Future force philosophy: Operators grapple with the art of fifth-generation pilot training

With fifth-generation aircraft now beginning to enter service in meaningful numbers, global operators are re-assessing their future flying training needs. *Gareth Jennings* examines the preparation now underway to turn out the pilots of the future

Although the currently fielded third- and fourth-generation aircraft are set to remain in global service for decades to comes, they are being increasingly joined by the latest fifth-generation platforms that will require a new approach to pilot training.

The F-22 Raptor was the first fifth-generation fighter to enter service back in 2005. As such, the US Air Force is in the vanguard of efforts being undertaken globally to marry the new fifth-generation pilot training requirements with the continued need to train pilots for the older fourth-generation platforms. (US Air Force)

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For those operators - chiefly the United States Air Force (USAF) with the Lockheed Martin F-22 Raptor and the USAF and US Marine Corps (USMC) with the F-35 Lightning II Joint Strike Fighter (JSF) - that currently operate fifth-generation platforms, pilot training has largely followed the traditional path that has been used over decades for older generation aircraft. With more and more fifth-generation aircraft now entering service across the world, however, operators will increasingly have to marry up ongoing requirements to train for its older generation platforms with those for its newest ones.

Speaking in London under the Chatham House Rule, a senior USAF official noted the training challenges that it will pose, saying: "Not everyone will be flying fifth-generation aircraft. The USAF

will have the [fourth-generation] F-16 and F-15 in its inventory through to 2040 at least, so we are going to be faced with training both generations of pilots for quite a long time."

The United Kingdom is one of a number of Western and allied countries that will be operating fourth- and fifth-generation aircraft together for a number of decades. Marrying the different training requirements will be a challenge in the coming years. (Lockheed Martin)

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As the official noted, these different generational aircraft will require different skillsets of their pilots that will go to the core of how they will need to be trained.

"The difference between fourth and fifth generation is basically in the way that you employ an aircraft that is stealthy; in the way that you use sensor fusion; the [super cruise] speed of the aircraft; employing avoidance versus engagement; the concept of autonomous operations; the use of signature management and network integration; and how to integrate with a fourth-generation aircraft that is on your side. There are a lot of challenges from a pilot perspective, like the time compression you experience in the F-22 due to the high speeds, and the fact that even your friends cannot see you.

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A full-mission simulator for the F-35 JSF. Operators of fifth-generation platforms will increasingly be looking to synthetic training to reduce wear and tear and operating costs. (Lockheed Martin) 1645957

Traditional pilot training has followed a well-worn path for a number of decades, with students progressing through a linear regimen, which sees classroom instruction being followed by basic and advanced flight instruction (concurrent with ground-based simulator instruction), before being passed onto the operational conversion unit (OCU) for transition to their frontline fighter type. Given that fourth-generation pilots will need to be trained for decades to come, and that fifth-generation pilots will also need to learn the basic art of flying, this system will likely to remain the training template for the foreseeable future. What will almost certainly change, however, will be the nature of, and the degree to which both ground- and air-based (or off- and on-board) synthetic training will feature.

Most sophisticated Western operators rely heavily on simulation and synthetic training, mainly to reduce wear and tear on airframes and the associated costs, not to mention the increased safety factor, with the goal of many of the most advanced countries to reach a ratio of about 50:50 in terms of synthetic-to-live training. When it comes to future training pipelines that include those for fifth-generation platforms, however, this ratio is likely to shift significantly in favour of synthetic training for a host of reasons that still include costs, but which will also factor in the vastly increased sensor performance of the latest aircraft that, in many cases, means they will simply outgrow their real-world training ranges.

As the USAF official explained, "Fifth-generation aircraft have challenges for training, with the geography of ranges not being large enough to accommodate their advanced sensors. Also, the new sensors that we will have you may not want to turn on during training for mission security.

"Third- and fourth-generation aircraft require large numbers of adversary aircraft for them to sense and to react to - that's very expensive and hard to generate. The USAF uses a ratio of 4:1 for Red Air to Blue Air for training sorties, which means either using the very expensive frontline platforms [at which time all of our frontline pilots are pretending to be 'bad guys' and so not really learning what we want them to learn], or we look more closely at the synthetic environment.

