TROUBLES, THEY COME IN BATTALIONS

The Manifold Travails of the Indian Air Force

ASHLEY J. TELLIS

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ACRONYMS

AESA	Active electronically scanned array
AMCA	Advanced Medium Combat Aircraft
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AWACS	Airborne warning and control system
DASH	Display and sight helmet
DRFM	Digital radio frequency memory
FGFA	Fifth-generation fighter aircraft
IAF	Indian Air Force
LCA	Light Combat Aircraft
MICA	Missile d'interception, de combat, et d'autodéfense (*French interception, combat, and self-defense missile*)
MMRCA	Medium Multirole Combat Aircraft
MRCA	Multirole Combat Aircraft
PAF	Pakistan Air Force
PLA	People's Liberation Army
PLAAF	People's Liberation Army Air Force
RACR	Raytheon Advanced Combat Radar
SABR	Scalable Agile Beam Radar
UAV	Unmanned aerial vehicle

LIST OF FIGHTER AIRCRAFT, MANUFACTURERS, AND COUNTRIES OF ORIGIN

J-7	Chengdu Aircraft Industry Group, China
J-10	Chengdu Aircraft Industry Group, China
J-11	Shenyang Aircraft Corporation, China
JF-17	Chengdu Aircraft Industry Group/Pakistan Aeronautical Complex, China/Pakistan
J-20	Chengdu Aircraft Industry Group, China
J-31	Shenyang Aircraft Corporation, China
Q-5	China Nanchang Aircraft Manufacturing Corporation/ Hongdu Aviation Industry Group, China
Mirage	Dassault Aviation, France
Rafale	Dassault Aviation, France
Jaguar	SEPECAT, France
Typhoon	Eurofighter Jagdflugzeug GmbH, France/Germany/ Italy/United Kingdom
AMCA	Hindustan Aeronautics Limited, India
Tejas	Hindustan Aeronautics Limited, India
MiG-19	Mikoyan/Russian Aircraft Corporation, Russia
MiG-21	Mikoyan/Russian Aircraft Corporation, Russia
MiG-27	Mikoyan/Russian Aircraft Corporation, Russia
MiG-29	Mikoyan/Russian Aircraft Corporation, Russia
Su-27	Sukhoi Company, Russia
Su-30	Sukhoi Company, Russia
Su-35	Sukhoi Company, Russia
PAK-FA	Sukhoi Company/Hindustan Aeronautics Limited, Russia/India
Gripen	Saab Group, Sweden
F-15	McDonnell Douglas/Boeing, United States
F-16	General Dynamics/Lockheed Martin, United States
F-22	Lockheed Martin/Boeing, United States
F/A-18	McDonnell Douglas/Boeing, United States
F-35	Lockheed Martin, United States
A-10	Fairchild Republic, United States

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SUMMARY

THE INDIAN AIR FORCE (IAF) IS IN CRISIS. Despite being a world-class combat arm, the IAF's falling end strength and problematic force structure, combined with its troubled acquisition and development programs, threaten India's air superiority over its rapidly modernizing rivals, China and Pakistan. Indian air dominance is vital for deterrence stability in southern Asia and for preserving the strategic balance in the wider Indo-Pacific region. Resolving India's airpower crisis, therefore, should be a priority for New Delhi.

TROUBLES FACING THE INDIAN AIR FORCE

- The IAF's fighter force, as of early 2016, is weaker than the numbers suggest. At nominally 36.5 squadrons, it is well short of its sanctioned strength, and many of its frontline aircraft are obsolete.

- China and Pakistan field about 750 advanced air defense/multirole fighters against the IAF's 450-odd equivalents. The airfield infrastructure limitations in Tibet, however, prevent China from bringing all of its air capabilities to bear against India. Yet after 2025, China could be able to deploy anywhere between 300 and 400 sophisticated air craft against India, in addition to the 100 to 200 advanced fighters likely to exist in Pakistan by then.

- The IAF's desire for 42–45 squadrons by 2027—some 750–800 aircraft—is compelling, if India is to preserve the airpower superiority it has enjoyed in southern Asia since 1971.

- The IAF's likelihood of reaching its 2027 goal with a high proportion of advanced fighters is poor. It is stymied by serious constraints on India's defense budget, the impediments imposed by the acquisition process, the meager achievements of the country's domestic development organizations, the weaknesses of the higher defense management system, and India's inability to reconcile the need for self-sufficiency in defense production with the necessity of maintaining technological superiority over rivals.

