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White Paper: Reaching New Heights in Aerospace with Intelligent and Immersive Technologies

unity

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REACHING NEW HEIGHTS IN AEROSPACE WITH INTELLIGENT AND IMMERSIVE TECHNOLOGIES

The aerospace industry is responsible for adhering to the highest standards of product design, manufacturing and personnel training. Components must withstand intense stress conditions, including temperatures as low as –56°C (–69°F) and wind speeds over 100mph. Tasks are intrinsically complex, and thousands of different parts need to work together while featuring extremely tight manufacturing tolerances and low margins of error. Processes have critical safety implications, and the slightest mistakes can lead to catastrophic events. End products like planes are massively expensive to design and build, making it all the more imperative to get work done right the first time in order to avoid costly delays.

While the required skill level of aerospace employees is steep, in-person training has traditionally faced challenges involving a lack of scalability. There is also an increasing trend of newer generations moving away from industrial jobs in manufacturing and aerospace sectors, leading to a skills gap amidst a rapidly retiring workforce. Attracting and retaining aerospace workers is projected to be an ongoing challenge as the industry examines new ways to appeal to the workforce.

Emerging tech will be a differentiator; this is where augmented and mixed reality (AR/MR)—collectively dubbed extended reality (XR)—come in. The technology is expected to help renew interest and engagement, while simultaneously enhancing the precision and efficiency of workflows.

In this white paper, we will delve into how real-time 3D technology can enable optimization at all stages within the aerospace industry.

(Image courtesy of Varjo.)

HOW CAN REAL-TIME 3D TECHNOLOGY HELP STREAMLINE AEROSPACE WORKFLOWS?

Real-time 3D platforms, such as Unity, originated as engines for video game development but have evolved towards industrial use. These platforms provide tools to ingest and optimize data from 3D design and computer-aided design (CAD) software programs.

Real-time 3D platforms can be used to create digital twins that enable the real-time updates of features, processes and specifications across different stages of the end-to-end workflow. Rather than having to redevelop separate solutions for each department, these platforms extend software in a cross-disciplinary manner so that solutions are deployed across various niches, verticals and devices. For example, while design and engineering teams are reviewing 3D models of a new aircraft, training and marketing teams have the ability to leverage the same real-time renderings without having to wait for prototypes. Thus, visualization is enhanced across a broader scope of use cases.

PRODUCT DEVELOPMENT AND PROTOTYPING

Unity's platform can help create a connected environment for designers, engineers and program managers to collaborate and evaluate designs and manufacturing alternatives for complex systems. The platform enables agile collaboration across multiple disciplines, allowing for faster iterations and realistic representations of engineering designs by leveraging Unity's high-fidelity modeling and simulation environment.

Teams can import and optimize data from nearly 40 CAD and 3D file formats into Unity, which makes integrating, evaluating and collaborating across multiple designs easy and effortless. Vast libraries of physics models and the ability to import external models from engineering software allow for a true representation of complex systems behavior and interaction with the environment and other advanced systems. This helps reduce development time, risk and cost.

Unity can leverage the digital twins of a product to virtually prototype the system and its components. Utilizing physics engines integrated with the Unity environment, an infinite number of operational scenarios can be designed and used to virtually validate system controls and configurations. Unity can also be used to generate synthetic data required to train and test intelligent control systems using AI and simulation.

The gaming industry is proving to be at the forefront of developing true-to-life digital twin models, leveraging powerful physics engines and large swaths of behavioral data. This enables human engineers to rapidly create and test real-world prototypes using digital, virtualized replicas.

SIMULATION AND TRAINING

Unity's platform brings job-critical learning and training into interactive, immersive environments. In doing so, it accelerates training time and enhances knowledge retention across key skills, including team-based tactical situational training.

MAINTENANCE AND OPERATIONS

By leveraging as-built models from design and manufacturing phases, aerospace companies can simplify and optimize inspection, maintenance, repair and enhancement activities. Incorporating real-time IoT data and information from enterprise systems with the 3D models enables teams to identify issues, ensure safety, and enforce standard maintenance procedures.

