Digital Transformations for
Supporting Next-Generation Labour

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NEXT – Digital Transformations
for Supporting Next-Generation Labour

Deliverable D3.2

NEXT - Collaboration Virtual Platform

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1.4	28.2.2025	Gregor Rozinaj	STUBA	Final review

Deliverable Description

This is a PDF document that presents the description of the NEXT-Collaboration virtual platform as well as the report on a selection of the virtual platform, which is to be a core for creating the NEXT-Collaboration virtual platform, among existing virtual platforms.

1 Introduction

This document describes research and development of NEXT-Collaboration virtual platform which enables immersive hybrid meeting and hybrid education for participants physically present, as well as on-line participants. Individuals and groups of participants can join the meeting on-line. Each participant (present or on-line) has his/her defined personal place. Metaverse-like dynamic digital twin of the physical meeting room with all participants is prepared as an alternative to the physical communication.

This document reflects on the tasks of the NEXT project established in the final agreement.

- **Task T3.2:** The existing virtual reality platforms are to be considered to select one that is to be adapted for the purpose of creating the NEXT-Collaboration virtual platform aimed at satisfying the need of the student's formal/informal learning. The purpose of this virtual platform is to allow students to obtain practical experience in ‘digital’ communication and collaboration.
- **Task T3.4:** Establishment of the pilot NEXT-Laboratory in one of Ukrainian universities (ISKPI) to elaborate the best practices and validate the approach.

2 Hybrid Communication Principles

Hybrid communication represents a new standard for videoconferencing and remote collaboration where communication means are not determined by a single communication platform or technological requirements.

The entire concept is built around the **space of the meeting**, which is the go-to location where all participants, **on-site and online** alike, are present at the same time, being visible among themselves without the technological limitations. Key feature is that each participant, be it a single person or a group of users, has their **physical place** in the space of the meeting.

Diverging from the concept of virtual reality-first platform, the hybrid communication model brings multiple benefits to various general use cases, which we will describe further. In short, we can define different types of meetings and different forms of meeting participation, which serve as the basis for several combinations of on-site and online presence at the meetings and/or lectures.

2.1 Meeting Types

Based on hierarchy in the meeting, we can define two main types of meetings, illustrated in Figure 1:

Round Table Meetings

In this form, all participants are considered **equal** to each other in regard to responsibilities and the strength of voice. **No** distinct **role** or hierarchical model is defined implicitly. Each participant has the right to drive the discussion, ask questions or, generally, influence the conversation and activities at the meeting.

Presentations / Lectures
This form of meeting divides participants to at least two groups based on their activity, namely **active participants** or **presenters**, and **passive participants** or **observers**. Presenters take on the active role of leading the meeting, sharing knowledge and steering the discourse and flow of topics of the meeting. Observers, on the other hand, are mostly the passive recipients of the ideas and themes at the meeting, having limited options to influence the flow of discussion. Obviously, this form of meeting has an implicit hierarchical model with presenters having the leading role and observers taking on the viewer role.

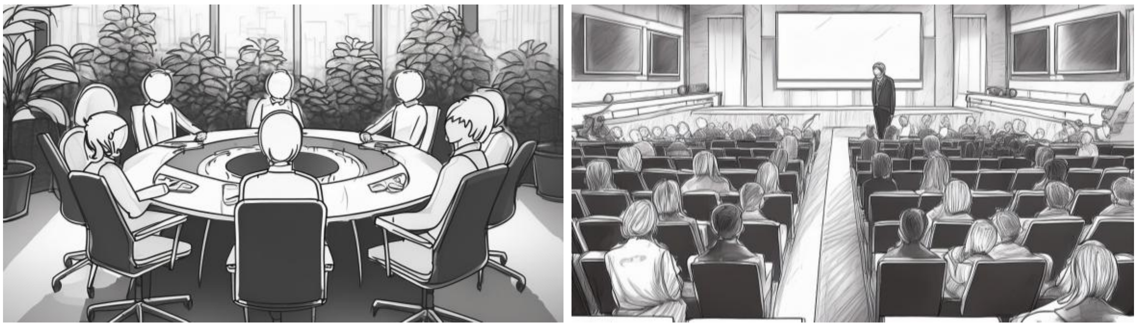

Figure 1: Illustration of the two types of meetings based on hierarchy. Round Table on the left, Lecture on the right. Images generated by generative AI.