- The IAF is attempting to reach its desired end strength by acquiring the Tejas Mark 1 to beef up its lightweight segment, filling out the remainder of its Medium Multirole Combat Aircraft (MMRCA) purchase in its medium-weight segment, and continuing with the Su-30MKI acquisition and the PAK-FA co-development programs to sustain its heavyweight segment.

- All three tiers of the IAF are currently in trouble. The Tejas Mark 1 is handicapped by significant technological deficiencies; the prospects for expanding the MMRCA component to compensate for the Tejas's shortcomings are unclear; and the IAF's reluctance to proceed fully with the PAK-FA program could undermine its fifth-generation fighter ambitions.

RECOMMENDATIONS FOR INDIA

- India needs to safeguard its regional air superiority over both Pakistan and China by mustering the requisite end strength and enhancing its extant operational advantages.

- The IAF should revisit some aspects of its current approach. It should be cautious about expanding the Tejas acquisition beyond six squadrons and consider enlarging the MMRCA component with the cheapest fourth-generation-plus Western fighter available. India should also reassess the decision to develop the Advanced Medium Combat Aircraft indigenously and avoid weakening the collaboration with Russia on the PAK-FA program.

- India should expand its investments in advanced munitions, combat support aircraft, electronic warfare, physical infrastructure, and pilot proficiency—all current strengths—while being realistic about its domestic capacity to produce sophisticated combat air craft. Indian policymakers must especially guard against the temptation to prioritize indigenous design and manufacture over the imperative of providing the IAF's able pilots with the best fighters available.

When sorrows come, they come not single spies
But in battalions.

-*Hamlet* Act IV, Scene 5, William Shakespeare

INTRODUCTION

THE INDIAN AIR FORCE (IAF) IS IN CRISIS—and it has been some time coming. It is a crisis caused not by poor airmanship, organizational dysfunction, or stunted ambition. On all these counts, the IAF remains exemplary among air forces in the developing world. In fact, given the range of its capabilities and the proficiency of its operators, the IAF increasingly stands in favorable comparison with its peers in developed countries. As a preeminent American scholar of airpower, Benjamin Lambeth, has noted, the IAF has acquired independent strategic missions, most notably including those of nuclear deterrence and retaliation, and it is a diversified fighting force with manifest ambitions toward global reach and status. It also is a full-spectrum combat air arm with a precision conventional strike capability, fielding not only fourth-generation multirole fighters but also force-extending tankers, a recently acquired airborne warning and control system capability, intertheater airlifters, unmanned aerial vehicles equipped with multispectral sensors for long-dwell strategic and tactical reconnaissance, and the beginnings of a military space surveillance capability.[1]

For all these strengths, however, the IAF finds itself in discomfiting circumstances in 2016: it is handicapped by diminishing numerical strength and a troubled force structure—and, even worse, a seeming inability to resolve these dilemmas satisfactorily. These problems are made more dangerous by the fact that India's principal adversaries, China and Pakistan, are making concerted efforts to resolve their own airpower problems in ways that will make them dangerous challengers of the sort unimaginable barely a decade ago.[2] The IAF, accordingly, must surmount both its quantitative deficits and a potential qualitative gap, especially

in relation to China, if it is to preserve the air superiority that it has enjoyed in its theater of operations for several decades. Protecting this advantage will require the service to make difficult decisions about its fighter acquisition programs in the years ahead and also to pay close attention to increasing its stockpile of advanced munitions, enlarging the number of its combat support aircraft, modernizing its physical infrastructure, and developing the necessary concepts of operations that will enable it to overcome what may be superior numbers of adversary aircraft over the long term.

The IAF is handicapped by diminishing numerical strength and a troubled force structure.

The aim of the analysis that follows is to sound the tocsin: to alert Indian policymakers to the risks of losing airpower superiority because of the continuing problems in the IAF's air defense/multirole fighter force and the importance of remedying these deficiencies for the sake of preserving wider deterrence stability on the Indian subcontinent. Consequently, the air balance in southern Asia is not examined systematically. Nor is there a comprehensive examination of the IAF in its totality, which would require a systematic assessment of its individual aircraft and its overall force capabilities, its operations and its doctrines, and its specific strengths and weaknesses in different warfighting regimes. The focus instead is principally on the IAF's force structure problems, highlighting the dilemmas that must be resolved if the service is to effectively discharge its primary obligation of ensuring the air defense of India.

