

2018 MCAA

MICROSOFT HOLOLENS RESEARCH REPORT

Seventh in the
**MCAA Technology
Research Series**

Performed by
**The MCAA
Technology
Committee**
for exclusive
use by MCAA

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Technology Committee Chair Remarks

To many contractors, the idea of augmented or mixed reality becoming part of their business operations seems a little far off in the future. That changed in 2016 when Microsoft released a \$3,000 developer version of their cutting edge mixed reality headset, the HoloLens. Through glitzy commercial videos, Microsoft showcased how this headset was an autonomous Windows 10 computer with an augmented reality interface. No cables were required to tether the display to a computer. You could walk around a space and the augmented reality would overlay holograms in your space so that you could interact in a new and different way. It could change the way you interacted with computers, people and your work.

The commercials demonstrated many functions that had practical application to our industry. They demonstrated how you could visualize construction models through an augmented reality visor in real space to collaborate on design or explain processes and features. They showed how videos could turn into real time collaboration with live instruction and someone else's annotations in real space.

Too often in our industry, we see well-produced videos that over promise and under deliver. It has become so common that it even has its own name – vaporware. What the technology committee wanted to determine was if this new hardware could not only do what it demonstrated in well-polished commercials, but in real life and on the jobsite. We created a taskforce to research the HoloLens as we think that augmented reality is a trend finding its way into our industry and of the available devices, this has the most promise.

What we concluded is that the device is able to perform most of the tasks that it demonstrates in the video (under ideal conditions). Its best feature comes from its ability to wow first time users with the ability to visualize a model in real space. It will immediately boost the impression of your company as being technology forward with those that try it out.

There are limitations to the device that will be explained in this report. There are also workflows that require better software to harness the technology in the device, but the Microsoft HoloLens represents a great beginning to augmented reality in the construction industry.

Brian Helm

CEO, Mechanical In. and MCAA Technology Committee Chair

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Research Format

With the potential application to MCAA and MSCA members, the MCAA Technology Committee decided to research and test the headsets with a broad test group of members. Initial investigation found that companies like Trimble had already partnered with Microsoft to develop applications for the construction industry. The taskforce worked with Trimble to evaluate that software as well as some applications still in development for the industry. Over the course of the year, contractors of varying sizes and expertise have tested out the devices to see how capable they were in various basic and advanced operations for the industry. This report will focus on testing results for the following applications:

- Marketing
- Design Coordination
- Jobsite Planning
- Quality Assurance / Quality Control
- Service Operations

In order to assess the full communication application of the devices, two devices were distributed at a time for taskforce members to test. This allowed for design coordination and communication capabilities research. The two HoloLens units were also sent out with a Wi-Fi hotspot and a Bluetooth keyboard. Wi-Fi is critical to the performance of the HoloLens and for the devices to be tested on a jobsite, having that remote capability was a pre-requisite.

The devices were initially installed with [Trimble SketchUp Viewer](#) and Skype for HoloLens. When [Trimble Connect for the HoloLens](#) was made available in beta testing, it was also loaded with the help from Trimble representatives. Through their partnership with Microsoft, Trimble was able to develop and release the SketchUp viewer app for the HoloLens with the release of the device. It allows users to upload BIM models to be viewed and coordinated through the devices. As the research progressed the taskforce was able to evaluate additional software, including Trimble Connect HoloLens, RedCrater's [Revit Holoview](#), and Visualive's [HoloLive](#).

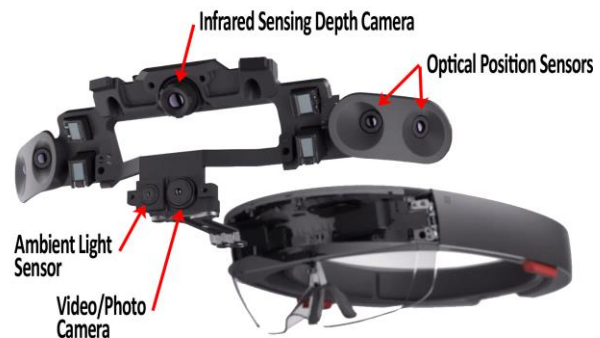
Due to the release schedule, not all taskforce members were able to evaluate all software applications. Only the Trimble SketchUp Viewer was utilized by all members for model visualization. Taskforce members were able to load and evaluate additional software throughout the process as needed.

Device Components

The HoloLens is unique in that it combines a fully autonomous Windows 10 operating system and computer components with wearable augmented reality. This is an important distinction from other devices that rely on a cable to tether a head mounted unit to a computer or run on their own operating system.

For the HoloLens, the processor is incorporated in the design and sits in the forehead area of the device above the lenses in what Microsoft calls the Holographic Processing Unit (HPU). The HPU processor incorporates information gathered through the sensor package and shifts the holographic projection around on the lenses to make them appear to remain in real space.

