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Air Power: The Cost-Benefit Conundrum

A Su-30MKI of the Indian Air Force

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One of the features of modern air power is the enormous costs associated with contemporary combat aircraft. Even the United States of America has been forced to cut back on its acquisitions of the F-22, the world's most expensive fighter. Likewise, fiscal problems are reported to have been the reason why the UPA government did not conclude the deal to purchase 126 Rafale fighters from France. Barring China, fiscal retrenchment seems to be a common obstacle being faced by air forces across the world.

To discuss the issues arising from this challenge, Dr Manoj Joshi, Distinguished Fellow, ORF and Mr. Pushpindar Singh, Chairman, Society for Aerospace Studies organised a conference on "Affordable Air Power" at Observer Research Foundation, New Delhi on October 30, 2013. The participants at the discussion included Air Marshal (Retd.) Brijesh Jayal, Air Marshal M. Matheswaran of the Integrated Defence Staff (IDS), Dr K. Tamilmani, CCR&D DRDO, Air Marshal (Retd.) Nirdosh Tyagi, and Dr Vivek Lall of Reliance Indistries Limited. Also present were a number of senior Indian Air Force (IAF) officers who cannot be named for reasons of confidentiality, as well as representatives of the Indian Navy and IDS. This Special Report is based on presentations and discussions at the workshop.

Introduction

A collated Indian view of "affordable air power" has three dimensions:

a. Capital Intensiveness

b. War Plans, Usage and Integration

c. Indigenisation

An additional factor that must be kept in mind in the Indian context is that, being surrounded by nuclear powers, there is a state of "nuclear deterrence" on the country's eastern and western fronts. This implies that outright war or total war is not a high probability. This factor alone plays a significant role in how "affordable airpower" may be defined in the Indian context, since it creates different patterns of cost-benefit analysis.

Capital Intensiveness and Technology

Air power has a distinct position in terms of technology and cost. Being the most technology sensitive wing of the military, it is uniquely susceptible to the slightest swings in innovation. Consequently, it is also the most revenue intensive of the three forces, owing to the need for near constant upgradation. Compounding this is the fact that defence budgets grow in a linear fashion while the unit cost of a new military aircraft grows exponentially. According to one calculation, the unit cost of a new military aircraft grows by a factor of 4 every decade.

Of course, it needs to be emphasised that affordability is a relative criterion. What is not affordable in peace time becomes so in times of war. Moreover, war adds impetus to innovation. It can be argued that, given a focussed effort during war time or as a result of lessons learnt during wars, significant reductions can be made in military costs.

The case studies and dilemmas presented here are particularly germane to the Indian discourse on the subject.

Radars

A simple example is the near 100-fold reduction in the cost of gallium arsenide (GaAs) chips so critical to active electronically scanned array (AESA) radars. While defence needs have driven down costs, the actual cost of an AESA radar is significantly higher than previous mechanically steered arrays (MSAs), as well as the first generation of passive electronically steered arrays (PESAs).

However, AESA radars have made quantum leaps, both in terms of the number of functions performed and reliability. Earlier, MSAs and PESAs faced massive reliability issues as they were routed through a single transmit-receive (TR) tube. This meant the failure of this one tube alone could result in catastrophic failure of the entire system and, thereby, failure of the weapons platform. GaAs has now made each module a TR device (an AESA radar has upwards of 1000 such TR modules per array). Consequently, even with a failure of 10 to 15 percent of the chips in an AESA, the effects are limited to a mere degradation in system performance as opposed to complete collapse.

Similarly, while previous radars were optimised for specific roles such as air-to-air or air-to-ground, an AESA performs several functions concurrently. Moreover, it can also cover greater ranges than traditional radars and be used in a variety of modes that bring new capabilities to aircraft such as electronic support, electronic counter-measures and communications.

