Heterogenous Air Power at War

Presenter:
Dr Peter Layton

GPCAPT J Laroche: Okay, our next session brings us to a small change in the program you would have seen. Brigadier General Tomasz Jacek of the Polish Air Force is unfortunately unable to be with us today, but we do thank him for his planned contribution and we hope to welcome him at a future opportunity.

We are, however, fortunate to have in his place Dr Peter Leighton with us today. Peter is a retired Air Force Group Captain and a distinguished air power strategist. He has extensive experience in force structure development and was awarded the US exceptional public service medal for force structure planning work.

Peter is a visiting fellow at Griffith Asia Institute and an associate fellow of the Royal United Services Institute and a fellow at the Australian Security Leaders Climate Group. He has taught security strategy at the US National Defence University. Peter has written extensively on defence and security matters and was awarded the Rusi Trench Gascoigne Essay Prize for original writing on contemporary issues of defence and international security.

Today he will be speaking to us on insights from contemporary conflicts on big and long wars and heterogeneous air power. Peter welcome.

Dr P Layton: Thank you very much.

So let's now have a talk about your future. The future is inbound. I hope you are ready.

Once again, there is talk of big wars where countries will battle with conventional arms for several years, equipment and personnel losses are heavy, and nations are fully mobilised. In such conflicts, many assume air forces would play a leading role. They may, but probably only for a fleeting time.

As presently designed air forces are fragile entities that once broken cannot be quickly repaired or consequently be, absent for the remainder of a major war.

I'm making an assumption here that there is a slide up there, is that so? Aha! Excellent.

Today's air forces are primarily built around highly sophisticated technically impressive aircraft yet this is their collective Achilles heel. Such aircraft if lost cannot be replaced for years. Moreover, the small numbers available at the start of a great war cannot be easily increased to provide the mass that great power wars call for.

Now for much of the Cold War resilience, scalability and mass were not sought after characteristics. Beginning in 1953 a great war with the Soviet Union was envisaged to shorten all out. The industrial capacity to quickly replace substantial combat losses was unnecessary. The war plans assumed that after a brief opening phase involving conventional forces there would be a large-scale thermonuclear exchange. One-shot air forces fitted this scenario perfectly.

The limited wars of Korea and Vietnam, the rate of combat attrition could be managed to stay within acceptable levels.

In the post-Cold War period resilience, scalability and mass were also not problems, at least for the Western air forces involved in those conflicts. The attrition rates experienced were either very low with the conventional war fighting phases short or virtually non-existent.

In contrast in the last great power air war, that of 1939 to 1945, the major characteristics of air forces were arguably resilience, scalability and mass. In that conflict, many tens of thousands of aircraft were built and lost. Air forces expanded hugely in size. Air battles often involved thousands of aircraft. Such numbers are almost unimaginable today.

They bring into sharp focus the striking disconnect between contemporary air forces and the demands another great power war might bring. A new model for air forces is now needed.

The traditional homogeneous model air force is designed around crewed aircraft. The emerging air power model is heterogeneous, that is where the major constituent elements are of a dissimilar kind.

Heterogeneous air power is a blend of crewed aircraft, rockets, missiles and drones. Such a model is emerging mainly through the use of air power by non-Western forces, some state, and some non-state.

In mid-1925, there were six air wars in six weeks. This talk discusses the new model using these six air wars as examples. This may all seem rather abstract as most of these wars are far away, except of course for the Wedgetail C-17 and KC-30 personnel now deployed to the UAE.

In the wars in the Middle East and the Ukraine one element of the kind of heterogeneous air power being used is the Shahed drone. This design is popular and even the Americans have copied it. Their range means that launched from Russia, North Korea or China they can reach across all of North East Asia and most of ASEAN. Countries that Russia, North Korea or China supply weapons to, in the future will probably get something like Shahed as part of building their own heterogeneous air power.

This talk is in three parts. First, we will briefly discuss last year's six air wars. Secondly, the key advantages of heterogeneous air power. Thirdly, the concluding thoughts looks at some implications and shortcomings.

This talk argues that heterogeneous air power model provides the resilience, scalability and mass that the traditional air power model lacks. This talk further claims that air forces preparing to

fight long big wars must become heterogeneous. I would be delighted if you would dispute my wild claims and questions after the talk. I will not address how to make such an air force but have started that conversation elsewhere and certainly happy to take questions about that later after the talk.

Heterogeneous air forces at war.

For a long time, air forces principally comprised crewed aircraft and their training and support structures. This traditional model has been quietly expanding as rockets, cruise missiles, ballistic missiles and uncrewed air systems (in popular culture called drones) have gradually entered service. Even so, in conventional air warfare, crewed aircraft dominated most debates and air force structures.

The difference now is not so much in the technological form but in the relatively swift application of low cost readily available digital technology to uncrewed systems. This technology was both created and shaped by the huge global consumer electronics market over the last few decades. Its use is a significant characteristic of this century and remains rapidly evolving as exemplified by the rush of countless artificial intelligence applications.

In the military domain, the seemingly sudden appearance in mid-2022 during Russia's war in Ukraine of small low cost consumer drones in very large numbers quickly grabbed both professional and public attention.

This focus however obscured a more fundamental shift.

Air operations have decisively moved from being homogeneous to heterogeneous. The means of air warfare have dramatically broadened. Air forces no longer need to be centred nor should be centred on crewed aircraft. The conceptual dominance of such aircraft is ending. Crewed aircraft simply have become one means available amongst many with all capabilities able to be used in a coordinated, synchronised and collaborative manner to efficiently achieve operational objectives.