The sensor package is front-facing and protected by the outside plastic visor. The sensor array consists of an Infrared (IR) depth camera, four optical cameras (two at each temple), an ambient light sensor and a front facing video/photo camera. The way that they work in unison is that the IR camera begins by scanning the room to determine the distances from the device and logging dimensional information. The optical position cameras are used to constantly determine where the device is within that space in order for the holograms to appear to not move. The ambient light sensor is used to determine brightness level of the projections and the front facing video/photo camera is used to take pictures and videos with the unit.



It is important to note that as of November 2017, the lenses incorporated into the design conforms to the basic impact protection requirements of ANSI Z87.1, CSA Z94.3 and EN 166, the most common protective glass certification standards. They have been certified PPE in a construction environment as basic eye protection.

The final AR component of the device is the lens itself. To project the holograms to the user, there are two separate downward facing HD 16:9 light engines (projectors). They project separate images through a 35-degree projection prism (wave guide) that refracts the images towards the users' eyes. To get the proper angle, there is a tilt mechanism that allows the user to slightly tilt the wave guide to find the proper angle.



To prevent any dust or scratching on the lens, the angled viewing glass is completely encased in safety plastic.



Fit

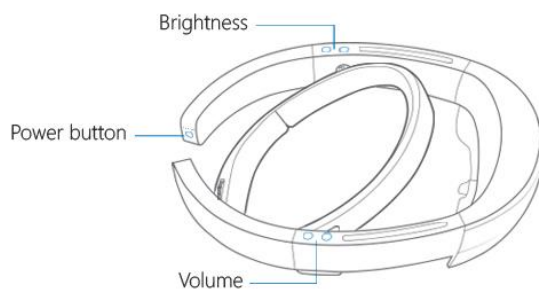
To ensure a proper fit, the HoloLens has an adjustable headband that goes around the head with a similar fit mechanism to most hardhats. A click wheel is located at the back of the headband to extend or loosen the headband and prevent the viewing angle from moving out of the field of vision. Glasses should be worn under the visor.

Once the headband is fit properly, the visor portion of the device can be adjusted forward or backward and a nosepiece rests on the bridge of your nose to further stabilize the device. While this does provide excellent stabilization, it does present some risk to nose injury. An optional overhead strap comes with the device, but is rarely used.

Above each ear are orange stereo speakers. Although there is a headphone jack at the back of the device, it is recommended that the speakers be used to allow for greater environmental awareness. Most of the apps that we tested did not utilize sound, but for communication through Skype or in design collaboration, headphone use might be required in order to clearly hear the person on the other end of the conversation on a construction site.



The device does not allow for audio input from headphones. It requires any audio input to come from the microphone array incorporated in the device. Four noise-cancelling microphones are included in this array between the orange speakers and the optical sensors. They provide excellent sound quality.



Volume, Brightness and Power

There are surprisingly few buttons on the device. On the right side of the visor are the volume buttons for the speakers. On the left side are brightness buttons. In the rear of the device is a power button that has five battery indicator lights. To power up the device, you need to press the power button once, release then hold

it down. The number of battery lights on will indicate the amount of power left in the device. Below the power device on the bottom of unit is the Micro USB charge port. The device comes with a 5.2V, 2.5-amp charger with the necessary Micro-USB cord. To fully charge the device it takes approximately three hours with a run time of approximately 2-3 hours. Through testing, the device was rarely worn for durations of over 30 minutes.

The HoloLens does not currently allow for infinity charging. Although external batteries can be used to extend the run time of the HoloLens, the charge rate will always be less than the usage rate. This allows you to extend the continual run time to 5-6 hours, but at some point the unit will have to be turned off to recharge.

Product specifications say that the device will hold its charge in a dormant state for 2-3 weeks. In practice, users often had it charging between uses without any major battery issues. It is recommended to use the charger that came with the device. When the device was charged with third party chargers, charging time took longer.

Hardware Specifications

OS	Windows 10.0.11802.1033 32-bit
CPU	Intel Atom x5-Z8100 1.04 GHz Intel Airmont (14nm) 4 Logical Processors 64-bit capable
GPU/HPU	HoloLens Graphics
GPU Vendor ID	8086h (Intel)
Dedicated Video Memory	114 MB
Shared System Memory	980 MB
RAM	2GB
Storage	64GB (54.09 GB available)
App Memory Usage Limit	900 MB
Camera Photos	2.4 MP (2048x1152)
Camera Video	1.1 MP (1408x792)
Video Speed	30 FPS
Price	\$3,000 for Developer Edition (Recommended)