TOP USE CASES OF REAL-TIME 3D TECHNOLOGY IN AEROSPACE

Some of the world's leading aerospace companies are already capitalizing on the benefits of real-time 3D technology, with top use cases including product development and prototyping, simulation and training, and maintenance and operations.

PRODUCT DEVELOPMENT AND PROTOTYPING

Aerospace companies are recognizing real-time 3D technology as a valuable tool to collaborate and align during the design and concept phase. Immersive design reviews for aircraft and facilities are enhancing the visualization of data, resulting in reduced design cycles and product errors. Real-time 3D platforms can be leveraged to test the performance of new aircraft designs through tools like aerodynamic simulations. With interactive renderings replacing physical prototypes early in the process, issues can be identified sooner without the need for multiple iterations. Customers can even provide feedback on configurations before the product has been manufactured, allowing for the accommodation of consumer-driven customizations while maintaining economies of scale.

Bell, for example, brought its unique FCX-001 helicopter to market in six months instead of the 5–7 years the process would normally have taken, through the combined use of the Unity engine and HTC VIVE VR headset during its design stages. Rather than starting out with a small-scale prototype, Bell's engineers used the VIVE to visualize a full-scale model right off the bat, enabling test pilots to provide faster and more specific feedback on factors such as visibility, access, safety and comfort. Design cycles were vastly reduced and issues were discovered before the development of prototypes, ultimately saving the company millions of dollars.

The Bell FCX-001. (Image courtesy of Bell.)

Virtual reality also proved to be an excellent marketing tool for the FCX-001. Bell modified aircraft configurations based on clients' needs (e.g., adjusting to a specific interior) without additional costs. XR technology allows buyers to virtually peel away the cowling to survey the helicopter's engine and other concealed components.

Lockheed Martin finds data visualization to be one of the top use cases of real-time 3D and extended reality.

"One of the biggest advantages of real-time 3D is the ability to take large sets of data streams and visualize them in new and innovative ways," asserted Scott Robertson, senior virtual prototyping engineer for Skunk Works at Lockheed Martin. "There's a limit to how much we can understand information by viewing it on a two-dimensional screen. As we start to extrapolate that information out into 3D space, we gain a greater level of understanding. It's the whole concept of taking data visualization to the next level for better decision-making."

Lockheed Martin has used Unity's platform to build its Collaborative Human Immersive Lab (CHIL) solution for product design and validation. CHIL provides an environment that supports the simulation of virtual worlds for design analysis across a range of products, from spacecraft and satellites to military aircraft. The discovery of issues in the development stage has significantly lowered the risk of incurring difficulties during and after manufacturing. After implementing the CHIL solution, Lockheed Martin observed a tenfold return on investment (ROI) in 2018 alone, with savings including $10 million in validation costs and over $500,000 in travel expenses due to teams collaborating virtually.

An aerospace employee evaluates a product design using the CHIL solution. (Image courtesy of Lockheed Martin.)

Lockheed Martin went on to leverage Unity for the development of Visar, a HoloLens-based application that serves as a visualization aid. Visar allows for the scanning of QR codes laid up against hardware, resulting in the projection of holograms within the space. The solution can be utilized in various ways, such as assisting users to visualize the fit and feel of parts before they're manufactured.

"One client may want to use it for digital work instructions, while another may want to conduct reach tests," said Robertson. "Where the power of Unity has really come into play is the ability for us to develop tailored solutions in-house very efficiently. Bringing that capability to the table has been amazing, and has earned Unity an internal nickname of a 'solutions toolkit.'"

Robertson continued with a discussion of how real-time 3D platforms like Unity have enabled a more flexible approach than commercial off-the-shelf (COTS) solutions with limited extensibility.

"With COTS, trying to add features to adapt to our end users' needs can be very difficult and time-consuming," stated Robertson. "Due to the efficiency of development—as well as the licensing ease and the ability to go from concept to minimum viable product (MVP) so quickly and effortlessly—gaming [real-time 3D] companies have led to a lot more use cases where we can bring that experiential technology to the forefront. Using Unity, we were able to create an out-of-the-box solution for our end user in the same amount of time it would probably have taken us to get a COTS tool spun up and properly licensed."

