Viewpoints

Future Mission Training in the Royal Air Force: The Utility of Live, Virtual and Constructive (LVC) Technologies

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Introduction

> 'We must remember that one man is much the same as another, and that he is best who is trained in the severest school.'

Thucydides, 'History of the Peloponnesian War' (431-404 BC)[1]

Thucydides' statement neatly captures the truism that *training matters*. Indeed, this ancient observation is echoed in the more recent aphorism 'train hard, fight easy'. Training is the very foundation of military capability for all armed forces, and underpins warfighting success. The Royal Air Force has long prioritised excellence in training, pushing its people to their limits in peacetime so that they can achieve decisive outcomes when deployed in support of operations.

However, the environment in which training is conducted is changing. Tactical mission training, once largely the preserve of live flying, is expected to be revolutionised by advances in simulation-based and hybrid training capabilities. Blended live, virtual and constructive (LVC) technologies promise to fundamentally change, and enhance, the Royal Air Force's ability to prepare its personnel for future operations. The implementation of these technologies falls within a broader trend in which the balance between live and synthetic training will shift in favour of the latter.[2] Indeed, the Royal Air Force is already seeing the leading edge of this change, necessitated by ever more complex operational training tasks and decreasing resources. However, *fundamental* change will only be achieved with appropriate investment and an understanding of the challenges that must be overcome. Ultimately, LVC capabilities should erode the distinction between live and synthetic training and this should in turn free the Royal Air Force to be more effective in what it does, both in terms of outputs achieved and resources expended.

This paper briefly defines LVC technologies and then describes the nascent capabilities that the Royal Air Force already employs on its training aircraft, specifically with reference to the Hawk T2 but also describing the Rear Crew training solution that is provided within the UK Military Flying Training System (MFTS). It then explores how the Royal Air Force will benefit from the extension of these capabilities onto the front line. Here the paper considers just how far the Royal Air Force might take synthetic and hybrid training, including the possibility of transferring experimentation and development activity into the synthetic environment. The paper then highlights some of the challenges that must be overcome if LVC technologies are to be exploited as part of a general increase in synthetic training. Conceptually, there are safety and operational issues to consider. There is also a pressing need for early financial investment and there are linked issues surrounding military-industrial relationships. Finally, a broad culture change will be required in order to realise maximum benefits. Inevitably it will be the Royal Air Force's people, and the way in which they are organised, who will be the key to unlocking future potential.

LVC technologies are defined as those in which synthetic capabilities (for example simulated sensors, and entities such as aircraft and missiles) are integrated into, or combined with, live aircraft systems in order to provide an enriched training experience. These capabilities allow pilots flying live aircraft to 'fire' simulated missiles, or react to synthetically inserted tracks and threat indications that are presented in the cockpit via datalink and warning displays. This synthetic information can either be generated onboard each aircraft, and transmitted via datalinks, or within a ground-based synthetic environment that interacts with live participants in the air. Developments in this latter area might allow mixed formations of simulation-based and live aircraft to fight as coordinated units in a single coherent scenario, maximising the size and complexity of an exercise and providing simultaneous benefit to a larger number of trainees than the use of live aircraft alone would permit.

The Royal Air Force has made some early, and impressive, steps towards embracing the potential of LVC technologies in its current flying training capabilities. The Hawk T2, which provides fast jet pilot training at RAF Valley, contains embedded synthetic training systems that are enabled by a combination of onboard avionics and a datalink facility. This permits a wide range of tactical training events to be undertaken without advanced real systems. For example, the T2 has no radar, but student pilots can complete air intercept training using in-cockpit displays that emulate a typical air-to-air radar scope. Target information is provided by other aircraft that are transmitting location and attitude information via their underwing instrumentation pods. Student pilots can then 'engage' this synthetic radar track with simulated weapons. In addition, instructors are able to either preload, or reactively insert, ground-based threat systems into the airborne scenario. These threats subsequently 'engage' the student as he enters their range. The aircraft then dynamically generates survival or mission kill feedback based on the pilot's defensive manoeuvres.

