The Future Warrior Has Arrived

Taking warfighting to the next level with mixed reality systems

by LtCol Marcus Reynolds

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For the DOD to remain relevant in great power competition, it needs to adopt the innovative technologies already in use by the U.S. private sector. Over the past ten years, technological advances in mixed reality have allowed companies to become more innovative, reducing the time it takes to perform routine tasks and increasing collaboration while performing more complex tasks. Mixed reality systems are transforming how U.S. companies innovate, train, communicate, and work. By leveraging Other Transaction Authorities (OTAs) as they were originally intended, the acquisition community can rapidly put newer innovative technologies in warfighters' hands if DOD officials are willing to accept the risk that some of these acquisition programs may fail.

In one futuristic example, protagonist Tony Stark in the 2008 movie *Iron Man* utilizes mixed reality to manipulate data to design a better suit (see Figure 1). Stark uses mixed reality to harness the power of rapid prototyping to quickly increase the capabilities of his suit.[1] While this example is fiction, technological advances in industry have brought this closer to reality. The ability to effectively prototype digitally versus physically has the potential to save large amounts of time and money. Prototyping using new innovative technologies, such as mixed reality, has potential to make the DOD innovative once again.

The 2018 *National Defense Strategy* (*NDS*) states the priorities for the DOD to modernize, pursue new methods for acquisitions, increase the size of the joint force, improve readiness, and retain a full spectrum force that is capable of deterring and defeating aggressive competitors.[2] Currently, mixed reality headsets like the Microsoft HoloLens 2 and the Magic Leap One bring some of the futuristic capabilities depicted in Iron Man to our DOD service members. More significantly, mixed reality systems will help the DOD to meet the goals of the NDS to modernize, pursue new methods for acquisition by leveraging OTA agreements improve readiness, and increase the joint force's ability to compete. Mixed reality systems have a multitude of potential applications that can be used on the battlefield, in maintenance bays, aboard ships, in aircraft hangars, and in testing, modeling, and planning. It has the potential to change how the DOD wargames. Mixed reality systems, when partnered with Artificial Intelligence (AI), advanced peripherals, and edge computing will increase the lethality and effectiveness of the DOD service member wielding this technology. Using these advanced technologies, the DOD can bring Multi-Domain Op-

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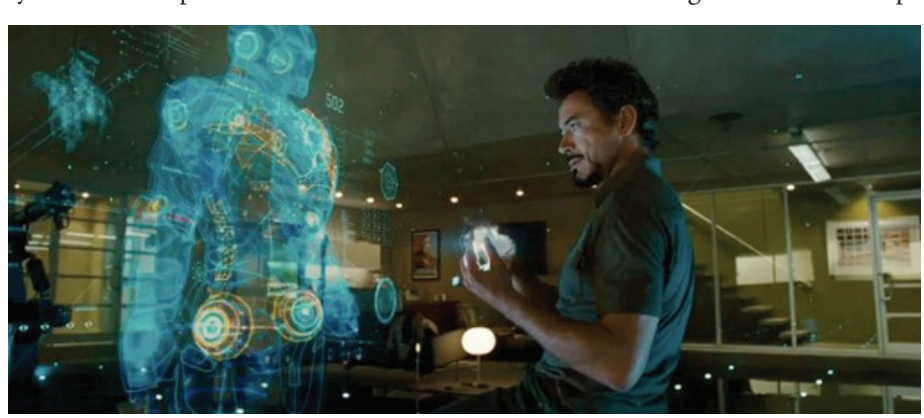

Figure 1. Tony Stark from* Iron Man *using mixed reality. *(Figure provided by author.)*

erations concepts such as Joint All Domain Command and Control (JADC2) (see Figure 2) into action.

Virtual Reality, Augmented Reality, and Mixed Reality

The basic concepts of virtual, augmented, and mixed reality can be easily confused. Augmented reality and mixed reality are typically used interchangeably. For this article, the three realities will be defined as follows: Virtual reality immerses the user into cyber environments where the user interacts with a three-dimensional world. Systems such as HTC Vive Cosmo Elite and Oculus Quest 2 allow a user to be fully immersed into a virtual three-dimensional world but typically force the user to define a digital barrier to keep them from hitting objects such as walls or furniture in the real world.

Augmented reality, as defined by the Oxford dictionary, is "a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view."[3] The user sees a layered view of data that they cannot manipulate. Examples of this are the Google Glass and Kopen Solos headsets. These devices offer the user a type of heads-up display that can overlay or enhance the real world.

