RED 6 STANDING BY

TRAINING COMBAT PILOTS IN AUGMENTED REALITY

STORY AND PHOTOGRAPHY BY MIKE KILLIAN

FOR A LONG TIME now the U.S. Air Force has been facing a big problem when it comes to training new pilots for combat. The costs are astronomical, they don't have enough pilots, and the jets they train against are not comparable with present-day threats from Russia and China. Battling an F-16, F/A-18, or privately owned third-generation fighter in an aerial combat training exercise is quite different than going up against an Su-57 or China's J-20.

Plus, the costs to use F-35s or F-22s in that role are prohibitive, and the aircraft are in limited supply. An F-22 Raptor alone costs more than $40,000 per hour to operate.

That's where Red 6 Inc. comes in. The Santa Monica-based defense tech company believes it has figured out how to answer all of those issues — and both Lockheed's legendary Skunk Works and the U.S. Air Force (USAF) believe they have, too.

F ounded in early 2018, Red 6 looks to solve those problem by employing augmented reality (AR) in flight, something that was once thought impossible. It's "not just a technical revolution, but a social, human, and business revolution," company CEO Daniel Robinson, EAA 1275186, said.

He knows a thing or three about being a fighter pilot. Daniel was a Royal Air Force Tornado pilot for 10 years and graduated from both the U.K. Combined Qualified Weapons Instructors course (the RAF equivalent to the Navy's Topgun) and the United States Air Force Weapons School. In 2006, he became the first non-American to fly the F-22 Raptor as well, something unheard of at the time because the program was so early on. It took many people by surprise.

"My time on the F-22 was the real genesis of Red 6," Daniel said, as he realized the U.S. Air Force was struggling to get training.

He said the USAF didn't have the airplanes or pilots, and it was expensive.

"I think, most significantly, after being involved in conflicts in the Middle East for the last 20 years, we've seen the reemergence of Russia on the world stage and proliferation of sophisticated IADS and technology coming out of Russia, and, critically, the pace of innovation coming out of China," Daniel said. "That's significant because, for us to train against those threats, we need to be able to simulate those threats, and we just couldn't do it."

He left his service as a fighter pilot in 2009 and went to business school, worked in finance, and started and sold a business. But, like any fighter pilot, he wanted back in the sky. That's when he met Nick Bicanic and Glenn Snyder. The three of them are the co-founders of Red 6. Glenn, in particular, had been working on virtual reality (VR) in race cars. While the drivers were not in the same physical place, when they looked, they could see the other racer.

Red 6 CEO Daniel Robinson

For today's modern military pilots, training for combat operations against the latest generation of threats is extremely expensive, and limited by the availability of both personnel and equipment.

When Daniel saw the work Nick and Glenn were doing he wondered if that could be the solution to all the problems he saw firsthand with modern day combat pilot training. The main difference between VR and AR is that VR is a completely made-up environment. You can be underwater, on the moon, or wherever you like; you can't see the real world at all. In AR, you can see absolutely everything in the real world, but additional objects get superimposed.

The biggest problem currently with AR is that it does not work outdoors. It's only an indoor solution, for two key reasons: It isn't bright enough, and you can't track properly.

That's the key issue Red 6 has solved, developing what Daniel calls the airborne tactical augmented reality system, or A-TARS.

"We've come up with a number of pieces of technology — some are hardware, some are software — which enable AR outdoors," said Nick, Red 6's technologist and CTO. "It

While it is no secret that the U.S. government has used Russian aircraft for training at Groom Lake/Area 51 and the Nevada Test and Training Range for decades, such aircraft are surely hard to come by. Therefore, only a small percentage of pilots actually get to train in those scenarios.

The bottom line is that it's simply not possible for the Department of Defense (DOD) to reach its target goals for training pilots without relying on synthetic assets. Up until now, nobody has been able to do that, so the USAF is currently using live virtual constructive (LVC) training. Live meaning real people in real aircraft, virtual meaning real people in simulators on the ground, and constructive meaning AI generated.