Engines

Single-engine aircraft have recently become the mainstay of several air forces. The cost savings of a single engine over a two-engine system are clear, not just in terms of purchase but also in terms of the logistics chain. The main barrier in the past had been the higher failure rate of single engines and the consequently higher attrition rate. Today, however, significantly more expensive engines incorporating Full Authority Digital Engine Control (FADEC) have brought about marked improvements in reliability. Thus, while in the past, more engines meant more safety, today the inverse is true: two engines translate into twice the probability of engine failure.

This trend towards fewer engines being more reliable has also been reflected in the civil aviation sector, where twin-engine airframes have rendered the four-engine airframes obsolete and uncompetitive in the wide body segment. Similarly, in the general aviation sector, single-engine aircraft have slowly augmented reliability to the point where they have a higher safety record than twin engines.

On average, a Western fighter engine, though considerably more expensive than a Russian engine, has significantly better mean time between failure (MTBF) and mean time to repair (MTTR) by factors of anywhere between 3 to 7. This means a much higher availability rate—Indian estimates pin the Mirage 2000 availability at 85 percent compared to 50 percent or less for the Su-30s. This trend is largely the result of improvements in processes and quality control. Furthermore, during servicing, modern fighters such as the Gripen and the Rafale, which seem more expensive than planes such as the Su-30 on either outright or "bang for buck" basis, do not need to be recalibrated when fitted with new engines. This equals a low repair turnaround time (RTT). While a Sukhoi's RTT for engine replacement can be anywhere between 2-3 weeks, it is a matter of hours or a day at best for a Gripen or Rafale. Notable fact is that the Gripens are cheaper than the Sukhoi and yet have significantly higher rates of availability owing to higher MTBF and lower RTT.

Maintenance

Others aspects of capital intensive purchases are lifecycle, maintenance and reliability. For example, while modern aircraft cost significantly more than their predecessors, some actually offer significant savings in their life cycles. These savings can be myriad, covering engines, turnaround times, calibration times and schedules.

Similarly, the placement of diagnostic electronics within an aircraft, while enormously expensive, can gauge wear and tear at the press of a button, avoiding the need for time-consuming strip-downs and detailed inspections. NATO-style plug and play racks mean the plane recognises a weapon system the moment it is secured to the platform, reducing turnaround times to as little as 30 minutes. By contrast, cheaper analogue systems such as those found on the Sukhoi need the launch parameters to be separately programmed into the plane, meaning a turnaround time of anywhere upwards of 1.5 hours to the next sortie.

Cutting-edge Technology

Cost-savings either hit the laws of diminishing returns or turn patently absurd when dealing with cutting edge technologies, particularly in the stealth realm. The once-revolutionary F-22, for example, touted as the most advanced fighter in existence, needs 45 hours of maintenance for every hour it spends in the air--and this by a chain of around 3,000 technicians. This means it cannot be rapidly deployed to forward areas and is constricted to pre-designated bases with the necessary infrastructure.

On the other hand, non-stealth aircraft with essentially "safe" evolutionary designs such as the Gripen, can be deployed anywhere including on highways, and a whole squadron requires only 28 people to maintain. In terms of price, the F-22 costs around US$ 412 million per unit while one Gripen is worth around US$ 80 million.

Although it was believed for a long time that "reduced learning curves" in the construction of stealth aircraft would bring about lower purchase prices and greater savings in operational and life-cycle costs, this has not proven to be the case. The Government Accountability Office (GAO) of the United States concluded in 1985 that "[t]he absence of any such progressive "learning curve" in unit cost has been thoroughly demonstrated by the analysis of Chuck Spinney, using actual procurement data".

This not only means that the per unit purchase price is unlikely to come down, but also that the F-35 programme is now estimated to be 30-40 percent more expensive, both in terms of operations and maintenance, than the three kinds of aircraft it replaces.

War Plans and Versatility

Another measure of affordability is how far expenses incurred on an aircraft can be amortised over various roles. This aspect has two primary determinants: a)How the air force intends to fight wars, including how integrated its battle plans are with the other Services and how it intends to deploy its assets; and b) Platform versatility.

