CAE

AIRCRAFT MAINTENANCE TRAINING

Transforming aircraft technician training with Extended Reality (XR)

A white paper from
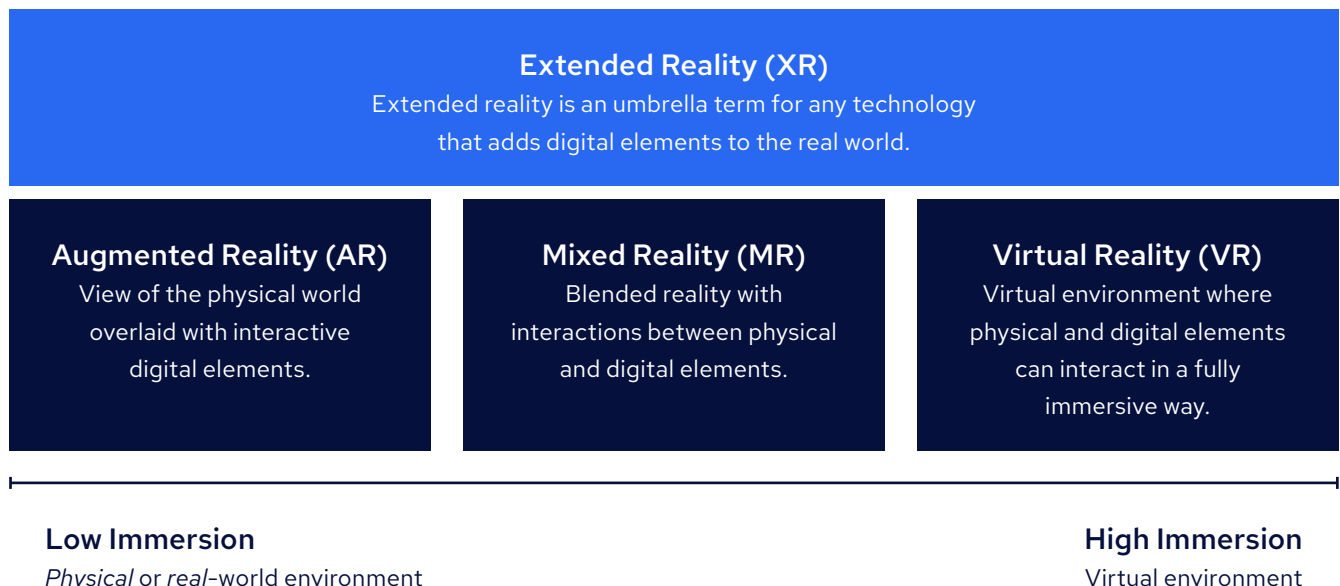CAE and Xennial

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Introduction

An exploration of the transformative synergy of Extended Reality (XR) and its capacity to revolutionize aircraft maintenance technician training.

In this white paper, CAE and Xennial look at the benefits of the current Virtual Reality (VR)-based maintenance training as actively employed in classrooms through instructor-led sessions, aircraft simulation, and virtual walkarounds. We also explore the future benefits of combined VR and Artificial Intelligence (AI) technologies, by incorporating intelligent powered interactions, realistic avatars, and increasingly immersive experiences. Also visited are the exciting possibilities offered by Augmented Reality (AR) as a follow-on technician training tool, and a look to how the industry might collectively shape aircraft maintenance training, by embracing and advancing technologies that most broadly benefit stakeholders in a constantly evolving aviation ecosystem.

Extended Reality (XR)
Extended reality is an umbrella term for any technology that adds digital elements to the real world.

Augmented Reality (AR)	Mixed Reality (MR)	Virtual Reality (VR)
View of the physical world overlaid with interactive digital elements.	Blended reality with interactions between physical and digital elements.	Virtual environment where physical and digital elements can interact in a fully immersive way.

Low Immersion
Physical or *real*-world environment

High Immersion
Virtual environment

An urgent need

To secure a sustainable future in the aviation sector, it is vital to have a consistent flow of aviation technicians. CAE predicts a demand for approximately 402,000 skilled personnel in the next ten years. This emphasizes the need for new training methods that speed up learning and appeal to the younger generation of aircraft maintenance technicians. In this context, the emergence of XR technology offers an innovative and highly efficient industry solution for ensuring competency, readiness, and sufficient global growth of the aircraft maintenance workforce.