Over the past few years, an extraordinary diversity of crewed aircraft, rockets, cruise missiles, ballistic missiles and drone systems have been used in air operations. The six-week period from 5 May to 16 June is illustrative of this new way of air warfare where it is clear that crewed aircraft were just one of the means used in combat.

Six air wars in six weeks.

At the start of May 2025, the Americans declared victory over the Houthis in Yemen. Since late 2023, the Houthis have been attacking merchant shipping, transiting through the Red Sea using attack drones, anti-ship ballistic missiles and cruise missiles fired at irregular intervals.

In March 2025, the Americans had launched Operation Rough Rider, a counter-force air campaign that hit some 1,000 targets using systems ranging from Tomahawks to the first combat use of GBU-53 Stormbreaker glide bombs. Some seven Reaper drones were shot down.

Around 5 May, the US reached an agreement with the Houthis and they briefly stopped attacking ships. They restarted two months later.

At the same time, the Israelis were also fighting the Houthis. The Israeli Air Force conducted an episodic counter-value campaign to unsuccessfully stop the Houthis periodically firing ballistic missiles and drones at Israel some 1,500 kilometres distant. The Houthis attacks were among the longest-range ballistic missile attacks in history. Most, but not all, were defeated by Israel's integrated air and missile defence system.

While the US and Israel fielded leading-edge air power, the Houthis, a non-state actor without an air force, challenged them, kept fighting and survived, albeit not in good shape. The survival of Houthi attack units is attributed to very small unit sizes, dispersion, continual mobility, shoot-and-scoot tactics, camouflage, good electronic emission control and shrewd signature management.

Meanwhile, a few days later, starting on 7 May, a four-day air war erupted between India and Pakistan. This involved subsonic and supersonic cruise missiles, glide bombs, hundreds of various types of drones, ballistic missiles, very long range air-to-air missiles and surface-to-air

Missiles (SAMs).

The air war featured some notable events, including the first ever more than 100 beyond visual range missiles were exchanged in a single engagement, the use of third-party targeting to shoot down hostile aircraft at quite long ranges, and the first large-scale mutual drone war between India and Pakistan, with probing missions, strikes, interceptions and spoofing attacks occurring almost continuously. Crewed aircraft were involved, but remained in their own national airspace. Although it was Russia's war in Ukraine, this proved to be not as safe as anticipated.

Across the six weeks that we were discussing, Russia launched some 4,000 drones and smaller numbers of ballistic and cruise missiles in attacks on Ukrainian cities, mainly at night. Many were defeated by the Ukrainian air defences, although probably 700 drones hit during this period. In the last week of May, Russia, on the other hand, claimed to have intercepted more than 2,300 Ukrainian drones.

The largest attack of the war by that time occurred on 25 May 2025. Russian forces launched nine ballistic missiles, 60 cruise missiles, 298 Shahed and decoy drones. It is notable that the crewed aircraft launching cruise missiles did not penetrate Ukrainian airspace and that large numbers of easily produced drones dominated.

In early June, Ukraine used 117 small drones in a now famous covert attack on air bases deep in Russian territory, destroying or seriously damaging some 20 strategic bombers and other aircraft.

About the same time, two Russian Su-30 fighters were shot down over Russian territory by a Ukrainian uncrewed surface vessel that fired modified air-to-air missiles from off the coast.

At the land force front line, the whole nature of close air support has by now been transformed. In terms of numbers, first-person view, FPV drones, now dominated the war. Well-trained and scarce pilots were flying them by remote control, sitting in nearby positions wearing virtual reality goggles to see through the drone's cameras. They were striking armoured vehicles, intercepting helicopters and hostile drones, dropping anti-personnel mines and landing near roads to wait in ambush for enemy vehicles.

Not surprisingly, both sides were now targeting the FPV drone pilots. To avoid electronic warfare jamming, Russia controlled their drones via fibre optic cables up to 40 kilometres long. The battlefield was now littered with tens of thousands of very thin fibre optic cables.

Air support by crewed aircraft was done now using glide bombs launched at long range to avoid the other side's SAM systems. Battlefield air interdiction now involved rockets, cruise missiles and drones. Ukraine was starting building a so-called drone wall or drone line, able to defend against Russian ground and air forces. The wall was actually a weapons engagement zone, growing to be some 1500 kilometres long, 30 to 50 kilometres thick and several thousand feet high. The wall would feature large numbers of attack drones, drone interceptors, drone mining systems, counter drone systems, airborne sensors, electronic warfare systems and be supported using robotic logistics delivery systems.

We've been talking there, Ukraine is of course the world's largest drone war. The world's second largest drone war may perhaps surprise you, but it's the civil war in Myanmar. During this time period we're talking about, the Tatmadaw military forces were for the first time in four years advancing against the People's Defence Forces as they had learnt how to best employ their new paramotors, yes, paramotors, and new Russian and Chinese military drones.

Crucially, they had acquired Chinese electronic warfare jam equipment to jam the People's Defence Forces drones. The civilian People's Defence Forces used mainly commercially available Chinese hobbyist drones, mostly from DJI, and larger drones used for aerial photography and agricultural purposes. These are modified in makeshift workshops to drop ordnance.

Towards the end of the period that we are talking about, Israel launched large scale air operations against Iran. Iran responded by firing more than a thousand ballistic missiles and drones against Israel. This 12 day air war, like the Houthi conflict, was unusual in that it was fought almost totally in the air. The protagonists did not share a border, making long range air warfare the primary method of waging war. This is a bit of a change from history.