Unity's portfolio of products includes artificial intelligence (AI) and machine learning (ML) solutions. There are numerous use cases on the defense side where real-world data on its own isn't diverse enough to capture all of the possible scenarios, lighting, and occlusion. Unity's AI/ML software can overcome these barriers by generating synthetic data for training computer vision models, resulting in the efficient replication of real-world environments.

Unity Computer Vision generates synthetic images that can help train computer vision models. (Image courtesy of Unity.)

"For a lot of aerospace use cases, synthetic data reduces the burden on the amount of real-world data you need to collect to get to a functioning model that you can use in the real world," said Joe Mercado, senior product manager for AI at Unity.

Unity Computer Vision has been leveraged for aerospace applications including object detection and anomaly detection. In one use case, a machine learning model trained with synthetic data demonstrated a 100 percent detection rate of objects like ear plugs, pocket change and hex nuts on a runway—a critical issue due to the damage caused if these items are ingested by aircraft. On the anomaly detection side, Boeing developed computer vision models for conducting predictive maintenance by anchoring digital twins against aircraft to easily assess which components need further examination or repair.

SIMULATION AND TRAINING

Many aerospace companies are implementing high-fidelity VR training to accelerate proficiency in subject matter, improve knowledge retention and enhance quantitative safety measures. Traditional manual-based or instructor-led training can not only be extremely time-consuming, but expensive when factoring in travel costs, machinery downtime, and numerous iterations of multilingual training materials. Immersive learning allows learners to retain processes using a hands-on approach, considerably decreasing the likelihood of errors.

(Image courtesy of Varjo.)

Simulation-based training enables pilots to train on a new aircraft before it's even released. When it comes to safety training, pilots can use virtual reality to prepare for emergency situations without putting their lives at risk. Complex scenarios can be simulated through procedural generation and customized for the environment.

Let's take a look at Unity's applications in virtual and constructive training.

Virtual Training

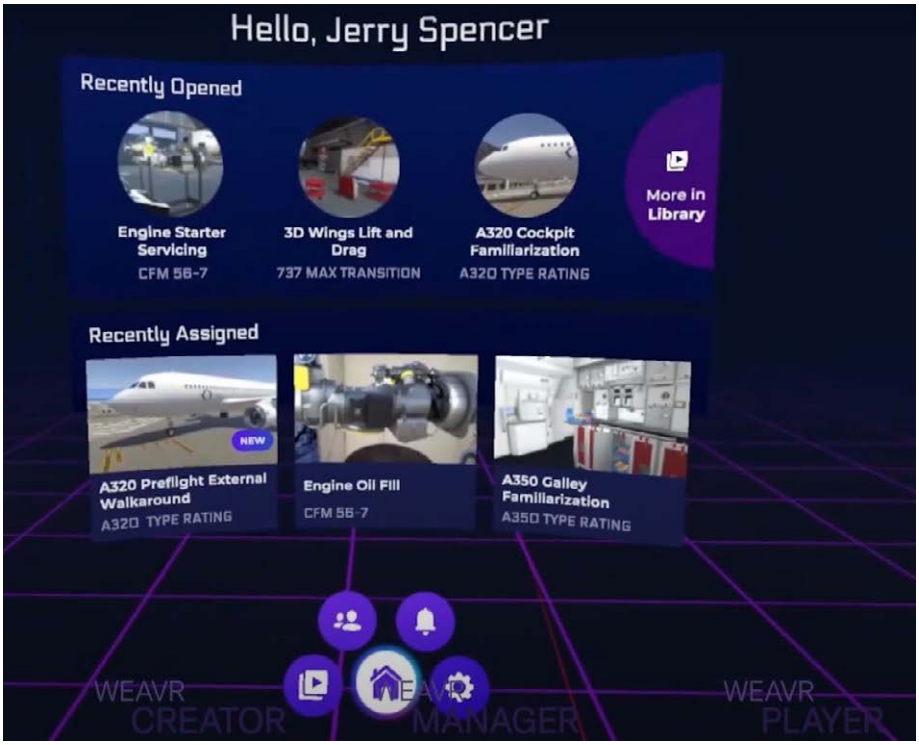
Virtual training involves real people operating simulated systems. These virtual simulations serve to exercise motor control, decision-making and communication skills.