Both these measures are linked to how a country intends to counter adversaries and how the intention correlates to the budget outlay. Invariably, there is a mismatch between plans and budgets, and plans and reality. These mismatches, more often than not, require plans to be altered and made more modest (more likely), or for budgets to expand (less likely). The current trend, however, seems to be a middle path of increased budgets matching more modest plans.

For instance, plans pertaining to dealing with Chinese aggression may begin with acquiring defence suppression systems such as anti-radiation missiles like the AGM-88 HARM or Kh-31A Krypton and subsequently expand to air dominance over the entire Tibetan plateau, followed by deeper offensive operations into the core Chinese landmass. However, financial realities may end up diluting air dominance to mere air superiority and diluting deep strike capabilities. Escalation in programme costs would impose further financial constraints and may force a shrinking of the air superiority zone, or further dilute air superiority to merely air defence.

This plan-reality mismatch can be countered by the versatility of systems and the budget accounting systems used to justify them. Such versatility could mean either multitasking: consolidating several roles onto one platform, or amortising: expanding operational limits and parameters across sectors and services.

A current example of role consolidation is the Saab Gripen, which is roughly three times more expensive than its predecessor, the Viggen. The Gripen combines 10 different Viggen variants onto one platform. These include air combat, ground attack, reconnaissance, electronic warfare and maritime strike which formerly required specialised platforms but are now merely functions of weaponry and software coding. This consolidation of roles onto one platform has been accompanied by a massive reduction in weight, significant increases in reliability and range, and a much broader set of deployment options. It may be pertinent to note that the Rafale is between 25 to 60 percent more expensive than the Gripen, but brings with it expanded range, higher payloads and more hardpoints. The priority in terms of affordability is how added capability spreads per additional dollar – effectively "bang for buck".

An example of expansion of operational parameters is the C-17. India is acquiring 10 C-17s at a per unit cost of US$ 410 million. This may seem excessive since it carries merely 60 percent greater load than the plane it replaces (the IL-76) at nearly 10 times the cost of procurement. If this aircraft is counted purely for use by the Air Force to deliver paratroopers and supplies, it is clearly not a smart buy.

However, this should be considered an aircraft that serves not just the requirements of the IAF but also those of the Army and the National Disaster Management Agency. A completely different cost dynamics comes into play instantly, making the C-17s more cost-effective.

The IL-76, owing to its cabin width of 3.75 metres, could not load up the Army's T-90 (3.78m wide) and Arjun (3.8 meters) tanks without considerable disassembly of those tanks. These tanks and the T-72 form the mainstay of the Indian armoured divisions and all three weigh 43 tons or more, close to the 47 load limit of the IL-76. As a result, the IL-76 faced severe restrictions in its short takeoff and landing capabilities, its ability to deliver its load into unprepared airstrips, and a significant reduction in its range.

While the IL-76s could deploy two-third of India's tank fleet with severe limitations and not deploy the remaining third, the C-17s allow the entirety of India's tank force to become air deployable to far greater ranges. This has opened up significant new deployment possibilities at previously unimaginable airstrips. This also means that the costs of the C-17 have to be measured against the opportunity costs of those remote airstrips that do not need development as a result of the C-17 rough landing and autonomous navigation capabilities.

This improved handling, autonomous navigation and ability to land massive payloads on very short strips without ground control also make the C-17 an indispensable platform for disaster relief. This was specifically acknowledged by former Defence Minister A.K. Antony at the aircraft's induction when he said, "Today's induction of C-17 will further boost IAF's capability for humanitarian assistance and Disaster Relief".

Nonetheless, incorporating versatility into a platform is not an exact science and there is scope for such versatility to backfire. A classic example of such miscalculation is the F-35, which was meant to replace four platforms for three different services: the US Air Force (USAF) F-16 in the traditional roles of air combat, defence suppression and ground strike; the USAF A-10 role of close air support (CAS); the Marine Corps' AV-8 in the vertical/short takeoff and landing (VSTOL) – CAS role; and the older variants of the F/A-18 for the Navy while maintaining air dominance and augmenting the land-strike capabilities of newer F-18 variants such as the E, F and G.

