project is received by PD_A. A meeting is held between PD_A, PD_S and PD_MEP to discuss the situation and agree on actions. PD_MEP requests the updated models from PD_A and PD_S. PD_MEP then informs the LD_MEP about the changes

2. LD_MEP wears the headset and logs in to PAW. After the PAPS is accessed then a new WIP revision of the model is created to reflect the latest changes. The model returns to PS1.

3. LD_MEP receives the notification of the newly linked files and loads them in PWS with the MEP project file. LD_MEP performs a visual inspection and uses the Annotation tool to highlight instant major conflicts and isolates the views with the Toggle View tool

4. LD_MEP performs a visual inspection in the basement area. LD_MEP evaluates the incidents affected by the change in the slabs and ceilings. Initially a walk through the plant rooms will give a better understanding of the high level services affected. This may include change of services routes, rising or lowering services and coordination of MEP disciplines. This should also include changes to BW holes for services such as drainage, both horizontally and vertically (in high level)

4. LD_MEP inspects the risers and identifies any changes in the risers transformations, sizing, and maintenance voids. By performing visual inspection and within the VR environment LD_MEP understands better the spatial arrangement and recognises any needs for amendments. LD_MEP uses the spatial arrangement tool to highlight any potential changes.

5. LD_MEP inspects the corridors' services and ceilings in the rest of the areas affected. LD_MEP uses the Annotation tool to provide information on changes, Speech to text to quickly take notes and the Spatial Arrangement tool to highlight potential spaces needed throughout the coordination exercise. Throughout the coordination and clash investigation, several views are taken by using the Toggle Camera Tool to aid the navigation process in future meetings and push this data as Viewpoints in Navisworks.

6. LD_MEP publishes this data to SE_MEP and arranges a PAMS with SE_MEP to discuss solutions. The model receives a status of SP2 under the same WIP revision.

7. SE_MEP logs into the PAMS with LD_MEP and start investigating the model. All issues raised by LD_MEP are discussed. LD_MEP pushes data back from PASP through Mindesk/Speckle to Revit and Navisworks. They both log out of the session.

8. LD_MEP performs a clash detection in Navisworks and resolves clashes in Revit. Navisworks' saved viewpoints of clashes are pushed back through Mindesk/Speckle in PAPS and are monitored by the Toggle Camera View tool. Some of the clashes need input from PD_A and PD_S such as ceiling drops and raises, BW holes adjustments, bulkhead positions etc. LD_MEP logs in his PWS and sets up a PAMS with PD_MEP, SE_MEP, PD_A and PD_S to discuss the issues. LD_MEP logs out of the session.

9. PD_MEP, SE_MEP, PD_A, PD_S and LD_MEP wear their headsets and log in PAPS. They are then joining the PAMS and navigate around the model discussing and resolving the issues. To keep track of the agreements, a combination of speech to text, annotation, listing and the rest of the tools are used where appropriate. After the end of the meeting, the data is distributed to PD_A, PD_S and PD_MEP.

10. LD_MEP performs all necessary actions and issues the model in PASP changing the revision from WIP (e.g. P.01.03) under the formal revision (e.g. P.02) for comment and review (based on BS EN ISO 19650).

12. Status SP3 will be achieved upon agreement of the resolution of all issues

11. A cycle of the above process is performed until the project is agreed to be released as SP4 to the client. For lessons learned the singular calendar tool is used to better understand the timeframes needed to perform these actions and where the bottlenecks happened. This will allow for future time waste to be avoided.

