



Air Force Global Strike Command // Find the Why! Advanced Training Systems Challenge

Challenge Road Map Questions

1. Why did you accept the invitation to participate in this AFGSC Find the Why! Challenge?

We accepted the invitation to participate in this AFGSC Find the Why! Challenge? due to our interest in the topic, as we hope to take this opportunity to learn more about and clarify our understanding of the Air Force Global Strike Command. Additionally, given we are all students interested in pursuing technology, we are passionate about modernizing the administrative aspect of educational systems and integrating immersive experiences to improve learning as a whole. We hope to design more interactive learning methods with higher quality data analytics through video games and gamified incentives (<https://www.gamify.com/what-is-gamification>). As non-profit educators, we have witnessed first-hand the transformative impact education has on those that need it most. Unfortunately, education remains inaccessible to a large percentage of the population, and the situation has only worsened with the new wave of Omicron cases (<https://www.nytimes.com/2022/01/22/us/omicron-cases-us-deaths.html>, <https://news.yahoo.com/california-schools-under-intense-strain-130059166.html>,). For example, LAUSD recently reported a 66.8% student attendance rate (https://www.latimes.com/california/story/2022-01-14/130000-laUSD-students-absent-amid-omicron-covid-surge#:~:text=53%20PM%20PT-,Incoming%20Los%20Angeles%20Unified%20Supt.,the%20district's%20coronavirus%20safety%20measures))—with no personalized remote learning alternatives, students are forced to choose between school and safety. Therefore, we hope to explore technology-based solutions to educational inequity. We feel that this challenge is an ideal opportunity to do so, especially as we delve into the potential of extended reality and machine learning in education as well as their drawbacks and areas of concern (<https://www.forbes.com/sites/tmobile/2021/08/24/extended-reality-is-ready-to-revolutionize-higher-education/?sh=7ed91ce253c1>, <https://aws.amazon.com/education/ml-in-education/>). In our own experiences in high school, we've been more drawn to immersive, hands-on activities, such as conducting labs and the following interactive biotechnology activities:

https://www.labxchange.org/library/items/lb:LabXchange:9548bee3:lx_simulation:1,
https://www.labxchange.org/library/items/lb:LabXchange:f7f6962a:lx_simulation:1,
<https://learn.genetics.utah.edu/content/labs/microarray/>).

2. Explain your overall solution or concept in a summary of 500 characters or less.

Launch. Play. Learn. Knoll makes it that easy. Knoll is seamlessly integrated into the MOTAR platform—just put on your VR goggles and haptic gloves, step on the VR treadmill, and click launch. Once in the game, you'll spawn in the Barracks, where you can invite friends and enter a custom lobby. After, you can choose from a list of preset missions or customize your own. Multiplayer missions can consist of defusing explosives, identifying IED threats, responding to WMDs, and more tasks developed by expert EOD drill designers on AI-generated or modded maps. Meanwhile, you're collaborating and communicating through the voice chat offered by an in-game radio, and instructors can watch the gameplay live with spectator mode. Following the mission, you'll have access to cutting-edge analytics and game review commentated by our AI Instructor Kane. Replay the game from the perspective of any player in the mission and receive personalized feedback on every action from Kane. Based on your aggregate performance over past games across set success metrics like ordnance disposal times, collateral damage incurred, and adaptability, Kane will prescriptively optimize future missions as well as recommend specific training. Back at the Barracks, you can view these specific recommendations—whether it be single-player training practices and tutorials on Knoll or expert demonstrations and course resources back on MOTAR. The Barracks also display game statistics that can be viewed over time and in comparison to benchmark and goal levels. These quantifications of more abstract skills will enable trainees to clearly understand their strengths and weaknesses and incentivize individual progress through our gamified system's ranks. To keep trainees engaged, push notifications across devices can send out reminders for overdue training, upcoming practice sessions, time-sensitive announcements, and weekly summary reports. Exiting the game takes you back to MOTAR. Knoll's integration into MOTAR enables single-sign-on and syncing across MOTAR's communities and courses. Progress from Knoll can intertwine with the rest of MOTAR's statistics on the student and instructor dashboards. These various options for learning content combined with the centralization on the MOTAR platform shape a structured yet flexible curriculum. Knoll wants to best accommodate the need of every student. To ensure accessibility to the training 24/7, Knoll provides both the single-player option for offline and individual training and the multiplayer option for collaborative work. Knoll is also flexible to various learning environments. For indoor or at-home training, virtual reality will be used with simulated terrain while for outdoor and on-site training, augmented reality with real terrain will be available. Either mode provides students with full access to the Barracks, simulated scenarios, reference materials, and system configurations. If students prefer blended learning, the training content will also be available to access on mobile devices or PC through the interactive and self-paced MOTAR modules. Knoll is a modern and sustainable approach providing a both cost-effective and agile training system. We focus on the needs of every individual, as Knoll reimagines learning as a robust, immersive, and personalized experience to look forward to.