A solid background

In 1982, CAE's Boeing 727 full-flight simulator became the world's first commercial simulator to receive the new FAA Phase III Approval, certification entitling the user to conduct initial, transition, and recurrency training of flight crews entirely via simulation. Over the more than four decades since this innovation breakthrough, the aviation industry at large has grown in both recognition of and reliance upon simulation as an invaluable asset in honing the skills of aspiring pilots and other aviation personnel, providing them with realistic scenarios and hands-on experience. As such, simulation today is an integral part of industry training programs, and a significant contributor to optimized aviation safety worldwide, as demonstrated — in the context of technician training — by CAE's successful recent piloting and implementation of one such program for Gulfstream G500/G600, and G650 aircraft.

"Aviation is one of the industries where the adoption of emerging technologies is accelerating. Virtual Reality, especially when it comes to aircraft technician training, is proving to be a high value solution. One of the main reasons VR is used in maintenance training is to lower the risks associated with traditional training methods."

Alexandre Prevost,
Division President - Business Aviation and Helicopter Training, CAE

Acknowledging the impact of Virtual Reality in accelerating learning for aircraft technicians

The use of VR continues to demonstrate a significant acceleration in knowledge retention. In the *PricewaterhouseCoopers 2020 Soft Skills Training Efficacy Study*, and its ensuing 2022 article: "What Does Virtual Reality and the Metaverse Mean for Training?", VR use is shown to result in better retention rates compared to traditional training methods, as it leverages spatial memory and experiential learning. According to the study, VR learners were four times faster to train than in the classroom, and 275% more confident to apply skills learned after training.

Within the aviation industry, it is already accepted that aircraft technicians absorb and retain information more effectively when they engage with content in three-dimensional, immersive spaces. As such, training technicians within VR environments can provide highly engaging and effective skills-development and training experiences, enhancing their retention of knowledge by allowing them to experience and interact with aircraft, tools, and equipment, and with unprecedented access and efficiency. Such immersive experiences contribute to a deeper understanding and better retention of complex concepts and procedures particular to the aviation industry. As aviation organizations increasingly recognize the potential of VR in accelerating learning, the technology is poised to play a pivotal role in shaping the future of learning and training methodologies for aircraft technicians.

Time to complete training[1]

E-learn
45 minutes

VR
29 minutes

Classroom
120 minutes

VR learners were:

4x faster to train than in the classroom

275% more confident to apply skills learned after training

3.75x more emotionally connected to content than classroom learners

4x more emotionally connected to content than classroom learners

[1] Source: PwC 2020 Soft Skills Training Efficacy Study

Seeing key benefits of using Virtual Reality for training aviation industry technicians

By leveraging VR for aircraft technician training, the aviation industry can realize substantial cost savings, increased training efficiency, and a higher return on investment (ROI). The technology's ability to provide realistic and immersive learning experiences contributes to a well-prepared and skilled workforce, while contributing to the operational efficiency of the organization overall. Key among the many optimizing benefits:

- **Reduced need for physical equipment**
  VR allows technicians to train in virtual environments that replicate real aircraft systems and components, reducing or eliminating the need for physical aircraft and training equipment.

- **Minimized downtime for aircraft**
  With VR enabling training without physical interaction with the aircraft, downtime is reduced and more aircraft remain in service.

- **Cost-effective repetitive practice**
  VR facilitates repeated practice and simulations without consuming physical resources. Technicians can hone their skills in a virtual environment, practicing complex procedures as many times as needed without incurring additional costs for materials or equipment.

"The impact of Virtual Reality on aircraft technician training will be profound as it expands its foothold in the aviation industry. One of the key benefits our clients are perceiving, is that VR offers a cost-effective and efficient alternative to traditional training methods."

**Douglas Fajardo,
CEO & Founder, Xennial**

- **Safety training without physical risk**
  VR allows technicians to undergo training in virtual scenarios without exposing them to physical risks. This not only ensures a safer learning environment, but also minimizes potential loss of productivity due to injury during training.

- **Performance monitoring and evaluation**
  VR systems can digitally track and evaluate technician performance during training, identifying areas that may require additional focus and refinement, optimizing the training process and improving overall competence.

- **Adaptability to new aircraft models**
  As aviation technology evolves, VR training modules can be updated to incorporate new aircraft models and systems.

Assessing the advantages of Artificial Intelligence–Virtual Reality integration

The future convergence of AI and VR represents a transformative synergy which will revolutionize how we build immersive training and skills-development solutions within the aviation industry. As these technologies continue to evolve in tandem, the convergence of AI and VR is poised to redefine the boundaries of human interaction and pave the way for new and innovative applications across diverse domains within the aviation industry. Among the already existing or anticipated advances:

- **Ever-increasing enhancement of intelligent interactions**
  The constant evolution of AI is bringing increasingly advanced cognitive capabilities to VR, enabling more personalized experiences, and more dynamic content interaction within immersive environments.

