Viewpoint

More Science, Less Art: Big Data, The Information Revolution and Decision-Making in the Royal Air Force

By Wing Commander Keith Dear

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Introduction

Before we work on artificial intelligence why don't we do something about natural stupidity?
Steve Polyak, Computer Scientist, Psychologist.

The information revolution – the exponential increase in volume and detail of data on almost everything[1] – is fundamentally re-shaping modern warfare, enabling the measurement of effect in war to be infinitely more empirical than ever before. For professional airmen and women, the rise of big data should be driving greater rigour into how decisions are made in organising for war, planning for war, and fighting wars. We are moving from a world in which decisions were made principally qualitatively, on human judgement and intuition, to one in which data science predominates.

If the arguments that follow are accepted, the implications are profound. Orienting the RAF around big data analytics will drive unprecedented rigour into its decision-making. In practice this will principally require the far-reaching adoption of quantitative, statistical, analytics. The primary consequences of this will be felt by commanders, whose decisions will need to be far more clearly derived from evidence and defined assumptions than is currently the case.[2] The secondary consequences are significant too, and will be manifest in how the RAF recruits, trains, educates, structures itself and manages careers. Furthermore, adopting such an approach will enable the automation of many decision-support functions a process that will also require the logic, evidence and assumptions that make up and support the premises underlying decisions to be made much more explicit – both in HQ staff functions and commanders' decisions.

In this viewpoint, I first provide an overview of the scale of the information revolution and demonstrate how this is providing unprecedented insight and foresight, principally through quantitative analytics. Secondly, I show how this is driving doctrinal and organisational change in the RAF. Thirdly, I demonstrate how it will drive greater rigour into, and enable significant automation of, the RAF's decision-making and decision-support functions. Finally, I examine the arguments advocated in the context of previous attempts to conceptualise how Air Forces approach warfare. This viewpoint is written for *Air and Space Power Review*, so the focus here is on the RAF, but many of the insights are just as applicable across all three Services, and indeed across Government more broadly.

What is the big data revolution and why does it matter?

We live today in a virtual panopticon,[3] in which the volume of data available on each of us is unprecedented.[4] It is estimated that by 2020 this will equate to some 5,200GB of data per person.[5] By my calculations this equates to some 18.5 million books of data on each and every one of us.[6] This is because, as Google's Chief Economist has noted, 'Nowadays there is a computer in the middle of virtually every transaction...' which is enabling 'data extraction and analysis', 'new contractual forms due to better monitoring', 'personalisation and customisation', and 'continuous experiments'.[7] All of this enables data scientists to model and manipulate

human behaviour, providing unprecedented insight and foresight, creating what Harvard Business School professor Soshana Zuboff calls 'behavioural futures markets'.[8]

The evidence for the kind of insight Big Data analytics can provide is well-reviewed in Berman, Felter and Shapiro's 2018 book, '*Small Wars, Big Data*'. Between them, the authors combine their military experience in the Israeli Armed Forces and the US Special Forces with doctoral education in economics and political science to turn quantitative analytics to the study of war. They demonstrate how data-analytics have been able to provide metrics demonstrating what works, and what does not, in a range of counter-insurgency operations. They answer with clarity and detail questions like: Do civilian casualties drive violence? What's the relationship between poverty, employment and violence? Does paying for tip-offs work?[9] Furthermore, their decision to focus on what they call 'micro-data',[10] that related to district level activity, clearly provides commanders with more precise, quantitative, detail on the nuances than the staffs I was a part of, or on occasion led, were routinely able to do. For example, in 2008 ISAF intelligence staff were heavily reliant on the Asia Foundation's Afghan Attitudes survey[11] to understand whether the various military operations, security sector reforms, economic, governance and other development initiatives were helping us win the support of the undecided middle, to turn public opinion for the Afghan Government and against the Taliban – something our doctrine made the main objective.[12] The Asia Foundation report aggregates attitudinal data across district, tribal and other boundaries offering categories describing opinion in Central/Kabul, South East, East North, North East, North West, Western, South West, and Central/Hazarjat as if the variances within these huge regions were unimportant or insignificant. Yet this was a war that was so localised such numbers were meaningless. This was highly localised conflict driven by interlocking grievances and feuds overlaid with ideology, ethnicity, and tribalism.[13] Berman et al. report research showing the differential effects of aid across 250 villages in a genuinely randomly selected sample, vice the Asia Foundation's crude regional aggregations (this is not to say these aggregations were without merit in their survey – just that they could not provide the kind of insight we needed and weren't suited for what we were forced to rely on them for). The more detailed data showed that aid projects reduce violence only after 12 months of consistent implementation, only in areas where violence was previously 'moderate' and not in areas where it was high, and that aid improved attitudes to government.[14] They also report a study showing that aid in areas controlled by the Taliban may have brought more stability, but in Government controlled areas aid projects seemed to increase violence.[15]

