Title: *'TWO DECADES AT THE CHUO KEIBA[1]'*

A presentation by Air Chief Marshal Sir Andrew Pulford KCB CBE ADC RAF, Chief of the Air Staff, Ministry of Defence, to the Air Commanders' Dialogue Japan on 23rd October 2014.

(SLIDE 1)

Introduction

General [Harukazu] Saitoh, fellow air chiefs, ladies and gentlemen. Session Chair, thank you for your kind introduction. The opportunity to speak to delegates is a real honour for me. In return, I hope that you will find the Royal Air Force perspective challenging and interesting.

Context

It seems to me that my title: *'Two Decades at the Chou Keiba'* offers a good local metaphor for the challenge that you have given me. Predicting the future is difficult. And predicting how developments in science and technology will fit into that future is probably even harder. But, in the context of what I am going to talk about, it is not just *one day* at the horse races. We are trying to pick a potential winner from a field of strong competitors every day for at least *two decades*.

Over those two decades we must study the developing 'form' of science and technology, and then place our 'bet' to invest at just the right moment. This is the only way we can identify today the potential for a battle-winning air power capability of tomorrow. A difficult task, but not an impossible one. And one we cannot afford to ignore. But we may not always make the right decision and so a degree of 'spreading our bets' will be required. Failure to invest sufficiently in our future - particularly in research and development - will ultimately lead to only one outcome in a business where fine margins do count.

And our history confirms this. Next year the Royal Air Force will lead commemorations for the 75th anniversary of the Battle of Britain. (SLIDE 2) A battle whose outcome was fundamentally shaped by one technological development - that of radar, and the innovative way it was incorporated into the air defence network for Great Britain.

Content

The timeframe that my comments are directed at is predominantly 2035. While that year may seem a long way off to some, the reality is that it is not. To become a fielded capability by

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[1] The *Chuo Keiba* is a 'central horse race' organised by the Japanese state. The flagship event of the Japanese horse racing calendar is *The Japan Cup* which is run each November.

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2035, the science and technology that underpins that capability will need to be approaching a reasonable level of maturity around 10 years earlier. And being *discovered* up to 10 years before that. It is therefore exactly these matters which we should be discussing today.

My presentation has 3 elements. (SLIDE 3) First, I will identify the key trends within the technological environment that we believe will impact on the generation and delivery of air power by 2035. Next, I will focus on those technologies which appear to have utility in new air systems. And finally, I will consider what this could mean for the future character of aerial warfare.

UK thinking

The Ministry of Defence's Development, Concepts and Doctrine Centre (DCDC) is responsible for providing the UK armed force's view of the future. (SLIDE 4) The output of its analysis is encapsulated in 2 documents: *Global Strategic Trends* and *The Future Operating Environment.*

Global Strategic Trends, or GST, looks out to 2045. It sets the strategic context by first identifying discernible patterns of change - or trends - then considers how they might impact in 30 years time.[2]

The Future Operating Environment, or FOE, looks out to 2035. It offers a broad and plausible vision of the future operating environment based on the anticipated strategic context. The FOE represents a *prudent guess.*[3] It provides evidence-based insights. This is used by government policy makers and the armed forces to test and plan, and informs their development of future defence capability.[4]

Both GST and FOE acknowledge the potential for strategic shocks to disrupt anticipated trends. These shocks could lead us to a very different future from that considered most likely. I commend both documents to you as the latest UK thinking.

Key trends

My view is that there are 2 very significant technological trends that will impact on air power. The first trend involves *time* - change is happening more quickly and therefore we have less time to adapt to new circumstances. The second trend concerns *leadership* - the

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[2] *Global Strategic Trends - Out to 2045*, 5th Ed., (MOD) 2014, p. vii.
[3] *Defence Planning for National Security: Navigation Aids for the Mystery Tour*, Colin S Gray. 2014.
[4] *Future Operating Environment 2035*, 1st Ed, (MOD). 2* Study Draft, Introduction, p. xx.

commercial sector increasingly leads development and consequently air forces are now forced to adapt the ideas of commercial ventures to meet their needs. The combination of both trends presents very real dilemmas for air power. I would like to examine these a little further.

Reducing time

The increasing pace of technology discovery and development is fuelled by the broadening worldwide access to: information, education, materials, tools and manufacturing capabilities.[5] This mixture promotes almost limitless opportunities for technology development - for us, and our potential adversaries. But keeping track of this rapid pace of development is very difficult. And technology is also proliferating widely at the same time. (SLIDE 5) To compare our situation to Colonel John Boyd's thinking on air power employment - global technological change is now so broad, and occurring so fast, that it is arguably already inside the OODA[6] loop of many militaries. This condition constrains our ability to exploit advances in technology.

