Architectural Design in Virtual Reality

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ABSTRACT

B201, one of the most recent construction efforts at the Johns Hopkins University Applied Physics Laboratory (APL), is a 263,000-square-foot building with a 647-person occupancy. As part of change management efforts, the Research and Exploratory Development Department (REDD) created an application allowing future B201 occupants to lead themselves on a virtual tour through the under-construction building. Beginning in late 2018, the team did a road show of the final product, which offered staff members the option to either point and click through the space on their computers or to take a virtual reality (VR)-based tour of their new accommodations.

INTRODUCTION

With workplace design undergoing a revolution, transitioning away from traditional offices, the architectural design process now requires more, and more frequent, feedback from vested parties. Still, 2-D printed drawings remain the medium of choice for sharing designs and soliciting feedback, perhaps in conjunction with a handful of 3-D renderings. However, with laptop computing capabilities reaching the level of processing power necessary to render a building design from different points of view in real time, it is now possible to leverage virtual reality (VR) to expedite the architectural design process. Instead of mentally constructing a 3-D image of a floor plan in their heads, eventual occupants of a new building can now virtually immerse themselves in their future workplace—looking, walking, and even flying around it. With VR enabling this fast-forwarding in time, the ability to evaluate and constructively contribute to the design process becomes ubiquitous. This article describes how APL used VR in one of its recent construction projects.

B201: APL'S NEWEST AND LARGEST BUILDING

APL's most recent construction project, known as Building 201 (or B201), includes complex lab and open office space around a four-story atrium. The 263,000-square-foot building, with a 647-person occupancy, consists of four floors plus a basement, an open lobby, multiple collaboration areas, hoteling spaces, a 200-person auditorium, breakout spaces with flexible walls, conference rooms on every floor, a café, and a third-floor terrace. B201 architects and stakeholders kept in mind a number of goals throughout the design process: maximizing natural light, ensuring close proximity of labs and workstations, designing interior spaces that promote collaboration, making common areas accessible, and accommodating future growth.

B201 marks a stark shift from APL's traditional building designs. The Lab's buildings, for the most part, are similar in design, with offices and labs sectioned off by hallways and interior walls. Most of the offices seat from one to three staff members, and labs do not usually provide permanent staff seating. B201 could not be more

Figure 1. Early B201 design. The early design, longer than a football field, dedicated the north side of the building to office space and the south side to labs, with a hallway spanning the entire 460-foot distance dividing the two sides. Top, An early floor plan for the first floor. Bottom, An early rendering of the exterior.

different. At its core, it is an open-concept research center that encourages staff members to collaborate and connect by providing intersection opportunities at their workstations, labs, and common areas.

The Design Process

The architecture, engineering, and design firm CannonDesign began the architectural design of B201 in mid-2015 with feasibility studies, data calls, and questionnaires. Early in 2016, the firm finished compiling the requirements and calculated the requisite square feet for the variety of labs, conference rooms, huddle spaces, secure areas, etc., all of which culminated in a preliminary design. That early design, running east to west and longer than a football field, dedicated the north side of the building to office space and the south side to labs, with a hallway that spanned the entire 460-foot distance dividing the two sides of the building (see Figure 1).

The PDF files of the floor plans were circulated via email to APL group supervisors and program managers, along with a request for feedback. The group began meeting in a war room dedicated to the review process, where they pored over poster-size 2-D layouts and marked comments in red ink. In addition to considering room size, shape, access, and proximities, stakeholders realized they shared a key aspiration for this flagship building that changed the design requirements in a big way—namely, that it inspire creativity, that the building itself be exciting and inspiring.

By the fall of 2016, this realization had motivated a complete overhaul of the design, on every level (see Figure 2). What was originally planned to be small building with a commensurate budget blossomed into a

Figure 2. Updated B201 design. The updated design reflects a modern integrated approach, with common areas for multidisciplinary collaboration and innovation. Top, The updated floor plan for the first floor. Bottom, The updated rendering of the building exterior.

much larger building with a much larger budget. The B201 team spent nearly all of 2017 working out the details, often in the war room. The result is a building, now under construction, with great promise. Ground was broken in October 2017, and occupancy is slated for March of 2021.