Considerations

- Physical Space – In order to move around a life sized model, a decent amount of space is required. Our taskforce members tried using conference rooms and fabrication shops primarily. Tables, chairs, equipment and small floor space can require you to continually reposition models or bump into objects. Ideally, an empty 25' x 25' space should be used to walk through models adequately.
- BIM Capability – Much of the functionality of the device for mechanical contractors will be predicated on BIM usage. If you are not using BIM, the practical applications you will have for the device will be limited. This is an important note for service contractors. We will go into further detail in the review of service contractor workflows, but you will need to start with a BIM model to visualize in space to perform many of the device functions.
- Wi-Fi connection – As an untethered device, the HoloLens relies heavily on its ability to use a Wi-Fi connection. This impacts usual suspects like file transfer, downloading speed and audio connections. However, with no keyboard or mouse, the HoloLens relies heavily on voice commands and gesture controls. The voice command aspect of the device requires internet connectivity to function. While there are workarounds through gesture control, voice control is often the fastest way to navigate around the operating system.
- Cloud Storage – While there is a micro USB interface that could be connected directly to a PC, most file transfer is done through Wi-Fi access to cloud storage services. The HoloLens almost forces users to utilize the Microsoft OneDrive service to store files. This includes when you are using third party apps.
- Calibration – The realism of the holograms will depend on how well the headset is calibrated to each user. The distance between each person's pupils can vary widely. In order to properly project accurate holograms, the HoloLens needs to be calibrated to the correct pupil distance of the user each time. The farther away from the correct calibration, the less realistic the effect of the projections will be for the users. Some taskforce members noticed that when the calibration was off, they began to get a feeling like a headache after extended usage.
- Software Costs – The third party software that was evaluated ranged from \$1500 - \$5,000 a year. This needs to be considered when considering the total costs.

Capabilities and Limitations

Visualization

For all of its marketing promises, the HoloLens will more or less actually do what it demonstrates in its advertisements. The holograms are fully visualized in your space and you are able to look at, move around, and see models from all angles. You can zoom out and see a complete building design on your conference table, or make a model life sized to walk through the designed space. When models are rendered through the HoloLens with great amount of detail, they are realistic, immersive and lifelike.

While some devices can give users a feeling of nausea similar to seasickness, there were no reports of that effect in testing. Users were able to wear the device up to an hour without suffering any discomfort. Some users had headaches if the device was not calibrated.

The initial reaction when someone wears the device for the first time is extremely positive. First time users are often amazed at the technology and the capabilities of the device to display 3D graphics and sound in real space.

While you can walk up to and around a visualized model, researchers have found that the optimal placement of holograms is between 1.25 – 5 meters (4 – 16 ft.) from the device with the sweet spot being about 2 m (6 ½ ft.) away. This is due to the size of the display directly in front of your eyes. The field of view (FOV) of the HoloLens viewing glass is about 30 degrees by 17 ½ degrees. This means in order to see models up close, you need to tilt your head up and down to see a model in the glasses.

Limitations:

- Model Size – There are distinct limits to the size of models that can be loaded and viewed on the device. If you are trying to view an entire building in full detail, most of the apps will not allow you due to file size. File size is not the true issue with the device but rather the polygon count. The higher the level of detail in the model, the greater number of polygons. The higher the number of polygons, the slower the frame rate in the HoloLens and the images become slow or “laggy”. You are forced to move your head slower in order for the model to appear in your view.

To fight polygon limitations, many contractors break down the spaces that they want to view into rooms, fabrication segments or isometric drawings. Some software, like [Revit Holoview](#), will also restrict the part of the model visualized to a 50 x 50 meter box or smaller. That way the device is not slowed by unused polygons. As you walk through the model, the portion of the model you walk towards is generated while the portion you walk away from disappears.

- Tracking – To visualize a model in real space, the headset needs to process a lot of information. It needs to scan the space using depth-sensing IR, it needs to determine proximity to what you are visualizing with the four optical positioning sensors, and it needs to determine angle and size of the model visualized in the optics package. For it to appear lifelike, the device refreshes the video 240 times a second at a frame of 60 frames per second. The hardest part of that is scanning the space and determining proximity. The IR depth sensor will scan a space, but its accuracy is much less than that of other technology like Lidar or phase-based laser scanners. Additionally, the accuracy of the optical sensors is insufficient to keep the position of the model in the same place in real space. The effect you have is that as you walk around a virtual object, it has a tendency to move around in real space. This effect is amplified over greater distances or over surfaces with no patterns like concrete. Some apps are trying to counter tracking issues by utilizing a tracking stamp that is printed and placed in real space. When the optical sensors see the stamp, the model is immediately re-oriented in your field of vision.

Fit and Ergonomics

The HoloLens weighs merely 1.28 lbs. This isn't heavy enough to cause a lot of stress in the neck, but by repeatedly aiming the device and selecting objects requires a lot more neck movement than usual. When a hardhat is added to the device, the weight can cause neck fatigue, but rarely were taskforce members wearing the device with a hardhat for more than 15 minutes. The general feeling of the taskforce was that the fit was comfortable, could be worn for long periods of time without fatigue and discomfort.