We are becoming increasingly reactive and less proactive. This is because our acquisition structures and processes remain those built for an era of slower-paced technological development. But this era will soon be over. And consequently, modern militaries will find it increasingly difficult to maintain capability levels.

The only consolation - for now - is that arguably all air forces, including those of our potential adversaries, face the same situation. But for those who place a premium on retaining a technological advantage, the sense of that advantage 'slipping' is perhaps more acute. I will return later to what the UK is doing about this.

Development leadership

Traditionally the military requirement has driven industry's technological innovation. This innovation was then subsequently adapted by the commercial sector for alternative uses. That paradigm has now been mostly reversed. It is due to 2 factors: the relative scale of the military and commercial operation; and, the rate and breadth of technological change. The latter fuelled by advances in information and communications technology which has had a catalytic effect on globalisation. In short, there is now a much higher demand for

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[5] Cited in *Technology and Innovation Enablers for Superiority in 2030*, a report by the Defense Science Board, 2013 (US DoD), p. 5.
[6] Col (USAF Ret'd)) John Boyd - Observe, Orientate, Decide and Act (OODA).

technological innovation from the commercial sector vice the military sector.   And rising development costs for the most technologically advanced equipment has also reduced the numbers that can be purchased. As General Saitoh pointed out in London last year, this only leads to a vicious spiral of decline if left unchecked.[7]

A recent report by the *Centre for New American Security* highlights this emerging trend very well. It cites US defence spending on independent research and development having dropped by one-third as a percentage of sales between 1999 and 2012.   The report also highlights there are no defence companies in the top 20 industrial research and development spenders worldwide. In fact, it states that if the top 5 US defence contractors added together their combined spends, it would still not put defence in the top 20 list.[8]

(SLIDE 6) And the market capitalisation of those 'big 5' US defence contractors[9] is approximately half of that of Apple.[10] (SLIDE 7) But perhaps most telling is the prediction by 75% of the professional people surveyed that commercial technology will drive development of military technology by 2030.[11] And that commercial companies will become increasingly active in the Defence sector.[12]   My view is that this US analysis merely reflects a worldwide trend. Consider the most 'recent' examples when development of technologies flowed from military to commercial. Arguably it was the internet in 1991 and global positioning system, or GPS, in 1995.

Disruption through technology

It is therefore when technology disrupts, supplanting older ways of doing things and rendering old skills and organisational approaches irrelevant that our paradigm shifts irreversibly, away from what we know towards what we must now learn. Militaries and defence industries will have to adapt to these new circumstances.

Systems: platforms, sensors and weapons

I will now turn to the potential application of emerging technologies in UK air power. But as those technologies are numerous and time is short, I will limit my comments to those

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[7] http://www.slideshare.net/RUSIEVENTS/saitoh accessed 11 Oct 14.
[8] *Creative Disruption: Technology, Strategy and the future of the Global Defense Industry*, Fitzgerald and Sayler. Center for New American Security. 2014. p. 6.
[9] Boeing, Lockheed Martin, General Dynamics, Raytheon and Northrop Grumman.
[10] *Creative Disruption: Technology, Strategy and the future of the Global Defense Industry*, Fitzgerald and Sayler. Center for New American Security. 2014, p. 9.
[11] Ibid, p. 10.
[12] Ibid, p. 9.

undergoing active research and development efforts in the UK today. It is erroneous to separate out platforms, sensors and weapons for specific attention because it is the air power *system* they collectively represent which will be the most important.

The UK's policy position on technology investment was outlined by Her Majesty's Department for Business, Innovation and Skills in 2013. (SLIDE 8) It identified *the eight great technologies* the Department believed to be the most important and thus warrant increased investment by the UK. These were: big data; space; robotics and autonomous systems; synthetic biology; regenerative medicine; agri-science; advanced materials and energy. [13]

For the Ministry of Defence, exploitation of emerging technologies for military purposes is led by the Defence Science and Technology Laboratory or DSTL. (SLIDE 9) It has identified 19 future and disruptive technologies – the outer ring shown here. And 9 science and technology priorities for the UK to address today's and tomorrow's challenges – the inner ring on this graphic.[14]   Over the next 5 years, DSTL expects to invest just under £0.7Bn annually in its work.

(SLIDE 10) The *Air Account* of DSTL's work comprises 8 project portfolios and 14 programmes. It is the <u>breadth</u> of the *Air Account* that is the key here. Because it is not just a breakthrough in <u>one</u> area that is important. Rather it is the ability to integrate and harness the benefit of <u>many</u> breakthroughs to the air *systems* of the future. It is this that will be the <u>most</u> important. For example, new aircraft materials and better platform protection may improve performance and survivability. New sensors can detect things more easily and at greater range. And information can be exploited by new and novel weapons offering greater stand-off, precision and lethality. It is the overall air *system* that will maintain a technological advantage, not just one technology.