However, the complication of combining so many roles into one has meant the current per unit cost of an F-35 hovers around US$ 210 million per unit, 10 and 16 times the purchase cost of early model F-16s and A-10s, respectively. Moreover, stealth is not a factor in the CAS role but armour is. Yet, the F-35 is nowhere near as well armoured as the A-10. Stealth also imposes significant limitations on payload. Given that its combat survivability is linked directly to its stealth, it cannot even carry half the number or weight of weapons in stealth configuration as the F-16, A-10, AV-8 or F/A-18 can.

No one would argue that the F-35 can perform the task of close air support as well as the A-10. No one can argue with the cost differential either. In 1994, an A-10 cost about US$ 13 million. Today, an F-35 is expected to cost around US$ 210 million. Yet, the USAF cut five squadrons of A-10s in 2012, intending to replace them with F-35s.This is because the A-10 was a valuable asset with the US fighting two essentially low-intensity conflicts in the past decade.

Now, with the "pivot" or "rebalance" of US global strategy away from Europe and towards Asia, the US has reverted to preparing for a wide area of conflict against larger and more capable air forces. In such a scenario, the A-10 is a casualty because the US Air Force seeks to perform more roles with less aircraft emphasising other roles such as simultaneous defence suppression and air superiority over close air support.

Further, while it is true that the F-35 in full stealth mode cannot carry the number of weapons the F-16, A-10, Av-8 or F-18 can, its stealth largely obviates the need for defence suppression or air superiority, allowing it to focus on more decisive and critical land attacks. This is because aircraft sent out to engage them, or surface-to-air missiles intended to shoot down non-stealth aircraft, have limited detection capabilities against the F-35.

This raises the following question: if an aircraft that spends 30 percent of its mission time performing a role which could be fulfilled by another variant at a fraction of the cost, is the expenditure justified? Does one define affordability by the platform itself, whose costs are guaranteed to keep increasing over time, or by the cost curves of the weapons and the sensors, some of which are platform agnostic? Is it more affordable to have aircraft that are role specific versus emphasising commonality? One could make the argument that a quest for commonality or multirole capability in effect increases costs. The F-35 is a case in point although its problems are also related to the cost of concurrency (that is the need in the initial contract for all three variant having to be developed side by side despite different technical challenges as well as the need to produce active duty models alongside the testing process of the prototypes). The Gripen, on the other hand, would be the counter example that disproves the case.

What, then, is the science of relating affordability to long-term planning when budgets and politics are fluid? The US can make a pendulum swing in affordability within a decade but countries with smaller budgets cannot. What is affordable for the US, therefore, may not be for other countries even in the long run. Consequently, affordability is a function of the resources available, be they capital or intellectual, and how they are commanded and deployed.

How does this concept reconcile with what was seen as the Medium Multirole Combat Aircraft (MMRCA) contest?

The competition essentially started out as a hedge against the failure of the Light Combat Aircraft but rapidly morphed into a competition to replace the IAF's medium fighters, the Jaguar and MiG 27. The initial Request for Information went out in 2004 to a series of single engine fighters—the Gripen, F-16 and Mirage 2000-5 in addition to the MiG 29 OVT. The Parliamentary Standing Committee on Defence of the 13th Lok Sabha had given a nod to this purchase purely based on a cost-benefit analysis of a MiG-21 upgrade.

However, when the Defence Secretary testified to the Standing Committee on Defence of the 14th Lok Sabha in 2005, this project had morphed into a medium aircraft replacement aimed at the Jaguars and MiG-27s. In the same testimony (in the 2nd report of the committee), the Defence Secretary stated that "any air force has a mix of High, Medium and Low." Clearly, this was at variance with conventional wisdom since the accepted standard even in the USAF and USN is a high-low combination. Moreover, even at this point there seemed to be confusion as to what constituted medium and what constituted light. The Secretary classified the F-16 as a medium fighter and the F-18 in the heavy category along with the Sukhoi.