2.2 Participant Types

Meeting participants can also be distinguished based on the form of presence at the meeting. We identify the following types of participation:

Local participant is a person that is physically present at the space of the meeting. His/her presence is visible to other participants directly or via the meeting room cameras and microphones. Therefore, there is no inherent need for specific devices the participant is required to be equipped with to join the meeting. The space of the meeting manages everything.

A**n on-line participant** is the well-known type of user who is not physically present at the space of the meeting, rather is he/she connected to the meeting via the webcamera and microphone from a distant location. On-line participant is therefore required to be equipped with the camera and microphone to be visible and audible to the participants present at the meeting in person. He/she is then displayed in the meeting room using a dedicated display.

A **virtual remote participant** is a type of participant, who is not necessarily represented by his/her realistic image captured by his/her camera but is displayed in the form of a virtual **avatar**. There is no explicit requirement that the avatar represents the participant's true physical form – it can be an enhanced, "beautified" rendition of the person, or a different type of figure altogether. However, it is recommended to be represented as realistically as possible to support the realistic nature of the meeting.
Virtual participant is displayed in the meeting room on a physical display like the on-line participant.

Figure 2: Illustration of the three types of participants at the meeting. To the left, there is the local participant. In the center, a physical remote participant, and on the right, imagine a virtual remote participant represented by an avatar. Images created using generative AI.

To further increase the immersive effect, it is recommended that each remote participant has a dedicated display in the space of meeting. This ensures multiple quality traits:

- Remote participants appear at (near) real life size to those who are physically present.
- Each remote participant has a dedicated seat among the participants, making the distance less protruding, and helping the meeting inclusion.

Remote participants are better regarded as being present at the meeting. Both on-site participants and other remote participants can interact among each other in a more natural way, e.g. showing attention by orienting toward the specific remote participant rather than to a mosaic of distant attendees.

2.3 Meeting Room Types

Meetings are preferably held in physical rooms. However, two types of meeting environments are possible. They are either:

- Physical rooms, or
- Virtual rooms.

Physical room is the most common premise to organize a meeting: it gives attendees sense of commonplace, unity and directness. The room may be equipped with TV screens and cameras to provide access for the remote participants (both physical and virtual) to see and be seen at the meeting.

The **virtual room** is a concept of physical meeting room transformed into the virtual reality environment. It also aims at giving the virtual attendees in the virtual room a sense of common area to meet, where the virtual attendee observes the true-to-life copy of the physical meeting room. Virtual rooms are basically only a temporary/auxiliary solution for the meeting, e.g. for the first orientation of the on-line participants before entering the meeting room or observing the meeting room from any place in the room independently from the positions of cameras in the meeting room. This virtual room is a Metaverse-based Dynamic Digital Twin.

Figure 3: Physical room (left) vs. digital twin model of the physical room (right). Note the near photographic quality of the digital twin. Displayed is the Hybrid Communications Laboratory established at STUBA.

2.4 Metaverse-based Dynamic Digital Twin

Photorealistic quality is paramount to achieve life-like experiences. To provide the experience to remote users in a virtual environment, we have investigated the existing virtual communication platforms suitable for incorporation into the NEXT Collaboration Virtual Platform.

2.4.1 Realism in Metaverse Applications

Below in Table 1, we summarize the most notable virtual reality-based communication platforms, which act as the Metaverse environments. The review shows that all platforms focus primarily on the cooperation activities while realism of the environment is pushed back in favour of functionality.

However, multiple studies show that realism in virtual environment plays an important role in multiple aspects:

- They support more impactful and memorable experiences.
- They drive stronger emotional responses.
- They improve the sense of presence and connection to virtual content.
- They help boost overall enjoyment.

All these aspects are crucial for high quality learning experience for distant learners and educators alike. Therefore, our primary focus is the creation of a collaboration platforms which predominantly focuses on the quality of the virtual environment, while supporting key communication features, such as video streaming and video calling in the virtual reality.