3. Using one or both of the Challenge Scenarios provided, explain your solution in detail and note how your solution boosts AFGSC efforts to advance and improve training.

Launch. Play. Learn (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6234876/>). Knoll is seamlessly integrated into the MOTAR platform—just put on your VR goggles and haptic gloves, step on the VR treadmill, and click launch. In-game, the player spawns in the Barracks, where they can invite friends and enter a custom lobby. Next, they can choose from a list of preset missions or customize their own with any number of trainees. Multiplayer missions include defusing explosives, identifying IED threats, responding to WMDs, and more tasks developed by expert EOD drill designers on AI-generated or modded maps. These AI-generated maps can be inspired by real-life locations and data from historic deployments. During a mission on Knoll, trainees can cooperate and communicate through the voice chat powered by the in-game radio. Meanwhile, Knoll supports spectators, where instructors can watch the gameplay live (https://leagueoflegends.fandom.com/wiki/Spectator_Mode, <https://www.midiaresearch.com/blog/the-case-for-next-generation-spectator-modes-in-games>). Following the mission, you'll have access to analytics and game review generated by our AI Instructor Kane. Replay the game from the perspective of any player in the mission, receive personalized feedback on every action from Kane, and refine your personal training recommendations (<https://learninginnovation.duke.edu/blog/2017/03/learning-objectives/#:~:text=Learning%20objectives%20should%20be%20used,they%20are%20actionable%20and%20measurable>). Based on your aggregate performance over past games across success metrics like ordnance disposal times, collateral damage incurred, and adaptability, Kane will intelligently optimize future missions as well as recommend specific training of all skill levels on Knoll and MOTAR to target weaknesses and produce specific outcomes (<https://educationaltechnology.net/adaptive-learning-what-is-it-what-are-its-benefits-and-how-does-it-work/>). Back at the Barracks, you can view these specific recommendations—whether it be single-player training practices and tutorials on Knoll or expert demonstrations and course resources back on MOTAR. The Barracks also display game statistics that can be viewed over time and in comparison to benchmark and goal levels. These quantifications of more abstract skills will enable trainees to clearly understand their strengths and weaknesses and incentivize individual progress through our gamified system's ranks. To keep trainees engaged, push notifications across devices can send out reminders for overdue training, upcoming practice sessions, time-sensitive announcements, and weekly summary reports (<https://www.jeeng.com/blog/benefits-of-push-notifications/>, <https://www.webiotic.com/benefits-of-push-notifications/>). Exiting the game takes you back to MOTAR. Knoll's integration into MOTAR enables single-sign-on and syncing across MOTAR's communities and courses. The game's scalability, modularity, and cost-effectiveness support groups of any size and smooth adoption. Progress from Knoll can intertwine with the rest of MOTAR's statistics on the student dashboard (<https://docs.motar.io/motar-services/motar-training/student-dashboard>). It will also be accessible on the instructor dashboard and joined into collective class performance to aid in cohesive data patterns (<https://docs.motar.io/motar-services/motar-training/instructor-dashboard>). MOTAR offers more traditional course modules with readings and videos that cater to various types of learners (<https://teex.org/program/explosives-ordnance-training-eot/>, <https://docs.motar.io/motar-services/motar-studio/apps>, <https://docs.motar.io/motar-services/motar-training/course-creator>). These various options for learning

content combined with the centralization on the MOTAR platform shape a structured yet flexible curriculum. Knoll wants to best accommodate the need of every student. That is why different modes are available. To ensure accessibility to the training 24/7, Knoll provides both the single-player option for offline and individual training and the multiplayer option for collaborative work. Knoll is also flexible to various learning environments. For indoor or at-home training, virtual reality will be used with simulated terrain while for outdoor and on-site training, augmented reality with real terrain will be available (<https://medium.com/@brentmerswolke/vr-games-you-can-play-with-your-friends-who-dont-have-a-headset-56cc704f9b61>). Either mode provides students with full access to the Barracks, simulated scenarios, reference materials, and system configurations. If students prefer blended learning, the training content will also be available to access on mobile devices or PC through the interactive and self-paced MOTAR modules. Knoll can best assist AFGSC's vision of cultivating qualified EOD personnel with a modern and sustainable approach by providing a both cost-effective and agile training system. The mixed reality technology can significantly reduce the budget for "operation and maintenance" while creating personalized and collaborative learning experiences on a centralized platform that is sensitive to improving its flaws. We focus on the needs of every individual, as Knoll reimagines learning as a robust, immersive, and personalized experience to look forward to.