- **Enriched and accelerated learning**
  By aiding adaption to user behaviour, predicting preferences, and generating randomized scenarios that are expected to lead to improved critical decision-making, AI can accelerate learning while elevating the overall training experiences.

- **Experiences progressively closer to the real thing**
  Integration of AI within VR contributes to the development of more sophisticated and realistic avatars to enhance real-time, multi-user instruction and collaboration. Conversational AI will add further user engagement through realistic and context-aware conversations with virtual entities.

- **A robust technological infrastructure**
  Establishing and maintaining a robust technological infrastructure is crucial for seamless AI-VR integration. This includes high-speed internet connectivity, VR hardware distribution, and compatibility with various devices, along with the integration of AI algorithms.

- **Best practices sharing worldwide**
  Collaboration with aviation institutes and training centres globally enhances the effectiveness of AI-VR integration. Sharing best practices and standardizing training modules ensures consistency across different regions and allows for collective advancement in the application of AI within VR.

- **Interactive learning modules**
  Developing interactive and engaging VR modules is also essential for success. These modules should cater to diverse learning styles and incorporate real-world scenarios. AI-driven adaptability can further enhance the effectiveness of such modules by personalizing the learning experience for individual trainees.
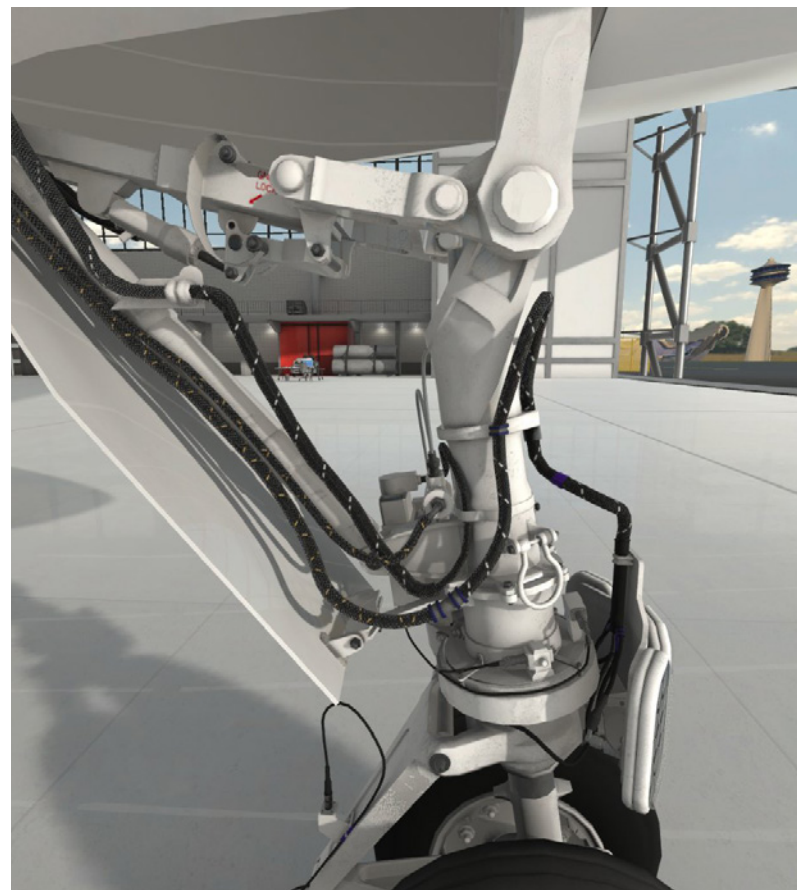
G500/600 landing gear in the CAE VR environment

Increasing efficiency via Augmented Reality in technician training

AR holds exciting potential for training aircraft technicians by providing a follow-on tool to the skills learned in VR. Implementing AR for aircraft technician training can improve learning, overall efficiency, and safety in aircraft maintenance. As the technology continues to advance, it is likely to become an integral part of aerospace training programs. Here are some key areas where AR can be utilized for effective aircraft technician training:

- **Interactive guided maintenance procedures**
  AR can overlay digital information, such as step-by-step maintenance procedures, directly onto the technician's field of view while working on an aircraft. This real-time guidance ensures that technicians follow correct procedures, enhancing accuracy and efficiency in their tasks.

- **Virtual mock-ups and simulations**
  AR can create virtual overlays of aircraft components, allowing technicians to interact with 3D models superimposed on the actual aircraft. This enables hands-on training without the need for physical mock-ups, reducing costs and facilitating repetitive practice.

