Virtual and Mixed Reality for Pilot Training and Simulation

Executive Summary

In this whitepaper, we explore the use cases and benefits of virtual and mixed reality across the pilot training and simulation value chain. You will hear from world-class professionals and organizations who are already pioneering the new reality of immersive training. You will discover several benefits to using virtual and mixed reality (collectively known as XR) as a part of the training process compared to only using traditional tools and curricula.

The main benefits include cost efficiencies, improved utilization of existing full-mission simulators, portability of devices to enable training at the point of need and saving travel costs, greater availability of training tools to allow trainees to achieve more reps and sets, engaging training that encourages trainees to repeat tasks until they achieve mastery, and all-around better scalability. When training organizations successfully implement these solutions, they will train more pilots faster, provide more flexibly in the training, and with less cost than ever before.

Read on to discover why these technologies are not flights of fancy but the future of pilot training that industry pioneers are already using.

1. Introduction

Challenge: Cost Pressures and Pilot Shortage

Substantial changes are afoot in the world of aviation. Both the aviation industry and government organizations are under increasing cost and operational tempo pressures.

Recent reports indicate that NATO member states are significantly increasing their defense investments, with many nations facing an urgent need to expand their training capacity due to heightened security concerns.

Additionally, an aging demographic, continued growth in commercial airlines and an emerging electric aviation industry are causing a worldwide pilot shortage. It is estimated that by 2029, there will be a shortage of 60,000 pilots globally. This will cause massive challenges to airlines and operators – unless measures are taken to grow the qualified pilot ranks. With civilian airlines recruiting heavily from the military, defense organizations face growing pilot shortages which could affect national defense. For aviation to flourish, pilot training must become drastically more productive, scalable and cost-effective.

As a result, the aviation training community is looking to emerging virtual and mixed reality technologies to enable this shift to meet the growing demand.

Enter Virtual and Mixed Reality Simulation

Virtual simulation has long been successfully used to train both military and civilian airline pilots. These devices typically use large, collimated displays and domes with arrays of projectors to present the virtual environment. Where these displays are extremely realistic, they are highly expensive to acquire and operate, difficult to maintain, and require trainees to travel to a fixed location since they cannot be moved.

The prospect of using head-mounted displays to eliminate the need for collimated displays and domes has long been envisioned but has not come to fruition because of technology deficiencies. Previous HMDs have lacked the resolution, field of view, and low latency needed to produce adequate image quality and cue mismatch often lead to simulation or cyber sickness.

Recent developments show that a major shift is underway to leverage emerging HMD technology to support a variety of new training devices and modalities targeted to address the pilot shortfalls. For example, the U.S. Air Force is reworking their flight training curriculum to leverage virtual and mixed reality devices to support basic pilot training.

While virtual reality has been utilized to varying degrees by civil aviation organizations and eager hobbyists alike, it has not received official recognition in pilot training – until now. In civilian aviation, both the European Union Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA) have, for the very first time, officially qualified a head mounted display based, virtual reality training solution for helicopter training. Pilots can now formally log time spent in a VR-based simulator and have that time credited to their flight training – as if they were flying the actual aircraft. The capabilities, credibility, and efficacy of highend virtual reality training solutions have started to increase massively – and we have only scratched the surface of the capabilities of all extended reality simulation technologies.

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Where Does XR Training Fit in the Pilot Training Curriculum?

Today's pilot training curriculum is a well understood progression of coursework delivered via on-line and/or instructor lead training and typically some simulator training leading to live flights in a real aircraft. Follow-on recertification is typically performed in high-fidelity simulators. XR-based devices should be thought of as high context training tools which can be inserted into the curriculum to supplement and in some cases replace the existing coursework and exercises. The goal is to maximize student engagement while learning and to present material in the appropriate context. This is best done in a setting that closely simulates the true operational environment.

Special purpose, low-cost XR-based devices can be built to support a wide variety of core commercial and military flight training tasks, including the following:

- Aviation Aptitude Assessment
- Cockpit Familiarization
- Air Traffic Pattern Review
- Checklist Practice
- Emergency Procedures
- Communication
- Navigation
- Sensor and Weapon Deployment
- Formation and Tactical Flight

XR-based devices enable students to immediately grasp the point of each lesson as they experience them in proper context as they would in a real aircraft and are able to see cause and effect relationships. They can repeat exercises again and again until they achieve proficiency. And since the devices are low cost, they can be made available to students as needed so they can learn at their own pace. Students will get more reps and sets in the proper context, supplementing or replacing tasks in the traditional curriculum.

2. The Benefits of VR/ XR for Pilot Training and Simulation

There are a multitude of benefits in using XR-based devices for pilot training. First and foremost is an immense cost benefit to using high-fidelity virtual or mixed reality headset-based devices. VR and XR can complement or replace training in full-flight simulators that can cost tens of millions of dollars. Low device cost means that multiple trainers can be made available to students which can increase training velocity. For military pilots, headset-based simulators can supplement training in real aircraft, where the operating costs alone can run up to tens of thousands of dollars per hour. By replacing or even complementing a single live sortie can pay for the entire development and deployment cost of an XR-based training device.