The suitable technique which provides photorealistic 3D environment reconstruction based on photogrammetry with performance comparable to industry-standard polygon mesh representation is 3D Gaussian Splatting.

Table 1: Summarization of existing virtual reality communication platforms.

Platform	Avatar Realism	Environment Realism	White-boarding	3D Object Manipulation	Cross-Platform	Custom Spaces	Notable Integrations
Spatial	Photo-based avatars with limited expressions	Stylized, non-photorealistic	Yes	Yes	VR, AR, Web, Mobile	Yes	Google Drive, Microsoft 365, Slack
MeetinVR	Photo-based with facial expressions	Stylized, functional	Yes	Yes	VR, Desktop	Yes	Miro, Microsoft Teams
VIVE Sync	Customizable with eye/face tracking	Functional, non-photorealistic	Yes	Yes	VR, Desktop	Limited	Microsoft 365
Horizon Workrooms	Cartoon-like with hand tracking	Stylized, non-photorealistic	Yes	Limited	Quest headsets, Desktop	Limited	Physical computer integration
AltSpaceVR	Customizable, stylized	Varied, non-photorealistic	Yes	Limited	VR, Desktop	Yes (World Editor)	Microsoft Mesh
Glue	AI-powered "super-expressive"	Animated, non-photorealistic	Yes	Yes	VR, Desktop	Yes (Enterprise)	Google Workspace, Office 365, Miro, MURAL, Jira
The Wild	Stylized	Design-focused, non-photorealistic	Yes	Yes	VR, AR (iOS), Desktop	Yes	SketchUp, Revit, BIM 360
NVIDIA Holodeck	Realistic digital humans	Photorealistic	Limited	Yes	VR	Yes	Autodesk, SOLIDWORKS

2.4.2 3D Gaussian Splatting

Gaussian splatting is an advanced rendering technique that uses Gaussian functions to represent and project point clouds into continuous volumetric representations. In practical terms, each point captured from a camera system is treated as a small, diffuse “splat” with a Gaussian profile. These splats overlap and blend smoothly to form a coherent image, providing a highly accurate and realistic representation of the original scene. This method is particularly valuable for creating digital twins of rooms, as it allows us to transform raw sensor data into detailed and reliable three-dimensional models.

By integrating data from sophisticated camera systems, we can use gaussian splatting to generate a digital copy of a room that faithfully reproduces every nuance of the physical space. The technique not only smooths out noise but also captures subtle variations in texture and lighting, ensuring that the digital twin is as close to reality as possible. This high-fidelity replication is crucial for applications where precision is paramount, whether it’s for virtual walkthroughs, simulation environments, or architectural planning.

A similar approach can be applied to the creation of digital avatars. By representing an individual’s features with overlapping Gaussian distributions, it becomes possible to generate avatars that not only look lifelike but can also be animated smoothly. This methodology allows for realistic deformations and transitions, meaning that the avatars can be made to mimic human expressions and movements accurately. Ultimately, whether we are modelling a room or crafting a digital representation of a person, the use of Gaussian functions through splatting techniques enables us to produce dynamic and believable digital twins that enhance the overall realism of virtual environments.

3 Hybrid Education

Hybrid communication can be successfully used for educational purposes, as well. Hybrid education allows a concatenation of two or more seminar rooms into one hybrid space. Basic scenario is based on a physical lecture room “A” with a capacity of places for participants physically present. This capacity is virtually extended, e.g. on a back wall with monitors or projection, which allow view to a distant lecture room “B” elsewhere (Figure 4). The lecture room B is equipped with a projection from room A on the front wall of the room B. Additional screens and cameras in both rooms can provide virtual teleportation of participants to the other room. The basic functionality of hybrid education can be extended with various features, e.g. two synchronized interactive white boards for interactive collaboration.