As for the virtual and constructive side, sure, guys on the ground or on a computer can fly simulated aircraft that appear to be present-day threats, and the real pilots will see them digitally beyond visual range. However, when they come within visual range (WVR), there's nothing there because it's a computer simulation, which means they cannot complete the training cycle. So, the entire LVC system, which is billed as the future of NATO training, has a massive flaw; it simply does not work within visual range.

allows us to take off in an aircraft, look out the canopy, and see an enemy or friendly aircraft in wide field of view, in full color and high resolution, which is able to maneuver against you and you against it. In essence, we built a video game in the sky, except it's not something you play for fun. It's a highly accurate, high-fidelity simulation to enhance training capabilities and ultimately enhance the war fighter."

In the movie *Top Gun*, F-14s fought against MiGs, which were actually F-5s pretending to be MiGs. In reality, they were training against F-5s, too, and could do that because those F-5s could fly and perform similarly to a MiG of that generation nearly 35 years ago.

That's no longer possible. An F-16 or F/A-18 cannot simulate a J-20 or Su-57. While the airplanes do feature upgraded systems and sensors with the best and most experienced fighter pilots in the world flying them, at the end of the day such an aircraft from decades ago still cannot replicate the modern-day threat.

The simulated fighter aircraft that appears superimposed over the pilot's view of reality could be controlled by AI, or by a pilot on the ground or in another aircraft miles away.

Not anymore, according to Red 6. It fills that WVR gap and has essentially created an environment with A-TARS that plugs into the LVC ecosystem and allows the training to actually reach its full potential.

"The beauty of AR is, if we have the intel on the platforms, which we do, then it's just a simple matter of code," Daniel said. "And we can code anything, so you can go up and train against anything."

Red Flag, perhaps the best known USAF combat training exercise, was born decades ago out of lessons learned during the Vietnam War. New crews experiencing combat for the first time were suffering a disproportionate loss rate when compared to crews who reached a 10-mission mark. Red Flag was the result, to give those crews 10 realistic missions in a safe, controlled, and convincing environment, before ever seeing combat. For some time, they were training against aircraft that could simulate the present-day threat of the times, but that is no longer the case.

To say this kind of training is expensive is an understatement. For one thing, everyone has to fly to Nellis Air Force Base from all over the country. Instead of that, imagine one squadron taking off from one location, while another does the same elsewhere, and they both together go into an AR scenario against realistic present-day threats to conduct joint squadron operations.

Instead of relying on promises of future developments, Red 6 has taken an agile approach and has been solution-driven since the very beginning.

"Everything we've built was based on moving very quickly and showing an actual solution to a problem, rather than creating technology and having to then find a problem for it," Nick said. "That has paid dividends, because we've been able to continuously impress various different stakeholders in the USAF, because we tell them we're going to do something, and after a few months we show them what we've done. It's not just a demo where we point and wave; it's a

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demo they can actually sit in and experience."

The core of the first part of Red 6's A-TARS product was a modular system built into a Berkut, which Red 6 built. It has the engine in the rear, like a fighter, which is the main reason that platform was chosen. Four key modules are integrated into it — one to track the aircraft, one to track the head, one to create the wide-view AR that draws the image for the pilot of whatever scenario is being flown, and one that is the main brain of everything.

The company's highly modified, experimental amateur-built Berkut is the perfect test platform for Red 6.

Red 6 has two Berkuts, but only the primary one is equipped with A-TARS and currently used to demo A-TARS in flight. It's made of mostly carbon fiber, weighs just 1,200 pounds, and is pretty special because it's believed to be the lightest, most powerful, and most capable Berkut in the world. The airplane can pull up to 9*g*'s and features molded wings and an O-540 engine powerplant, or a "Super 540" according to Daniel, since the standard 540 engine puts out about 260 hp. The engine used by Red 6 was custom-built and pushes nearly 350 hp and

drives a custom-designed three-bladed Catto climb propeller on the rear.

The twist distribution in the airplane's climb propeller is pretty similar to the top speed of a constant-speed propeller, but with slightly more surface area and sharper tips, so it grabs the air a little better. But it's not without issues. It generates more heat in the engine. While the standard 540 engine has an 8.5-to-1 compression ratio, the Super 540 Red 6 is using has 11-to-1 compression. Needless to say, the airplane is a fire breather.

The cockpit itself is extremely modern, entirely glass, and there's not a flight instrument in it. It's based around the Dynon SkyView HDX. It's all touch screen and even features a grab rail because the Berkut is very unforgiving in turbulence. It's aligned to a Garmin GTN 650, and has a Garmin G5 as a backup and a GMA 245 audio control panel. The throttle and stick

top are custom made. The stick top actually came out of an A-10 Red 6 ripped apart and rewired and fully integrated into the Berkut's systems.