The increased portability of extended reality simulators makes it possible to deploy them at the point of need, such as in smaller, local training facilities – or even on an aircraft carrier. This can reduce the need to travel to specific simulator facilities. Training can be kept up and running continuously, regardless of weather or other unforeseen causes.

With significantly lower cost and higher accessibility, the number of repetitions per trainee can be increased, promoting proficiency. Immersive virtual reality simulation also allows practicing complex and dangerous scenarios which are hard to train in real aircraft – such as emergency procedures and operations in extreme weather conditions.

Virtual and mixed reality training can provide enhanced levels of student assessment that are not available via traditional simulators. Thanks to innovations in headset technology such as eye tracking, student performance can be monitored to ensure proper procedures are followed. Artificial intelligence can be leveraged for trainee assessment, and one trainer can easily monitor several trainees simultaneously. The performance and gaze data are recorded, which means they are available for analysis later and can be used to personalize training further based on the performance of individual trainees. For example, if a fighter pilot forgets to scan the horizon often enough, the trainer can easily detect and address this during debriefing.

Mixed reality offers an even more immersive experience – it gives you the ability to see your hands, surroundings and your colleagues while training. Mixed reality supports tactile feedback by combining the virtual environment with the ability to interact with real-world objects such as instrument panels, cockpits, hands-on throttle and-stick (HOTAS).

Virtual Reality (VR)

Virtual reality means replacing actual reality with computer-generated 3D content. With head-mounted displays (HMD) for VR, also known as VR headsets, a user is entirely immersed in a computer-generated virtual simulation. Depending on the device, a user can interact with virtual elements using hands or eyes, but all content seen by the user is computer generated.

VR headsets are typically tethered to a PC when a more powerful graphical experience is needed than cannot be generated by untethered devices. The virtual experience seen can be anything between a photogrammetric capture of the real world or a computer-generated scene, 3D modeled and built with a gaming engine or represent real-world terrain. The most significant limitation (and sometimes also a benefit) of virtual reality is a high degree of isolation from the real world.

Pros: Complete flexibility of content, true immersion, an endless number of virtual scenarios and experiences can be created.

Cons: Isolated experience, detaching the user from actual surroundings and colleagues, high-quality graphics require a high-end PC and tethered experience.

Augmented Reality (AR)

With augmented reality (AR), the user experiences the real world with virtual elements projected onto it. Most of today's AR devices use optical see-through-based glasses that create holographic images that float in front of a user's eyes in a narrow, augmented window.

While useful for several use cases, the problem for simulation training is that the augmented images are hazy and ghostlike because optical see-through devices can only display light, not black or opaque content. AR devices must also make significant compromises on the field of view, resolution, or both. The result is a loss of immersion which is not ideal for pilot training. On the other hand, AR goggles are lightweight and portable. Some are also wireless, which means they can be worn and used outside of learning centers.

Pros: Portable, wireless, enables interacting with the reality around the user. Great for portraying simple content like information overlays

Cons: Holographic, unrealistic augmentations, narrow field of view, limited immersion, and limited enterprise applications.

Mixed Reality (MR – or sometimes XR)

Mixed reality is all about merging virtual and real-world content – offering the best parts of both VR and AR without drawbacks. Ideally, in a mixed reality solution, it's impossible to discern which elements are real and which are computer generated. Virtual objects appear as a natural part of the real world and will be occluded behind real objects where appropriate. Physical objects around the user can be seen and touched as needed and the real objects can also influence the shadows and lighting of virtual elements.

Pros: Support for tactile feedback and development of muscle memory. An immersive environment that matches reality, suitable for simulations that need to reflect more realistic operating environments. Mixed reality provides complete flexibility of the virtual world with the reliability of the real world.

Cons: More complex solution development, less portable, higher price, larger headsets compared to AR glasses, tethered, more complex to set up and align.

With XR, a user can see their hands and body and interact with colleagues and real-world objects, such as control sticks and instrument panels. For mixed reality to be valuable for professionals, it must be convincing – blending real and virtual content to the point that it is impossible to tell where reality ends and the virtual world begins. Mixed reality typically comes with a higher price tag compared to VR or AR solutions but the added fidelity of support for tactile feedback is gained. The processing power required to display these experiences also means that these headsets are currently tethered to a computer.

3. Technological Requirements

The emergence of VR/XR technology has raised hopes for major cost savings and portability with the use of head-mounted display-based devices to supplement or replace dome or collimated display-based simulators. However, consumer-grade headsets simply do not deliver the visual clarity and other capabilities required in more demanding training scenarios.

For VR/XR simulators to be effective, the headset needs to fulfill demanding criteria. These include sufficient visual quality, resolution and immersion, elimination of simulator or cyber sickness, the capability for extended use, and, in the case of mixed reality, sufficiently low latency video pass-through which can be seamlessly composited with virtual content.