4. Explain how your system incorporates a Learning Management System given the following guidance: A Learning Management System (LMS) launches the training environment and allows for accessibility and availability of all types of immersive content (Augmented Reality/Virtual Reality/ Mixed Reality, tests, videos, devices, etc.).

We plan to integrate our system with the Learning Management System as an app to be launched on the MOTAR training platform using MOTAR's Unity SDK (<https://docs.motar.io/develop/sdks/unity>). This integration enables single-sign-on and syncing across MOTAR's communities and courses (<https://docs.motar.io/>), as the game's scalability, modularity, and cost-effectiveness support groups of any size and smooth adoption. In syncing with MOTAR's statistics, progress from the game can be joined with the statistics of other EOD-related courses on MOTAR on the student dashboard and task summary (<https://docs.motar.io/motar-services/motar-training/student-dashboard>). It will also be accessible on the instructor dashboard and aggregated into collective class performance to aid in cohesive data analytics (<https://docs.motar.io/motar-services/motar-training/instructor-dashboard>). Knoll's Barracks feature serves as an in-game "base," designed to review game analytics, trends, game settings, tutorials and single-player training ranges, physical fitness training. In the Barracks, players can also chat and voice call other players to enhance social capabilities (https://www.researchgate.net/publication/278016074_Using_Video_Games_to_Develop_Social_Collaborative_and_Communication_Skills), inspect tools (details, use cases, instructions, etc.), and review gameplay from previous runs from the perspective of any player in that round. Additionally, trainees can add other trainees as "friends" on Knoll using unique MOTAR IDs; players can invite friends to enter a custom lobby for a mission on Knoll or design a custom game as well as view certain statistics of friends, such as rank, mission history, etc. to cultivate a community around Knoll. To decrease toxicity and aggression common in

competitive gaming

(<https://cardinalscholar.bsu.edu/bitstream/handle/123456789/201987/2019ColemanRobert-combined.pdf?isAllowed=y&sequence=1>), players can choose to hide certain or all statistics so that they are only viewable to themselves. MOTAR itself allows for collaborative capability with current and graduated students, from chat rooms up to avatar participation, that trainees can utilize to network with others (<https://docs.motar.io/motar-services/motar-communities>). Knoll will work in tandem with traditional course modules created on MOTAR—videos, readings, etc. to cater towards various types of learners (visual, auditory, kinesthetic, reading and writing)

(<https://www.rasmussen.edu/student-experience/college-life/most-common-types-of-learners/>). The various options for learning content combined with the centralization on the MOTAR platform shape a structured yet flexible curriculum. The more conventional learning modules can be recommended as resources to address specific learning targets and allow for on-demand offline learning in remote locations 24/7 without VR/AR equipment—flexibly accessed on mobile devices, tablets, and computers. Furthermore, the ability to launch MOTAR and connect to Knoll among other training resources allows for synced notifications across all devices. Push notifications can be implemented to alert trainees conveniently on their phone or other commonly used devices regarding overdue training, upcoming training times, deadlines, time-sensitive announcements, weekly analytics reports, events logged in the MOTAR calendar, etc. These push notifications can be modified by users and modeled after daily Duolingo push notifications for language practice (<https://push.duolingo.com/>); Canvas notifications for weekly summaries, instructor announcements, assignment deadlines, and conversation messages

(<https://s3.amazonaws.com/tr-learncanvas/docs/CanvasNotifications.pdf>); and Google Calendar notifications for upcoming events and reminders logged on the app's calendar (in MOTAR's case, either by the user or administrator)

(<https://support.google.com/calendar/answer/37242?hl=en&co=GENIE.Platform%3DDesktop>). Relating to Airmen records and certifications (<https://amsrvs.registry.faa.gov/airmeninquiry/>,

https://www.faa.gov/licenses_certificates/airmen_certification/copy_of_certification_records/) as well as performance-tracking awards/levels, this information will be logged not only in the Knoll Barracks but also in users' MOTAR profiles. In the Knoll Barracks, these levels and certifications parallel ranks or levels in video games, such as the divisions from Iron to Radiant in the Valorant ranking system

(<https://www.alphr.com/valorant-ranking-works/>) as well as other games:

<https://www.leagueoflegends.com/en-us/>, <https://supercell.com/en/games/clashofclans/>,

<https://clashroyale.com/>, <https://www.naeu.playblackdesert.com/en-US>). In the MOTAR profile, these

certifications and awards are displayed in a less gamified way, as verified certificates from online courses are displayed on accounts across Coursera (<https://www.coursera.org/>), Udemy

(<https://www.udemy.com/>), EdX (<http://edx.org/>), Khan Academy (<http://khanacademy.org/>), Code

Academy (<https://www.codecademy.com/>), and BTree Code Academy (<https://www.btrecode.com/>).