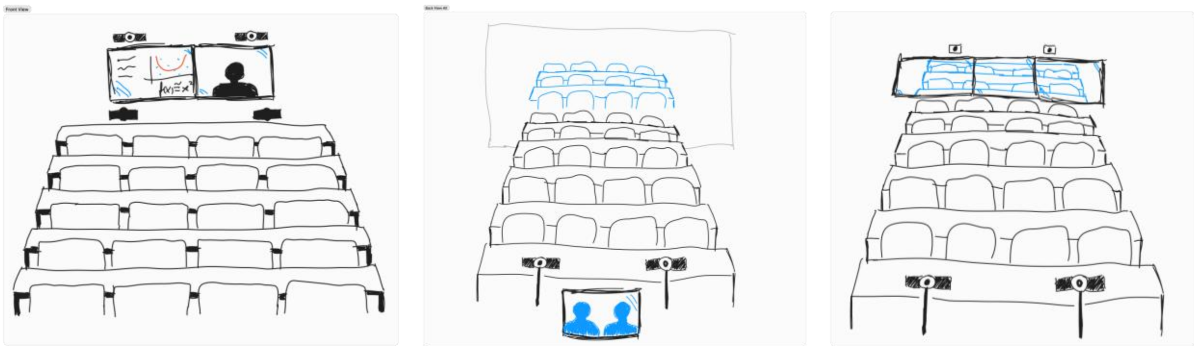

Figure 4: Concept of hybrid education with virtual concatenation of seminar rooms and virtual teleportation to distant seminar room

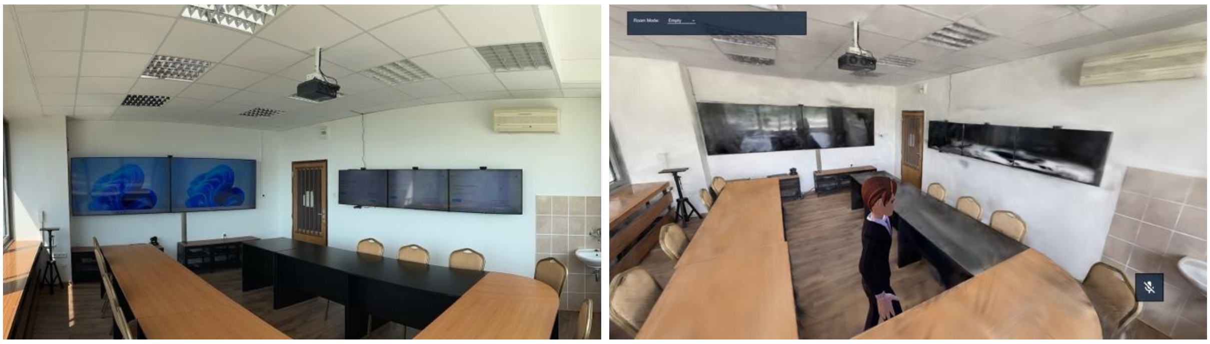

Figure 5: Preview of the real room synchronised with digital twin room. Shown is the left is the real-life meeting room, and, on the right, there is the digital twin of the premise with a virtual avatar present.

4 Building a Hybrid Communication Platform

Hybrid communication platform integrates all involved hybrid laboratories and allows communication within each lab, as well as interconnection of several labs to one virtual environment. Beta web application for creating, monitoring and managing the whole connectivity has been developed. This platform allows to create communications channel between the on-line participant and the meeting room. The platform allows to use several screens and windows on both sides of the system which results in multiscreen communication with several multimedia streams. As the functionality of the proposed system is rather complex and non-trivial, we decided to build our own videoconferencing system where the implementation of desired functions is straightforward. Among the basic functionalities we mention a possibility of several video streams from either different cameras/screens which can be managed individually by each participant. This approach allows all participants to possess their real place in the meeting. On the other hand, they can observe the meeting room from various angles according to the positions of supplementary cameras.