"Between all the levers on the throttle and the stick, I can fly the airplane, control the airplane, control all the radios and the autopilot and everything just from the stick top, and also control the A-TARS from the stick top and throttle as well," Daniel said.

A simulated tactical display — similar to what you'll find in an F-22 or F-35 — is mounted below the main instrument panel between the pilot's knees, providing info on the aircraft's position relative to the bull's-eye, and Daniel can cycle from looking at things in front of him to things around him. When a target appears, he can move a cursor over the target and click on it to see its information such as speed, altitude, distance, and bearing. Once the target is selected, it appears in the visor as a green circle target designation.

Configured with both internal and external fuel tanks, the airplane can carry 86 gallons of gas. While it is capable of guzzling gas at an alarming rate, it can also burn it at an amazing remarkably frugal 5 gph if needed.

The company first started showing ground demos to the USAF with its first-generation headset. AFWERX, a USAF program fostering a culture of innovation within the service, awarded Red 6 $2.5 million to continue research and development.

After interactions with more USAF stakeholders, the second-generation headset came online, used for in-flight demo. It offers a 105-degree field of view and is just about daylight visible. This system was designed to work off the standard HGU-55 Gentex helmet, which is the standard issue for many USAF pilots. Even though the tech was in its early stages, it has demonstrated sufficient training value, so much so that Air Combat Command (ACC) asked Red 6 to continue with development. The company then became the recipient of an SBIR-1 (Small Business Innovation Research) award, as well as an SBIR-2.

Red 6 is now into SBIR-3 and was the first AFWERX company to go to SBIR-3. One of the reasons it has moved forward so fast is because the right people are getting excited about what the company is doing. They're excited because AR is, according to Red 6, the correct solution for the correct time and for the correct problem.

Having learned about what Red 6 was doing through various aspects of the USAF, Skunk Works eventually decided to pay the company a visit to see the A-TARS system.

"Initially we were a little nervous about that," Nick said. "We built this with a lot of insight and years of experience and understanding of the strategic problem USAF is having. But still, it's Skunk Works, so we

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thought that they'd come over and say, 'Yeah, that's nice boys, but here's how you really do it when you have a billion dollars. We've got the system, we just want to see what yours is like.' But that didn't happen. What happened was they came over and were very humble. They did the AR flight demo and asked a lot of questions, and then told us that they've seen everything including stuff we haven't even heard of yet, and that our A-TARS system is orders of magnitude better than anything they've currently seen."

Skunk Works wanted to work with Red 6, and after a few months of negotiations, Lockheed gave Red 6 a strategic investment to accelerate the development and

Glenn Synder

commercialization of A-TARS. Lockheed knows what it can do, but it's missing some critical pieces, so it wanted to get involved and get the relationship going as quickly as possible to understand how it could accelerate the tech.

"Our charter is to strategically invest in smaller companies focused on innovative technologies that can be utilized within Lockheed Martin's existing businesses. Red 6 fits this mission," said Chris Moran, executive director and general manager of Lockheed Martin Ventures, the strategic investment arm of Lockheed. "We are excited to add Red 6 to our investment portfolio and look forward to working with their team and gaining access to their synthetic training capability that could be applied to both current and future platforms."

So, of course, I had to experience the A-TARS flight demo for myself. To say I was blown away is an understatement. The day started on September 21, 2020, when I arrived at Camarillo Airport (KCMA) just north of Santa Monica. I had already met the team previously to fly a sunset air-to-air photo mission the month prior, so I already knew what to expect. Nick and Daniel went over a company overview with me, followed by Red 6 pilot and Director of Business Development Tom Mackie leading our flight demo briefing. Known by his call sign "T-MAC," Tom is a former Marine Corps pilot and graduate of Topgun, with more than 3,000 hours flying the F/A-18 Hornet.

We were to take off and proceed north to the aerobatic box to conduct the demo. Heading out to the hangar, I was met by Chris Randall, director of aircraft ops, and Glenn Snyder, who developed the hardware. After shooting some photo and video, it was time to get in the Berkut. Using a step ladder, I hopped in the back seat where Chris strapped me in and gave me a brief on the cockpit, what not to touch, etc. before Glenn helped me put the headset on. It really feels no different than any other helmet I've flown with, but it's what you see that's different. A box for the AR is attached to the front of the helmet, with a pair of goggles to view through and a visor on top of the goggles.