Beyond Hawk T2, the current Rear Crew Training solution that is delivered within the UK Military Flying Training System (MFTS) also offers LVC capabilities, this time for the Royal Navy's student Observers who train on the King Air 350 Avenger aircraft. This system allows the onboard manipulation of real surface radar contacts, attaching emitter and sensor signatures to otherwise benign tracks and so creating a training target for students to interact with. The next stage of MFTS Rear Crew Training, which will also train Royal Air Force Weapons System Operators and Electronic Warfare specialists, is intended to further broaden these airborne capabilities. Simulation across the entire electro-magnetic spectrum will allow students to train with electro-optical sensors in addition to augmented radar returns. In effect, the student will see a graphical representation of a combat ship on his displays, with correctly calculated aspect and speed, when the reality might be a simple fishing boat in the Irish Sea. This visual simulation could be extended to include weapons engagement cues and battle damage assessment. There is also potential to establish a link between ground-based simulators and aircraft, thereby allowing larger scale exercises involving multiple trainees.

This will represent an impressive capability; however, it is again limited in its current scope to *training* aircraft. There are only basic precursors of these capabilities among *operational* types. The Royal Air Force, alongside other air forces, must therefore understand the feasibility of extending these LVC technologies onto front-line fleets. This might be achieved by modifying core aircraft avionics and systems or by incorporating podded datalink technologies, with the latter option likely to be more affordable for in-service platforms such as Typhoon. Where future aircraft are expected to possess their own native embedded training capabilities, such as with Lightning II, the question will be how to achieve integration between different aircraft types.

These are questions that are worth answering. True front-line LVC capabilities will erode the live/synthetic distinction and contribute to a fundamentally changed future training paradigm. They will offer qualitative benefits and also minimise resource expenditure on live support assets. For example, live formations will 'fight' virtual threats which: require no maintenance; can be limitless in number; can accurately represent the characteristics of threat types; and which can be directed to behave according to the requirements of a specific mission and training audience. To extend this revised paradigm further, hypothetical future capabilities might blur training and operational outputs. Perhaps a future hybrid system might allow the real-world stimulation of an adversary's air defence systems, whose reactions would then be observed and presented to pilots who are training within a parallel synthetic environment. This could represent the ultimate in mission rehearsal fidelity, inserting near-real time and demonstrably 'real world' intelligence into a training environment of unprecedented complexity and flexibility.

Beyond training, there is also potential to transfer experimentation into LVC systems as part of a wider increase in the exploitation of synthetics. The repeatable and controllable nature of synthetic entity behaviours and environments will lend itself to tactics development; indeed, it already does as the Royal Air Force seeks to understand how it will employ Lightning II. Entity and sensor models of sufficient fidelity should also allow exploration of weapons performance, along with assessment of other warfare techniques, notably in the electromagnetic spectrum. It should also be possible to trial system performance in a variety of operational contexts, for example incorporating geo-specific data, and trends that are forecast in publications such as DCDC's Future Character of Conflict.[3] The potential benefits of enhanced synthetic and LVC capabilities are therefore not limited to operational training alone; they offer a way in which trial-based understanding of *how* the Royal Air Force should fight will increase alongside competency in established tactics and procedures.

Of course, there are a number of challenges that must be overcome if the full potential of LVC training is to be realised, many of which are relevant to synthetic training more broadly. Conceptually, the Royal Air Force must identify the appropriate limits that should apply when transferring live flying to synthetic and hybrid systems. There are potential safety issues that are not yet fully understood, for example concerning the volume of live training that should be preserved, whether LVC-augmented or otherwise. The US Navy has found that a reduction in live flying below 10 hours per month is seemingly linked to an increase in mishap rates.[4] While this conclusion dates from 2008, and therefore interprets older data that does not reflect the true capabilities of current and future synthetic training systems, this still represents an obvious issue of which the Royal Air Force must be mindful. A linked concern is that LVC systems might over-saturate pilots with synthetic data and this could create dangerous real-world situations, with excessive scenario immersion resulting in a lack of appreciation of airspace or terrain.