The nuance, or lack of it, matters. Understanding these various moderating and mediating variables at the local level is critical, it seems, to estimating the likely success or failure of an intervention. Without accurate diagnosis at the right level of detail, decisions taken at a higher level of aggregation might lead to the application of a remedy that helps resolve the problem in some areas but exacerbates it in others. To gain the kind of insight Berman et al. deliver, they recommend staff employ 'theoretically grounded microlevel research'.[16] Their examples are principally quantitative, and dispassionate – starting with the question: What evidence would prove me wrong? In short, they advocate a rigour in the provision of insight that would

significantly improve support to decision-making, not just in the RAF, but across UK (and allied) Defence and security organisations.

A raft of primary research demonstrates how living in the virtual panopticon provides not only the unprecedented insight described above, but unprecedented foresight too. The Bank of England has recognised this. Speaking in April 2018, Andrew Haldane, the Bank of England's Chief Economist drew his audience's attention to some of these developments and his vision for their use in ways that merit quoting at length:

> *…data on music downloads from Spotify has been used, in tandem with semantic search techniques applied to the words of songs, to provide an indicator of people's sentiment. Intriguingly, the resulting index of sentiment does at least as well in tracking consumer spending as the Michigan survey of consumer confidence.*
>
> *And why stop at music? People's tastes in books, TV and radio may also offer a window on their soul.*
>
> *So too might their taste in games. Indeed, I am interested in the potential for using gaming techniques, not just to extract data on people's preferences, but as a means of generating data on preferences and actions.*
>
> *… In time, it is possible these sorts of data could help to create a real-time map of financial and activity flows across the economy, in much the same way as is already done for flows of traffic or information or weather. Once mapped, there would then be scope to model and, through policy, modify these flows. This is an idea I first talked about six years ago. Today, it looks closer than ever to being within our grasp.*[17]

This kind of revolutionary insight is just as relevant to those in defence as it is to bankers. For instance, recent research shows how online contact between groups can be predictive of offline violence,[18] how the 'integrative complexity' of a leader's language – how 'black and white' their pronouncements on a given country are – can probabilistically predict the likelihood of countries going to war,[19] and how flexible – and perhaps therefore effective or ineffective – political and military leaders will be.[20] The former points the way to innovative indicators and warnings allowing much earlier prediction of adversary intentions. Instead of watching for the movement of tanks, recall of personnel or bursts of electronic communications from key headquarters to predict attacks, perhaps, it may be that monitoring videos feeds of political leaders from public TV appearances, via CCTV, webcam, their personal voice communications or video telephone conference data might prove more reliable indicators of future hostile intent. In an age where personality models with high external predictive validity – such as of one's political attitudes,[21] propensity to engage in political activism,[22] violent tendencies[23] or how one is most easily influenced – can be built from social media data,[24] call data,[25] the music people stream,[26] consumer purchase information,[27]

banking data,[28] and even from tracking their eye-movements,[29] this kind of early detection of adversary intentions might enable much earlier and effective deterrent activity.