Situation B: Uniclass data addition

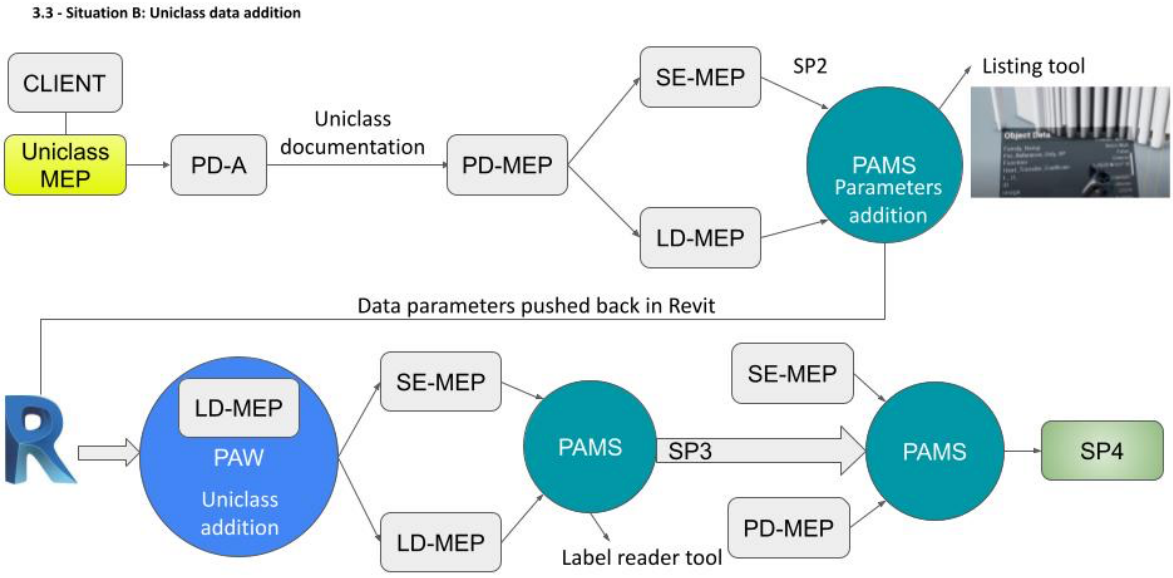


Figure 35: Sweco, Graphical representation of Situation B: Uniclass data addition workflow.

Situation: Before the project was released as SP4 the client sends an instruction to add Uniclass Data in Electrical, Mechanical and Public Health assets.

1. PD_MEP receives a request from PD_A about the addition of Uniclass Data of MEP assets. PD_MEP requires relevant documentation from the client about the details of the data addition.

2. PD_MEP receives updated documentation from client and assesses the data requirements. The information is distributed to SE_MEP and LD_MEP.

3. SE_MEP evaluates areas of data addition, adequate parameters setup and consistency within the services. SE_MEP arranges a PAMS with LD_MEP and sends the meeting invitation. The model receives SP2 status

4. SE_MEP and LD_MEP log in the PAW, access the PAPS and log in the PAMS session. They investigate the elements and evaluate existing data in the model and the required additional data. They use the Listing Tool to write down the data parameters to be added. SE_MEP pushes the data back to the Revit project file. They both then log out of the session.

5. LD_MEP accesses the Revit project files and starts the data addition. After the data is added, the model is loaded in PAW through Mindesk/Speckle. LD_MEP logs in PWS and verifies the data exists and is correct. LD_MEP sends a PAMS to SE_MEP aiming on demonstrating the correct data is added. LD_MEP logs out of the session

6. SE_MEP and LD_MEP wear their headsets and log in PAPS. They access the PAMS and start evaluating the Uniclass data. The Label Reader tool filters the data information and presents it to the participants.

7, SE_MEP approves the Uniclass data addition and requests the status to become SP3. A notification is sent through the Listing Tool to PD_MEP and a PAMS is arranged to discuss the Uniclass data addition between PD_MEP and SE_MEP. They both wear their headsets and log into the session. PD_MEP approves the data and approves the SP4 status.

Summary

Next step:

- Visualising the PrismArch four root classifications using a game engine and review the content inside VR
- Designing User Interface and the platform content considering artistic and ergonomic aspects and visualising them with a game engine and reviewing them inside VR.
- Develop VR prototype of navigation functionalities (spatial hyperlink to review the PACM from multiple scales and camera angles)
- Develop VR prototype of sphereing functionalities (selection, highlight, compound)
- Develop VR prototype of metadata visual and aesthetics (metadata tree growth in ration to project development aspect)
- Develop VR prototype of tagging functionalities (how to enter tag content and assign the tag to a design object)
- Develop VR prototype that complies the above user experience to demonstrate the overall on-boarding system of the platform design

The deliverable D6.1 studies to write a brief and to propose a roadmap for the upcoming VR prototype developments. As a final outcome of WP1, we expect to have a series of VR demonstrations to illustrate the teasers of how the selected functionalities are to be experienced from artistic and ergonomic point of views. These functionalities, user interfaces and user experiences should be professionally accessible from the three basic AEC disciplines namely architects, structural Engineers and Mechanical, Electrical, Public Health Engineers, and these should be customisable and personalisable at internal discipline-specific and cross disciplinary levels and should be able to be utilised for multiple scenarios noted in this report. For the demonstration, users will design inside the PAPS accessing their own propriety, PrismArch default and core functionalities and interact with pre-loaded PrimArch Assets. The prototype development will be conducted collaboratively between the three partners Zaha Hadid Virtual Reality Group, AKT II and Sweco - with technical consultations from the PrismArch consortium.

We would like to emphasize that what is described in this report thoroughly is the ideal and desired PrismArch platform design and its usage scenarios that are collected, agreed and authored by the three main disciplines, architects, structural engineers and MEP engineers. The final results of this research project are subject to technical feasibility analysis within the time-frame and resources of the PrismArch research project.

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