Simulator sickness and eye strain

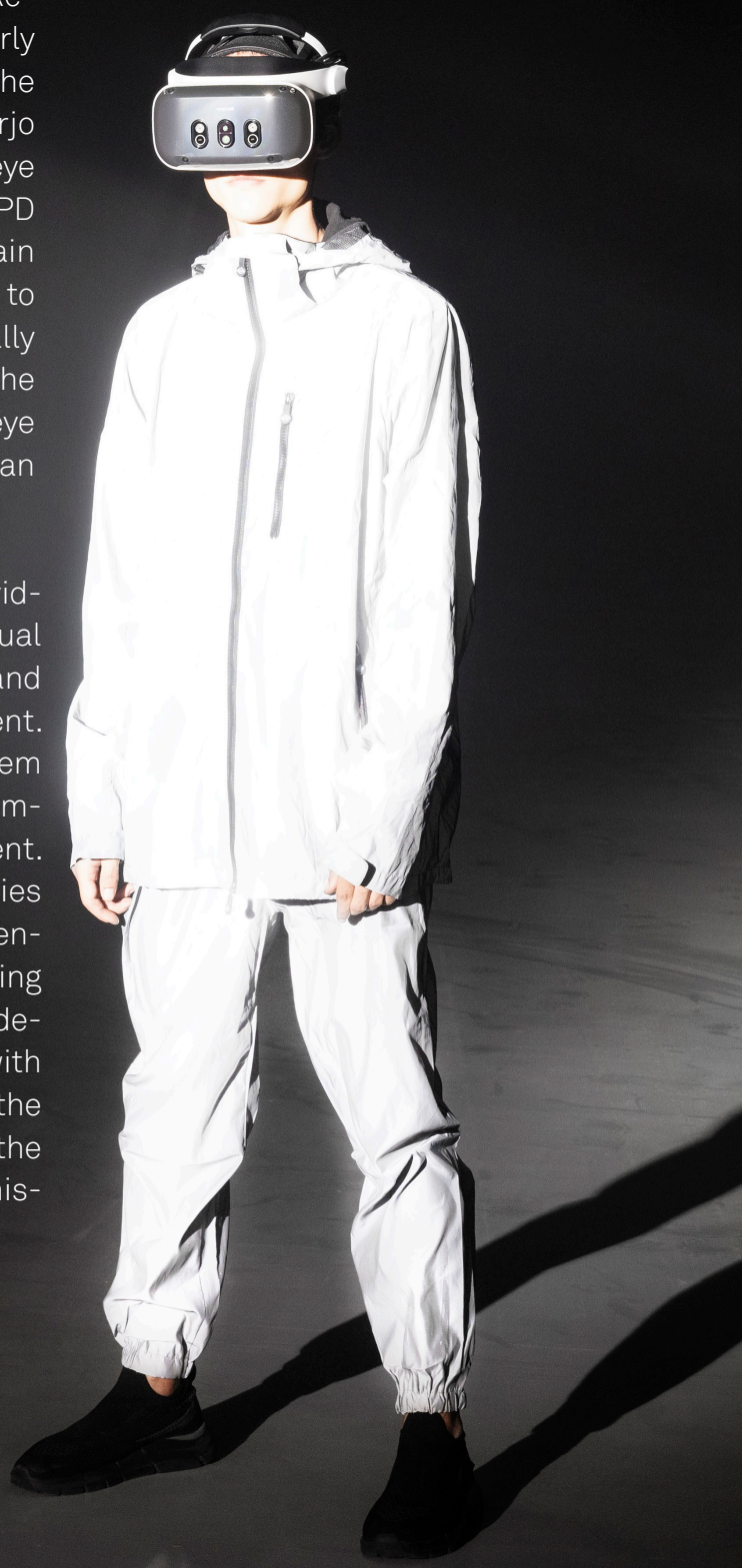
For many years, training system developers tried to use HMDs to support pilot training with negative results. Users invariably became nauseated due to a variety of factors typically caused by a mismatch of physical cues between what the pilot was seeing in the headset and physically experiencing in the real-world.

However, professional-grade headsets, such as the Varjo XR-4 Series, have made massive strides in addressing simulation or cyber sickness issues. With features such as high-quality ergonomics, high refresh rates, high visual quality and resolution, automatic interpupillary-distance adjustment, and low-latency video passthrough, these headsets can be used for hours on end with no simulator sickness. This ensures that training can be run for longer without issues, ensuring a more accurate representation of real-world scenarios.

A mixed reality cockpit environment built using Varjo's XR device and real-time chroma keying. Chroma keying enables multi-user training scenarios as even complex and dynamic shapes occlude accurately.

Varjo HMDs support a variety of features that reduce or eliminate simulator sickness. Recent studies have shown that an improperly adjusted interpupillary distance (IPD) is the cause of 40% of all cyber sickness, so Varjo headsets come standard with a built-in eye tracker that automatically adjusts the IPD every time a user put on the device. Eye strain can be caused by forcing the visual system to integrate low resolution scenes, especially when the content is displayed close to the eye. Varjo HMDs minimize the effects of eye strain by displaying scenes close to human eye resolution.

Mixed reality visual systems that rely on video captured by cameras can create visual anomalies including double imaging and mis-matched scenes with virtual content. Varjo's pass-through video capture system provides synchronized video enabling seamless integration of real and virtual content. Varjo HMDs support time warp capabilities to compensate for graphics systems that generate new frames at less than 90Hz, reducing the effects of lag and increased transport delay. Finally, Varjo headsets come standard with an active fan that circulates air around the eyes to keep the device from fogging and the eyes comfortable during long duration missions.