The Air and Space Power Centre will shortly publish three posts I've written on this air war. In the meantime, I'll tell you a couple of events, which I was struck by. Firstly, the Israeli Air Force's 50 years of dedication to the suppression of enemy air defence mission, SEAD, was evident in the use of F-35s as electronic reconnaissance and warning aircraft. Newish long-range air launch ballistic missiles fired from F-15 and F-16 aircraft operating outside SAM range. Covert ground forces using small drones to remotely operate and spike any tank missiles to attack radar and SAM systems deep in Iran, and Heron drones undertaking 15 hours a day surveillance.

The result was that no Israeli Air Force crewed aircraft were lost, while some 80 of the 100 SAM systems in areas being attacked were destroyed, together with 70 associated air defence radars.

Secondly, those SEAD missions gained medium altitude air superiority in the areas of Western Iran where ballistic missiles are being launched from. Israeli Air Force drones, like Hermes 900s, could then with a reasonable certainty of survival conduct long range stand in surveillance searching for missile launchers and missile stockpiles. Once found, these were then attacked by armed drones.

In 12 days, some 400 of about 500 launchers were rendered inoperative. Without this, arguably, Iran may have been able to launch more than 200 ballistic missiles a day, but with Israeli air interdiction, the launch rate average declined to about 50 a day.

Now the US THAAD and the Israeli Arrow anti-missile systems then intercepted about 85 per cent of the missiles fired. Had Iran's missile launchers not been contested, I believe the interceptor supply would probably have run out and left Israeli cities defenceless.

This was an air defence battle without crewed fighters. No more Spitfires and Hurricanes shooting down Dorniers and Heinkels.

The Israeli Air Force demonstrated the emerging heterogeneous air power model where crewed aircraft are elements within a careful blend of crewed aircraft, rockets, missiles and drones. With avoiding the loss of crewed aircraft high priority, they were used only when essential. Notably, some 70 per cent of the offensive air operations' overall flying hours was by drones. That 70 per cent is a telling figure that one might surmise will grow further in future wars.

In considering these busy six weeks in mid-2025, it is evident that heterogeneous air large numbers, certainly hundreds of elements at a time and sometimes thousands. Moreover, heterogeneous air power is relevant to small and large-scale offensive and defensive air operations and can be used asymmetrically by states and non-states.

Heterogeneous air power advantages.

The heterogeneous model is here, it’s not coming - it’s here, and demonstrably effective. But the three key advantages over the traditional homogenous model centred on crewed aircraft is resilience, scalability and mass, particularly when we are talking about long big wars. These are the fundamental reasons for adopting the heterogeneous air power model.

Resilience. Resilience involves both the speed of recovery from attacks and the reduction of the impact of attacks. For air forces, timely recovery from combat losses has become challenging as modern crewed aircraft have low production rates. The highest production rate in the Western world at the moment is the F-35 line making 13 new aircraft a month. A single F-35 takes 18 months to build. Europe's highest production rate is a Dassault Rafale, which is approaching three aircraft a month. Building a single Rafale takes about two years. The Typhoon rate is just over one aircraft

each month, achieving 14 a year. A single Typhoon takes about three years to build. Moreover, modern aircraft are assembled from components made by subcontractors. If the production line is not hot and needs reopening, these times may increase by at least a year.

The impact of a major war's attrition rates set against the crewed aircraft production rates means an air force's combat force would probably steadily decline over time and probably not recover until post-war. Today's air power model built around highly sophisticated, technically complicated aircraft is inherently not resilient.

Russia's invasion of Ukraine in February 2022 is an instructive real-world illustration of such a scenario. Both Russian and Ukrainian air forces suffered unacceptable attrition rates at the start of the war. In response, both then quickly moved to carefully husbanding their remaining crewed aircraft while shifting to a heterogeneous air power model where rockets, missiles and drones played significant roles.

The production rate of these technologically simpler assets is considerably higher than that of crewed aircraft. As an example of relative production rates, as you can see on the screen there, in mid-2025 Russia each month in broad terms is making about two combat aircraft, 15 hypersonic missiles, some 70 ballistic missiles are scanned to rockets, 60 cruise missiles, 7,100 Shahed –like drones and more than 170,000 first-person view drones.

Now, clearly the counter argument is that crewed aircraft are reusable. Rockets, missiles and drones are generally one-use items. Yet in a major war, production rates make up this difference. Crewed aircraft, rockets, missiles and drones will all be consumed in a war. But only crewed aircraft cannot be produced at a rate that keeps pace with usage.

A force structure of rockets, missiles and drones is resilient in being able to recover losses at speed. A force structure solely composed of modern crewed aircraft is not. Furthermore, resilience also includes reducing the impact of attacks. Crewed aircraft and their air bases are difficult to protect, as shown by the adoption of agile concepts that aim to widely disperse aircraft.

By comparison, attacks on rockets, missiles and drone forces are likely to have less impact as there can be much greater numbers of them to engage, they can be mobile and widespread dispersal is certainly easier.

Scalability. This higher production rate of rockets, missiles and drones allows a much quicker expansion in the force employing them. As an extreme example are those FPV drones again, one Ukrainian manufacturer is producing 4,000 a day with the country overall making 5 million annually. Such extraordinary rates are possible using digital technology, fourth industrial revolution techniques and distributed production across some 150 companies.

Moreover, combat aircrew typically take years to train so that even if large numbers of appropriate aircraft suddenly arrived, they might be unusable. Learning to operate and maintain rockets, missiles and drones involves far less time. FPVs again offer an extreme example. Courses run by accredited commercial operators train Ukrainians to use combat FPVs in about 36 days.

Production rates of crewed aircraft, rockets, missiles and drones vary considerably. Consequently, a heterogeneous force structure would have highly different levels of expansion with the balance across the force varying almost daily. Such a force gains scalability although at the cost of constant change in what that force materially comprises.