Mixed reality is defined as

> a blend of the real-world environment and computer-generated content viewed on a screen or other display, in which the virtual content and the physical environment coexist and react to each other in real time.[4]

Mixed reality brings together augmented reality, virtual reality, and the real world. Mixed reality allows the user to see the physical world while having digital content that enables interaction with real-world and virtual objects.[5] Mixed reality also allows the user to create and leave data in a data block accessible to other users. A soldier, for example, conducts a bridge reconnaissance and creates a data block containing the bridge report. A Marine wearing a mixed reality system leading a convoy would be able to see the data block as he approaches the bridge and open the report to determine if the bridge would support the vehicles that are in the convoy. A combat engineer on a mission to deny the enemy access to the bridge could use that data block that is located physically by the bridge or accessible remotely in the cloud to destroy the bridge and block an enemy advancement. An Air Force pilot could access the report in the data block to determine the size of precision munition needed to destroy the bridge with minimal collateral damage during mission planning or during the mission.

Figure 2. JADC2 concept. *(Credit:* **USNI News.***)*

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Several companies in the U.S. private sector are already using mixed reality to assist in developing their systems and programs. NASA, for instance, uses mixed reality in its Artemis Program. Lockheed Martin workers are using Microsoft's HoloLens 2 to build the Orion spacecraft. A complicated project such as spacecraft-building generally does not allow for errors and is a time-consuming endeavor. The HoloLens frees workers' hands to install hardware while receiving voice instructions with holographic animations overlaid on the parts to be installed (see Figure 3 on next page). Using HoloLens, workers that were performing jobs that required a lot of precision measuring by hand, such as placing marks for hundreds of fasteners on the Orion spacecraft, have been able to complete these repetitive tasks 90 percent faster using HoloLens.[6] Imagine reducing repetitive tasks for the F-35 Joint Strike Fighter or a Bradley Fighting Vehicle by 90 percent. Readiness levels could reach all-time highs with the reduction in time to maintain and repair aircraft and vehicles. The reduction of man hours for routine tasks could be performed by fewer DOD service members, thus saving time and money.

In the medical field, surgeons are using mixed reality glasses, such as Microsoft's HoloLens 2, to enable worldwide collaboration during surgeries. Doctors can rotate, twist, and resize three-dimensional images during surgery for realtime reference. In fact, the technology is so popular that surgeons

call the HoloLens 2 "the smartphone for doctors."[7] Without the use of HoloLens, doctors are limited to only a few screens of data while performing an operation. Surgeons are using mixed reality to plan their surgeries by practicing the surgery as many times as needed, versus printing a three-dimensional image of a bone and getting one practice. Typically, doctors must watch a surgical procedure 100 times before being able to perform the procedure themselves. Residents are now able to use mixed reality to perform the surgery with worst-case scenarios, allowing the surgeon to get hands-on experience prior to operating on a real person.[8] Space programs and the medical field have shown mixed reality systems to be a stable technology ready for use by the DOD. Mixed reality systems should be examined by the DOD for potential uses to support all phases of operations during peacetime and war.

Incorporating Mixed Reality for the DOD

Incorporating mixed reality systems into DOD training has the potential to reduce the time it takes to school-train warfighters, increase their retention of the training they receive, and reduce the amount of retraining once the individual reports to their unit. DOD units would have access to the same training that a warfighter receives at their formal school, potentially reducing the time an individual needs to spend at the school. Small unit leaders would have the ability to rehearse their Mission Essential Task Lists with better accuracy and availability of school approved curriculum creating better prepared service members who are ready for deployments sooner than current practices allow. Small unit leaders would also be able to train during down time with more realistic training environments.

Mixed reality systems can replace legacy training systems such as the Multiple Integrated Laser Engagement System that is based on a laser tag system and uses blank ammo. The Multiple Integrated Laser Engagement System gear does not provide the feedback today's warriors need. With mixed reality systems, warfighters will be able to see their movements and engagements after a training session and can use this information (or data) to improve tactics, techniques, and procedures, without the need for additional observers to provide feedback. Larger units seeking this feedback today require a lot of extra manpower to observe or fight against other units in the field. With mixed reality systems, a digital enemy can fight against the training unit in the field or in garrison. Mixed reality system will enable the warfighter to get the reps in before conducting an exercise to help units maximize their time in the field conducting live fire. Furthermore, mixed reality systems are not constrained to being used indoors.