Moreover, these displayed certifications and awards can incentivize trainees and encourage healthy

competition in an otherwise collaborative game. The Air Force Credentialing Opportunities On-Line (COOL)

“has a credential mapping for 642 professional certifications and licenses to support the 190 enlisted Air

Force specialty codes” (<https://training.nhlearninggroup.com/blog/af-cool-program-explained-nhdod>) that

aid in professionalizing the enlisted force with industry-recognized certificates and provide a path to return

to civilian workforces (<https://resources.infosecinstitute.com/topic/af-cool-program-your-complete-guide/>).

With regards to the help desk interface, we propose Knoll and its integration in MOTAR to utilize AI-powered customer service, as intelligent chatbots using natural language processing can simulate human interactions while dramatically increasing efficiency by handling multiple queries at once, reducing human resources, and eliminating wait times for users.

(<https://www.ada.cx/ai-chatbot#:~:text=What%20is%20an%20AI%20Chatbot,%2C%20sales%2C%20and%20human%20resources>,
<https://community.canvaslms.com/t5/Canvas-Basics-Guide/How-do-I-contact-Canvas-Support/ta-p/389767>,
<https://www.salesforce.com/products/service-cloud/best-practices/how-ai-changed-customer-service/#:~:text=AI%2C%20in%20its%20various%20incarnations,and%20struggle%20with%20wait%20times>).

5. How does your system welcome collaboration with other innovative minds given the following guidance: The training environment simulates the real world and will be made available for multiple content providers and creators to develop dynamic training scenarios.

Our system welcomes collaboration largely through game modification, where creators can customize the aspects of the game. To be modification-friendly, we can define gameplay variables in text and have graphics of a standard format such as bitmaps, yet we plan to maintain these in proprietary files to ensure the privacy and exclusivity of US Air Force EOD training

(https://www.jstor.org/stable/j.ctt46mt37.5?seq=2#metadata_info_tab_contents,
<https://docs.microsoft.com/en-us/dotnet/desktop/winforms/advanced/types-of-bitmaps?view=netframeworkdesktop-4.8#:~:text=BMP%20is%20a%20standard%20format,bits%20per%20pixel%20are%20common>).

Add-on mods provide an avenue for content creators to implement new elements in the game, such as a new explosive, map, vehicle, etc., and can be easily distributed whether it is adopted by the game or operates independently without changing the original game's existing content. This allows for unofficial bug fixes, overhaul mods, and entire new modes to the specific needs of each training department and scenario

(<https://www.sapphireation.net/the-importance-of-modding>). This level of customizability allows the system to stay up to date without the added cost and inconveniences of official support (development cycle, <https://www.g2.com/articles/stages-of-game-development>).

Besides AI-generated training scenarios, creators can create custom scenarios and enable dynamic scenarios by creating their own random map scripts (RMS, <https://steamcommunity.com/sharedfiles/filedetails/?id=155256742>).

Custom scenarios allow creators to recreate historic scenarios and innovative new training grounds. Existing scenarios employed by EOD training include stateside scenarios, deployed environment scenarios, dismounted scenarios, and more

(http://www.forthoodsentinel.com/living/tests-eod-skills-in-realistic-scenarios/article_4d5d7798-f5e5-11e5-ae00-bbe3fff11821.html). As the rules of combat evolve, so must the training. Mods will allow expert EOD drill designers to create secure, sharable maps for EOD training system-wide to adapt to new situations that arise on the battlefield.

Dynamic scenarios, on the other hand, provide customizable randomness to training, applying both expert design and computer variability to challenge the trainees. One of the most important abilities an EOD technician should acquire through training is to be "prepared for anything that may that may be thrown at them in the future, stateside or deployed"

(<https://www.nellis.af.mil/News/Article-Display/Article/755945/eod-training-for-any-scenario/>). Both types

of modded scenarios will be available on a shared marketplace for free mods to allow for sharing between training centers (air force bases, for example) if intended, or kept private. A committee on the Knoll team will help connect experienced game developers and EOD trainers to develop game mods to ensure the quality of both code and training.