Clearly, the aircrafts were being evaluated on weight and not their capabilities, effects or costs. Judging an aircraft in such a fashion essentially divorces the costs from capabilities and runs contrary to the concept of affordable airpower.

Indigenisation

While for many countries the correlation between indigenisation and affordability may seem strange, it is a key element for India. This is due to several reasons, including a unique threat environment, maximisation of return for investment, and the functioning of market forces.

Europe does not have a 5th generation fighter as they are not dealing with a 5th generation adversary. In fact, it could be argued that Europe today is without an adversary, which is why they have not felt the need to react to Russia's development of the PAK-FA. However, being the second hub of high technology after the US and considerably ahead of Russia, Europe's lack of interest in a fifth generation fighter has restricted India's choices to a Russia-US duopoly, with little room for manoeuvre.

This is where India's threat environment becomes relevant. China is developing two 5th generation aircraft with seemingly superior stealth characteristics to the Russian equivalent (the Sukhoi PAK-FA) and seemingly superior range and weapons carriage to the US equivalent (the F-35). This means that neither the US nor Russian equivalents suit India's strategic requirements or counter the threat environment, and place costs on India for either expensive modifications of already expensive designs or an even more expensive new development.

Given the rule of arithmetic growth in the defence budgets and geometric growth in the cost of aircraft, such added costs as imposed by a bespoke imported system skew the mismatch between plans and reality even further.

Nonetheless, this does not imply the requirement of full indigenisation because India simply does not have the internal market to sustain a completely custom-made aircraft. The ratio of total exports to national defence expenditure in the US is about 7 to 8 percent. For the US, such defence exports are at best marginal, as internal demand alone is enough to sustain defence production and innovation. In Britain and France it is between 20 and 25 percent, and in Israel 45 percent, reflecting the progressively smaller internal markets and consequently greater dependence on exports. Given that India's defence budget at approximately US$ 37 billion stands between Israel's US$ 16 billion budget and US$ 60 billion budget each of France and the UK, India should be exporting somewhere between 20 and 45 percent of its defence expenditure for a sustainable innovative defence industry.

Is export targeting a valid and viable long-term planning solution? There are three markets to aim for here – subsystems and add-ons, which is what the Israelis focus on; complete systems as exported by France, the US and Russia; and systems integration, which is probably the most evolved and technically complex market. India has chosen to place itself in the highly competitive systems market where bespoke developments that require massive capital outlays end up becoming too specialised for broader sales. On the other hand, sub-systems and the integration markets provide significant benefits and allow a different route modification that is of lower profile but significantly more profitable. This is a route India might want to consider more closely instead of focusing on big-ticket items.

Another option might be to look at the economies of scale to be created from combining India's modest military aviation market with its massive civil aviation market. This has particular relevance to India's quest for an indigenous engine and the acquisition of crystal blade technology.

While in theory this is workable, in practice this requires the rationalisation of defence purchases to create sufficient bulk demand. Owing to a lack of rationalisation, the current situation is that India does not order 1,000 or 2,000 parts at once but rather 10 or 15. This has a direct bearing on affordability.

For example, India today operates nine different kinds of transport/support aircraft, all imported and all using different engines: the IL-76M with the D-30KP engine, the IL-78 and A-50 with the PS-90 engines, the HS 748 with the Rolls-Royce Dart RDa.7, the An-32 with the ZMKB Progress AI-20DM, the C-130H with the Allison T56-A-15, the C-17 with the Pratt & Whitney F117-PW-100 turbofans, the EMB-145 with the Rolls-Royce AE 3007-A1, the P-8 Poseidon with the CFM56-7B and the Dornier Do-228 with the Garrett TPE-331-5-252D. Adding to this will be the new A-330-based tanker with a choice of three engines – Rolls-Royce Trent 772B, General Electric CF6-80E1A4 or Pratt & Whitney PW 4168A turbofans.