The USAF has begun teaming live F-16 Aggressor aircraft (pictured) with synthetic F-22s in Live, Virtual, Constructive training packages that are designed to bring down the overall cost burden of fifth-generation pilot training. (IHS/Gareth Jennings)

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"In the past, the highest end training that we could offer our pilots was at Red Flag, but even that range is limited in size. There is no range in the world that is big enough to do fifth-generation training as you'd really like to do it - this forces you back into the synthetic environment, which now requires very high fidelity and expensive simulators. That's the only way that you can do it, though.

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Despite the expected increase in reliance on synthetic training, the official conceded that the provision of real-world flight training will remain critical to turning out fully formed fighter pilots. "What you use the live training (the most expensive part, and the part that burns through airframe hours) for is the dynamic part such as manoeuvring. All the things that a simulator cannot do well - replicating spatial disorientation, pilot stress and fatigue, etc - you still have to do in an airplane," he said.

The cockpit of the F-35 shows how the fifth-generation human-machine interface differs from that of the current fourth-generation, leading to different training challenges. (Lockheed Martin)

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This was a viewpoint that was backed up by an Israeli Air Force official speaking at the same event under the Chatham House Rule, who said that, while simulation will become an ever important training tool for the Israeli Air Force as it stands up its F-35A 'Adir' force, the service will remain heavily focused on real-world training for those events that cannot be replicated synthetically. "I don't think that we will be able to say that we will do 90% synthetic in the future and 10% real, because you'll still have to expose the pilot to the full spectrum of the mental,

physical, and cognitive load that they will only experience in the air. We could maybe go to 75% to 35% [in favour of simulation] in the future, but certainly not more than that."

In terms of real-world training, there will be no lead-in fighter trainer (LIFT) trainer aircraft anywhere in the world that will be geared solely towards fifth-generation pilot training. The latest types, such as the BAE Systems Hawk Mk 128 (T2 in UK service), Alenia M-346 Master ('Lavi' in Israeli service), and the future T-X for the USAF, are all centred on the fourth-generation fighter types in terms of their human-machine interface (HMI). Even so, many fifth-generation traits and capabilities can still be synthetically replicated, and this is the path, rather than an expensive wholesale change to the HMI that operators look set to follow as the fifth-generation fighters begin to come online.

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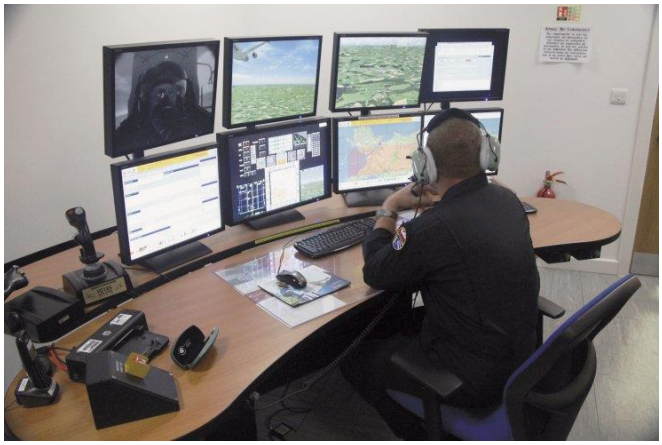
One of the operators now beginning to address the 'balancing act' that is required between fourth- and fifth-generation training platforms is the Royal Australian Air Force (RAAF), as it prepares for the arrival of the first of its planned 100 F-35As in 2018.

The RAAF currently fields 33 BAE Systems Hawk Mk 127 advanced jet trainer (AJT) LIFT aircraft that it began receiving in 2000. When the requirements for these platforms were drawn up in the 1990s, they were geared at training pilots for the service's Boeing F/A-18A/B Hornet fleet, rather than for any future fifth-generation procurements. Since then, they are also being used to instruct pilots for the Boeing F/A-18F Super Hornet, and will do so too for the EA-18G Growler.



The UK's pilot training school at RAF Valley in Anglesey uses simulators and the Hawk T2 LIFT aircraft to train fast jet crews. This system will remain in place for both fourth- and fifth-generation students for decades to come. (IHS/Gareth Jennings)

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As the LIFT platform, the Hawk is used by the RAAF to teach the fundamentals of flying, such as prioritisation, flexibility, and airmanship in a system known as Contextually Relevant Cognitive Development (CRCD), before the pilot moves onto their OCU for transition into their operational type.