After doing a through walk-around check of the airplane, Daniel hopped into his seat, and after a few checks by Glenn to program the AR, Daniel started the Berkut and off we went toward the runway. Once airborne and in the aerobatic box, we were to join on a simulated KC-46 refueling tanker and an F-22 Raptor, followed by a simulated dogfight with a Russian Su-57.

With clear skies and calm winds, ATC gave us the go for takeoff, and off we went, screaming down the runway and banking north into a climb for our aerobatic box a few miles away.

That's when Daniel hit the switch on A-TARS. Communication was easy and clear, as he walked me through what I was seeing. At first the scene looked the same as if you're looking through tinted windows, until a cube appeared, indicating our first target. After that, a green circle appeared, indicating we were within visual range of the tanker and F-22. We approached as a fighter pilot normally would, playing catch-up to join formation. No matter where I turned my head or eyes, the targets were independent, just like in real life, and as we approached both airplanes the amount of detail became clearer and clearer. We joined just feet away, and the images were so clear that you'd have no problem identifying exactly what they were. Had they had squadron insignia, I could have made them out easily.

The major difference with a simulator is it may look real, but it doesn't feel real. Whereas flying with the AR you're really flying, you feel the *g*'s and everything the airplane is doing, and the environment is real. I've never experienced anything like it; it was like a video game in the sky but in real life. I couldn't help but laugh as it was such a new and amazing thing, and I knew I was one of only a few people to ever experience this.

After a few minutes with the tanker and Raptor we broke formation and began the dogfight sim. Once again a green circle appeared in the visor indicating the bandit was WVR, so Daniel hit the afterburners and engaged the target. After pulling upward of 5*g*'s and flying some maneuvers to catch the bandit, we pulled up alongside so I could have a closer look. Again, the amount of detail with the simulated Su-57 was incredible. It absolutely looked and felt real, even this early in the tech's development.

After about 20 minutes of flying we returned to base, with an overhead 5*g* break as we circled around to land. I've been blessed to fly a lot over the years as a photojournalist, and this was definitely something that will always rank high on my list of coolest assignments. Back on the ground Dan had another demo to fly, and with my

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specialty being air-to-air photography, I hopped in the company's second Berkut (not configured for A-TARS) with T-MAC as my pilot to produce some aerial imagery of the demo airplane in action.

Flying with both a U.K. CQWI and USAF Weapons School graduate as well as a Topgun graduate in the same day, I have to admit I was pumped and honored for the opportunity; who wouldn't be?

Both flights went smoothly and without issue, and while A-TARS is still in its early stages, it's already mind-blowing just how real it looks and feels. That said, Red 6 is constantly improving the tech, the brightness, and the resolution, and it's evolving at

a rapid pace. It really hit the ground running and won't be slowing down any time soon. Red 6 recently demoed A-TARS in flight for a four-star general and has already moved on to a third-generation A-TARS headset that is said to be 10 times better than the second-generation headset I flew with in September 2020.

The USAF hopes to incorporate A-TARS into a T-38 training jet by early 2021, evaluating it on its own aircraft and in its own scenarios. Daniel expects A-TARS to be an operational part of USAF pilot training within the next five to seven years.

Retired USAF Gen. Mike Holmes recently joined Red 6, and he will be serving on the company's advisory board following his last tour in the USAF as commander of ACC. As a former fighter pilot himself with more than 4,000 hours, he understands the job and what is needed to train skilled combat pilots.

"Part of my job as a general was to think about the future operating environment and the tools our airmen will need to do the job we ask them to do in the future," he said. "I believe Red 6 has something we need. We cannot afford to train combat pilots the way we always have — we simply cannot produce the numbers required. So, we should look for new ways to do this, and Red 6 is one of those ways."

And while Red 6 started with addressing the USAF and combat pilot training problems across the broader DOD, because it is the most challenging aspect and the problem it knows the most about, ultimately the company intends to fully expand from there to a joint augmented battle space aiding all branches of the U.S. military.

The possibilities are truly endless. *EAA*

Mike Killian is a freelance aerospace photojournalist and writer covering all aspects of the space program, military and civilian aviation, with a focus on aerial and space launch photography. You can follow his work daily on social media @MikeKillianPhotography on Instagram and Facebook.