Human Vision Computerized

High resolution is required to support a trainee's ability to read text used in cockpit displays, HUDs, and other virtually generated indicators needed to support aircraft operation. Varjo XR-4 Focal Edition provides up to 51 PPD and introduces the world's first XR gaze-driven autofocus camera system that mimics the way the human eye works. It is especially beneficial for detecting, recognizing, and identifying objects at realistic distances. Basic Fighter Maneuvers require the ability to detect, recognize and identify a wingman and/or objective at realistic ranges which is only possible with a highest resolution displays.

Synchronized, Low Latency High-Definition Video Pass-Through

Synchronized, low-latency high-definition video pass-through is required for effective mixed reality training applications. Varjo XR-4 devices are capable of true mixed reality where reality and synthetic content blend seamlessly.

The core technology that provides mixed reality is video-passthrough, enabled by stereo 20-megapixel cameras (90 Hz) that digitize the world in real time, and a process that mixes the video inside the GPU with synthetically generated virtual content and displays the results in high resolution. Video is processed by Image Signal Processors (ISP) that pass context and focus streams from the camera to the GPU where it is mixed with virtual content. This makes it possible to transfer data and use it effectively at the GPU – typically under 20 milliseconds. This low-latency solution is undetectable in normal interaction situations and universally deemed good enough to avoid creation of false sensations.

Performance Assessment

Accurate measurement of training effectiveness can be enabled using virtual and mixed reality solutions. A critical component is eye tracking (and, to a lesser extent, other biometric sensors) so a trainer can effectively follow and evaluate the trainee's gaze at all times. For example, one of the main training tasks for pilots is scanning the horizon. Today, pilots are told to scan the horizon, and instructors monitor results as best they can. With eye tracking, there is no more guessing as the data is clearly presented to the instructor.

Varjo headsets feature industry-leading eye tracking at up to 200 Hz and sub-degree accuracy, which enables capturing even the most minute movements of the trainees' eyes, such as saccade velocities and rapid glances. With eye tracking, the trainer can follow on a separate screen exactly what the trainee looks at and accurately personalize training further if behavioral changes are required. The data is also collected so that it can be analyzed later or even combined with data from other sensors, such as heart rate monitoring.

Why Fidelity Matters

Fidelity, the degree of exactness with which the simulated environment is reproduced, is an intuitively simple criterion, yet it is extremely hard to measure objectively with a single metric. High fidelity is essential for transferring skills from the virtual world to the real one. In pilot training, it is a combination of several criteria, such as the following:

- Visual detail: The level of detail of the simulation graphics and how accurately they mirror real-world objects. Also, in the case of mixed reality video pass-through, the level of detail of the real world is passed through to the wearer via the cameras.

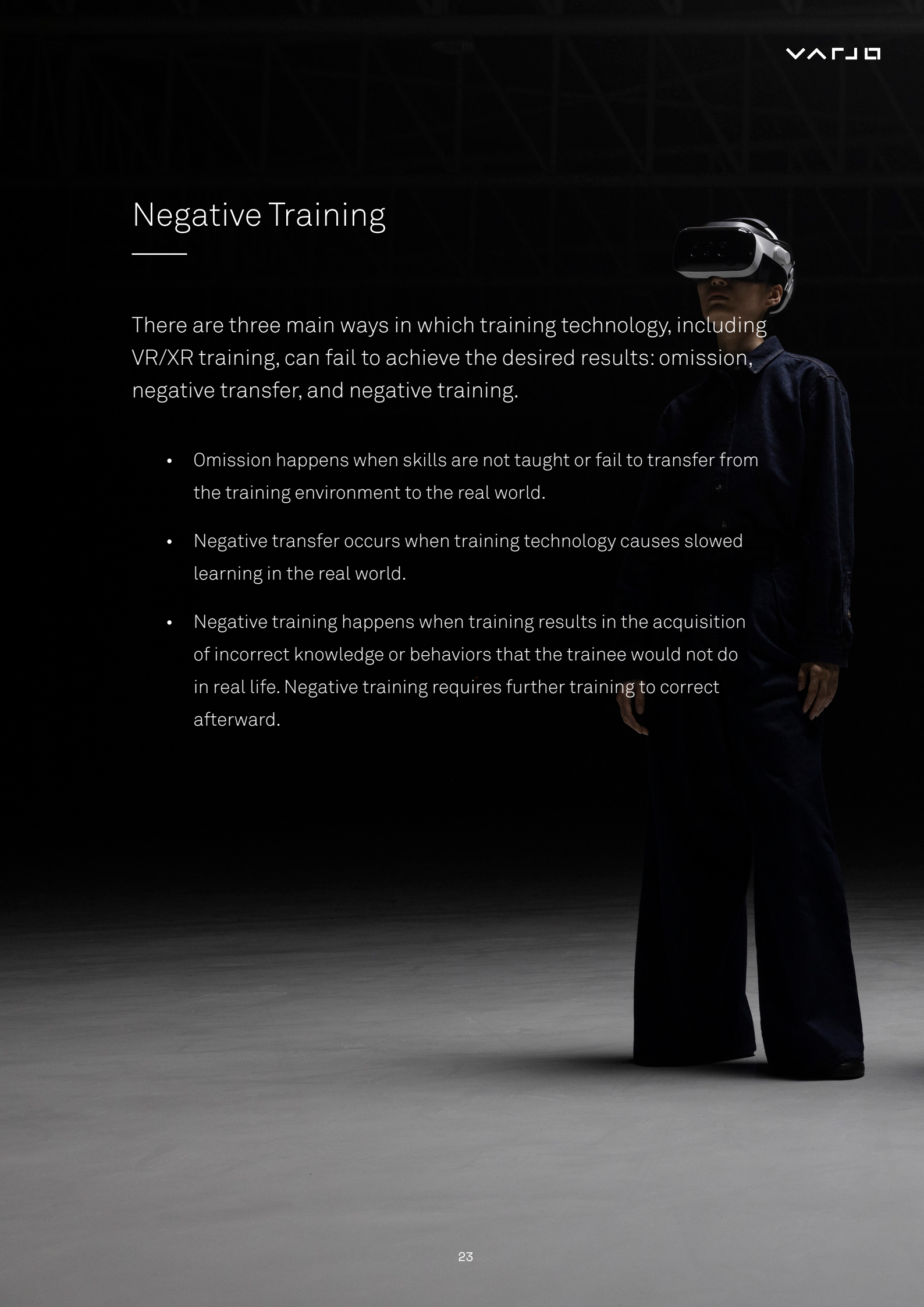
- Depth perception and field of view: Objects need to be shown (and need to be perceivable by the wearer) at realistic visibility ranges, and distances need to be perceived naturally. It is also essential when using VR/XR headsets that the users have a wide enough field of view so they can practice using their peripheral vision similar to the real world.