Pacelab WEAVR is a Unity Verified Solutions Partner that uses its software platform to create immersive training programs for various industries.

"Virtual training is digital experiential training, and therefore it's more effective," said Josh Swanson, head of extended reality at Pace Aerospace Engineering and IT. "It's engaging, and leads to better learning retention rates than lectures do. It's also attractive for newer generations of workers."

Training in a 3D environment additionally provides aerospace workers the opportunity to practice their skills on exact-as-configured aircraft.

"One of the challenges right now is that training is often done on a generic aircraft," continued Swanson. "When an airline takes delivery of their specific configuration, there's some retraining or configuration-specific training that needs to be done. We're looking at ways that we can create synergies between our products that support better blending and efficiencies along that whole value chain."



The learner-facing WEAVR Player ensures that training content is well-organized and easy to launch. (Image courtesy of Pacelab WEAVR.)

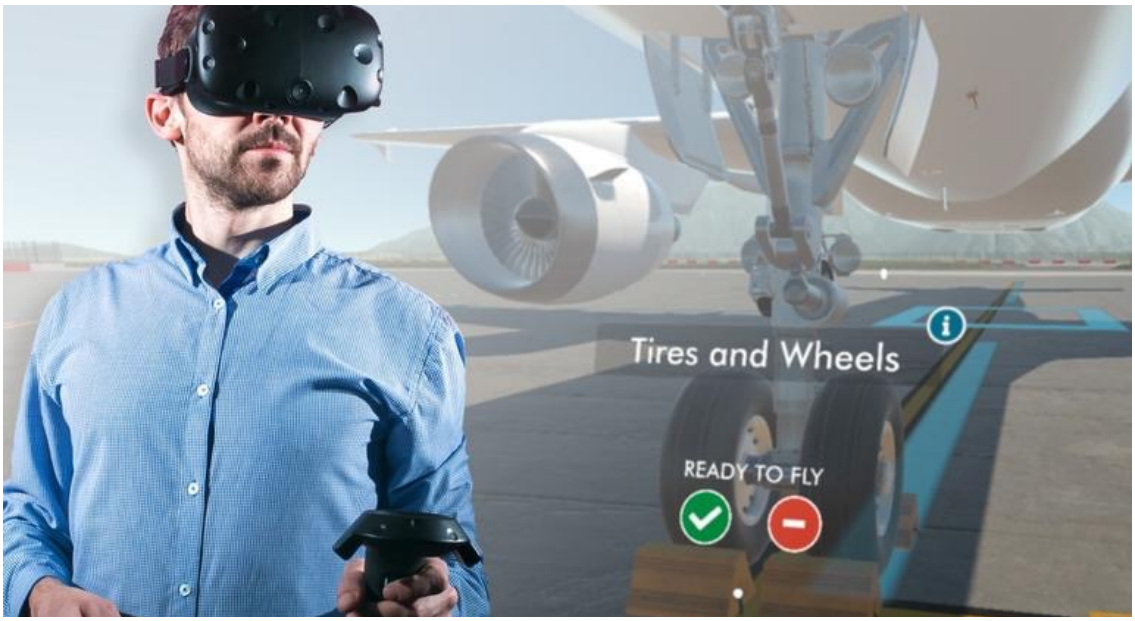
Pacelab WEAVR enables the layering of procedures and workflows on top of virtual environments deployed across multiple platforms. Learners can access training content on a range of devices, from desktop PCs to mobile devices and AR/VR headsets. The platform supports content creation, user management and training execution. Users have the flexibility to train alone or in groups, with or without instructor guidance. Training experiences can be launched on demand through an organized Netflix-style portal, where built-in modes exist for free play, guided instruction and assessment. The platform supports switching between multiple languages without the need for reworking entire procedures.