Amplifying the ongoing change is that such a force can exploit innovation. As we all know, innovations in uncrewed systems are inherently simpler to achieve and generally more affordable than in crewed aircraft. Innovation with uncrewed systems can be frequent and ongoing. In Russia's war in Ukraine there is now a three-month innovation cycle of prototyping, experimenting, testing, mass-producing and then fielding drones. In contrast it takes many years to introduce innovations into crewed aircraft. Obviously flying safety for humans has an impact. The long drawn out F-35 Block 4 upgrade is an example of being at least five years later than originally planned even after being reduced in capability. Five years versus three months is notable.

Uniquely the heterogeneous model can combine scalability and rapid innovation. Yet this combination means the elements comprising such an air force will experience considerable churn numerically, in type and in performance. It is unlikely to be the set and forget form of air force that the homogeneous air force comprised of 30 year life crewed aircraft has become.

Mass. Homogeneous air power gives air forces the potential to employ large numbers of elements or mass. The largest Russian air attack on Ukraine in 2025 was in fact on the night of 6-7 September. Russia launched some 810 attack and decoy drones and 13 ballistic missiles. It's likely that in the near future countries could potentially mirror World War II's allied bombing raids into Germany and routinely launch 1,000 rockets, missiles and drones against their neighbours.

Lesser power is that the heterogeneous attack just noted needed relatively little infrastructure compared to what an all crewed aircraft attack would have needed. Crewed air combat aircraft require air bases of varying sizes. In contrast, the missiles and drones require much smaller launch systems and these can be dispersed widely. Heterogeneous air power imposes much less demand for specialised infrastructure than traditional homogeneous air power.

Significantly generally the mass employed is not necessarily all one kind or one type. Heterogeneous air force can include multiple diverse constituent elements, each optimised for specific tasks, single role rather than multi role. For example, for battlefield tasks there are now low and medium altitude reconnaissance drones, electronic warfare and GPS jamming drones, communication relay drones, bomber drones, FPV ground attack drones, interceptor drones for air defence against helicopters and hostile drones, mine-laying drones and ambush drones that wait for enemy vehicles to approach.

Some concluding thoughts.

The ability to create and employ such large-scale packages of diverse air assets has traditionally been restricted to the United States. Heterogeneous air power has overturned this convention allowing most states to now devise and use large offensive and defensive air packages.

At the generic strategic level, or the strategic level talking generically, the rise of heterogeneous air power makes the balance of power in the international system more fragile. In the recent past the traditional air power model created the balance that changed only slowly as crewed aircraft stayed in service for decades.

In contrast heterogeneous air power includes cruise missiles, SAMs, ballistic missiles and many types of drones, all built using digital technologies that can be rapidly updated, quickly upsetting long standing military power balances.

Such concerns are further deepened as many emerging digital technologies come from the civil sector, are devised for consumer sale, and such technologies may appear suddenly, be affordable and quickly proliferate globally.

At the regional strategic level, the US national security and defence strategy is now both stress building a strong defence posture along the first island chain. This is aimed to deter through denial but is not aimed to win but aimed to prevent others winning. Heterogeneous air power, the geography of the first island chain is very favourable. This is unlike traditional air power that needs large air bases and significant on-going logistics support.

It's not surprising the US Marine Corps littoral operations concepts pick up ideas similar to those the Houthis have been using in their anti-ship operations. Or that the idea of constructing a form of littoral drone wall has spread to Taiwan and Japan both planning to build in 2027-2028. Europe is already building a drone wall of a kind on its borders with Russia.

Now a key issue in designing heterogeneous air force is balancing across the crewed aircraft, rockets, missiles and drone alternatives. Achieving resilience scale but in large numbers depends on choosing a balance appropriate for the war being fought or the war being designed for. Britain's latest strategic defence review offers a useful way to think about this using its 20-40-40 conceptualisation. 20% of combat power might come from crewed aircraft, 40% from expendable autonomous systems such as rockets, ballistics and cruise missiles and the remaining 40% from reusable assets like drones.

This construct highlights that today's traditional air forces moving to be heterogeneous would need to embrace lower cost systems able to be rapidly produced at scale. An emphasis should be placed on designing simplified missiles and drones can be mass-produced quickly and at low cost from readily available locally sourced materials and components. Russia has done this with a shared drone design and now makes them 7,500 monthly.

Simplification however involves accepting a reduced operational performance including having lower reliability drones, rockets and missiles. It also means less stress on individual element survivability and a certain sometimes high loss rate is accepted.

Hidden in this are some shortcomings of heterogeneous air power. In a long big war, heterogeneous air power will require continual innovation to keep up and hopefully stay in front of the adversary just as in Ukraine today. Ukraine finds this hard as Russia can draw on China. China is

both a very innovative nation and the world's largest manufacturer. It can potentially support others to stay in the fight longer than the middle power can alone sustain its heterogeneous forces. Heterogeneous air forces need to worry about innovation and large-scale manufacturing. Neither are easy. That changes the relationship between heterogeneous air force and defence industry quite a lot.

Moreover many of the elements of heterogeneous air force may be single role not multi role. This talk has been about heterogeneous air power at war and the wars focused on have been long big wars. There are other kinds of wars and crucially modern air forces do more than just fight wars. Air forces undertake air diplomacy including reassuring allies through large multinational exercises. They also do air policing and peacekeeping tasks. Moreover, as climate change accelerates air forces increasingly frequently undertake humanitarian assistance and disaster relief operations. These are operations other than war. Those tasks would influence the balance of heterogeneous air force in times of peace.