The RAAF modelled the HMI of the Hawk Mk 127 AJT on that of its legacy Hornet, and is currently going through an upgrade process that should bring it up to the Hawk 128 standard by mid-2017. While the current Mk 127 HMI did not provide the RAAF with the training value that it was originally hoping for from its commonality to the legacy Hornet, the embedded synthetic training capability did give the service the flexibility to carry out the cognitive development that it was looking for.

"The HMI was less important than we thought it would be - it doesn't have to be the same as the frontline systems," an RAAF official said, adding: "What is important is that we have an HMI that doesn't leave a residue on the student as they pass through so that they are not learning bad techniques that they will take with them to the frontline. For the LIFT there is a specific role, but it is not as simple as taking someone from the basic flying training through to the OCU - there is also an ethos that is important beyond the basic skills.

The cockpit of the Hawk T2 LIFT aircraft is modelled on that of current fourth-generation aircraft. The lack of a fifth-generation HMI need not be an issue as many of the advanced capabilities can be replicated synthetically. (IHS/Patrick Allen)

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"We use a building block process to try and make sure that the lessons we are giving at the appropriate time are relevant. The key thing is that we are training for, not toward - basically, instead of trying to focus specifically on an F-35 training system we are looking to train the best fighter pilots and then give them the F-35. There's an important difference there. Having a pre-frontline training system that looks, feels, and smells the same as a frontline system seems to be a hiding to nothing."

Whatever the eventual make-up for live-to-synthetic flying happens to be, pilot training will not stop once the student arrives at their operational fifth-generation aircraft type, which for the USAF and a large proportion of its allied air arms will mean the F-35. With the F-35 set to serve alongside current fourth-generation fighters for decades to come, future training systems will have to marry up with these differing requirements in one universal and cohesive system.

The US military currently uses the Cubic P5 Combat Training System (CTS) as its Program of Record instructional aid, giving it a real-time breakdown of the scenarios being run and the missions being flown.

Speaking to *IHS Jane's* in 2016, Cubic's senior business development manager, Waylan Cain, said that the company is already addressing how the P5 and follow-on systems can satisfy future fifth-generation training needs.

"We are looking at evolving that system from the fourth- to the fifth-generation training requirements before we transition to the LVC [Live, Virtual, Constructive] system, which will be the culmination of the current system's capabilities.

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A USMC pilot checks the Cubic P5 pod on his Hornet combat aircraft prior to a training mission. Cubic is already addressing how the P5 and follow-on systems can satisfy future fifth-generation training needs. (Cubic)

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While current fourth-generation aircraft carry an external pod, the airborne sub-system for the F-35 is internalised and integral to the aircraft, so as to maintain the platform's stealth characteristics (all F-35 customers except Israel, which has its own system, will use this). Cubic is currently under contract to deliver 500 boxes through low-rate initial production (LRIP) 11 for the F-35, of which more than 150 had been delivered by mid-2016. The box goes live in the F-35's Block 3F software block (full combat capability) due in the third quarter of 2017, and Cubic is currently undergoing testing with the system. The US Department of Defense (DoD) has also contracted the company to deliver encryption to the ground sub-system for classified briefings.

Following Block 3F, there will be further upgrades of the P5 system, Cain said. "Initially, [the DoD] will be using it really just as a 'live monitor' to assess training in real time. For the future it will be looking to encrypt the fourth-generation pods and open up the datalink to share data and information back and forth across [the different generation platforms]."

Beyond these enhancements, Cain noted that a new way of teaching fifth-generation pilots will be needed, as the current methods are not sustainable due to their costs, and that Cubic is already forging ahead with this in developing its LVC technologies.

"One thing that everyone is agreed on today is that we can't just keep sending up more and more capable 'Blue Air' against an ever increasing number of adversary aircraft - it's just cost prohibitive. Also, you can't tax the fifth-generation aircraft's sensor suites and weapons in a cost effective or realistic manner.