“The tool also allows you to do visual testing—so as you’re building out each step of the process, you can actually play the procedure and see the flow on your programming canvas,” explained Swanson. “If there’s a bug, the platform will tell you exactly where it is, or what you’re missing.”

WEAVR can further be used in a hybrid approach called augmented virtuality, where the virtual space is enhanced with physical controls in the real world while simulated feeds are integrated with the environment. Companies have the option of purchasing off-the-shelf mixed reality flight simulators—control yokes and all—and replacing the monitor with a VR headset, for example.

“The ability to basically stitch around the physical in a mixed reality sense shows the value of the extensibility of not just WEAVR, but also of Unity,” said Swanson. “Flying an aircraft is very hands-on, and this is a cheaper way of simulating the aircraft environment and providing physical haptic feedback without buying a full simulator device.”

Without the need for travel to training locations with capacity limitations, throughput can be increased due to training solutions becoming vastly scalable. Aerospace professionals can gain familiarity with aircraft technology and significantly reduce training time when visiting actual aircraft, as they work on becoming certified within a heavily regulated industry.



(Image courtesy of Pacelab WEAVR.)

NASA is working with Unity to bring real-time 3D software to its virtual universe. The aerospace giant is beginning to phase out the VR equipment it used to build in the '90s (costing $30,000 to $40,000) by transitioning to real-time 3D platforms for recreating the International Space Station. The agency is also utilizing VR systems for training crew members on the use of the SAFER (Simplified Aid for EVA Rescue) jetpack, which allows astronauts to return to their shuttle in the event that they become untethered and float away.

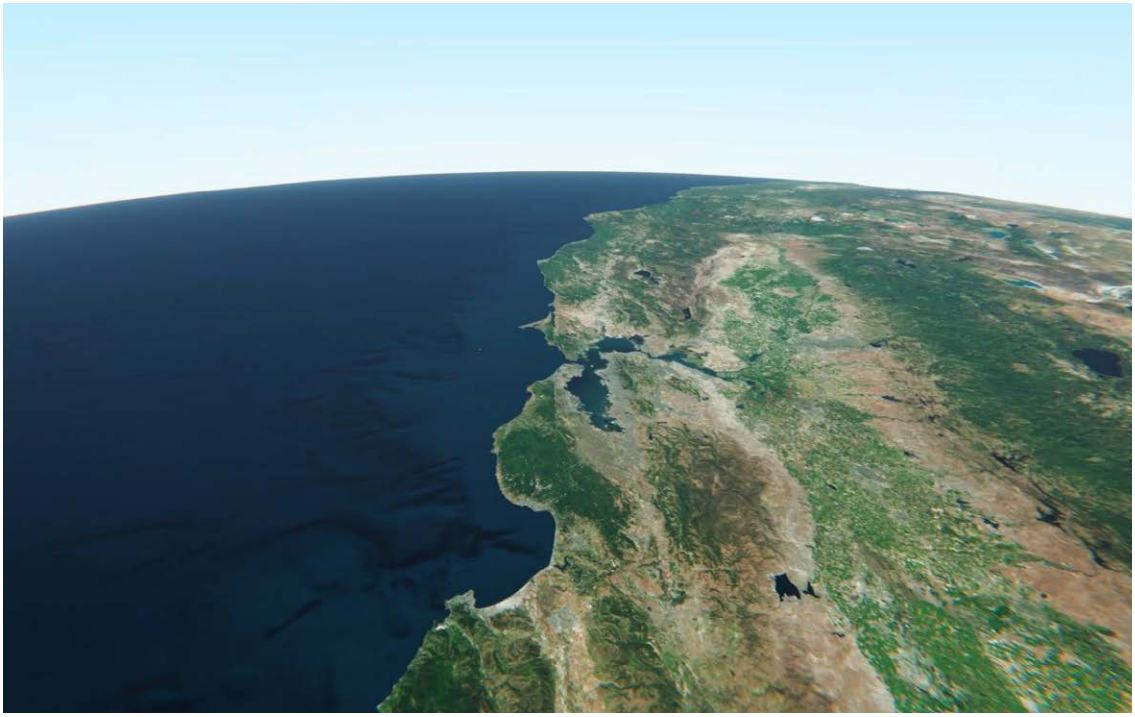
Constructive Training

Constructive training involves simulated people operating simulated systems. While real people provide inputs to these simulations, they are not involved in determining their outcomes.