- Sufficient complexity and similarity of tasks compared with the real world: For example, virtual controllers need to closely resemble real-world ones, so that you can operate them in a natural enough manner, and that you don't just practice one or two stages of more complicated procedures.

When the goal is to have as effective virtual training as possible, headsets geared towards the consumer market typically fall short. While some headsets offer a wider field of view these days, the visual quality is simply not up to par with what is required for the efficient transfer of skills.

In the case of mixed or augmented reality content, the devices need have sufficiently low latency, or it will cause similar problems and simulator sickness.

Negative Training



There are three main ways in which training technology, including VR/XR training, can fail to achieve the desired results: omission, negative transfer, and negative training.

- Omission happens when skills are not taught or fail to transfer from the training environment to the real world.
- Negative transfer occurs when training technology causes slowed learning in the real world.
- Negative training happens when training results in the acquisition of incorrect knowledge or behaviors that the trainee would not do in real life. Negative training requires further training to correct afterward.

Negative training has traditionally been an issue in headset-based training. When pilots train with non-optimal devices, they learn mannerisms that do not accurately reflect what they would need to do in an actual aircraft in the same situation. This can include, for example, incorrect use of controllers, using their gazing in the wrong direction, failing to check specific gauges or instrument panels, etc. Several factors can cause these behaviors:

- **Insufficient resolution:** Control panels and gauges can't be read if the resolution is not sufficient. Objects far away are just pixelated mush or disappear entirely when they would be easily perceivable in real life.

- **Too high latency of video pass-through in mixed reality:** Reactions become unintuitive, may cause nausea.

- **Use of virtual controllers that differ from real ones:** Causes the trainee to learn incorrect behaviors not reflective of the real-world aircraft.