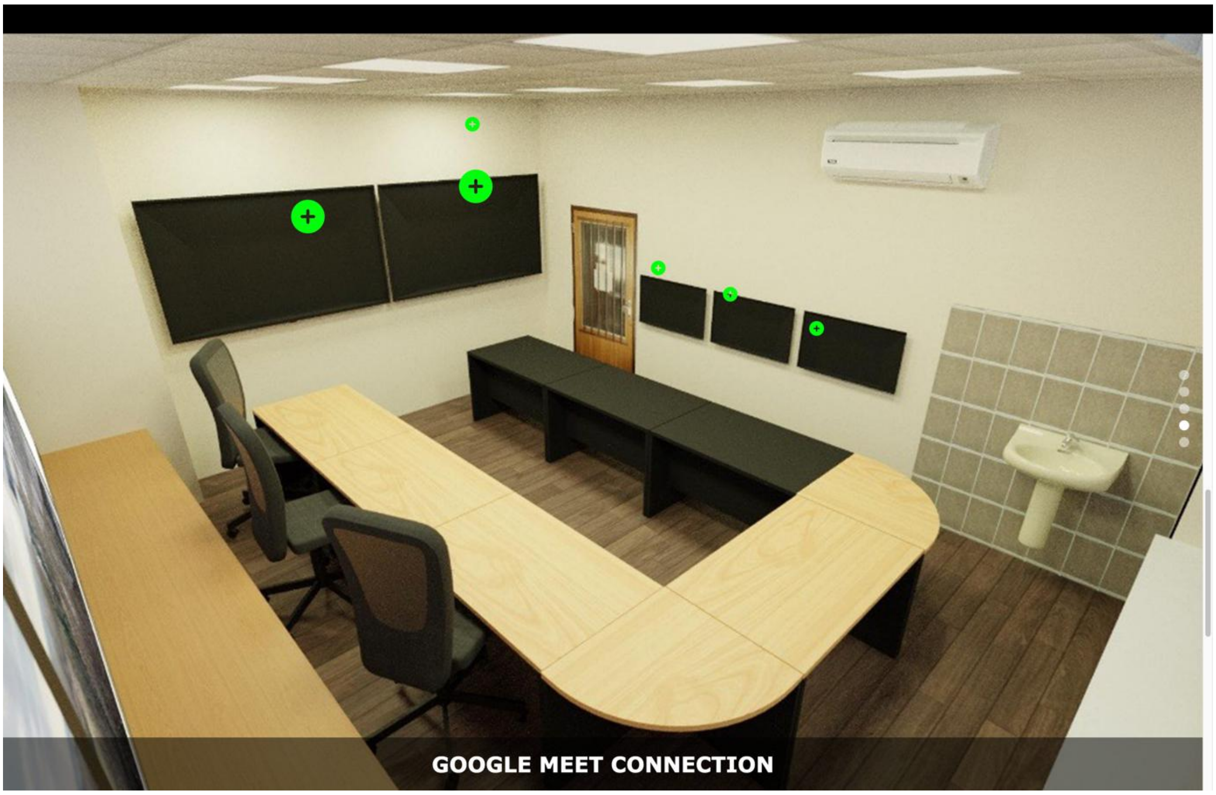

Figure 6: GUI for login, observing the meeting room and choosing participant 's place

4.1 Technology Requirements

Following are general suggestions for the equipment of individual laboratories to be fully connected to the NEXT Collaboration Platform with respect to the prevailing types of meetings held therein.

4.1.1 Physical Room

Equipment for Round Table Meetings

- Remote Participant Display
- Remote Participant Camera and speakers
- Interactive Board (displayed on participants' personal devices. Content is shared among all participants equally)
- Additional Cameras (provide additional views of the meeting, individuals, group, focus on subset of the room etc.)

Equipment for Presentations / Lectures

- Presenter Camera
- Interactive Board / Presenting Display (content is captured and shared to remote participants)
- Physical Participants Camera (to provide view of individuals and group participants)

- Remote Participants Display
- Active Remote Participants Display (highlight)
- Remote Participants Camera

4.2 Software Applications

Here we summarize the general requirements for the communication platform in terms of supported features. Additionally, an overview of logical server functionalities and software endpoints is listed. The endpoints provide access to the server infrastructure and content.

4.2.1 Platform features and required support for devices

Following are the key features of the collaboration platform to provide the communication and sharing functionalities among the connected laboratories, as well as physical and remote participants of the meeting.