Lockheed Martin's Skunk Works division is utilizing Unity to develop a solution called BattleViz, which is essentially a digital twin of the battle space.

"BattleViz uses procedural generation to overlay information on top of battle simulations," described Robertson. "It primarily allows users to view different battle scenarios through real-time data feeds or playback, with the option of conducting a review after the fact."

Skunk Works' battlefield simulations are supported by Unity's geospatial group, which works to ensure the fidelity of real-time 3D training environments. Unity provides geospatial capabilities delivering Round Earth visualization of the WGS 84 geodetic, along with other commonly used spatially referenced GIS data. Unity's partnership with key geospatial players ensures interoperability, while datasets are streamed live or rendered for offline use. In cases where data is missing, it can be procedurally inferred and generated using deep learning techniques in order to provide a smooth user experience.



Geospatial data visualization. (Image courtesy of Unity.)

A glimpse into the ML-Agents world. (Image courtesy of Unity.)

Unity's solutions can be utilized for generating scenarios procedurally during simulation. This gives users the opportunity to safely train for a variety of edge cases, including weather issues and natural disasters. Unity's ML-Agents deep reinforcement learning package enables the training and embedding of intelligent agents at scale.

"When I was working in the Navy, we had a request to allow students to practice their formation flight, which needs five pilots," said Mercado. "Game-based training for team scenarios does not require every team member to be there when a student needs to train. You want to train immediately, without having to round up four additional students to train with you—which can be difficult. ML-Agents could play the role of other students in the training scenario, while getting them to a fidelity of training that was closer to what they would experience in real-world training."

In another application, Unity's AI/ML software is being utilized by the Naval Air Warfare Center to simulate regular operations and emergency conditions for landing signal officer training.

The Navy implements virtual flight deck training. (Image courtesy of Office of Naval Research.)

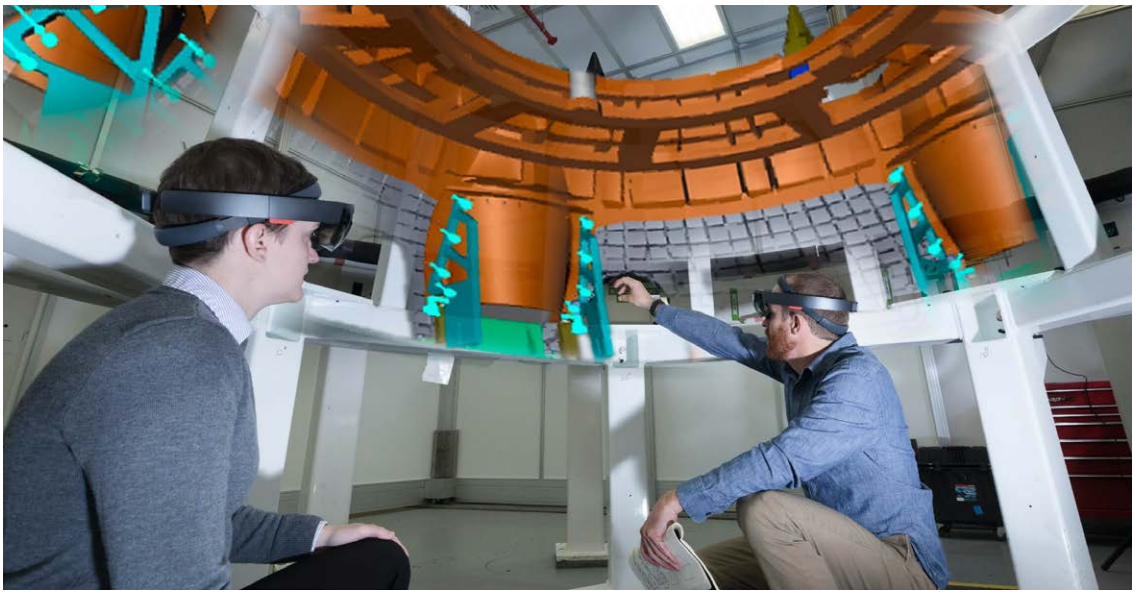
"The Navy has training centers that are isolated on one coast, but they need to train a fleet of sailors across the United States," said Mercado. "They are building a large-scale, transportable solution in Unity to try and facilitate as much as training as possible."