- **Equipment familiarization**
  AR can be used to familiarize technicians with various aircraft components and systems before they physically interact with them. This pre-training helps build confidence and reduces the learning curve when working on the actual aircraft.

- **Safety training**
  AR can simulate hazardous scenarios or emergency situations, allowing technicians to practice safety procedures without putting them at risk. This immersive training enhances safety awareness and preparedness.

- **Performance monitoring**
  AR systems can track a technician's actions and performance during training. This data can be used for assessment and feedback, enabling continuous improvement in skills, and identifying areas that may require additional training.

G500/600 cockpit in the CAE VR environment

Implementing a comprehensive technical infrastructure

The successful implementation of VR technology depends on establishing a sound and dependable technical infrastructure. This includes the deployment of high-quality hardware and simulation models capable of rendering realistic and immersive virtual environments. Top among these, and the optimized training they foster, are:

- **High quality VR headsets**
  Today's ever-more ergonomic, higher resolution, faster performing, and feature rich mixed-reality capable VR headsets are ideally suited to the task of training technicians in artificial environments.

- **Hand tracking technology for realistic interaction**
  A standout features of modern VR headsets, this functionality enables users to interact with the virtual environment using their hands, eliminating need for controllers in certain scenarios. It allows trainees within VR environments to manipulate virtual objects, operate controls, and perform intricate gestures as they would in a real-world setting.

- **This virtual realism in action**
  In the context of our current maintenance training program for Gulfstream G500/G600, and G650 aircraft, combined headset and hand tracking allows trainees to virtually grasp tools, inspect aircraft components, and manipulate intricate systems. This level of realism enhances training effectiveness by closely mirroring physical actions required in real-world maintenance procedures.

Leading the way with emerging technologies

The outlook for VR, AI, and AR in aircraft maintenance training is promising, with the potential for continued innovation and advancements. By embracing emerging technologies and fostering collaboration, the aviation industry can ensure that VR becomes a pillar in preparing technicians for the challenges of tomorrow.

As the aviation industry embraces innovative technologies for aircraft maintenance training, it is necessary to consider the trajectory of emerging technologies that could further enhance training methodologies. The continuous evolution of VR and advancements in AR and AI holds the promise of even more sophisticated and comprehensive training solutions.

> **"Virtual Reality has transformed the landscape of aircraft technician training by offering a realistic and hands-on learning experience. For example, we have the ability to build a full digital twin of a Gulfstream aircraft at this point, with all of the features of its physical twin. VR can now empower technicians to familiarize themselves with aircraft systems, components, and procedures in a simulated immersive environment, fostering a new era of competency, adaptability, and safety in the aviation maintenance industry."**
>
> **Douglas Fajardo,**
> **CEO & Founder, Xennial**

In conclusion, CAE and Xennial see collaboration across all aspects of industry adoption and integration as essential to the future of aircraft maintenance training through Extended Reality. Stakeholders including VR, AI and AR technology developers, aviation companies, educational institutions, and regulatory bodies, must collectively establish standards and best practices for XR-based training programs. By enabling a collaborative ecosystem, the aviation industry can accelerate their integration into mainstream maintenance training practices.

About CAE

At CAE, we equip people in critical roles with the expertise and solutions to create a safer world. As a technology company, we digitalize the physical world, deploying software-based simulation training and critical operations support solutions. Above all else, we empower pilots, cabin crew, airlines, and defence and security forces to perform at their best every day and when the stakes are the highest. Around the globe, we're everywhere customers need us to be with more than 13,000 employees in approximately 250 sites and training locations in over 40 countries. CAE represents more than 75 years of industry firsts—the highest-fidelity flight and mission simulators as well as training programs powered by digital technologies. We embed sustainability in everything we do. Today and tomorrow, we'll make sure our customers are ready for the moments that matter.

www.cae.com

About Xennial

Xennial is a leading Virtual Reality (VR) and Augmented Reality (AR) company focused on developing enterprise and academic training solutions for the Aviation Industry. Xennial builds VR/AR Aircraft Technician Simulation Training solutions for companies and technical colleges looking to train and upskill their workforces and students, through the use of immersive technologies that produce high learning efficiency and reduce risks. Xennial's solutions help its clients solve the challenge of limited access to physical aircraft for training, while enhancing safety and eliminating the risk of damage to aircraft. Among its flagship clients, Xennial has a deep partnership with CAE, the leading global aviation training company, as well as Aviation Technical Colleges, such as Florida-based Lorenzo Walker Technical College, Summit Tech Academy (Missouri) and University of Maryland Eastern Shore (Maryland).

www.xennialdigital.com