Network cameras – *individually accessible by all approved participants, usually provide room overviews*
USB webcameras – *both remote participant cameras i.e. on their laptops, and cameras connected to specific seats in the physical room assigned to remote participants*
Remote camera control – *system allowing access and control of PTZ cameras for better overview and focus*
Video stream distribution – *facilitates authorized access to video streams from the meeting. Handles both*

- *Multiple video streams to one endpoint*
- *One video stream to multiple endpoints*

Interactive Board capture & streaming – *allows collaboration on note-taking, brainstorming and ideation on white boards*
Presentation sharing – *facilitates sharing of presentation content*
Authentication and authorization for camera control – *controls the access to individual cameras and their features*

4.2.2 Platform elements and architecture overview

The general architecture of the collaboration platform is outlined with general functionality of individual software elements.

Video Streaming Server – *distributes video streams*
Coordinating Server – *coordinates access to meeting features and content*
AA Server – *facilitates authentication, authorization and user access control*
Remote Participant Web App – *provides access to the meeting for physical remote participants*
VR App – *provides access to the meeting from the Metaverse environment*
Physical 3D Display App – *possible future extension allowing display of 3D avatars in physical room*
Screen Capture Helper – *helps streaming the computer screens*
Interactive Board Helper – *helps capturing and synchronizing the white board*

5 Hybrid Communication Platform Instances within Partners – Current State

In this chapter we summarize current progress of development of the NEXT Collaboration Platform and the laboratories it comprises.

5.1 Bratislava

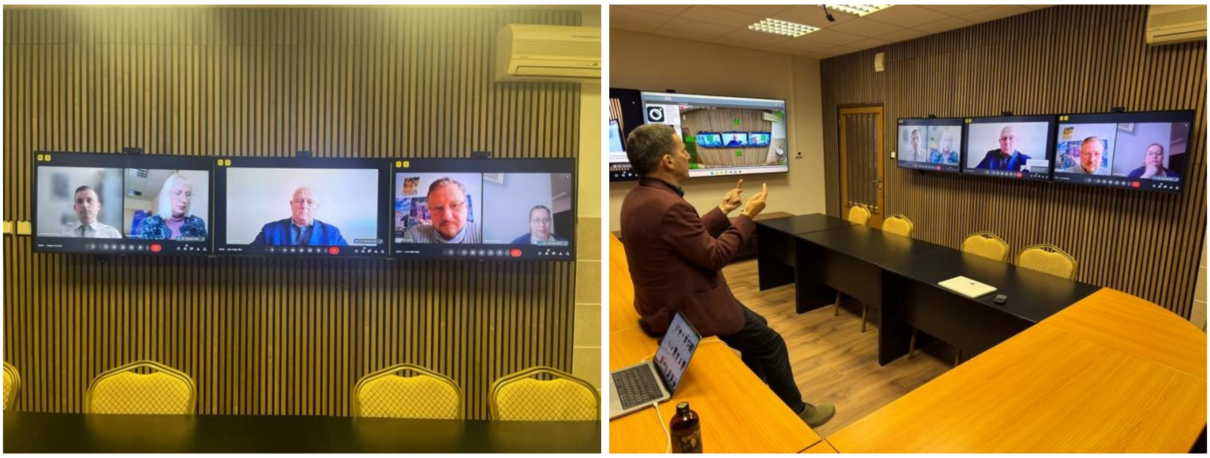

Figure 7: Testing of LHC lab in Bratislava with NEXT project partners in February 2025.

LHC - Laboratory of Hybrid Communications in Bratislava has been described before (Chapter 4). Here we briefly summarize the main functionalities:

- Place of the meeting for participants in person or remotely
- Immersive experience in the meeting
- Fixed “seats” for remote participants
- Fixed place for remote on-line groups

5.2 Odessa

At Odessa, the Odesa Polytechnic National University is establishing a multi-laboratory setup which will be connected to the NEXT Collaboration Platform. The laboratories are:

5.2.1 The Hybrid Communications Laboratory (HCL)

The **HCL** laboratory will be designed to facilitate high-quality video conferencing, allowing both remote and local participants to collaborate seamlessly. It aims to support interactive presentations, discussions, and workshops with advanced equipment, ensuring clear audio and video communication across multiple devices.