All players in the learning environment can be driven synthetically or by live players, from ship characters to flight deck crew members. Simulations also follow flight patterns conducted by actual pilots, so that trainees can be exposed to human-like behaviors.

MAINTENANCE AND OPERATIONS

Aerospace organizations are increasingly employing real-time 3D technology for guided manufacturing, operation, maintenance and repair. Augmented and mixed reality provides the ability to superimpose digital instructions onto equipment, leading to the accurate completion of complex tasks and the timely resolution of issues. AR allows workers to access crucial information safely while keeping their hands free. The technology also enables video conferencing with offsite experts, who can see through the operators' eyes and offer over-the-shoulder coaching. Apart from savings in travel expenses where experts remotely support multiple facilities worldwide, outcomes include improved product quality and reliability, along with a dramatic reduction in errors and operating costs.

A Unity partner called Scope AR developed the WorkLink mixed reality platform, which was leveraged by Lockheed Martin to build the Orion spacecraft for NASA's Artemis space program. Used in conjunction with the Microsoft HoloLens 2, WorkLink allowed technicians to visualize information ranging from the fit of pieces to torque values for tightening bolts. The AR goggles equipped engineers to work in cramped spaces without having to refer to 30 pounds worth of paper manuals or laptops. By using voice commands to record measurements on video, operators were able to maintain their flow and not constantly have to return to their workstations for data entry. In one case, a single technician was able to attach 57,000 cable harness fasteners along thousands of miles of wire in 2.5 hours, where the process had traditionally entailed two technicians working over eight separate shifts. The activity was completed with zero errors, with the added benefit of process capture for traceability.



Using the WorkLink platform for guided manufacturing, maintenance and repair. (Image courtesy of Scope AR.)

Airbus is another major aerospace company that is utilizing the HoloLens 2 to accelerate complex and hard-to-reach tasks during assembly—resulting in the shortening of manufacturing time by over 30 percent while improving quality. Along with applications in design and training, the company is using Azure mixed reality solutions to enable users to manipulate holograms the same way they would handle physical objects. The HoloLens 2 headset offers eye tracking—where relevant digital information is produced when a user's eyes land on a particular location or object—along with automatic scrolling as the user reads. Iris recognition for log-in allows multiple people to collaborate and share information securely.

Boeing has also been implementing augmented reality in its operations. For example, the company's electricians successfully used AR technology to overlay 3D wiring diagrams on aircraft for the installation of electrical wiring, when they would otherwise have had to interpret 20-foot drawings in 2D.

(Image courtesy of Microsoft.)