Some of this simply complicates the decision-making process in IAF when it comes to deciding replacements on a case by case, one on one basis, and a refusal to compromise on individual features and requirements. Clearly, there is much duplication in the armed forces resulting in a need for fleet rationalisation. Such a rationalisation would have to extend to a single fleet of aircraft with specialised transportation requirements being augmented by smaller niche purchases. If anything, combining the requirements with India's civil aviation space also throws up opportunities for cost sharing and a bigger market to exploit, which means India gains significant manoeuvre room in negotiations with the suppliers.

Rationalisation of procurements, however, is complicated when one chooses to import, more so when one lacks systems integration skills or chooses to ignore subsystems. A simple example of this is how two different fighters – the Jaguar and the MiG-27 – were chosen for essentially the same role. (But each uses different weapons systems and follows a completely different logistics chain.) Similarly, India's Sukhois use completely different weaponry from those deployed on the Mirage

2000. This has meant that India has to field four different kinds of air-to-air missiles performing the same role – the R-77, the R-27, the Matra 530 and the Rafael Derby. Thus, one does not have to indigenise the whole system; even competence in "small-ticket" items such as missiles can produce disproportionate results in terms of affordability.

One situation peculiar to the IAF that complicates affordability is the completely different operational philosophies guiding NATO and Russia, along with completely different maintenance and lifecycle routines. While Russia's dependence on quantity means their philosophy accepts a 50 percent or less availability rate, NATO's quality focus insists on 85 percent plus availability. This is the reason India has to either indigenise its systems manufacture, or specialise in subsystems or in systems integration.

While rationalisation creates massive economies of scale and engenders substantial spinoffs, a defence product (platform, subsystem or integration) is a manifestation of a complex ecosystem that should be able to absorb such spinoffs. The industrial ecosystem in India is a concern because market forces are not allowed to determine the right mix of imported and indigenous products, while having defence bureaucrats and government scientists sit on procurement boards skews the discussions and creates serious conflict of interest. The model to make air power affordable must be one which combines military aviation with civil aviation with the only profitable synthesis being one where 25 to 30 percent is sourced from the military aviation side and 70 percent comes from civil aviation.

Several other problems also need to be overcome to fix this ecosystem. India's supposedly advantageous labour arbitrage, for example, is a myth. The bill of materials is typically the same whether the goods are produced in Bengaluru or in Fort Worth, Texas. While labour may be cheaper in Bengaluru, India's poor logistics and infrastructure mean that savings in labour costs are frittered away in sourcing and transportation. Sadly, defence industries are seen as employment factories, restricting economically viable placement.

In the US, the ecosystem of the defence industry is a pyramid structure whereas in India, it resembles a slab structure: a small thin layer at the top and a larger layer of smaller companies who struggle to get into the tier-II.

In order to replace such a system, a few options are available. One method would be to aim for export targeting, if that is indeed something that can be striven towards, which would enable small companies to drive up their cash flows and move up in scale. Another option is to adopt the mentor model, where big primary assemblers mentor small-and medium-scale companies and create niche systems, subsystems and integration competencies. Yet another alternative, though not likely to be politically feasible, is for the Indian government to consider exiting manufacturing and focusing instead on regulation and control.

Conclusion

India clearly has significant cluster capabilities in aerospace. However, these operate in silos. Each of these silos works in its own niche and cannot be synergised into a whole until a comprehensive national aerospace policy is enacted.

At the same time, there is a crying need to clearly articulate an Indian cost-benefit analysis of capabilities. In an age of endemic cost escalation and shrinking defence budgets, there is a clear and comprehensive understanding within India's strategic community of affordable air power. The question remains one of translating this into actual policy and avoiding a repeat of the mistakes of the MMRCA competition, which saw costs being divorced from capability.

Finally, the sum total of capabilities has to be added up at the macro level. The current trend of spending too much on specific systems without knowing how these systems affect the whole will only result in the country having a limited ability to exploit its investments in military aerospace.

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