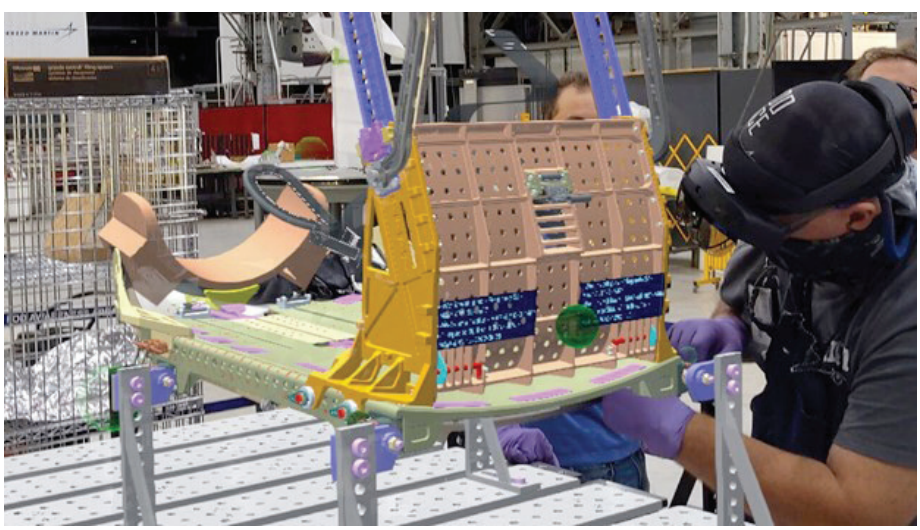

Figure 3. Lockheed Martin workers installing crew seats for Orion spacecraft using HoloLens 2. *(Credit: Lockheed Martin.)*

With built-in sensors, these systems enable warfighters to operate the devices at night or in smoke, fog, or other visually reduced environments—greatly increasing their flexibility to provide the warfighter with higher situational awareness. Finally, reducing the additional manpower to observe a unit can reduce the amount of manpower a range complex is required to have on staff, saving the DOD substantial amounts of money.

Using mixed reality while forward deployed brings a whole new level of lethality, communication, C2, and safety to our force. Mixed reality will play a critical role on the battlefield as it will allow for human and machine teaming at the edge and will assist in connecting ground forces into the JADC2 construct. JADC2 is the DOD's vision to connect sensors of all the Services within the DOD onto one network.[9] Mixed reality systems, when integrated with the right mix of sensors and communication devices, give the warfighter a full array of capabilities that have the potential to tie into the overarching JADC2 concept. Marine sensors such as drones, Army radar systems, or special forces' patrolling data could provide realtime data to an Air Force F-35 preparing to drop munitions on a high value target in the area. This data could be the location of friendly troops or civilians in the area, allowing the pilot to determine if the high value target could be safely neutralized. Likewise, the Marines and soldiers on the ground would have situational awareness of the assets that are available in their battlespace, allowing them to call on the best available asset to support their mission. This shared network could speed up a service member's decision-making process, such as Boyd's Observe, Orient, Decide, Act (OODA Loop) concept, to outpace the enemy's decision-making process. The concept of Boyd's OODA Loop is for an individual or unit to cycle quickly, observing a situation and reacting to unfolding events more rapidly than an enemy does.[10] Mixed reality systems can speed up a ground force's decision-making process by providing each warfighter with better situational awareness of the battlefield and thus aid

in employing accurate lethal firepower against an enemy.

The First Mixed Reality System for the Warfighter Has Arrived

Starting this fall, warfighters will start receiving mixed reality systems as the fielding process begins. Through Microsoft's success with a Prototype Other Transaction (OT), they were awarded a follow-on production contract worth nearly $22B to produce a mixed reality system for the Army and Marine Corps. The mixed reality system being fielded by Army Futures Command in coordination with Marine Corps Systems Command is the Integrated Visual Augmentation System (IVAS). Based off Microsoft's HoloLens 2, IVAS provides warfighters a myriad of data in realtime. It has sensors that give warfighters next generation night vision, thermal vision, AI with augmented reality for navigation, intelligence feeds, and communications. The heads-up display provides a three-dimensional map depicting the mission map, target data, friendly force locations, known enemy locations, cleared routes, resupply points, and a compass with realtime accuracy. IVAS can be paired with sensors on the weapon system being carried to allow a warfighter to fire from a protected area without exposing oneself. The IVAS has the potential to tie into ground vehicle cameras such as the Marine's Amphibious Combat Vehicles to allow the warfighters inside to have better situational awareness through all phases of the movement. The warfighter can communicate with aircraft or artillery to laser a target with the built-in communications that will tie into JADC2. IVAS users will have the computing power of AI that allows them to control drones, collect data, share data, and create data, even in a communication denied area. Once reconnected to the network, the warfighter can push the data collected to the rest of the force and pull the most current data to provide current situational awareness of the battlefield. While preparing for the mission, warfighters can use a three-dimensional tabletop to plan and brief the mission (See Figure 4). Warfighters will be able to leverage the Synthetic Training Environment that allows for computer-generated advanced scenarios that leverage AI and have After Action Review capabilities. The IVAS will allow for human and machine teaming at the edge, leveraging the power of AI to better inform the human user. Facial recognition will allow the service members to quickly identify potential threats in both combat and civil relief efforts. AI can assist ground forces to identify disturbed ground where IEDs may be placed based off the data collected in the area from other patrols or current data within the Area of Operations. AI will be able to help warfighters adjust to changing enemy tactics, techniques, and procedures more quickly than today, keeping DOD service members a step ahead of our adversaries.