There are also potential second-order operational effects that should be considered. For example, an entirely simulation-based operational conversion unit might be able to task its *personnel* in support of a period of operational surge, but it would have no pool of *aircraft* with which it could augment front-line force elements, or provide attrition replacements. Equally, reliance on computer-generated 'red air' assets would reduce the availability of live training support aircraft that might otherwise fulfil secondary operational roles. There is a further need to understand the distinction between what might be technically feasible, and what will actually provide tangible benefits, and meet identified requirements. A hybrid formation of live and simulation-piloted Typhoon aircraft might be technically possible; however, because the live aircraft will continue to suffer from restrictions associated with airspace, security and weather, an entirely synthetic approach might offer a more appropriate training solution.

LVC technologies also pose financial challenges. None of these novel technologies will come for free, and they will take time to understand and implement. There is therefore a pressing need to invest, and to do this early. Synthetic systems are likely to be *cheaper* than live equivalents, but cheaper does not necessarily equate to *cheap*. Even though the USAF estimates that one simulator-based hour of F-16 training can be achieved for one-eighth of the total cost of a live flying hour, this still amounts to $900 per hour per device.[5] Further, while virtual LVC-derived threats should allow significant reductions in expensive real-world fleets of 'aggressor' aircraft and electronic warfare hardware, the LVC systems themselves will need to be purchased, and proven, before real-world savings can be confidently realised. It is therefore likely that the Royal Air Force will need to 'spend to save' in order to maximise long term benefits. This will require difficult choices at a time of continuing operational pressures, but failure to allocate resources to future training systems in the short term will only increase the magnitude of the capability problems that will be faced further downstream.

Resources, however, are finite, and future systems need to be affordable and agile in order to have enduring relevance and maintain pace with continuing technological change, much of which is led from outside the defence sector. The Royal Air Force must not be stymied by legacy procurement processes and assumptions lest it end up with inflexible systems or, worse still, capabilities that are obsolete as they enter service. As a result, integration of commercial off the shelf (COTS) hardware and software solutions will increasingly replace 'traditional' bespoke equipment programmes. This, combined with an overall reduction in live flight hours, might threaten longstanding aerospace commercial models that assume high levels of spares provision and resupply. However, in reality this COTS-focused approach represents a shared challenge; it is up to the military to understand not only what industry can *offer*, but also what industry *needs* in order to thrive and play its own essential role in future innovation. Encouragingly, a number of international companies already promote front-line LVC capabilities at varying levels of maturity and these are largely based on COTS models. This is a keen growth area and all parties need to play their part in achieving mutual success.

The avoidance of bespoke solutions promises affordability and the ability to leverage the very best developments across various industries. However, there is potential that a broad international COTS-focused approach might in fact 'level the playing field', with the technologies that enable novel systems being commonly available to all, friend and foe alike. Such a levelling, or averaging, of underlying technology would need to be offset in other areas if the Royal Air Force is to ensure that its COTS-based solutions are used to better effect than similar systems possessed by competitors Here, the Royal Air Force must emphasise the importance of its people, rather than just its technology. It will be necessary to invest heavily in the conceptual component in order to maintain operational advantage.

The Royal Air Force must not be afraid to change the way in which it educates and employs its brightest personnel. The future conceptual edge will not be found only among officers and airmen who follow a career path that most closely fits the established model. The Service must therefore recognise and reward a variety of successes, not just the 'traditional' and typical; it should encourage specialisation where appropriate, and knowingly build a cadre of experts in training and simulation. This community must possess a cohort of leaders who are empowered to influence and lead in a fundamental, rather than niche, capacity. Simulation experts must be as influential as their peers who are charged with developing and delivering live training outputs; better still, the Royal Air Force should think of 'training' in its totality, and avoid attributing primacy to either the synthetic or the live domain. Efforts must also be made to prevent skilled people drifting out of the service as they feel compelled to seek other opportunities in the middle years of their career. In summary, the Royal Air Force must identify the right people and manage their careers so that they, and the Service, get the very best from future training and operational capabilities. Technology will enable the future, but only the right people can unlock its true potential.