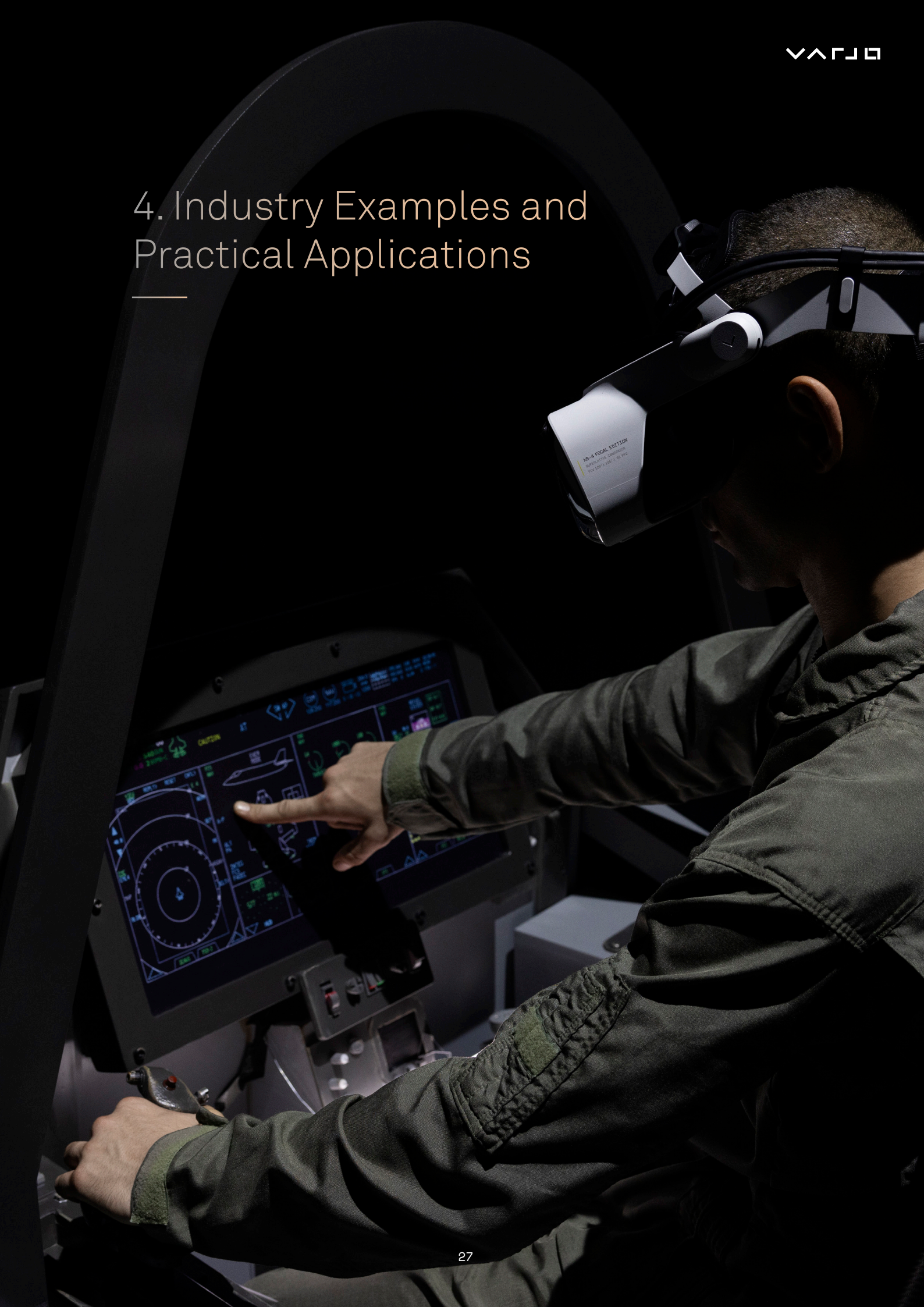
Varjo headsets address these issues by having an industry-leading resolution (up to 51 pixels per degree), and the lowest-latency video pass-through in both virtual and mixed reality scenarios. These capabilities ensure that objects near and far can be seen accurately, from instrument panels to other simulated aircraft even over a mile away. The low-latency video pass-through ensures that when operating in mixed reality, reactions always feel natural, and reaction time develops accurately. With mixed reality, trainees can see their own hands and use a HOTAS system in a very natural way for increased immersion.

Mixed reality unlocks additional possibilities as the trainee can be placed in a physical cockpit. They will be able to see all of the panels, just like in the real aircraft, and the virtual world is naturally combined with the physical objects. In addition, the headsets have industry-leading eye-tracking capabilities, so trainee performance can always be assessed accurately.

“Blending together the virtual and physical fidelity interfaces of our collective training applications to provide a revolutionary user experience”

THOMAS KEHR, PROGRAM MANAGER FOR SYNTHETIC TRAINING,
COLE ENGINEERING SERVICES INC.

4. Industry Examples and Practical Applications



Virtual and Mixed Reality: The Evolution in Pilot Training

Immersive technologies are already taking pilot training to the next level, making trainees better prepared and enhancing learning. A virtual or mixed reality training setup allows trainees to be more engaged and focus on the task at hand. Training scenarios can be repeated as many times as needed.

In pilot training, trainees learn primarily by seeing and doing. Thanks to mixed reality technology and 3D sound, trainees can practice in a physical aircraft cockpit while immersed in a synthetically generated virtual world. Mixed reality can help blend the physical with the virtual so well that trainees often forget they are in a simulator. This is possible due to the high-definition stereo pass-through cameras that allow trainees to see the real world and interact with the physical cockpit. This interaction includes all the knobs, dials, maps, and iPads, which train muscle memory that is a critical part of pilot training. More knowledge can thus be acquired in a shorter period. A virtual simulator an attractive investment to flight schools and companies as they can efficiently train more pilots in a shorter timeframe.

Virtual and mixed reality can be used in common training applications, such as pilot screening, basic flight procedure, check-list training, cockpit familiarization, traffic pattern operations, and geographic familiarization. Simulations also allow us to create training scenarios that are extremely difficult or impossible to replicate in real life. For example, it is hard to safely simulate an engine failure in a single-engine aircraft midair. With virtual and mixed reality, any safety-critical scenario can be replicated and trained for.

Further, virtual and mixed reality simulators allow multiuser collaboration. This helps crew members to coordinate, communicate and solve emergency scenarios safely together in a multiuser framework. Ultimately, virtual and mixed reality simulators help produce pilots that are better prepared and qualified for their jobs.

The Finnish Air Force, Varjo, Patria and Bohemia Interactive Simulations have collaborated on a pioneering Live-Virtual-Constructive (LVC) training solution. The innovative project shows how virtual simulation can augment live exercises and unlock new training possibilities.

Case Aechelon Technology

Aechelon Technology creates high fidelity, geo-specific representations of the real world, powering the world's most advanced applications for simulated training. To date, Aechelon has delivered over 200 systems that incorporate augmented, virtual, or mixed reality, predominantly designed for multi-sensor operations.

The most advanced XR simulations offer true-to-life immersion and resolution high enough to enable numerous mission-essential training tasks to be completed in headset-based simulators. These portable and highly scalable XR-based solutions can be inserted into the flight training curriculum to supplement and, in some cases, replace the existing coursework and exercises as well as being used as Deployable Mission Reharshal Systems (DMRTs).