However most future air wars are now likely to involve well-coordinated large scale heterogeneous air operations designed to combine the capabilities of various crewed aircraft, rockets, missiles and drones so as to most effectively overcome hostile air defences and inflict the required damage. An important concern will be managing the crewed aircraft rate of loss. Even replacing these may be very doubtful.

The air forces that undertake these heterogeneous air operations will be remarkably dynamic in actively balancing across the many diverse capabilities having constantly changing numbers of force elements available and in featuring embedded innovation. Heterogeneous air forces will not be defined by a single piece of equipment, the crewed aircraft.

This may trouble traditionalists.

However, the need to be able to fight a long big war undermines old ideas about air forces and air power. Air forces now urgently need to become resilient, be scalable and possess mass. Heterogeneous air power looks to be the way of the future, your future. You may not like heterogeneous air power but as Margaret Thatcher declared about capitalism there is no alternative – “TINA”.

Now over to you for your questions, comments and disputes with my wild claims.

Q & A

GPCAPT J Laroche: Thank you Peter. As always, we really appreciate your important research and those insights and you've certainly given us a lot to think about. Plenty of questions coming in.

I'll start by asking you around this concept of heterogeneous air forces, mixed crewed, uncrewed autonomous systems and given your workforce experience - in practical terms what do you think this means for how a moderately sized air force like ours or others should think about our workforce and force structure? I know you mentioned homogeneous structure currently and what does a heterogeneous one look like. Can you expand on that a little bit?

Dr P Layton: So workforce and structures?

GPCAPT J Laroche: **Yes.**

Dr P Layton: Okay. So from a workforce point of view of course it sounds like a nightmare because you're suddenly introducing a whole range of different systems of varying scales and what more some of those systems may be changing relatively quickly.

So you do need a skilled workforce that you can build upon and continually learn and to train. So I don't think heterogeneous air force in that respect is a simpler model if you like.

On the same token, of course many rockets, missiles and drones can be built and then placed on the shelf and when a war starts break glass and use. But that also introduces problems because all the operators and other maintainers that you might need might have to be in the reserve and ready to be mobilised when you require them. So it would be a different balance between your permanent air force and your part-time air force if you like.

And as certainly, structures go there's obviously some interesting developments going on with the Ukrainians with their unmanned systems forces and the Russians with their unmanned systems forces as well. So the question is whether this is rockets, missiles and drones is then spread if you like across our conventional idea of thinking about air power or there's some new innovative way of integrating into a force.

Now I also do some stuff on artificial intelligence. I've been quite struck; of course, I get struck by interesting things, by the octopus model. The octopus model involves that octopus uses distributed intelligence. They've got one third of their brain power is the centralised part that provides broad direction. Two thirds of the brain power is distributed amongst the eight legs. Now those eight legs are capable of independent action. They can decide what they'll do by themselves but they'll act in accordance with the general guidance provided by that centralised system.

Another thing about the octopus system of course is that you could lose a leg and the leg can go on doing whatever it's doing for a while and the new leg regrows. That sounds like a crazy idea but now if we think of the Indian, if we think about crewed aircraft, rockets, missiles, drones, in both the cases of Ukraine, Russia, India, Pakistan and the Indian side for instance, the crewed aircraft in the first day took some unexplained losses. So the Indian crewed air force, that part of the air force stepped back and let the rockets, missiles and drones move forward if you like and take up the slack. And then later when that crewed aircraft issue was addressed then the crewed aircraft returned to the fight.

In Ukraine and Russia they lost that leg if you like, that octopus tentacle of crewed aircraft but they grew up as far as rockets, missiles and drones went. So I think in our structures we have to have a think about independent structures being able to operate autonomously and expand.

I also quite like the idea of Mike Darm in the United States about disaggregated combat air operations. I think that sort of kind of model of integrating them all together works quite well.

GPCAPT J Laroche: Terrific, thank you. Well I'll ask for the house lights to go up a little bit so I can see if there's any floor questions. I'll ask you the most popular question through our app; it's a really easy one for you Peter.

"Australia's defensive problem set is compounded by the scale of distance. Are we better off investing in long range ballistic missiles and air defence missiles than the mass of drones per Ukraine?"

Dr P Layton: Okay so clearly Australia has the advantage of the tyranny of distance. It's both good and bad. But you'll recall the second slide that I showed up there in the slide about Asia and North East Asia covered by Shahed drones. So while some of our problems can be wished away by imagining all these things are short range and therefore we will never see them, it seems that Australian air forces often go overseas and fight in collective alliance structures. So the chances are if we move offshore we are going to encounter this particular kind of environment.

Now if we decide that all we want is the defence of Australia, I think you do certainly need a mix there. What that mix is will of course vary as I said. Long-range weapons, we always get, I suppose Australia always gets excited about that some country is a long way away and so we need either a B2 or a B21 range. But Australia need not necessarily think that it's going to fight a great power. There are other regional wars that we've normally been involved in if you like. So I'm less convinced by the arguments we have to have something that's hyper long range. But by the same token of course we've got cruise missiles that have a couple of hundred miles range or something I think. The army is talking of PRISMs and ATACMs; the navy is talking of Tomahawks of 2000 kilometres or so. We are getting some of those long range.

But what I said about that disaggregated combat air model of Mike Darm's, the F-35s in his particular example are used as electronic reconnaissance and warning aircraft as was done during last year's 12 day war and they provided targeting data for long range cruise missiles and ballistic missiles. His argument being that electronic warfare will be very intense in the future and so having somebody providing intelligence on the edge is a much more robust system and a much more robust means of transferring data around.