Limitations:

- Head Size - The headband on the device has an inner circumference (with padding) of 24.5 inches, which translates to approximately a hat size of about 7 $\frac{3}{4}$ (US). There were no responses in the research about the device not being able to fit on anyone's head, but some reported it to be a little tight. The largest hat size tested was 8 $\frac{1}{4}$ and they were able to use the device without discomfort.
- Hard hats – To be safely used on a jobsite, a hard hat must be worn on top of the device. To wear a HoloLens and a hard hat simultaneously, you need to use a hard hat with a flat brim. Trimble [announced](#) the release of a hard hat with an attachment for the HoloLens that costs \$300 per unit. To use the Trimble hardhat, the tension ring must



first be removed, then attached to the hard hat.

Some contractors have gotten around this dilemma by 3D printing an adapter to attach directly to the hard hat. One taskforce member tested out the concept and was able to 3D print attachment clips that can be used without removing the tension ring on the HoloLens unit. Use this [link](#) to download the plans to 3D print your own clips. The clips used a [Pyramex HP14110](#) hard hat.



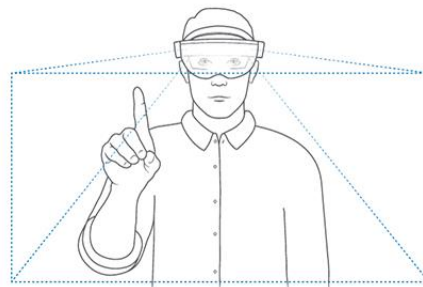
- Glasses – If a user has prescription glasses, they need to be worn underneath the HoloLens device in order to clearly see the holographic visualizations. If the user has large glasses or they sit on a similar position on the nose as the HoloLens nosepiece, this can be uncomfortable or prevent the user from experiencing the visualization.

Autonomy

The HoloLens has been touted as a stand-alone computer and by strict definitions, is considered a wearable device. It runs without any power cords or video cables attached to it so that you can freely move around the space. Depictions of this aspect of the device are completely accurate. A self-contained rechargeable battery is incorporated in the design and data transmission is achieved through Wi-Fi and Bluetooth.

There are no mice or keyboards controls and to control your operating system, you must use a series of gestures or Bluetooth devices.

- Aiming and Gesture Controls – Without a mouse and keyboard, using a HoloLens requires gesture controls and aiming a target. To select something in the operating system, you need to move your head to aim a target over a selection and highlight it. Once the target is highlighted, you will need to use your index finger to “tap” the selection while your index finger is in view of the optical sensors. From an outside observer’s perspective, you will look crazy. This is unavoidable.



Aiming and tapping takes some practice. The unit comes with a Bluetooth clicker that can be used in lieu of the tap gesture. This can work, but from

testing, the clicker batteries do not last as long and the committee had some pairing issues with its use.

Recommended - Purchase the [Microsoft Foldable Bluetooth Keyboard](#) for \$99. This will greatly reduce the amount of time it takes to type. If you are taking notes in model review, a keyboard is an absolute necessity.



- Windows 10 PC – Although you do not need secondary PC to use a HoloLens, it is recommend to use it with Windows 10 PC. Many of the device functions will require you to install the HoloLens app on a PC. This will allow you to load software directly to the device and stream live views from the device with models represented. Taskforce members tested with their own devices but many found that the Microsoft Surface Pro was capable of handling the communications and had enough processing power for the job.

Practical Applications

For the device to be useful, it needs to improve processes or practical applications within your workflow. For the purposes of the research, our taskforce focused on the following applications:

- Marketing
- Design Coordination
- Jobsite Planning
- Quality Assurance / Quality Control
- Service Operations

Each contractor was asked to provide feedback on performance, tricks and shortcomings of the HoloLens. In this section, we aggregated their responses and provide examples of their testing. It also includes apps and software used in the attempt to evaluate each process.

Marketing

Of all the potential workflow applications, marketing has the most immediate practicality. Through the use of the HoloLens device, customers can gain immediate visualization of your design work that just cannot be replicated on paper or through a video. They can walk through the design in a way that can't be replicated through virtual reality or videos.



An optimal example of this would be in the design of a hospital room. It is often imperative for end users to have a spatial understanding of the design and locations of objects in the room where they will be working. They want to feel comfortable that all of the tools are within reach and locations of medical gas access and sinks are appropriate. HoloLens provides a mixed reality environment that offers the best

solution. The end user can put on a headset and a representation of the space is visually overlaid in an existing area. This allows them to walk through the room; test heights and whether the check to see that important devices are within reach.

This approach could be simulated in a virtual reality environment, but is not as practical. In a VR environment, the end user would have to be tethered to a computer and walking in the space with VR goggles can be dangerous. Additionally, the user would not be able to see their hands in the space to test fit or use an existing room. A VR walkthrough would be done seated at a desk, with a headset connected to computer with no representation of reach visualized.