It's not just research either. This science has been, and continues to be, put to practical use by companies and states seeking an edge on their competitors. Witness efforts to influence elections in the UK using social media data,[30] the well-reported activities of Russia's Internet Research Agency in the US (and elsewhere),[31] and China's commitment to influencing public opinion in democracies making it harder for those states to oppose them.[32] Empirical evidence on the extent to which microtargeted political marketing – data-driven influence campaigns that predict who is vulnerable based on personality (or other) modelling of the type described, and then present persuasive campaigns around their target audiences' personalities or other criteria – is limited to correlational data, and inferences from research. For example, Cambridge Analytica have boasted of boosting Ted Cruz's popularity from 40% name-recognition in Iowa (vice Jeb Bush at 85%) to winning the caucus there and going from 5% to 35% support amongst voters in US Republican Presidential primaries, second only to Donald Trump.[33] Other primary research shows the techniques might work, for example, to increase voter turn-out,[34] or to change people's self-perception; to change, in other words, aspects of their identity, and their real-world behaviour.[35] What we can't prove is causality between Cambridge Analytica's claims to have influenced US Presidential primaries, the US election, #VoteLeave's claims to have influenced the BREXIT referendum and the outcomes of those votes.

Talking about how the big data modelling we have described is done in practice twelve months after #VoteLeave had concluded its role in the BREXIT referendum, #VoteLeave's Director, Dominic Cummings described how his team had contributed to the campaign. He noted that they used mathematicians and physicists to model human behaviour based on big data, suggesting that in the future there would be no role in advertising for '… charlatans… [with] …not very good degrees in gender studies or English…'. Rather in the future persuasive campaigns will be run by a '…combination of experimental psychologists and data scientists…'[36] While we can dismiss some of this as hyperbole, there is an important implication to be drawn – the science behind a big-data based approach to influence and decision-making is principally quantitative. As such, those in decision-support and decision-making positions across the RAF are going to need to be much more familiar with quantitative analysis, statistical methodology, its limitations, utility and potential applications. As Cummings makes clear with his colourful language, this is not a role for the enthusiastic amateur. The RAF is going to have to get much more comfortable with training specialists in these areas and finding ways to manage their careers that reward depth as well as breadth of expertise.

How big data and 'the information revolution' are re-shaping Air Forces

Awareness of what life in the virtual panopticon – the rise of 'big data' and the information revolution – means for Defence is already re-shaping our doctrine, and with it our organisational structure and approach to warfighting.

The RAF's 11 Group was re-formed in November 2018, specifically to enable the RAF to pursue multi-domain operations.[37] Perhaps surprisingly then, multi-domain operations are not currently defined in UK doctrine.[38] But insight into what multi-domain operations might be can be inferred from US attempts to define them. In a 2016 article published in the US *Air & Space Power Journal*, Dr Reilly offered Figure 1 as a way of describing this new concept of operations.[39]

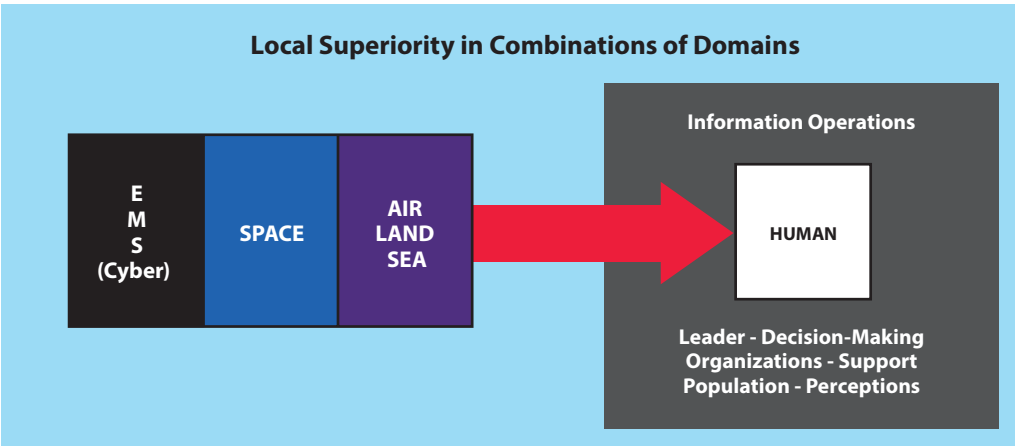

Figure 1: Continuum of domains and their interdependence.