Leveraging OTAs for Rapid Innovation

Over the past few years, OTAs have started to become more popular within the DOD. Most acquisitions in the DOD are governed by the regulations and statues found in *Title 10* of the U.S. Code, the Federal Acquisition Regulation, and the Defense Federal Acquisition Regulations Supplemental. The DOD also has the option to use OTAs when entering certain transactions without being required to follow the standard acquisition regulations and statues.

The OTA is not a new authority; it originated in 1958 with the passage of the National Aeronautics and Space Act, which created NASA. Congress was concerned the United States was falling behind the Soviet Union in space. NASA was created as a direct response to the Soviet Union's successful launch of Sputnik on 4 October 1957, thus creating a space race.

Recently, the OT authorities have been expanded by Congress, and the DOD has responded with an increased use of OTAs for research, prototyping, and production. There are three types of OTs that can be used by the DOD. Research OTs are used for basic, applied, or advanced research programs for dual use technology. This type of OT requires a 50/50 split on the cost of the program between the government and the civilian organization. Research OTs do not allow for follow-on production or transitions. Prototype OTs are appropriate for research and development and prototyping efforts that advance effectiveness of the military mission. Though the Prototype OT can only be used to develop limited numbers of prototypes, it can allow the non-governmental party a route to be awarded a follow-on production contract without having to re-compete against other companies for the award.[11] It is important to understand that for a company to be awarded a follow-on, non-competitive production contract, the Prototype OT solicitation must have explicitly stated that there was the possibility for a follow-on Production OT. There are additional restrictions on OTAs, such as each Service only has the authority to execute up to $500M for each OT. However, there are no limits on cumulative dollar amounts or the number of OTAs executed each year. Each Prototype OT must attempt to make

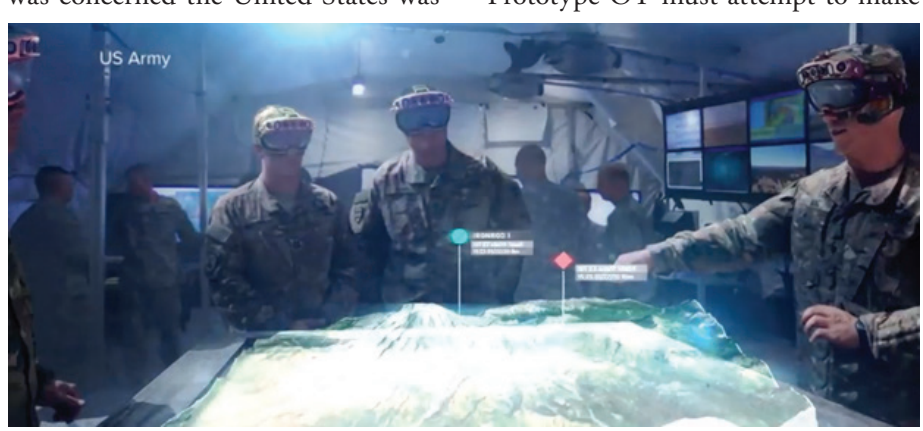

Figure 4. Soldiers performing mission planning with IVAS. *(Credit: Microsoft.)*

the process as competitive as possible. Production OTs are noncompetitive, which are follow-on agreements that follow a Prototype OTA.[12]

Microsoft's IVAS Prototype OTA, used to rapidly arrive at an innovative solution for today's warfighters, has been lauded by the VCJCS, Gen Hyten, as a possible roadmap for speeding up the acquisition timeline on similar future defense programs.[13] After Microsoft was down selected from the technology demonstration, they wanted to rapidly develop the prototype to best fit the needs of the end user. Typically, during prototyping the end user will provide input on the form, fit, and function of the prototype to the designers. The designers/engineers will take user data back to the lab and work to adjust the prototype. Once the prototype is adjusted it is typically returned to different users to test the prototype modifications.