GPCAPT J Laroche: Thank you. Any questions from the floor please? Okay, none seen there. So I'll go to the multiple we have online thanks. So the next question everyone wants to know Peter.

"How should Australia balance sovereign and international supply chains, alliance dependencies and capability to ensure that air and space power can be sustained through an extended conflict?"

Dr P Layton: Yes, now clearly this particular heterogeneous airpower model tries to limit some of those particular problems because clearly modern air forces that rely on equipment made overseas have very long supply chains. I have to say pretty much that applies to sort of most air forces in the world. It's not an exceptional thing here. So not only do you have to have a long supply chain but you have to have allies at the end of the supply chain who are willing to give you precedence and priority

over their needs. So the more complicated and complex a system you have in service the more difficult it will be to maintain or replace if it is lost during a conflict.

Now the rockets, drones, missiles things brings up a whole different sort of idea about industry here and the Ukrainians if you like have grown their drone missile rockets industry within the last few years driven by the imperatives of war. They also of course are also using imported parts although they now believe that their supply chain at least for drones is now does not call on China.

But I think the interesting thing about rockets, missiles, drones is that whereas we think about modern combat aircraft having a vertical manufacturing structure, a vertical industry structure where the designer and the integrator are sort of up the top, there's a whole pile of subcontractors under it, every single part has to be exactly right, the software has to be exactly right. So you've got a vertically integrated platform there that by its nature is hard to maintain and not that robust.

We start talking about rockets, missiles and drones there are opportunities here to move into if you like a horizontal industry architecture where things more plug together, that sort of plug and play that is often used in those commercial hobbyist drones and stuff like that. So I think that I see is a big advantage of moving to this particular model is that it is maintainable during combat.

Now the issue of whether you can necessarily have all the bits and pieces in Australia and you're able to actually manufacture each of those in Australia is probably a moot point, it's probably unlikely, it's pretty much like Russia relies an awful lot upon China. But you can still produce a fair number in Australia. If you start talking about that kind of idea then we're talking about innovation, bear in mind, two steps, innovation and manufacturing.

Now companies are not going to actually do anything unless you pay them because they're not going to have good ideas waiting on the shelf or build factories for you just sort of on spec. So the government would need to invest, government being the Air Force, would need to invest in innovation in the sense of whether you have government owned, government operated research labs or government owned contractor operated research labs that innovated on a continuous basis so that if there was a conflict you could quickly turn on innovation and you could quickly manufacture.

Now that requires obviously the reason why you tie it with the government of course is so you have the intellectual property because sometimes companies like to keep intellectual property for themselves. So you need to have if you like innovation on demand and you can see that relates to creates a whole little ecosystem in itself but then you want manufacturing on demand as well. To a certain extent that does require some form of dormant industrial capacity that can be activated when required.

That might not sound familiar to you having a dormant industrial capacity but of course Australia started building that in the late 1930s when the war was approaching and the same with the Brits, particularly the Brits built all those shadow factories which were just if you like replicated

factories, one, two, three and they just opened the doors and brought in the trained people when war started. When in doubt sort of break the glass and start.

GPCAPT J Laroche: Thank you. I guess a related question there on that idea of horizontal manufacturer, common components and the ubiquity of those systems:

"Given the proliferation and ease of building drones by civilians for recreational purposes, does this change the defensive paradigm for a belligerent country - I guess you could insert your own adversary there - given it's easier than ever to make an effective munition for guerrilla forces."

Dr P Layton: Yes, it does definitely mean that in the future, we spoke about those six air wars, and the great diversity of actors was immediately apparent. You could have such a great diversity because the world is awash with the technology that can be used for these specific purposes.

So there is a question then of course that arises as well, we don't need to invest in many of these things because when a war starts we'll simply draw on the commercial industry and they can start doing their thing. If it was a war like World War II, as it was for Australia say and it didn't really become serious until the end of 1941, so two years in there, that might not be a bad model. It's one of those things about how lucky do you feel? But if you don't have your industry, as I said, with that innovation and manufacturing ready to go and at least some skilled people in it who can then train other people, if you haven't got it ready to mobilize, expand, develop, it's pretty hard starting from scratch.

So I did some stuff looking at the history of the mobilization efforts of Australia, the UK and the US before World War II bearing in mind that the US joined sort of later. And for all countries it was about the same because the technology of the time, the second industrial era, was the same technology that everybody used. And it took each country about three years to decide what they'd like to build, find the cash for it, find a place, design the building and then two to three years to actually build a factory and get to mass manufacturing.

So if you work on five or six years to actually get to that mass manufacturing stage, that's for the second industrial revolution, Air Force, that kind of stuff. I think that still holds today. The facility up at Newcastle being built for the naval strike missiles, when you look at the development cycle of that, that's taking about the same period of time. These things don't happen overnight unless you prepare for it.

The naval strike missiles are another good example of that, what I said about being ready and having shadow factories. So the ministerial press release tells me that the factory's being designed to be able to manufacture maximum capacity of 100 missiles a year.

So if you think you're going into a long big war where you might fire more than 100 a year, you might need to have two or three factories dormant on standby, that your skilled people from the first factory can then train others to run. That starts to become quite a complicated business there and quite an expensive business.

GPCAPT J Laroche: Indeed. To switch gears a little bit, again, a popular question. I think this is really just to stir exceptional wing wearers like myself up.

"For the last 100 plus years, RAAF has been led by exceptional wing wearers. Given the changing nature of air power and the means of achieving air superiority, what does the future Chief of Air Force look like?"

Dr P Layton: Yeah, it's a great question. And the Royal Air Force appointing an engineer, it was quite startling. They'd rather have an engineer than a navigator, surely not. But there you go.