What we see is that multi-domain operations consider actions in the domains of the Electromagnetic Spectrum (EMS), Cyber, Space, and Air, Land and Sea are all in the end about informational inputs to the human domain – that is, to human minds to affect behaviours. Dr Reilly is now leading on the conceptual development of multi-domain operations on behalf of the US Air Force,[40] perhaps suggesting this understanding of war will soon be enshrined in the doctrine of the UK's closest ally. What we have seen in the preceding discussion is that increasingly, the way militaries assess which inputs might work to change behaviours is through the development of carefully designed, evidence-based and falsifiable hypotheses, tested using quantitative analytics. Big data is changing not only how effect is measured in war, and how war is planned for, but how the RAF structures and organises itself for war, and how warfare is conceptualised.

So What? How will this change the way RAF makes decisions?

Just as quantitative analytics are changing RAF doctrine, how it is structured and ultimately its approach to warfare, so too, will they have radical effects on how the RAF makes decisions, particularly when paired with Artificial Intelligence (AI) that could and should automate much of our information processing.

The volume of data previously described, 5,200GB per person by 2020, or 18.5 million books, is so vast that it will overwhelm human analysts' capacity to process it.[41] Furthermore, with

information in these volumes moving at ever-faster speeds,[42] human analysts won't be able to provide insights in anything like real-time – if there is to be a war-fighting equivalent of Andy Haldane's real-time economic modelling, analysis is going to have to be automated.[43] AI is just mathematics, statistical processes, run through a computer program. It is ideally suited to analysing the kind of big data described in the preceding section. In doing so, it will drive rigour even more deeply into our decision-making.

To automate a function, we first have to make explicit the logic and processes we are seeking to automate. Thus, as an intelligence officer, I might explain how I scan the titles of reports for certain key-words or phrases, rapidly triaging say 30-40 reports (on a good day) from the hundreds of intelligence reports received on a given topic (often already filtered by theme such as a region, state, or technology). From there I might skim read and print – or set aside for reading in depth – say 10-20 of those reports, looking for information that is particularly relevant to my geographic or thematic area of interest, that fits or breaks a pattern or that might indicate, usually in concert with other information, that something such as an attack might take place. Conceptually, we can see that this process could, over time, be largely automated, with an AI, (either expert system or machine-learning algorithm), being designed or trained (or teaching itself) to pick out those things that will be of interest – perhaps even able to spot the patterns in the language from which forecasts and inferences can be drawn. In support of this assertion we might look to the example of local newspapers where AI is already being used to write who, what, where, why and when stories.[44] Demonstrating just how advanced language processing is becoming, the non-profit research firm OpenAI announced in February 2019 that it wouldn't be releasing the new language model their engineers had built as it was writing passages of prose so convincing that its propagandistic potential was too dangerous to risk it falling into the wrong hands.[45] Repurposing language models to identify evidence of 'capability, opportunity and intent', the intelligence officers' mantra used to forecast likely attacks,[46] would begin to deliver intelligence reports of immediate value with no human in the analytical loop. The key deduction here is that in applying a methodology that has mathematics at its heart, there is less room for undefined assumption. Thus, intelligence officers have to think much harder about how they do their jobs and be much more explicit about the logic and evidence underpinning their recommendations.