6. Detail how your system incorporates a Virtual Instructor (AI)?

AI-driven learning can help make EOD training more accessible and personalized. More generally in education, AI tools that can be accessed remotely 24/7 can automate manual processes and quickly respond to commonly asked questions, leaving more time for instructors to focus on lesson planning and student engagement

(<https://thejournal.com/articles/2021/06/23/7-benefits-of-ai-in-education.aspx#:~:text=AI%20can%20help%20free%20up,and%20closing%20the%20educational%20gap.&text=By%20analyzing%20each%20student's%20specific,student%20falls%20too%20far%20behind>). Combining learning analytics techniques and explainable machine learning, AI-based curriculums can provide intelligent feedback and action recommendations to optimize learning performance and boost motivation

(<https://www.frontiersin.org/articles/10.3389/frai.2021.723447/full>,

<https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-020-00219-w>). For

example, there have been various cases of learning platforms onboarding machine learning models to enhance, personalize, and encourage the self-management of instruction, such as Quizlet's Learning Assistant (<https://www.zdnet.com/article/quizlet-is-betting-ai-machine-learning-can-tutor-students/>, <https://builtin.com/artificial-intelligence/ai-in-education>,

<https://www.shiftelearning.com/blog/artificial-intelligence-elearning>). Adaptive learning through AI offers real-time feedback and differentiated pathways to optimize learning uniquely for every individual

(<https://www.smartsparrow.com/what-is-adaptive-learning/#:~:text=Adaptive%20learning%20%E2%80%94%20or%20adaptive%20teaching,fits%20all%20learning%20experience>). BioBeyond, for example, has

supplemented and even replaced more costly, less efficient alternatives to learning through incorporating an adaptive and interactive biology course that emphasizes critical thinking rather than pure memorization (<https://www.inspark.education/biobeyond/>). Our EOD training system specifically incorporates an AI

Virtual Instructor through a recommender system and database storing each individual player's capabilities across defined learning targets (aligning with MOTAR's course objectives and modules). Because each

individual will have a unique degree of capability across skills and each training practice will be correlated with different degrees of different skills, there are no particular output values we expect to be predicted for

a given input (no fixed practice to be recommended); therefore, we turn to unsupervised learning models prevalent in recommender systems to create and recommend in-game practices/assessments

(<https://towardsdatascience.com/introduction-to-recommender-systems-6c66cf15ada>,

<https://www.ibm.com/cloud/learn/unsupervised-learning>,

<https://www.v7labs.com/blog/supervised-vs-unsupervised-learning#unsupervised-learning>). The

personalization in generating curriculum accommodates students at all levels of training. Learning targets in our system can be categorized broadly under the Air Force EOD's nine core mission areas and subsequently

divided more narrowly into specific skills by our AI's unsupervised clustering algorithms: aerospace systems/vehicles and conventional munitions; counter-IED operations; combating WMDs which may include incendiary, chemical, biological, radiological and nuclear hazards; nuclear weapon response; unexploded ordnance recovery operations; operational range clearance; defense support to civil authorities; irregular warfare security force assistance, counterinsurgency, stability operations, humanitarian mine assistance, and building partnership capacity; and VIP protection support activity to US Secret Service, Department of Homeland Security, and Department of State

(https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_42.pdf,

<https://www.youtube.com/watch?v=pzMnLV1Yugs>). Learning targets are effective in learning, as they clarify goals for both instructors and students

(<https://learninginnovation.duke.edu/blog/2017/03/learning-objectives/>) and have empirically benefitted students. Specific tasks within the game can be correlated with these learning targets; for example, successfully recovering enemy explosive stockpiles in-game individually or as an assist to others can be tracked as different degrees of success under the counter-IED operations learning target

(<https://www.dvidshub.net/video/511084/eodordnancedisposal>). Using data gathered from players' games, our AI-based platform in the Barracks (where players can view statistics on success metrics) can quickly analyze said data and continuously optimize and improve learning experiences; this involves altering scenarios, such as IED threat locations, types of explosives, etc. depending on past performance. Based on different combinations of strengths and weaknesses determined by success rates of learning targets, our Virtual Instructor is designed to dynamically recommend and filter training practices and learning modules based on this feedback. Historically, "an AI application might play the role of a tutor who observes students' learning processes, analyzes their learning performance, and provides instant assistance to them based on their needs." (<https://www.sciencedirect.com/science/article/pii/S2666920X20300011>). In the field of Artificial Intelligence in Education (AIED), the effectiveness of AI to serve as an intelligent tutor to promote learning outcomes has been supported by various meta-analytic studies:

<https://psycnet.apa.org/record/2014-25074-001>, <https://psycnet.apa.org/record/2013-44233-001>,

<https://www.cmu.edu/news/stories/archives/2020/may/intelligent-tutors.html>. Following games, trainees will be able to immediately review gameplay if they choose to do so and/or save their gameplay in their logs to review at a future time. While replaying gameplay, they have access to the perspectives of all trainees in the round and an AI instructor commenting on specific gameplay in side text during the stream. On chess.com (<https://chess.com/>), the chess analysis feature (<https://www.chess.com/analysis>) allows players to see the number of "perfect moves," "mistakes," "blunders," etc. as well as the evaluation bar following every move. We hope to replicate a similar intelligent instructor critiquing training games. "Although AI systems have been positively recognized for improving the quantity and quality of communication, for providing just-in-time, personalized support for large-scale settings, and for improving the feeling of connection, there were concerns about responsibility, agency, and surveillance issues. These findings have implications for the design of AI systems to ensure explainability, human-in-the-loop, and careful data collection and presentation"

(<https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-021-00292-9>). In our use of machine-based decision-making, we prioritize privacy and regular supervision to ensure ethical and fair use of AI.

7. Detail how your system incorporates mixed reality hardware given the following guidance: Mixed reality hardware is essential to the user experience. The training modules could be built on devices and be as simple as a smartphone or tablet, or extended reality goggles. Haptics such as gloves, suits, and other devices can further stimulate the senses and improve the user experience by adding realism.

Mixed reality is central to our EOD training system. Our gamified system offers two core modes: virtual reality for simulated terrain and use indoors, and augmented reality for real terrain and use outdoors. Both modes allow the player to view and navigate the system with access to the Barracks, simulated scenarios, and system configurations. The virtual reality mode requires VR goggles for immersive video and audio (Valve Index <https://www.valvesoftware.com/en/index>, Oculus Quest <https://www.oculus.com/quest-2/>, Refense <https://www.refense.com/?lang=en>), VR treadmills for mobility in indoor room with other players (KAT Walk C <https://www.kat-vr.com/products/kat-walk-c>, Virtuix Omni <https://www.virtuix.com/>, Infinadeck <https://www.infinadeck.com/>), and haptic gloves for simulated touch (HaptX <https://haptx.com/>, VRgluv <https://www.vrgluv.com/>, Meta <https://www.theverge.com/2021/11/16/22782860/meta-facebook-reality-labs-soft-robotics-haptic-glove-p-rototype>). VR mode is suited to stationary training with no access to outdoor terrain. The treadmill allows players to roam in a diverse selection of infinitely large virtual environments while physically moving to simulate real EOD field missions and implement elements of traditional strength and conditioning training. The glove enables players to hone their skills in operating EOD equipment (X-Ray systems, EOD disruptors, EOD knives multi-tools, explosive demolition equipment, EOD lasers, cap crimpers, grappling hooks, mine probes, metal detectors, EOD dive gear, EOD robots, emergency comms, and cameras, <https://www.eod-gear.com/eod-equipment/>, <https://idealblasting.com/eod-equipment/>) without access to real machinery, cutting cost, streamlining daily practice, and ensuring safety. Due to the extreme physical activity with this equipment, we use portable, rugged, and weather-proof hardware. On the other hand, the augmented reality mode requires AR goggles (Magic Leap <https://www.magicleap.com/en-us>, Hololens <https://www.microsoft.com/en-us/hololens>, X2 <https://thirdeyegen.com/x2-smart-glasses>). Although AR requires outdoor terrain for simulated scenarios, the mode requires less equipment. Haptic gloves can be used optionally to simulate touch as in VR mode. The benefits of using virtual and augmented reality in military training have already been recognized, with the military already contracting several companies for mixed reality goggles (<https://news.microsoft.com/transform/u-s-army-to-use-hololens-technology-in-high-tech-headsets-for-soldiers/>, <https://www.globenewswire.com/news-release/2021/02/04/2170147/0/en/USARPAC-Deploys-ThirdEye-s-X2-MR-Smart-Glasses-and-RemoteEye-Software.html>). MR technologies save money, create a safer environment for trainees, and help EOD technicians develop cognitive skills. According to the Official Naval Research (<https://www.onr.navy.mil/Media-Center/Press-Releases/2017/ONR-Tactical-Decision-Kits>), people who do not play video games are worse at memorizing visual objects, have a less developed field of vision, and process new information slower than gamers (<https://jasoren.com/augmented-reality-military/>). Therefore, creating game-like simulations with the help of mixed reality can enhance the EOD technicians' cognitive abilities and put virtual training in line with field practices. With regards to biometrics—sensors,