Change Management

Throughout the design process, the team considered how moving in to the building would impact APL staff members and looked for ways to best prepare them for the move and the new building. Since mostly Research and Exploratory Development Department (REDD) staff members would be the eventual occupants of B201, REDD leadership decided that change management initiatives were needed and commissioned a core team to lead the effort. Change management informs, equips, prepares, and supports individuals who will be impacted by a change. It became clear that the design process needed be transparent to staff members, with opportunities for them to understand the design criteria, ask questions, and most important, see the space.

Incorporating VR

During the early design and change management efforts, the potential of VR had not yet been realized, so the technology did not play a role in shaping these activities. CannonDesign provided a myriad of sketches, concept art, and 3-D renderings, and these were provided to REDD staff members in various forms and formats. While these representations of the design satisfied some of the curiosity surrounding the change, many on the design team had a feeling that something more could be done.

In 2018, augmented reality (AR) found a foothold in REDD's Mechanical Engineering Systems Analysis and Design Group (an eventual B201 occupant) when an engineer used it to solicit feedback on the layout of computer equipment within a portable, but size-limited, workplace for operating towed arrays that detect ultra-quiet submarines. The application of AR accelerated the design process, negating the need for scale models and enabling quick iterations based on feedback related to human factors and other considerations. With this new awareness of how AR could save design time and produce more valuable insight, the group began to explore the possibilities for using VR in other projects. While much of what the group designs is handheld in size and does not warrant immersion in the design, the possibility of applying VR to the B201 design process quickly rose to the surface. In the summer of 2018, CannonDesign shared its computer-aided design (CAD) models of B201 and the possibility started to become reality.

Revit, a building information modeling software by Autodesk, commands a tremendous market share among architectural firms, including CannonDesign. CannonDesign's Revit files included several individual files that, when combined, represented nearly every aspect of B201, including its infrastructure systems. Taking advantage of equipment and subject-matter experts in Immersion Central, an APL space dedicated to XR where staff members can collaborate, self-educate, experiment, and

Figure 3. Side-by-side comparisons. The square images show the building under construction and the circular images show the same perspective in VR. Shown are the north entrance (left) and under the north cantilever (right).

create, a team of REDD engineers hoped to port the model to a VR headset, like HTC Corporation's VIVE Pro. Working within the capabilities of readily available computers necessitated simplifying the models to only the relevant representations, meaning the walls but not what is in them. After simplifying the models within Revit, they used a plug-in called Enscape, by a company of the same name headquartered in Karlsruhe, Germany, to translate the design into a stand-alone application that, when launched, allows users to lead themselves on a tour of B201 by either pointing and clicking through the space on their computers or touring the space in VR with a VIVE Pro. See Figures 3 and 4 for side-by-side comparisons showing views of the building under construction and from the same perspective in VR.

Beginning in late 2018, the team took the application on a road show. With VIVE Pro headsets set up in a conference room in another building, future B201 occupants toured their new accommodations (see Figure 5). In VR, participants entered the building, looked up through the atrium, passed through security turnstiles, climbed the stairs, enjoyed the balcony, and found their way to their respective labs and other workplaces. They explored the auditorium, conference rooms, and café and admired the reflective surface beneath the overhang at the north entrance. The display from the headsets was simultane-

Figure 4. Side-by-side comparisons. The square images show the building under construction and the circular images show the same perspective in VR. Shown are the he atrium (left) and the fourth floor main corridor (right).

Figure 5. The B201 road show. Brian Alvarez, a group supervisor in REDD, taking a virtual tour of B201 from a room in Building 21.

ously projected onto a screen in a conference room so that those not wearing headsets could participate as well. Participants were immediately struck by how differently they perceived the spaces after taking the immersive 3-D tour than when viewing 2-D plans. Among other revelations, some spaces appeared smaller than people anticipated, and some seemed bigger.

CONCLUSION

Although VR was not incorporated in the early stages of the B201 design process, its incorporation in the later change management efforts added tremendous value. B201 is unlike other buildings on APL's campus, and its uniqueness could force occupants out of their comfort zones in many ways. The VR tour of B201 helped alleviate staff members' anxieties about the unknowns surrounding their new accommodations. Now that APL has mastered the process for viewing architecture in VR and demonstrated the benefits even after the start of construction, its processes for designing new buildings and managing the change associated with moving staff into them are forever changed for the better.

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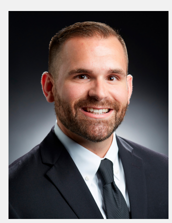

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