The same will be increasingly true of commanders' decisions. When recommendations are offered with falsifiable hypotheses they are going to have to be more explicit in describing the logic on which they are based. This should already be the case. As T.E. Lawrence once wrote:

> *Nine-tenths of tactics are certain and taught in books: but the irrational tenth is like the kingfisher flashing across the pool, and that is the test of generals.*[47]

Consequently, nine-tenths of a commander's decision ought to be explicitly evidence based, linked to the data, with explicit assumptions, and formulated in a way that allows metrics to be gathered that are falsifiable.

But the application of the irrational tenth is not an exhortation to apply evidence-free assertion. 'Kingfisher moments' are too often an appeal to this irrational tenth as a commander's genius, in need of no explanation. But really what is being talked of is a commander's deliberate incorporation of the unexpected, or the adoption of a seemingly high-risk high pay-off strategy, manoeuvre or tactic into planning – this is not irrational, it's just commanders calculating the probabilities differently to the adversary and received wisdom, or taking advantage of more effective recursive reasoning (I know that she thinks that I will do X therefore I will do Y, etc): therefore, its logic can be made explicit.

Discussion of 'military judgement' is similar, an appeal to intuition – or the accumulated heuristics and biases developed through involvement in previous conflicts. The problem is, in rigid hierarchies, if a senior commander sees 'Kingfisher moments' as creative genius, it is difficult to question the commander's plan without being seen to question that genius. To use a cricketing analogy, it becomes very difficult to play the ball and not the man since the two have become inseparable. It is only by making the logic of a plan explicit, citing for example the precedent on which it is based, or the recursive reasoning, that challenge can be brought to the plan without challenging a commander's authority. Simply put, in calling for falsifiable hypotheses in RAF planning, the argument is for more science in war.

Whatever happened to the 'art' of war?

To call for more science in decision-making risks setting up an objection from those who prefer to think of war as an art, placing greater weight on qualitative research. But this is a strawman. The most effective analysis weds ruthless transparency and logic in qualitative decision making to the harder edge of big data analytics and probabilistic inference. This is perhaps best exemplified by investment banker Ray Dalio's concept of 'radical transparency', on which the runaway success of his Bridgewater Asset Management was built – it relies on forcing everyone to surface all the assumptions and logic that underlie any decision, in so doing, Dalio ensured Bridgewater could continuously improve by holding quantitative and qualitative analysis to the same rigorous scientific standards.[48] Perhaps the challenge inherent in complex interactive systems require that we continue to make many decisions based on inferences from qualitative data. We should do this on an empirical basis as soon as possible. As my co-author WO1 John Hetherington and I argued in *APR* in 'Assessing Assessments',[49] we are moving in the direction of doing so already, assigning probabilities to language in qualitative assessment and beginning, in some circles, to more closely examine and isolate the attributes of effective predictive intelligence and mark its accuracy.[50] Adopting the approach advocated, would encourage a more rapid and widespread adoption of such rigour beyond the intelligence staff.

One of my own worries in writing this viewpoint was that it might fall into the determinist trap that caught Defence, and air forces in particular, as science and technology delivered unprecedented advance in sensor capabilities during the 1990s and early 2000s 'Revolution in Military Affairs'. From this, and the concept of 'information dominance', we got the hubristic

heights of Szfranski's Neo-Cortical Warfare which conceived of the notion that militaries would soon be able to deliver a form of mind control through bombing.[51] So total would the understanding of an adversary be that an Air Force could hit just the right spots predicting perfectly the effect this would have on the enemy's collective brain and making the outcome of conflict certain.[52] A less hubristic, but no less wrong, over-simplification was Warden's five Rings theory, which understood the enemy as a human body that could be blinded, deafened, paralysed, and not as the complex interactive system that it was.[53] The consequence was Shock and Awe, and the spiralling insurgencies in Iraq and Afghanistan that resolutely refused to be blinded or paralysed and, indeed could never be. We had misunderstood their nature, as I argued in 'Beheading the Hydra', mistaking simplified abstractions for the more complex reality.[54]