I will briefly pause on 2 types of future weapon programmes - the conventional and novel.

Conventional

DSTL's *Conventional Weapons Programme* is run under the Team Complex Weapons initiative. (Slide 11) This brings together industry specialists with government and the armed

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[13] *Eight Great Technologies*, speech by the Rt Hon David Willetts MP, HMG, Dept of Business, Innovation and Skills, to the Policy Exchange on 24 Jan 2013.
[14] *DSTL Corporate Plan 2014-19*, Crown Copyright 2014. p. 20-21

forces, and takes a portfolio approach to weapons procurement. This allows UK to pursue a strategy of: commonality, modularity and re-use, to give better value for money.[15] It is a good way forward for the UK. Although this programme will deliver the 6 weapons[16] shown here well before 2035, it is an approach to research and development that is likely to endure in the UK.

The next generation of conventional weapons may well operate at hypersonic speeds, Mach 5 and above. (Slide 12) The UK and its partners in the METEOR beyond visual range air-to-air missile programme will receive a world-leading weapon that is capable of high sustained supersonic speeds over great distance because of its hybrid ramjet technology. But hypersonic aspirations are much higher. The US' *Conventional Prompt Global Strike* (CPGS) programme for example aims to hit any target in the world within one hour of launch.[17] This would fundamentally redefine air power's ability to hold an adversary at risk from range.

Novel

Novel weapons such as those which utilise sound or strobe lighting are also possible by 2035. (Slide 13) But it is the potential for directed energy weapons which are currently attracting most attention. And we seem to have been talking about them for quite some time. These directed energy weapons may take the form of high power lasers or electro-magnetic pulse. But it is now likely that the barriers of power generation and storage for these weapons will almost certainly have been overcome by 2035.[18] And it is also possible that weapons using radio frequencies or microwave emitters could deliver energy on persons to cause lethal or non-lethal effects.[19]

I have touched on just a few technologies but all have the potential to play some part in the Royal Air Force of 2035 and beyond.

Character of aerial warfare in 2035

My final challenge is to consider if and how the character of aerial warfare might change by 2035.

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[15] Team Complex Weapons Press Release dated 15 July 2008.

[16] Fire Shadow Loitering Munition; Future Anti-Surface Guided Weapon (Heavy and Light); Selected Precision Effects At Range (SPEAR); Future Local Area Air Defence System/Common Anti-air Modular Missile; and, Storm Shadow Capability Enhancement Programme.

[17] http://www.theweek.co.uk/world-news/60107/hypersonic-weapons-blown-up-four-seconds-into-test-launch accessed 12 Oct 14.

[18] *Future Operating Environment 2035*, 1st Ed, (MOD). 2* Study Draft, Introduction, p. xx.

[19] Ibid, p. xx.

But I am in no doubt that its character <u>will</u> change. (Slide 14) Technology will be an essential and pervasive element of the future operating environment and a key driver of military change over the next 20 years.[20] The US research shown on this graph suggests that it is the emerging technologies of autonomous systems, unmanned systems and cyber that will be the most important for all actors. I will therefore briefly consider each in turn.

Automation

(Slide 15) Google's autonomous cars have driven over 300,000 miles with only one accident...and this was caused by human error.[21]

(Slide 16) The US' Defense Advanced Research Projects Agency, or DARPA, is developing an *automated assistant* that will 'transform the role of pilot from a systems operator to mission supervisor'.[22] And it will be backwards compatible with existing aircraft.

The message is very clear. Automated mission roles will be numerous by 2035 and if effective control mechanisms can be put in place, almost unlimited.[23] And these automated systems, including those that are armed, will proliferate widely due to low entry barriers and commercial application of the technology.

Therefore automation suggests 2 factors in our future. First, we should not be surprised when non-state actors employ such high-tech means against us in novel ways. And second, while automation may mean that we require less people to deploy, those that do may need very different skill sets to the ones they have now.

Unmanned

(Slide 17) The UK policy position on unmanned air systems is that there will always be a man-in-the-loop for weapon employment decisions.[24] But the same control mechanism may not be applied by our adversaries. And so the impact of death or injury from an autonomous or unmanned system may well be an additional psychological factor in conflict by 2035.

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[20] Ibid, p. xx.

[21] *Disruptive technologies: Advances that will transform life, business, and the global economy*. McKinsey Global Institute, 2013, p. iv.

[22] http://www.darpa.mil/NewsEvents/Releases/2014/04/18.aspx accessed 12 Oct 14.

[23] *Future Operating Environment 2035*, 1st Ed, (MOD). 2* Study Draft, Introduction, p. xx.

[24] *Remote Control: Remotely Piloted Air Systems – current and future UK use, Tenth Report of Session 2013–14, Volume II*. House of Commons Defence Committee, 2014, p. 1.