THE FUTURE OF REAL-TIME 3D TECHNOLOGY

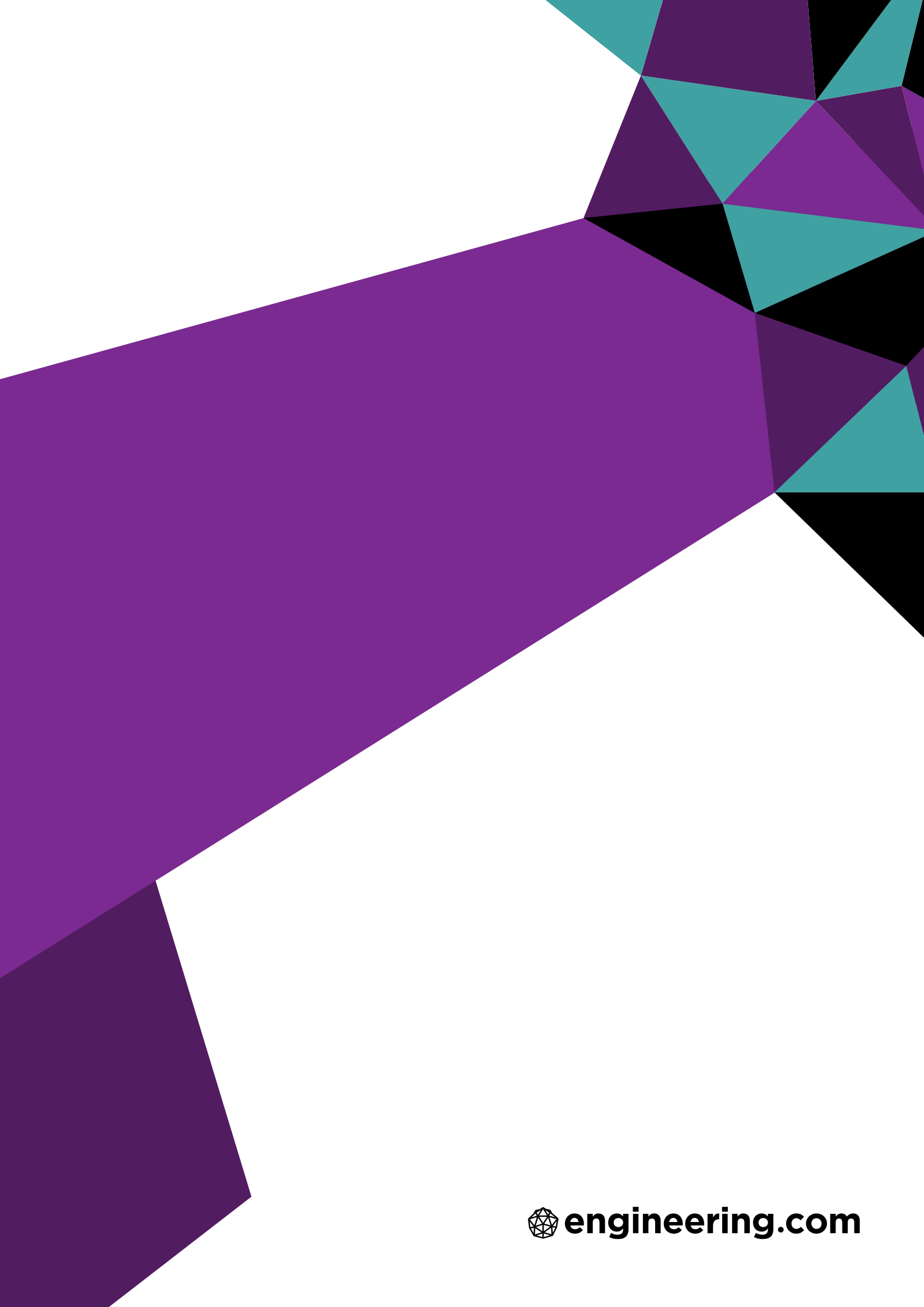
As real-time 3D technology continues to evolve and become more democratized, companies are expanding the range of use cases for mixed reality.

“People are updating their user interfaces and the way that people communicate with their devices, and so they need solutions that are interactive, customizable and easy to develop,” said Matthew Vorce, solutions engineer at Unity.

“We’re in an on-demand economy powered by things like real-time engines, augmented reality, AI, machine learning, 5G and edge computing,” added Mike Ray, senior account executive at Unity. “All these technologies are coming together, allowing people to make decisions in real-time instead of simply relying on 2D documents or even 3D models.”

Unity’s development platform provides a means to efficiently visualize information and interact with the physical world through digital twins.

“The entire invisible world will be visible to us someday,” said Ray. “And Unity can become that portal to connect everybody.”



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