biofeedback, eye trackers, etc.—AR/VR devices are capable of collecting a significant amount of biometric data that can be used to create better immersive experiences but raise privacy concerns (<https://www.mesaonline.org/2018/08/08/me-journal-the-biometric-data-concerns-around-virtual-and-augmented-reality-applications/#:~:text=Both%20AR%20and%20VR%20can,faces%20as%20they%20do%20so>), <https://itif.org/publications/2021/03/04/balancing-user-privacy-and-innovation-augmented-and-virtual-reality>, <https://drum.lib.umd.edu/bitstream/handle/1903/20513/CS-TR-5058.pdf?sequence=1&isAllowed=y>). Similar to Oculus’s data policy, we would collect the following information: physical features (such as estimated hand size when enabling hand tracking) as well as environmental, dimensions, and movement data to improve XR features (<https://www.oculus.com/legal/privacy-policy/>). For example, for Oculus’s voice services, the company analyzes and reviews users’ voice commands using human and machine processes to improve, troubleshoot, and train their speech recognition systems.

8. Describe the benefits that AFGSC will realize by adopting your solution.

Our gamified system satisfies AFGSC’s need for both cost-effective and agile training, allowing the efficient cultivation of qualified EOD personnel with a modern and sustainable approach. First, it is important to recognize that military training is extremely expensive. Breaking down the overall defense budget in 2020, more than 40% of the \$690 billion were spent on the “operation and maintenance” category, which includes “the cost of military operations such as training and planning [and] maintenance of equipment” (<https://www.pgpf.org/budget-basics/budget-explainer-national-defense>, https://dod.defense.gov/News/Special-Reports/0218_Budget/?videoid=641687&dvpTag=EOD, <https://www.jstor.org/stable/resrep22711>). As the mission of EOD spans to every corner of the world, the cost for transportation becomes a burden as it often requires expensive vehicles such as helicopters and RHIB boats ([https://www.navy.com/careers/explosive-ordnance-disposal-technician#:~:text=Basic%20Parachute%20Training%20\(3%20weeks,is%20in%20San%20Diego%2C%20CA\)](https://www.navy.com/careers/explosive-ordnance-disposal-technician#:~:text=Basic%20Parachute%20Training%20(3%20weeks,is%20in%20San%20Diego%2C%20CA))). The virtual reality environment of our solution accounts for that concern as students will be able to easily change the location setting to fully experience the process of carrying out their mission in different countries and scenarios without having to worry about the quantity and maintenance of vehicles for transportation (<https://www.mynavyhr.navy.mil/Support-Services/Distribution-Management/Foreign-Leave-Travel/>, https://www.army.mil/article/207956/opat_reducing_trainee_attrition_avoiding_millions_in_wasted_training_dollars_officials_say). Besides transportation, the cost for instructors could also limit the number of students AFGSC can train at once. With an urgent need for EOD specialists and trainers, the average salary for an EOD instructor ranges from \$60,000 to \$15,000 (https://www.glassdoor.com/Salaries/eod-instructor-salary-SRCH_KO0,14.htm#:~:text=The%20national%20average%20salary%20for,is%20%2458%2C036%20in%20United%20States, <https://www.ziprecruiter.com/Salaries/EOD-Salary>, <https://www.ziprecruiter.com/Salaries/How-Much-Does-an-EOD-Make-a-Year--in-California>, <https://www.indeed.com/cmp/U.S.-Army/salaries/Explosive-Ordnance-Disposal-Specialist>,

<https://jooble.org/jobs-explosive-ordnance-disposal>), meaning that a single instructor will typically have to oversee more than the optimal ratio of 6:1, potentially undermining the quality of the EOD education. Our system can effectively lower that cost in the long run while ensuring the quality of the training as Virtual Instructors, based on AI, embedded into the LMS will be working side-by-side with teams, even individual students who may need extra support, and guide them through their journey of becoming qualified personnel. The last section of the “operation and maintenance” category is the cost of equipment. EOD members employ both primitive and advanced technology from hand tools, goggles, chem lights, FBG-MK4 NFDD Flash Bang Trainer, to metal detectors such as Ceia - Metal Detectors MIL-D1 that costs over \$2500 each and K4500DS - T3 Disrupter DS E-Breach Kit that costs over \$8000 each.