Western militaries may also experience moral dilemmas when asking humans to risk their lives to defeat such an adversary.[25]

The future force mix is often debated. The UK's Future Combat Air System, or FCAS programme, will consider the requirement to introduce an Unmanned Combat Air Vehicle, or UCAV, into the future force mix of the Royal Air Force. The TARANIS Technology Demonstration Programme shown here will inform this thinking. Ultimately, a UCAV along the lines of TARANIS is one potential element of the UK's future force mix. An additional buy of JSF Lightning II, a Typhoon life extension or an alternative new-build manned aircraft could also be part of the UK's FCAS solution. The decision to commit to a UCAV acquisition programme will be taken by the UK's Strategic Defence and Security Review in 2015.[26]

But regardless of the UK's decision next year, I am firmly of the view that UCAVs will be a part of aerial warfare by 2035. Their ability to undertake high risk missions will make such a capability very attractive. But I do not really mind what the future manned / unmanned force mix for the Royal Air Force is in 2035. I just want it to have access to the capabilities it needs. How that capability is delivered is unimportant.

Cyber

(Slide 18) The impact of cyber activities on aerial warfare is perhaps less clear. Our understanding today of the military importance of cyber, like that of the Air environment just over 100 years ago, is still relatively new and immature, with actors slow to grasp its offensive capability.[27] By 2035 this will not be the case and the use of cyber for military purposes will be normative behaviour. Indeed, by 2035, achieving dominance in cyberspace could be as important as control of the air today. Cyber activity will also be able to contribute in every stage of conflict. And these cyber operations may be covert, reversible and have different collateral damage considerations to other effects.[28]

So what for air power? (Slide 19) It is the ability to combine cyber, air and even space operations against a single problem that has the potential to alter the way we may fight. This

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[25] *Future Operating Environment 2035*, 1st Ed, (MOD). 2* Study Draft, Introduction, p. xx.
[26] *Remote Control: Remotely Piloted Air Systems - current and future UK use: Government Response to the Committee's Tenth Report of Session 2013-14.* House of Commons Defence Committee Report HC611, 21 Jul 2014, p. 9.
[27] *Future Operating Environment 2035*, 1st Ed, (MOD). 2* Study Draft, Introduction, p. xx.
[28] Ibid, p. xx.

is what the recent US Air Force strategy calls *multi-domain operations*.[29] If air, space and cyber can operate together effectively, then it will help to preserve technological advantage over our near-peer adversaries. And so cyber will, in my view, be a factor in aerial warfare by 2035. Consequently, we must have sufficient resilience to defend against its use by adversaries and develop our own measures to exploit cyber for gains in the Air environment.

These are just 3 of the technologies which could alter the character of aerial warfare in 2035. But every emerging technology has the potential to do this in some way. And as this presentation has shown, there are many technologies out there which might prove disruptive as they mature. We just have to be ready to deal with them when they do.

Summary

I will close by drawing together my key points.

There are many technologies which might disrupt our approach to air power by 2035 but they aggregate into 2 key trends. First, the trend of *reducing time*. New technologies are discovered, developed and exploited extremely quickly in a world that is changing around us at a faster and faster pace. We are already struggling to keep up.

Second, the trend of *changing leadership*. The commercial pull on technological innovation will mean that it is the military which will increasingly need to adapt new civilian technologies for military purposes. We must recognise the situation that is evolving and adapt to it now in order to succeed in the future.

The new air systems which will be driven by emerging technologies are potentially quite numerous. But States will increasingly need to adopt a cooperative approach to research, development and acquisition. The UK has already done this through its Team Complex Weapons initiative.

In 2035 weapons will likely operate at hypersonic speed. New seeker technology has the potential to defeat even the most advanced electronic countermeasures. And directed energy weapons are possible in the *air arsenal*.

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[29] *America' Air Force - A Call to the Future*, US DOD, 2014, p. 17.

But simply developing superior weaponry will not be enough - the speed at which we can adapt and integrate technologies will be more important.[30]

And this adaptation will be down to the education of our people. Warfare in 2035, as now, will still fundamentally be a human activity. The ability to think may well be the difference.

But there is little doubt that technology will alter the character of aerial warfare from that which we know today. However, predicting exactly <u>how</u> it will change is simply no more than a *prudent guess.*

(Slide 20) And to reinforce that point, a recent McKinsey report very succinctly stated: *The noise about the next big thing can make it difficult to identify which technologies truly matter.[31]*

That is indeed true.

Thank you for your attention.

(Slide 21)

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[30] *Future Operating Environment 2035*, 1st Ed, (MOD). 2* Study Draft, Introduction, p. xx.
[31] *Disruptive technologies: Advances that will transform life, business, and the global economy*. McKinsey Global Institute, 2013, p. 2.

10