So it does change things, doesn't it? We, Air Forces, since World War I have relied upon the fact that you should be a good, that your motor skills should be exceptional. And there's a question there between does your cognition matter if your motor skills are exceptional?

So in the, some people got the joke anyway.

So the question then I suppose goes to what kind of an individual would you then put in this? Now I don't know whether, there's a famous book called the Icarus Syndrome, not a very good book, but there is another book quite common at the moment called Rules of the Game talking about the Battle of Jutland. And they make a distinction between two kinds of officers, if you like, running the show.

Those which are, if you like, the peacetime warriors. And they're the people who are, if you like, fascinated by the complexity of the system, in the Rules of the Game case by Battleships, these huge, you know, 10,000 tonne things that travel at up to 22 knots and hurl a Volkswagen 20 miles. These are very impressive technologically advanced systems sort of for their day.

And you must admit, even yourself, that the fascination of aircraft and aviation really gets you. I mean it's really, really interesting.

And so you've got a stream of officers who focus upon that particular fascination. And the Rules of the Game argued that there was a second kind who were quite different in aspects and they thought about using this to actually achieve things. So they were thinking about air power rather than about aircraft. And it's those kind of people who think about air power that we need some of. Of course the trouble about, you can't just worry about air power because like battleships, aircraft are things which can go wrong, technically speaking. You can have a disaster very, very easily. So you need to be fascinated. You need people who are fascinated by aircraft and aviation.

But you also need other people who think not just about the means of air power but about the strategy of air power. And those kind of people over there, that kind of, and education is an interesting question. Would you want technologists? Do you want operators? Do you want logisticians? Rockets, missiles and drones are to a certain degree, is industrial warfare writ large?

So there's a very interesting sort of debate there to be had. Bearing in mind that your sort of Air Force careers, if you like, the first 10 or 15 years are down at the flight level, but then sort of later years expands your horizons as well. So people can actually develop. I've even seen it happen that

people actually grow into a job. So there are some sort of nuances there. But it does bring up that in a concept like this, I think you probably would need to transform the existing Air Forces quite a lot.

Can you imagine what the Ukrainian Armed Forces said when someone said, well, we have an Army Navy Air Force, we're now going to have a fourth branch, if you like, called the Unmanned Systems Force. There must have been enormous resistance to that, just from a cultural point of view. But the demands of war, the demands of winning, created their own emphasis.

GPCAPT J Laroche: Thank you. Great answer. Do we have any questions from the floor up the back where I can't see? Any microphone runners? Put your hands up if you've got any questions. Yep, one over here. Thank you.

W Thompson: Hi, Will Thompson, AUKUS Advanced Capabilities. I noticed that in your previous slides, you mentioned that hypersonic's are almost as expensive and difficult to make as crewed aircraft. Where do you see the role of hypersonic's in an air wall dominated by mass and cheap assets?

Dr P Layton: Now, that, of course, was examples of what the Russians are doing now in 2025. It doesn't mean that hypersonics necessarily downstream when they enter service and become more simplified, one hopes for it, and actually affordable, one even hopes for that, that that equation will not change.

Hypersonics clearly are, if you like, a niche weapon in the sense that they get there really quick. They're very hard to defend against. From what I understand, the Israelis, in their attacks against the Iranian air defence system last year, during that 12-day war, they launched those rampages and missiles like that, which are air-launched ballistic missiles. And they approached the surface-wear missile system at something like speeds of Mach 2 or Mach 3. The S-300 system was not designed to handle something of that speed.

It also wasn't designed to handle hobbyist drones being launched by your covert forces 100 yards away either. So I think hypersonics definitely have a place in being used, if you like, to get through the defences at a very high speed. And, of course, they do impact with a tremendous velocity. And that in itself can be a very destructive force.

The hypersonic missiles we've seen so far, with the exception of ballistic missiles, which obviously at least the intermediate-range ballistic missiles are impacting it, or flying to the air at Mach 10, that's relatively fast as well. But the ones we've seen so far on the battlefield in Ukraine have been relatively slower, if you like, sort of supersonic, sort of more than sort of hypersonic. So I've yet to see what sort of impact that will have.

But that kind of prompt strike at the first day of a war would definitely be something to be concerned about. I suppose thinking about it while I'm talking, for a demonstration, I suppose, was that PRISM or ATACMs launch against the submarine on the wharf in Iran. Clearly a prompt strike on the first day of war against your naval forces docked would be both serious and something you couldn't recover from for a long time.

Because while I whinge about fast-jet aircraft take a long time to build, modern warships and submarines take even longer.

GPCAPT J Laroche: Thanks, Peter. I'll ask two questions that are related here. The first is:

"Are we missing the...sorry, are we mistaking the prevalence of drones in Ukraine for the effectiveness of drones, mass use of drones due to flight losses has not reversed Russia's gains?"

And the second related question is:

"As IAMD, EW countermeasures and directed energy weapons have time to develop operationally, they will undoubtedly - you can dispute that - they will undoubtedly catch up to disruptive drone technology. Is there a risk of drones becoming obsolete?"

Dr P Layton: Yep. Like sort of all things being...sort of cavalry officers and battleship sailors became obsolete as well, I suppose. What I'd sort of like to say...Those things are true.

Firstly, the first one, I suppose, about the drones in the Ukraine, the Ukrainians aren't winning per se. They've sort of held the Russians for a long time. Middle power and even perhaps - I don't want to sound too provocative here - but perhaps a lesser developed middle power, like Ukraine, that had a number of issues when the war started, but nonetheless had built up its armed forces since 2014. They were able to hold and for a while repel a great power, a major power, if you will.