The teams at Varjo and Aechelon have forged a strong partnership in their joint goal of developing industry leading XR solutions for mission-critical work. For Aechelon, Varjo's range ensures the technology compatibility with existing training frameworks and ongoing government programs versions.

Case Lufthansa Aviation Training

Lufthansa Aviation Training partnered with BRUNNER and Varjo to explore innovative mixed reality solutions to complement their traditional aircraft training. The NovaSim MR DA42 simulator developed by BRUNNER combines the use of a realistic cockpit with the advanced mixed reality of the Varjo headset. This provides several advantages over traditional physical simulators. With the high-quality video pass-through, the trainee can see their hands and body, and operate all switches, controls and instrument panels with perfect clarity. The virtual scenario is projected outside the cockpit and provides the trainee with a 360-degree view, allowing them to naturally look anywhere in the virtual environment – unlike in a traditional simulator which is often limited to around 180 degrees.

All of this allows Lufthansa Aviation Training to provide instruction to pilots of tomorrow in new formats the trainees are eager to engage in, while improving the training volumes and reducing costs and environmental effects.

Case FlightSafety International

FlightSafety International is the world's premier professional aviation training company and supplier of flight simulators, visual systems, and displays to commercial, government, and military organizations. Together with Varjo, FlightSafety International has developed a pioneering mixed reality flight trainer. Using Varjo's mixed reality headsets and FlightSafety's image generator VITAL 1150 Visual System, the trainer blends a virtual scene of the world with a real-life cockpit. The trainees are able to see real flight controls, all the instrument panels, and their own hands while flying in a photorealistic synthetic environment.

FlightSafety International has over 100 advanced full flight models or simulations that can be easily upgraded with virtual and mixed reality. This can add more immersion to the training as opposed to traditional full-flight simulation. The visual upgrade offered by Varjo expands the possibility to train tasks like single ship start, taxi, takeoff, traffic patterns and landings, approach to stall, acrobatic and confidence maneuvers, and emergency procedures.

Mixed Reality: Live-Virtual-Constructive (LVC) for Complex Training

Pilot training is facing new challenges in the 21st century. As aircraft technology evolves and matures, the competence requirements for pilots are shifting from motor skills towards cognitive skills. Pilots need to solve problems quickly while managing different systems simultaneously, detect and analyze live situations, and make life-altering decisions in a heartbeat.

An innovative way to simulate complex and large-scale flight training is called LVC (Live-Virtual-Constructive). LVC trains pilots via live aircraft, physical simulators, and computer-generated aircraft, all networked into the same 'airspace.' This means that the pilots flying in the air can see the same aircraft and virtual targets as the trainees behind the physical simulators on the ground. The LVC system allows them to train either side-by-side or against each other as part of the same training environment.

LVC makes flight training more motivating and increases the level of readiness before actual deployment. Multi-pilot capability means that training can happen across the world, enabling better collaboration. Multi-pilot capability provides enhanced learning results when trainees know they work together in the same scenario with a live aircraft. LVC allows pilots to use flight hours more efficiently by studying the readiness level in-flight scenarios. Afterward, scenarios can be modified and repeated again and again until the pilot is ready to proceed to the next step. LVC allows trainees to go through technically difficult and even dangerous scenarios securely.

Case Finnish Air Force and Patria

The Finnish Air Force and its partners have developed a novel way of conducting LVC training. Currently, the Finnish Air Force utilizes the LVC environment in Hawk fighter jet flight training where Live, Virtual and Constructive elements are networked into the same environment. For the virtual flight simulators, Finnish Air Force is using Varjo's mixed reality technology that allows trainees to detect even the smallest details in the cockpit. The level of detail creates a highly immersive training experience.

To complement the solution, Patria, the Finnish provider of defense, security, and aviation training and technology solutions, has developed a unique operator performance analytics system called Operator Performance Analytics System (OPAS). OPAS monitors the stress levels and cognitive loads of pilot trainees during the exercise from physiological data, such as eye movements and heart rate variability. The system utilizes Varjo's integrated eye tracking with its <1-degree accuracy to collect accurate psychophysiological measurements to further study trainees' cognitive loads.

All the exercise data, including psychophysiological measurements and combat exercise data, are stored for performance assessment. This includes details such as the air-craft's location, the number of missiles fired, and hit accuracy. Trainers can review all data afterwards to ensure the level of difficulty of the task is ideal.

“Learning is more effective when the difficulty of the task is at an optimal level.”

JUSSI VIRTANEN, BUSINESS DEVELOPMENT DIRECTOR,
PATRIA AVIATION OY

Case U.S. Army RVCT Air Program

In 2023, the U.S. Army selected Varjo's devices as part of its Reconfigurable Virtual Collective Trainer (RVCT) Air program, which offers portable training capabilities for three different helicopter types: Apache, Chinook, and Blackhawk. This multi-million-dollar, multi-year contract supports the Army's goal of creating a synthetic training environment that enables collective training regardless of location.