Presentations with Augmented Reality

The HoloLens allows for an immersive visualization of a design without being limited to a chair. It also allows you to mirror the visualizations from the device through a computer to an external monitor or TV set. By using the HoloLens App for the PC, you can stream a live view from the HoloLens to a PC. This live view can be displayed on the device itself or on a monitor in a conference room.



There is a slight difference in the visual you will see in live stream mode. While wearing the device, you have a limited range of visualization of the model that can be displayed of about 30 x 17.5 degrees. When live streamed through a PC, the entire model, including the portion outside of the users' field of view is visualized on screen.

Please note: Live stream demonstrations can appear with a slight lag behind the actual visualization on the device. The live stream is also heavily dependent on strong Wi-Fi connection and can disconnect with weak connection or some times for no reason. Please test out ahead of time before presenting.

Some apps, like [Trimble SketchUp](#) allow for simultaneous viewing of a model. If you have multiple HoloLens devices, it can allow for a remote presentation as well as an in-person collaboration. When viewing a model simultaneously, an avatar representing the other person will be displayed with what appears to be a laser pointing from their headset. This allows you to see what they are looking at. If using multiple headsets for in-person meetings, be sure to orient models in the same position and direction, otherwise users will be in different positions and places talking about the same thing.

Design Coordination

The taskforce reviewed [Trimble's Sketchup Viewer](#) and the Trimble Connect for the HoloLens. At the time of the review, they were the only apps available to simultaneously view models. Two sets of the HoloLens were sent to taskforce members to test this workflow to adequately prove the concept.

In taskforce testing, users were able to successfully use SketchUp Viewer to collaborate in models when not in the same physical location. The microphone and speaker combination of the device allowed users to communicate easily. When reviewing the model, avatars of other users are present in the holographic space and you can see exactly where they are focusing their attention by following a laser that is displayed from the avatar's head to the holographic object.

Taskforce members remarked that an important consideration when using a HoloLens to coordinate is the size of the room being used to walk the space and to limit model sizes. Moving through a model takes some physical space.

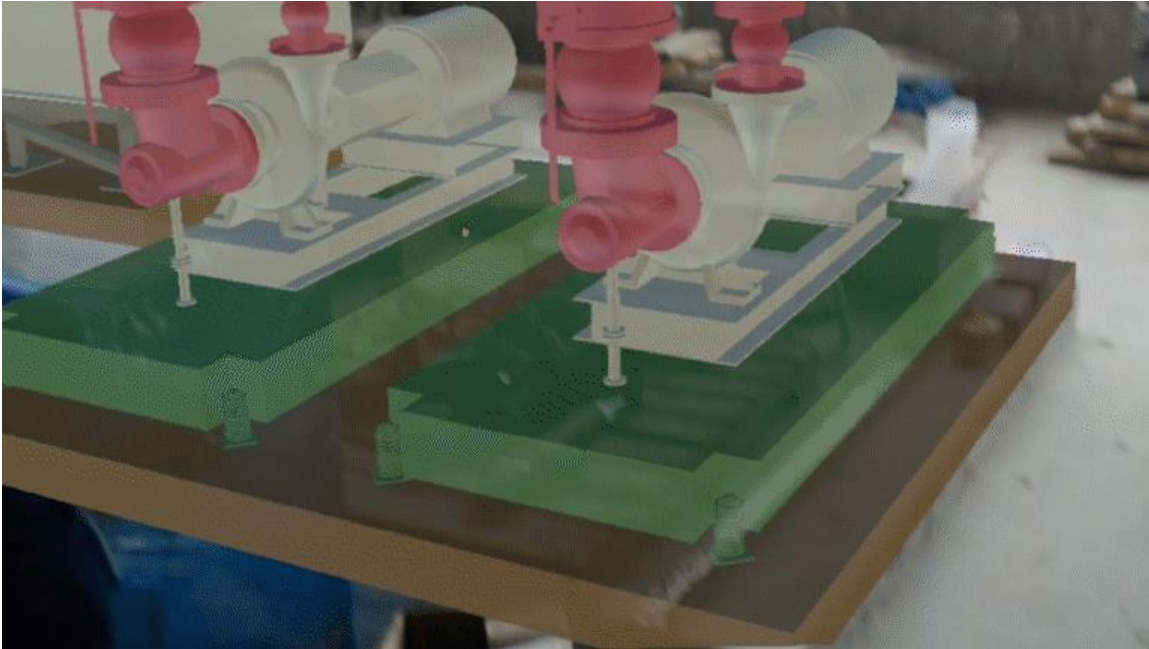
Users can move through a model through two main methods, using the walk function and the jump function. Walk allows you to move at a slow pace in the direction you are aiming through a model. Jumping teleports you to the spot in the model you are pointing at.