There are also real opportunities to create beneficial change in how the Royal Air Force organises these people. A new training paradigm will require revised doctrine and organisational structures. For example, a Live and Virtual Training Centre, combining concepts and doctrine experts from the Air Warfare Centre at RAF Waddington with those personnel currently tasked to deliver live and synthetic training, would offer impressive coherence and synergy. This would become a cross-domain centre of training excellence. It would also represent the body that oversees experimentation and the development of tactics and fighting doctrine. Finally, it would more effectively allow the UK to follow and develop initiatives such as the United States Air Force's plans to combine Exercise RED FLAG with its virtual equivalent.[6]

This is an air-centric model but it could easily be expanded into a Joint structure, which would ultimately enable truly Joint and Whole Force experiences based upon mutually beneficial training events. Air, land and maritime assets, comprising both live and virtual formations, could be coordinated and exercised together in order to maximise the scale and complexity of capstone mission rehearsal exercises. None of this will be possible if legacy training stovepipes endure. Again, the Royal Air Force, and wider Defence, will benefit from changed conventions that no longer discuss 'live training' and 'synthetic training' as separate and distinct, but rather talk simply in terms of 'training'.

LVC technologies offer revolutionary training capabilities that will provide the Royal Air Force with real advantage in future conflict. They will enable operationally relevant training, harnessing the best aspects of live and synthetic training even as the overall balance of activity shifts towards the latter. These are technical possibilities, with precursors already in service today, but this is not just a technical debate. These are conceptual issues that must be understood and some significant challenges to overcome. It will be important to distinguish between what *could* be achieved and what will actually be safe, useful and operationally desirable. This understanding must be matched by tangible financial commitment; effective exploitation of LVC technologies will rely upon early and appropriate investment, 'spending to save' if necessary, and emphasising COTS solutions rather than 'traditional' bespoke models. This latter imperative will likely challenge the existing procurement system and the relationship between the military and industry. In managing these relationships, and exploiting the resulting capabilities, the Royal Air Force will rely most of all upon its people. The conceptual component must be developed, promoting a revised culture that allows novel training systems to thrive in both the air and Joint domains. This will be critical if the Royal Air Force is to redefine the live/synthetic training paradigm and create the 'severest school' that Thucydidean success requires.

Notes

[1] Thucydides, *History of the Peloponnesian War*.
[2] HM Government, *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review* (London: HM Stationery Office, 2010), 31. Also Ministry of Defence, *SDSR Study 9.2: Simulation and Training* (RESTRICTED, 25 June 2010).
[3] Ministry of Defence, *Future Character of Conflict* (Swindon: Development, Concepts and Doctrine Centre, 2010).
[4] US Government Accountability Office, 'Navy Training: Observations on the Navy's Use of Live and Simulated Training.' *GAO-12-725R*, 29 June 2012, page 16. Accessed 11 March 15, http://www.gao.gov/assets/600/592056.pdf.
[5] Maj. Gen. James Jones, USAF Assistant Deputy Chief of Staff Operations, Plans and Requirements, quoted in Aaron Mehta, 'Under Budget Pressure, US Air Force Looks to LVC Training.' *Defense News*, 20 May 2014, accessed 11 March 2015. http://www.defensenews.com/article/20140520/TRAINING/305200048/Under-Budget-Pressure-US-Air-Force-Looks-LVC-Training.
[6] Staff Sgt Siuta B. Ika, USAF Air Combat Command, 'LVC Integration Takes Red Flag to Next Level.' 5 March 2015, accessed 15 March 2015, http://www.acc.af.mil/news/story.asp?id=123440862.