At the completion of testing, more data is collected and returned to the lab. This process is typically slow, and since different users are used, genuine feedback on the adjusted prototype may not be collected. Microsoft's IVAS team led by David Marra, the Program Director for Mixed Reality at Microsoft, partnered with the Army Program Office and Marine Corps Systems Command to integrate his engineers with the warfighter. This partnering was meant to adjust the IVAS prototype to suit the end-users' requirements in real time. Soldiers and Marines were on the firing line alongside Software Engineers physically linked into the IVAS headsets, adjusting programing to give the warfighter better target telemetry while they were firing their weapons. Throughout the prototyping phase, engineers would deploy to the locations where warfighters were testing the equipment to receive direct feedback in realtime. Programmers were adjusting features between sessions and giving the Marines and soldiers the opportunity to test out the suggested changes the very next day. The warfighters could refine what they needed and see the changes immediately. This process greatly increased the speed and innovation of the program to move from prototype to a production-ready system.

Traditional Defense Contractors and Risk

Traditional defense contractors are well known; names like Lockheed Martin, Boeing, or General Dynamics come to mind—but not Microsoft. Over the past several years, a few companies such as Amazon, Oracle, and Microsoft, who are not normally associated as traditional defense contractors, competed for the huge DOD Joint Enterprise Defense Infrastructure (JEDI) cloud contract. IT companies are not typically thought of as being able to provide hardware systems that would be used on the battlefield. Early in the bidding process for the IVAS prototype OTA,

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Microsoft decided if they were to win the contract with no guarantee to receive a production contract, they would build, at risk, a factory in the United States. Furthermore, Microsoft knew that to meet the requirements for a system to be made in America and to meet the Army's aggressive timeline, they would have to build a factory in the United States for fielding the IVAS mixed reality system. Microsoft risked their own capital to stand up an IVAS production plant in the United States. Typically, defense contractors will not take this type of risk because their margins for error are very tight, and they do not have the liquid capital to accept this much risk. Microsoft had the cash and saw the risk as worth the investment, which paid off for them with up to a $22B award over a ten-year period. To put this in perspective, the JEDI contract is worth an estimated $10B over ten years and is still locked up in the courts using a more traditional acquisition approach. The JEDI contract process started in October 2017 with a Request for Information to industry and had a target award date of July-September 2018. As of this writing, the contract, awarded to Microsoft but stuck in the courts, has the Pentagon considering scrapping the whole idea.[14] When a contract award is as massive as the JEDI contract, it is in the company's best interest to protest the award, which greatly affects an acquisition timeline.

Competing for a contract in the prototype phase when there is not as much money on the table may not hit the value for a company to invest in a protest especially when there is no guarantee of a production contract following the prototype OTA.

Future Warfare

The future operating environment as expressed in the *NDS* and *NDS* Commission describe the challenges with advanced anti-access/area denial (A2/AD) against likely adversaries.[15] All domain operations (combat operations, cyber operations, information operations) converge mission-focused technologies with traditional information technology such as communication, cyber, space, communications, productivity tools, Internet of Things, AI, machine learning, data and visual tools, computer resource management, sensor reporting post, and Development Security Operations. Senior DOD leaders have stated that the access to information will be critical in combating enemies on future battlefields, and All Domain Operations or JADC2 is the method to keep the United States ahead of its adversaries.[16] Operating across all domains brings the DOD's full potential online, keeping the United States ahead of near peers. Having the most current data and being able to process that data faster than an enemy will be the keys to the success of JADC2.

Mixed reality systems that were once science fiction have arrived. These systems are being used in the civilian sector, helping companies innovate faster while reducing overhead from mistakes. If DOD officials are willing to accept risk to allow programs to potentially fail, the acquisition community can rapidly put newer technologies in warfighters' hands through the appropriate use of OTAs. JADC2 will require U.S. ground forces to change how they interact with the joint force; mixed reality systems can be the technology that fills that role.

Mixed reality systems can help to make a more lethal force that can also help forces maneuver on the battlefield more safely. Mixed reality systems have the potential to change the way the DOD trains, works, communicates, plans, and fights, creating cost saving measures and a more resilient force to bring the DOD firmly into the 21st century.

Notes

1. *Iron Man*, directed by Jon Favreau, (New York, NY: Marvel Studios, 2008).

2. Office of the Presidency, *National Security Strategy of the United States,* (Washington, DC: December 2017).

3. *Oxford Dictionary*, s.v., "Augmented Reality," available at https://www.lexico.com.

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14. Robert Burn, "Pentagon Reconsidering Huge JEDI Cloud-Computing Contract," *Associated Press*, (May 2021), available at https://apnews.com.

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