Jumping can slightly disorient the user the first time, but users were able to get more comfortable with it the more they did it. It was more successful to limit the model size to about a room and move around through the walk or jump feature rather than actually walk around a lot.

- **Tabletop Design** – Models could be scaled down to a size that would fit on a table. While this could be done, it was rare that enough detail could be seen from scaling to this size.
- **Jobsite Design Coordination and Changes** – Promotional videos depict a user on the jobsite identifying a design change with the HoloLens to another design team member back in office. Together they review the space and the offsite team member changes the design immediately. This use case could not be replicated with any of the existing apps for the HoloLens.
- **Comparing HoloLens Model Coordination to Desktop Review** – While the use case was proven, it was found to be more difficult to coordinate every day use cases with a HoloLens. Only in situations that required real world visualization of the space or to market your company was this method found more efficient than standard desktop based design coordination through Navisworks or similar software.

Jobsite Planning and QA/QC

With the ability to generate a model and place it in real space, the taskforce tested out HoloLens' capabilities on a jobsite. In user tests, a BIM model was brought to an actual project site and generated over top the real-world area where the work was to be installed or had already been installed. The taskforce was asked to test out device's ability to verify installed work compared to the model and to visualize the model in real space to assist the final installation.



In one case, the HoloLens was brought to a project that had already installed hangers. The model was loaded for the project foreman and piping was accurately visualized running through the hangers. This made it easier to visualize the final install.

In another use case, a complicated series of ductwork and racking was visualized in a space for a project foreman. Through the use of the HoloLens, the foreman changed the order of installation and scheduling on the spot, making notes about spacing issues and concerns about obstructions.

For visualization purposes, the HoloLens proved extremely effective for the jobsite. None of our taskforce members were able to test out the device with a clash or obstruction onsite, but it was noted that having a HoloLens with a model there to show a GC or other trades the issue would make communication much more effective.

One user often uses their HoloLens to allow an owner to visualize a completed design or understand a design change in the actual space. The visualization power of the HoloLens in real space allows for better conceptualization than virtual reality or any other solution on the market. It allowed design changes to be made by the end users while still in the design phase and increased the overall satisfaction by the owner.

QA/QC is a little more challenging. With model drift, it is difficult to walk around work to accurately check placement. When holographic representations of pipes move 6-8 inches from where they should be in real life when you move around the space, it makes it very challenging to verify correct placement on the jobsite. Until object recognition is more integrated into the software, it would be difficult to use a HoloLens for true QA/QC.

- **Safety Concerns** – During most of the testing, the HoloLens was not a certified PPE for safety glasses, so jobsites had to shut down for testing. Since then, the plastic around the eyes have been certified as valid PPE safety glasses.
- **Drifting** – it was difficult for the model to hold position on jobsites. Uniformity of concrete slabs can provide difficulty for the optical sensors to hold placement, sometimes exacerbating the placement. Some apps like [HoloLive3D](#) are using QR code markers as a way to hold placement better, and have shown some improvement in this area. Users found the most success using HoloLive3D, marking the QR code placement in the model, and using a printed QR code onsite to snap the model in place on the jobsite.
- **Punch lists** – You can use the HoloLens to take pictures and videos while using any app on the HoloLens. To generate punch list items, users would pull up a model in completed space, often when walls were already obstructing areas, and capturing videos of the problem with audio describing the necessary change to be made or item to complete.

Service

Some companies like Thyssenkrupp elevators and Boeing have devoted resources to utilize the HoloLens to facilitate maintenance and service on their products. Their applications were able to incorporate object recognition, holographic instructions, and a detailed walkthrough of the service required. They were able to do this because they invested a great deal of resources into the applications. These applications were limited to only their products, so they had no value to the taskforce research.

While there are apps in development for mobile devices that are starting to facilitate service operations tasks like [XOI](#), none are available for the HoloLens. Upon evaluation by the taskforce, the consensus is that hardware's capabilities are ahead of the software being developed at this point. There is great potential for service technicians to be able to use a hands free device to assist in complex service and maintenance tasks, especially those that are early in their careers, but it does not yet exist.

The committee did review two workflows with applicability for service contractors.

- **Live Support Software**

The apps with the most applicability for service contractors were those that could provide live support to technicians in the field. Two solutions available for the HoloLens are [Skype](#) and Scope AR's [RemoteAR](#). Both of these apps provide very similar functionality, but Skype is a free to download application. When using [Skype](#) for the HoloLens, a technician is able to stream video from their perspective to support personnel hands-free. The video is shot from the outward facing center video camera on the device. With stereo speakers located above each ear and a four-microphone array, two-way audio communication is established clearly.

Once a connection is established, video of the support staff can be placed and held in the technicians' space. For example, the video could be placed on a nearby wall while the technician works on a piece of equipment. Additionally, the support staff is able to draw in the technicians' 3D space and upload support graphics and diagrams in view. If the support staff makes an indication with arrows or circles, those annotations will remain fixed to the area that they are highlighting while a technician moves about the environment.