So, you've got a country of 40 million people against a country of 130 million people. The Ukrainians have achieved something that in the history of warfare you would not expect to see. Now, the Ukrainians have received a lot of support from outside, in particular from the industrial field, if you like, but also intelligence support, et cetera. So, it's not just - I mean, the Russians have point to a point that you're not just fighting - the Russians are not just fighting Ukraine, just like Ukraine is not just fighting Russia, it's also fighting the people supplying Russia.

So, I think that the Ukrainian story has been a great success, if you like, in that they've by and large held for three years or more. It's been a phenomenal performance, not just from a technical or tactical point of view, but certainly from that human will point of view that somebody spoke to this morning. I mean, to get out of bed every morning and go and fight the Russian hordes year after year requires a special kind of courage and a special kind of will.

Now the second one there about drones being obsolete, yes, I mean, they will. And look at this being directed energy weapons, in particular laser weapons or electromagnetic pulse weapons have been the next big thing since at least 1955. And there's no doubt that they must get here soon and some would argue that they're pretty much here now.

There are a lot of reasons against what I'm saying there because there are environmental issues and a whole pile of other factors that influence the use on a crowded, congested battlefield that has stuff called rain and fog and haze.

But if you step back for a moment from what I'm talking about here and look at perhaps two things that will make things slightly complicated here. An artillery officer, Jonathan Bailey who was a major general in the British Army in the late 1990s, made an interesting observation that before about 1916 most wars, most battles had involved direct contact with the enemy, direct fire if you like. You saw the bad guys coming at you, you picked up your rifle or your sword or your Saber and you shot them.

After 1916, indirect fire becomes important. Airplanes are the ultimate indirect fire. They provide long range, very great depth. Cyber provides sort of that non-connect fire. But you could argue since 1916 the history of warfare has been that indirect warfare has got longer and longer range and more and more effective. We have precise mass now. This is an idea that even 20 years ago was considered bizarre. But it's bizarre. But a Shahed drone costs $50,000. Not very precise, but you could have 800 of them, it helps.

So you've got indirect fire, that long term trend, now for more than a hundred years. At the same time, rockets, missiles, drones. We're talking if you like crewed systems versus uncrewed systems in that dichotomy. Why uncrewed systems? Because since about 1970 the technology of the time, the digital era, has taken off. It's accelerating. It's not going away. So we've got two things going on here. One is indirect fire becomes more and more important. The second is that there's more and more robots out there, if you like. There's not going to be less robots. They're not going to go away.

So even if we have lasers and electromagnetic pulse weapons, we're still going to be using robots because lasers and electromagnetic pulse weapons are going to be really good against crewed aircraft. They're going to be a lot more effective than our current surface-to-air missiles and stuff like that. So that possibility exists and must surely happen one day, but it will make crewed aircraft even more vulnerable, I think.

Air Commodore Pendlebury asked me to answer a question and would have liked it asked. Was that passed on to you?

GPCAPT J Laroche: Unfortunately not. Would you like me to make one up?

Dr P Layton: No, I have it here.

GPCAPT J Laroche: Please go ahead and then this will be the last question, thank you, Pete.

GPCAPT J Laroche: Right. The Air Commodore said “I hear your Six Wars argument out there, Pete, but what's enduring? Which goes a bit to that particular question about drones. What is important here in those Six Wars that will actually, if you like, affect you for the next, say, 10 years? Sort of something like that.”

So I think just a few points.

One is control of the air, which we did talk about very early this morning, is becoming more and more important. As I said, indirect fire is really all about to defend yourself, you need control of

the air. But the Six Wars show that control of the air is not just hurricanes and Spitfires anymore. It's quite complicated.

Shahed drones travel 110 knots and intermediate range ballistic missile travels at Mach 10. There's a lot between that. So it's really a complicated battle. It's both more and more important and harder and harder to do.

The other thing, of course, is that mass is the new black. Those wars, as I said, were showing hundreds and thousands of things. Now, that becomes a logistician's nightmare. You need to replace hundreds of missiles, it seems, in this strange trade-off we have today as we're having the transition between homogeneous and heterogeneous warfare, if you like, trying to find low-cost ways to defeat low-cost incoming drones.

I was reading something, in fact, by the Swedish Air Force on immobilisation. It was written about a decade or so ago. And they were remarking upon the 1973 Yom Kippur War. And for that war, the Americans took out of NATO a lot of air-to-air missiles and anti-tank missiles they'd been keeping in stock holdings there in anticipation of the big war on the central front.

They took those missiles out, they were used in Israel, they helped win the Israeli war. It took something like seven or eight years before those stock holdings were replaced. So if we translate that to today, perhaps, with those wars going on and the current wars going on everywhere, you're probably talking in the middle of next decade before we get back to where we were five, six years ago.

So mass is important from both an offensive and a defensive point of view, and it's quite a difficult logistician problem.

And lastly, deception. All those there, decoy drones figure prominently. People will try and confuse you, distract you, and make sure you don't understand the battlefield out there. That seems to be a big trend, probably has been since about World War I as well.

GPCAPT J Laroche: Thanks, Peter. Unfortunately, that's all the time we have for questions. I will say there's some fantastic ones coming in and particularly focused, and people would love to hear maybe in a future paper, how this applies to the rest of the Integrated Force as the Chief mentioned this morning in terms of air mobility and delving down into things like anti-submarine warfare. I'm really interested in what a heterogeneous air force looks like in that context.

Can you please join me in thanking Dr Peter Layton for his insightful presentation? Ladies and gents, it's now time for lunch, which is available in the exhibition hall.