U.S. Army pilots will leverage Varjo's high resolution displays augmented with video pass-through technology to experience a fully immersive training environment where they can interact with physical controls in real-time. The headset has advanced video pass-through capabilities, performs well in dark and light environments, allows for deep immersion for long periods of time and also can simulate night-flying scenarios. RVCT also leverages Varjo's high-security offering as the headsets are Finland manufactured TAA-certified products and do not have radio frequency.

Helicopter Training in a VR Simulator Offers Huge Cost Savings

Virtual reality fits helicopter training perfectly because operating a helicopter requires good peripheral vision and the ability to look around to have spatial and situational awareness. For training to be realistic, the virtual cockpit should appear as it would in real life, and it needs to have full immersion. For example, a dynamic motion platform simulates the finest changes in attitude and touchdown on the ground, enabling the realistic feeling of flight behavior.

Flight schools and helicopter companies can benefit from VR/XR by offering more efficient and cost-effective, environmentally friendly training. According to Ryan Aerospace, an Australian helicopter flight simulator provider, some of their customers have reduced helicopter training in physical helicopters by around 40% by taking VR trainers into use, offering huge cost savings. With Varjo, Ryan Aerospace can achieve a level of immersive training that was unimaginable until now. Students are able to see everything in the virtual cockpit as they would in real life due to the unique visual fidelity in the immersive environments using Varjo headsets.

Helicopter simulation can be used to learn hovering and other basic helicopter maneuvers. Different emergency procedures, such as autorotation landings, slope landing, and tail rotor failure, can be practiced. With a virtual simulator, trainees can go through scenarios that are impossible or too dangerous with a real helicopter—for example, landings to hostile areas, upset recovery, and autorotative landings. Training for these scenarios in VR/XR environments helps increase flight safety.

Case Loft Dynamics

Both the European Union Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA) have, for the first time, approved a virtual reality-based training solution for pilot training. This accreditation shows that the quality of leading high-fidelity headset-based simulators now fits even the most demanding scenarios and criteria. The certified simulator is developed by Loft Dynamics and uses Varjo's VR headset as its display. The certifications from EASA and FAA allow training conducted in virtual reality to count toward official flight hours in helicopter pilot training programs.

Since the qualification for the trainer is done directly by the officials, any customers of Loft Dynamics can start using the VR training solution without further national certification. For the first time, training time can be credited toward flight training, allowing pilots to train more efficiently. Furthermore, this allows the industry to push the future of aviation training further. The certification also enhances safety since statistics show that around 20% of accidents occur during training flights. Rotorcraft pilots can now practice dangerous maneuvers safely in a VR environment.

“Pilots should receive realistic training on simulators. This allows helicopter operators and flight schools to fly more efficiently and safely.”

FABI RIESEN, CEO, LOFT DYNAMICS

5. How to Get Started with an Immersive Training Solution

To get started with your virtual reality training, the first thing is to scope out the training needs. What are the key operations and scenarios you want to train for? What are the locations this training should ideally take place in? What training software and providers are you already using that would need to be supported by the chosen immersive technology? What kind of virtual, augmented or mixed reality technology would best suit your training needs?

Due to their flexibility and versatility, Varjo headsets are a great match for pilot training regardless of the simulation scenario. The strong immersion and high degree of visual fidelity ensure effective training scenarios and training for extended periods of time – without any simulator sickness or discomfort. The real-time trainee performance can be recorded and accurately assessed thanks to the high-accuracy, built-in eye tracking.

TAA-Certified Training for Secure Environments

Next, are there any security considerations or certification requirements that need to be met by the technology provider? Unlike other headsets in the Varjo XR-4 Series, all XR-4 Secure Edition units are assembled in a secure manufacturing facility in Finland, ensuring full TAA compliancy.

Each XR-4 Secure Edition headset runs completely offline and can be configured to have no radio components, ensuring they are suitable for exceptionally high-security situations and closed-loop network environments.

The Varjo Base software has also received a Certificate to Field (CTF) from the United States Air Force. This certification validates Varjo technology's deployment within the Air Force's Operational Test and Training Infrastructure.

In addition, the headsets have extensive software and hardware compatibility. We support Lockheed Martin Prepar3D, Unreal Engine, BISim VBS Blue IG, as well as industry-leading 3D platforms and standards like Unity, Unreal Engine and OpenXR 1.0. Our headsets run on a broad range of high-end PCs, which makes them easily usable at the point of need – allowing you to easily supplement training in large, dedicated simulators.

Professional-grade Support

Third, how can the headset solution provider support you in your efforts? For demanding scenarios such as pilot training, you ideally want a partner whose product development is geared towards professional end-users rather than consumers because the needs and demands are extremely different. Varjo headsets are not just hardware; we constantly develop software capabilities geared towards professional use cases, such as real-time chroma keying. The development pipeline is built based on feedback from our customers – professionals operating in the most demanding industries with no room for error, including aerospace, aviation, and defense.

In addition, the Varjo team has years of experience in serving safety-critical and high-security customers in training and simulation, aviation, and defense. Our expert team of solution engineers offers dedicated setup assistance and support for complex VR/XR training systems.

Contact Us and Learn More

Want to hear more about implementing photorealistic virtual and mixed reality technologies in your training? We'd love to give you a demo and discuss how Varjo's professional-grade virtual and mixed reality solutions can benefit your simulation needs.

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