"We want to go to the LVC, which is the next evolution from P5. Today, if I have four 'Blue Air' F-15s, it takes roughly about 12 other aircraft to generate a problem for them. The F-35 is so much more advanced that you now need sometimes as many as 20 more airplanes and a bunch of surface threats - those things cost a lot of money. Also, you sometimes don't want to use your full capabilities on a training range, you want to internalise them based on a virtual constructive system of networked simulators that can be your virtual wingmen."

In August 2016 the USAF conducted its first integration of fourth- and fifth-generation fighter aircraft during an LVC event. As part of the Distant Frontier training exercise at the Joint Pacific Alaska Range Complex, Northrop Grumman integrated two virtual F-22 Raptor fifth-generation fighters to fly and train alongside four live fourth-generation F-16 Fighting Falcons operating out of Eielson Air Force Base (AFB). The synthetic F-22s were operated by members of the 90th Fighter Squadron from simulators at Joint Base Elmendorf-Richardson in Anchorage, Alaska.

Northrop Grumman's LVC Experimentation, Integration and Operations Suite (LEXIOS) is an interface 'gateway' that enables live and virtual elements to operate with each other. (Northrop Grumman)

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The virtual F-22 and live F-16 participants were linked by the Northrop Grumman LVC Experimentation, Integration, and Operations Suite (LEXIOS) system, which enables virtual aircraft operated by actual aircrew members to participate in the same airspace alongside their live

counterparts via networked simulators at full security levels. The package of simulated F-22 and real-world F-16s trained for air-to-air combat against four live F-16s from the 18th Aggressor Squadron based at Eielson AFB.

Northrop Grumman is the prime contractor for the USAF's Distributed Mission Operations Network (DMON), a system that enables dissimilar aircraft platforms located across the globe to interoperate and train together in a realistic virtual environment.

The USAF and USN/USMC are currently looking to define their future requirements in a technology demonstrator programme called Secure LVC Advanced Training Environment (SLATE) Advanced Technology Demonstration (ATD). The overall approach in the SLATE ATD will be to employ fourth-generation aircraft with modified Air Combat Manoeuvring Instrumentation (ACMI) airborne sub-systems repurposed for multilevel encrypted LVC. Cubic is on-contract as the lead systems integrator, and is working with the Air Force Research Laboratory (AFRL), Boeing, Lockheed Martin, and others. After the technology demonstration phase, the DoD plans to instigate a future Program of Record.

"A lot of people think that you can do all of the fifth-generation training synthetically," Cain said, adding: "No, that's just not going to be the case, you have to have that live component also."

Outside of the United States, this live component is to the fore of the fifth-generation training solutions being proposed in Israel by Elbit Systems and Israel Aerospace Industries (IAI).

For Elbit, its thinking is based on blending the synthetic with the real world around the already fielded Targo helmet-mounted display (HMD) system. Speaking to *IHS Jane's* at the Farnborough International Airshow 2016, Ran Kril, executive vice-president of International Marketing and Business Development, said with the Targo HMD already being flown by the Israeli Air Force (IAF) on its Alenia M-346 Lavi trainer aircraft ahead of the introduction into national service of the F-35A Adir, it is likely to be rolled out to the international JSF fleet at some point in the future also.

"The F-35 is the first combat aircraft without a head-up display and with a helmet [-mounted display system] only, and so the pilot must train with a helmet. In the IAF, the Targo is already mandatory with the M-346, and as most F-35 countries fly with [other] Elbit helmets in their F-16s, already we see the Targo as the future baseline standard [for training]."

First showcased at the Paris Airshow in 2009, the Targo HMD uses a standard helmet, onto which is fitted a software module that removes the need for integration with the host aircraft. During a previous demonstration of the Targo HMD aboard a Piper Cherokee light aircraft over Megiddo in Israel, *IHS Jane's* was shown how the system can be used to practice formation flying, aerial combat, air-to-ground attack, and counter surface-to-air missile training. According to Kril, the IAF's feedback on the Targo HMD, which it has been using since the first M-346 was delivered in 2014, has been positive. "It has changed dramatically how the IAF trains its pilots," he said.

An artist's impression of the Targo HMD being utilised aboard an F-16 fighter. Elbit sees the Targo as providing an ideal training solution for the fifth-generation fighter. (Elbit Systems)

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