Key Equipment and Technical Features
Screen Panels - Three screens, sized between 32 to 40 inches, form the core visual elements. They support at least 1080p resolution and are equipped with HDMI (or similar) connections to integrate easily with various video conferencing systems.
Computers and Webcams - Nettops are used as connection hubs that interface with the screens. Each screen is paired with a webcam capable of 1080p resolution to ensure clarity in capturing participants' images.

Pan-Tilt Camera - Strategically installed on the ceiling in the room's center, this 4K camera can be remotely controlled. Its design ensures that the camera can follow and focus on active participants, enhancing the video conferencing experience.
Audio Equipment - A series of wide-range microphones are distributed around the space. Their automatic volume adjustment capability helps capture clear audio from anywhere in the room.
Network Equipment - Robust routers and Wi-Fi access points maintain a stable and high-speed internet connection, which is critical for uninterrupted video streaming and collaboration.
Presentation Monitors - Two larger monitors (50–60 inches) are positioned along the side walls. One serves to display presentations, while the other focuses on the current speaker. A pan-tilt camera above the speaker's monitor adds an extra layer of visual tracking.
Software Integration - The HCL is designed to work with popular video conferencing platforms (e.g., Zoom, Google Meet) capable of supporting up to 12 devices in full HD or higher. In addition, integrated cloud services facilitate file sharing and collaborative work.

Figure 8: Premises in Odessa where the laboratories will be built. Source: OPNU.

5.2.2 The Virtual Reality Laboratory (VRL)

The **VRL** will be dedicated to using Virtual Reality (VR) and Augmented Reality (AR) technologies for immersive learning, research, and virtual collaboration. It allows participants to interact with virtual environments and models, while also supporting video conferencing, offering a versatile platform for both educational and professional use.

Key Equipment and Technical Features
VR Headsets - Three VR headsets are provided to ensure immersive experiences. Each headset meets a minimum resolution standard of 1080p per eye, which is essential for clear and effective virtual interaction.
Graphics Station PC (GSPC) - A high-performance computer, equipped with a powerful graphics card (such as those from NVIDIA RTX series), a fast processor, and a minimum of 32GB of RAM, supports the demanding requirements of VR/AR content creation and 3D modelling.
Displays with Webcams - Two large displays (50–60 inches) with integrated webcams serve dual purposes—showing VR/AR content to the audience and capturing real-time video for presentations and later processing.
Nettops - Two additional nettops act as connection points, managing interactions with the displays and VR headsets to ensure smooth and continuous operation.

Conference Camera - One 4K conference camera, which can be remotely controlled, is included to capture video and assist in hybrid interactions within the virtual environment.
Mobile Devices - A tablet and a smartphone are integrated into the setup. These devices offer additional flexibility, serving as controllers for AR applications, as well as tools for mobile demonstrations and real-time monitoring of VR/AR content.
Specialized Software - The VRL will run dedicated software for creating, viewing, and interacting with VR/AR content. This software supports both immersive educational and research applications, and it also enables collaborative virtual meetings.

6 Future development

In the next period of the project NEXT we plan to address following enhancements and extensions:

Hybrid communications platform

- Complete functionality for the physical and on-line participants
- Advanced control of remote capturing and displaying devices
- Intuitive GUI

Metaverse-based Meeting Rooms

- Fully functional digital twin of the physical meeting room
- Visualisation trough realistic avatars/holograms
- Combines advantages & disadvantages of previous versions
- Possibility to combine parallel meetings in LHC and digital twin

7 Conclusion

In this document the preliminary version of NEXT - Collaboration Virtual Platform has been described. The platform possesses reduced functionality, as it was developed within the first period of the project NEXT. However, it offers real possibility for virtual collaboration and the platform was tested by the NEXT consortium for project meetings. In the future we plan to enhance the functionality with more advanced features for immersive communication experiences. The laboratories of selected project partners are planned in the near future, and they will create the complete set of basic functional blocks for the collaboration platform.

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