While this is seen as an upgrade over standard video communication tools like FaceTime, some contractors might not see it as a good enough justification for the device.

To properly utilize this app, the video connection requires very strong Wi-Fi signal. This necessitates the use of a facility's Wi-Fi connection or connection through a Wi-Fi hotspot. In test cases where strong Wi-Fi was not present, this app was severely limited.

- **Work Instruction**

ScopeAR offers a second HoloLens based application that has potential for service contractors called [WorkLink](#). This app allows you to create your own work instruction for specific tasks using a HoloLens. To achieve this, your company must scan a piece of equipment with the device, apply a series of actions for the service operation, and create 3D instructions and overlays.



While this can achieve exactly the innovation and efficiency that you are looking for from a device like the HoloLens, this process must be completed for every service action for every piece of equipment that your company performs to be effective. A lot of time and energy can be spent on content creation. This app might be most effective if creating training content on new products or if your company specializes in one specific line of equipment.

- **Reuse of Existing BIM Models**

For contractors that secured the service contract after their installation, there is the possibility of using any BIM models to visualize the systems behind the walls and above the ceilings. For contractors that did not secure the service contract after the project completed, this can be a tool to help demonstrate an advantage that your company could provide. It can provide a sales team with a list of potential clients based on how far back BIM has been utilized in the company.

Applications

Although the HoloLens is a very powerful piece of hardware, it is only as good as the software to use it with. One of the biggest advantages that Microsoft has over its competitors in the mixed reality or augmented reality space is its partnerships with outside companies and third party developers to build useful applications early in the development.

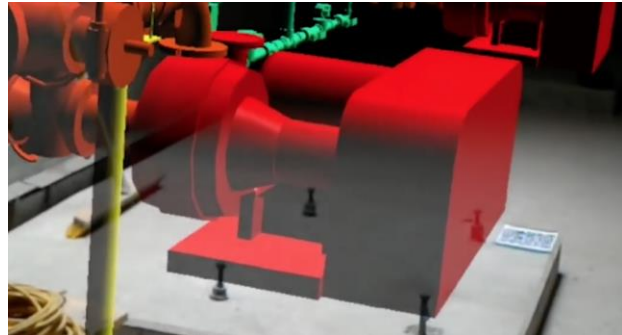
Below are some applications that the taskforce tested and the uses that were demonstrated.

HoloLive3D

HoloLive is a mixed reality app developed by the company Visualive3D. It has the ability to import both Revit and NavisWorks files directly into the HoloLens for holographic viewing.



Of the various applications currently on the market, HoloLive seems to have the most going for it. The publish process is quick and easy with models ready on the device in minutes. Their use of QR code targets as a point of reference to align the model make it the most accurate model placement we've used. Their latest release introduced the ability to pick to reference points, which should also increase accuracy. If the model is off some, they've enhanced their fine manipulation tools to allow you to move the model into a better position.



Based on user feedback by taskforce members, the basic version is all that is needed to use the app for visualization, QA/QC, constructability reviews in the space and the like. They have a Pro version that allows you to push BIM data properties into the headset, making it a very useful tool for FM and service.

The most useful aspect of this software is its ability to use multiple tools to address drifting and placement. To begin, a QR code stamp can be placed in a Revit or Navisworks model. Once this QR code is printed, it can be placed in the corresponding location on a jobsite. When the app is running, it can see the QR code and automatically generate a model in place with the correct orientation.

Additionally, HoloLive allows you to identify two points in a Revit or Navisworks model and use that for jobsite placement. This can include two structural beams, corner of a concrete pour or walls. Once the two locations are identified in the software, the model is placed in the real space. While these features are helpful for placement and alignment, the QR code can assist in locking the model in place to prevent drift. HoloLive also allows you to nudge the model back to the correct place. It has a feature that can turn the holographic models more transparent and move them into the correct location in the real space.

One of the new developments of the software are the voice commands. Through voice commands, you can track issues, toggle the model overlay, take measurements and bring up additional menu commands.

The limitations on the software come from its lack of a coordination feature. There are no features that allow for design coordination or model review. The same Revit or NavisWorks model can be pushed to multiple HoloLens units and viewed in real space with the same QR code, but both users must be physically in the same space.

Price: \$399/month per unit for basic version, \$799/month per user for pro version. Bulk discounts available

Recommendation: This is the best app for alignment, placement and addressing model drift. After conversations with the manufacturer, there are additional features in development that make this app even more valuable. For contractors that are already using tablets in the field, an iPad version is available called [MobiLive](#) with more limited features but can also be utilized when full visualization is not required. The manufacturer offers a 30-day free trial that is worth evaluating.

Trimble Connect HoloLens (TCH)

Trimble has two apps that are geared towards the HoloLens, Trimble Connect HoloLens and the SketchUp Viewer.