These criticisms – of over-simplification, and hubristic determinism – were also levelled at Effects Based Operations (EBO), a more moderate version of neo-cortical warfare and Warden's five Rings model, which simply argued that militaries ought to first identify what the object was in any attack, and then estimate the first, second, and third order consequences of this in order to decide what, when and how to attack.[55] It quickly came to be applied as if the prediction to third order effects and beyond could be undertaken with the same precision available in the accuracy of the bombs themselves, contributing to the chaos in Iraq and Afghanistan and, famously, leading the then Commander of US Joint Forces General James Mattis, to publicly ban the use of the term and employment of the concept, insisting on the need to accept the inherent uncertainty of war.[56]

This was a necessary corrective at the time, but I would argue that General Van Riper, who wrote in support of Mattis' decision, was wrong to claim there was no baby in the bathwater.[57] What we threw out along with the concept of EBO was the framework that forced something akin to Dalio's radical transparency.[58] The key difference between Dalio's Bridgewater and the military here was in culture – in the military, predicting the consequences wrongly led to the abandonment of the framework rather than allowing continuous refinement through the exposure of flawed logic, in their attempt to assert an alternative, the US military and allies threw out the model, demanding the embrace of uncertainty.

But, I'd suggest, embracing uncertainty made it harder to learn, and, more importantly, in my experience, meant that some senior officers no longer felt the need to predict the outcome of an attack, nor to surface the assumptions and logic on which their decisions were based. Rather they could fall back on their own 'gut feelings', their 'military judgement', that enabled them to act in uncertainty.

Today, EBO is finding interdisciplinary support for reasons that precisely contradict the basis of which it was abandoned by the military. Looking at what the combination of big data and AI can teach us about decision-making economists have begun arguing that to operate in uncertainty necessarily requires the formulation of hypotheses and predictions about likely

outcomes.[59] Similarly, some psychologists now argue that the ability to form probabilistic predictions about the future may be the very foundation of human intelligence,[60] and therefore of sound decision-making. Prediction – hypothesis driven decision-making - was the baby in the bathwater.

The evidence for how militaries have indeed thrown the baby out with the bathwater, in contradiction of Van Riper's eponymous article, is the awkward efforts that have followed in trying to find something to replace EBO. I would assert that neither multi-domain operations nor the UK's 'Full Spectrum Operations',[61] 'Joint Force Advantage',[62] 'Joint Action',[63] or 'Information Advantage',[64] have the merit of the descriptive and conceptual clarity behind EBO. None are so easily explained and understood. This is not to say they are not useful rallying points around which to re-orientate the Royal Air Force and Defence. Their utility is to re-start effects-based planning with an increased focus on cognitive effects and behavioural-outcomes in the human domain, without EBO's baggage – but we should acknowledge the conceptual debt they owe Deptula.

In arguing that for a data-based approach to decision making in the RAF – and Defence more broadly – this article is calling for a third way, between mathematical determinism and obscurantist reliance on gut feelings, a way of probabilistic prediction, and transparent reasoning, the surfacing of assumptions and logic. The greater hubristic danger lies not in adopting the model of a scientific, data-based approach to Air Force decision-making, but in empowering commanders to believe that all is uncertain and their instincts are therefore more valuable than evidence.

If the arguments presented in this viewpoint are accepted, the RAF will need to address shortfalls in quantitative, that is statistical, analytical skills across the force. Career paths for specialists in the application of the human and behavioural sciences, and big data analytics to warfare will be needed. Doctrine will have to capture the requirement for campaign and operational planning to include the formulation of testable hypotheses designed around the desired behavioural outcomes. Automation will be driven far deeper into decision-support and decision-making functions. Commanders and intelligence staff in particular, but all across the RAF, will have to get much more comfortable with exposing the logic and foundations of their assessments, recommendations and decisions. Before the RAF starts introducing AI, it first needs to bound and limit the human propensity for natural stupidity.

Notes

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