(<https://www.blasterstool.com/eodmilitarylaw.aspx>,

<https://www.eod-technology.com/shop/page/3/?orderby=price>,

https://www.rand.org/pubs/research_briefs/RB9124.html). This equipment is necessary for each student to have during the training to help achieve their missions from discovering nuclear threats to performing diagnostics on the devices to reduce their damage. However, it would be difficult to provide every student with the proper equipment while being under the budget

(<https://ui.adsabs.harvard.edu/abs/2005SPIE.5804..130C/abstract#:~:text=Current%20commercial%20robots%20capable%20of,from%2040%2C000%20to%20over%20%24150%2C000>). To address this concern, we

will reduce the cost of equipment by spending the budget on providing haptics including gloves and suits to allow each student to become completely familiarized with different EOD tools. This will also allow individual students to train 7/24/365 at any location without AFGSC having to supervise the use of expensive equipment. Besides effectively reducing the cost of training, our solution can also help AFGSC to improve the EOD training quality. According to the Poorvu Center for Teaching and Learning at Yale University, in order to help students to better engage in the learning process, several key mechanisms are crucial to implementing in the training (<https://poorvucenter.yale.edu/FacultyResources/Student-Learning>). First, students must be able to learn by building upon their prior knowledge and skillsets. Since each individual has a unique background thus different skills and learning curves

(<https://poorvucenter.yale.edu/StudentsPriorKnowledge>), our AI Virtual Instructor can create personalized learning experiences for every student through a recommender system and database storing each individual player’s capabilities across defined learning targets. Social learning is another important aspect of

creating an effective learning environment. According to research in cognitive and educational science published by the National Research Council, “students make significant learning gains when instructors cultivate a social classroom environment. Because instructor-to-student interactions are necessarily limited, a social approach provides a dynamic space of ‘joint negotiation for discovery’ where students can spend more time articulating understanding, recognizing misconceptions, and learning to communicate”

(<https://www.nap.edu/catalog/9853/how-people-learn-brain-mind-experience-and-school-expanded-edition>,

<https://www.nationalacademies.org/our-work/how-people-learn-ii-the-science-and-practice-of-learning>).

Understanding the importance of building an interactive learning community and the value of brotherhood to EOD members (<https://www.dvidshub.net/video/511084/eod-mission-brief-video>), we incorporated collaborative elements into our system including multiplayer mode and home base / barracks where EOD students can connect and create strong bonds virtually. Lastly, it is crucial for the system to be able to effectively collect feedback from students and constantly improve the curriculum

(<https://poorvucenter.yale.edu/FacultyResources/Feedback-Student-Learning>). This can be easily achieved with our centralized learning platform that can monitor students' performance to receive feedback in real-time and efficiently update modules and scenarios for all future students. Virtual small group feedback sessions and end-of-training evaluations led by EOD experts will also be implemented to ensure that the curriculum and maps are constantly improving. The digital technologies involved in Knoll—artificial intelligence and mixed reality—are traditionally prone to privacy and cybersecurity violations. Many AI systems that utilize personal data are susceptible to algorithmic discrimination, such as predictive policing that could disproportionately affect minorities

(<https://www.brookings.edu/research/protecting-privacy-in-an-ai-driven-world/>). Similarly, VR and AR systems often collect and store biometric data from their users

(<https://www.kaspersky.com/resource-center/threats/security-and-privacy-risks-of-ar-and-vr>). Our system requires no sensitive data from its users and solely collects statistics collected from simulated scenarios, protecting the users' privacy and ensuring fairness among users. To protect individuals' data, avoid linkage attacks, and optimize both privacy and utility, we can make use of differential privacy by injecting the database with noise (<https://blog.openmined.org/use-cases-of-differential-privacy/>,

<https://privacytools.seas.harvard.edu/differential-privacy>,

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.101.1298&rep=rep1&type=pdf>,

<https://www.microsoft.com/en-us/research/publication/privacy-preserving-datamining-on-vertically-partitioned-databases/?from=http%3A%2F%2Fresearch.microsoft.com%2Fpubs%2F64353%2Fcrypto04-dn.pdf>).

On the other hand, data that is collected by traditional systems can often be mispurposed or hacked

(<https://www.isaca.org/resources/news-and-trends/isaca-now-blog/2021/beware-the-privacy-violations-in-artificial-intelligence-applications>). To prevent this, all AI data is processed with zero-knowledge proofs

(<https://www.aitrends.com/ai-insider/zero-knowledge-proofs-zkp-and-ai-systems-the-case-of-ai-self-driving-cars/>) and uploaded to secure cloud databases with military-grade AES-256 encryption

(<https://nordpass.com/blog/military-grade-encryption-explained/>), protecting the user by hiding sensitive information and the data snippet by securing its route to the cloud.