Connect is a software already available for the desktop, mobile and web, but

Trimble has expanded the platform to mixed reality through a collaboration with Microsoft on the HoloLens



Although both apps can be utilized for the HoloLens, Trimble Connect is better suited for mechanical contractors. The software on all platforms is designed for project management and collaboration in a construction project. It is intended to contain more detailed information beyond geometric data across the design team.

To be able to view Revit models through the Trimble Connect App, a plug-in must first be installed in Revit that exports information directly into the cloud-based app. The plug in does the conversion and models get published to the Connect Project

Folder. These models can then be synchronized and made available through an app menu. Wi-Fi connection is required to obtain model data and cannot be pre-loaded onto the HoloLens.

The 3D renderings in real space are excellent but take a little work with placement, scaling and alignment. As with any of these apps, the further you walk away from your original placement, the more the model will drift away from its intended position. TCH offers advanced alignment tools for on-site work to better fit and hold position in 1:1 scaling onsite.

The largest differentiator of this app to others is its ability to have collaborative sessions. The app allows you to collaborate with other users both in a shared space or remotely. Once a model is shared in collaboration mode, multiple users can have a virtual presence in a model for design review or even clash coordination. As users walk through the model, an avatar, representing other users location within the model and what they are looking at is represented in real space for other users. This allows for the design team to better understand what they are talking about during a review and for the model to be visualized simultaneously.



Design changes cannot be made during collaboration, but to-do items can be created for other users within the app. Additionally, sessions can be recorded to assist in documentation through the Cortana. Currently, this feature is still in beta, but performing well.

Another unique feature is the ability to load multiple models and filter by classes like slabs, walls, etc. When visualizing the model in real space, users can select classes to be displayed like structural or electrical.

Price: \$50/month per user.

[Trimble SketchUp Viewer](#)

The second software from Trimble that is designed for the HoloLens is the SketchUp Viewer. This was the first app available for the HoloLens that is geared towards the construction industry. For mechanical contractors, this app is not as useful as the Trimble Connect HoloLens. SketchUp viewer has more of a focus on geometrical information than embedded data. Architects favor it to visualize design. It lacks the



connection to product specification and enhanced data that is available through Trimble Connect.

On the positive side, the software does a great job of viewing models in real space and displaying scaled down models for presentations. Changes to the design can be transferred from a PC to the HoloLens in near real time. Additionally, models can be stored on the HoloLens itself to be viewed offline. This is a helpful feature in areas that have limited Wi-Fi connection.

The tricky part for contractors working natively in an Autodesk family of software is conversion back and forth to SketchUp. In order for a Revit model to be converted to SketchUp, it must first be exported in a DWG file format. This limits the model data to simple geometry and any changes made to the design within SketchUp are not forced backwards. Any changes to the design need to be made separately in the native Autodesk software.



For visualization purposes, SketchUp Viewer does a good job of toggling between a tabletop mode and an immersive mode. Tabletop mode provides a scaled down version that can be positioned on a conference room table. If users want to see the perspective within any part of the model, they can toggle into an immersive mode and jump into a 1:1 scale of the building. Enhanced controls allow you to walk around or teleport through a model without too much practice.

Price: \$1,500 per unit (one-time purchase)

Conclusion

Research on the HoloLens began with a hopeful expectation. Holograms and augmented reality had always been the thing of science fiction movies. Many of the committee members had seen some of the demonstrations and commercials, but were hesitant to think that they were going to be able to incorporate this device into their standard workflow immediately.

For most people, it takes years of experience to be able to conceptualize in your mind the way a project should be built when you are looking at a 2D drawing. The HoloLens takes away that conceptualization and provides immediate visualization of the project.

This had real potential to provide value for contractors if it could overcome some initial challenges:

1. Software would have to be developed that could render holograms out of BIM models.
2. The devices could be safely utilized on the jobsite.
3. There were enough practical applications of device to justify the expense of the hardware.

We were fortunate in that Microsoft began the rollout of the devices after they had already developed software with industry partners like Trimble. Since then, more software developers have built apps capable of filling this role.

Initial safety concerns focused on eye and head protection. In late 2017, the HoloLens received an ANSI Z87.1 rating making it certified PPE. Head protection was overcome with 3D printable clips to integrate with a hard hat or through the Trimble's HoloLens specific hardhat system.

The committee also determined through research and testing that there are practical applications for the device. This report demonstrates many of those processes in detail.

This is just the beginning. Microsoft is already in development for a second generation HoloLens, with a release date that is not yet public. Software developers have also demonstrated to the taskforce incredibly innovative applications in development for processes that were not covered in this report due to non-disclosure agreements.

The most telling result from this research is that after every mechanical contractor on the taskforce tested the device; their company purchased a set. If your company is already developing BIM models and you have someone on your staff that can dedicate some R&D time to the implementation, it could be worth the investment.

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