Toward that end, the first section surveys the growing challenges posed to the IAF by the airpower modernization programs in China and Pakistan. The second section discusses the IAF's shortfall in its force strength and the overly diversified makeup of its inventory. The next three sections successively analyze the specific force structure problems confronting the IAF in the lightweight, medium-weight, and heavyweight segments of its air defense/multirole force. And the substantial conclusion highlights the broader problem facing India at this juncture, namely, the difficulty of reconciling the national desire for indigenously produced combat aircraft with the strategic necessity of preserving the IAF's operational dominance—a nettlesome conundrum given the importance of airpower for successful conventional deterrence in southern Asia.

Although the analysis offered here is aimed primarily at Indian security managers and strategic analysts, it should also be of interest to American policymakers involved in overseeing bilateral defense cooperation. Because enhancing IAF capabilities remains part of the larger U.S. objective of supporting the rise of Indian power—in order to, among other things, preserve the desired geopolitical equilibrium in Asia—the future and the fortunes of the Indian air arm remain a subject of continuing importance in the wider Indo-Pacific region.

A DARKENING THREAT ENVIRONMENT

CHINA'S IMPROVED AIR CAPABILITIES

The transformation of the Chinese People's Liberation Army Air Force (PLAAF) represents the most formidable threat to the security of India's airspace, its population centers, and its military forces. From the large force of some 5,000 aircraft that the PLAAF possessed two decades ago—about 3,000 of which were antiquated MiG-19 variants in different guises—the PLAAF is a smaller but far more capable force in 2016. It consists of some 1,500-plus fighter aircraft, and its high-performance core includes more than 600 advanced J-10 and Su-27/30 variants, which is somewhat less than the total combat strength of the Indian Air Force (IAF) today.[3] This shift in the numerical balance—where the high-end component of the PLAAF, which traditionally was smaller than its Indian counterpart, is now well on its way to exceeding the IAF's entire combat strength—does not bode well for India's maintaining the airpower superiority needed to successfully deter China in the conventional realm.[4]

Beyond the improved fighter balance in its favor, China possesses a large inventory of bombers, combat support aircraft, and numerous unmanned aerial vehicles (UAVs) for both lethal and nonlethal operations. The Chinese bomber force has virtually no penetrating capability against Indian air defenses, but its air-launched cruise missiles for standoff attacks represent an entirely different proposition. India, in contrast, shied away from acquiring a bomber contingent after retiring its old Canberras because it began to emphasize the tactical dimension of airpower largely for theater counterair operations and for backstopping

its ground forces. Accordingly, it settled for multirole fighter aircraft because of their cost effectiveness in these missions.

Like China, the IAF possesses various combat support platforms, but its airborne warning and control systems (AWACS) and its aerial refueling aircraft in particular are still too few in number to support effective air operations on a sustained basis around the Indian subcontinent. The IAF operates a small number of medium UAVs for tactical reconnaissance and maintains some armed drones, such as the Harpy, for the suppression of enemy air defenses. The service's UAV force, however, does not match the Chinese inventory in numbers or in its diversity of capabilities. India's needs are admittedly different from China's in this regard, but the IAF, recognizing its shortfalls, is working purposefully to acquire more capable UAVs, including in armed variants, by reaching out to international suppliers, especially the United States.

China's aeronautical research efforts have yielded dramatic gains with new aircraft, sensors, weapons, and signature reduction advances.

The broader, and widening, gap between Indian and Chinese airpower is perhaps most tellingly illustrated by the comparative achievements in military aeronautical research and development: while India's endeavors here have demonstrated at best faltering progress during the last three decades, the comparable Chinese effort has yielded dramatic gains with new aircraft, sensors, weapons, and signature reduction advances. These achievements have enabled Beijing to produce prototypes of two new fifth-generation fighters (the J-20 and the J-31), an impressive fourth-generation multirole aircraft (the J-10) as well as a light combat fighter (the JF-17, which is intended primarily for export and has already been sold to Pakistan), and significant improvements in the mission effectiveness of its legacy combatants. In contrast, India is still struggling to perfect its Light Combat Aircraft (LCA), the Tejas, which after over thirty years of effort is still not ready for prime time. More important, there seems to be little recognition in the Indian defense research establishment or its national leadership that the IAF's needs today far exceed the capabilities represented by modest platforms such as the Tejas.

While China's new combat aircraft will likely pose an ever more dangerous threat to India in the air, this prospect is magnified by the intensifying perils that are materializing on the ground.[5] What is actually most distinctive about the PLAAF's evolving aerospace campaign strategy is not an undue emphasis on aviation assets—however formidable these may be—but on exploiting the synergy between aircraft, missilery, electronic, and information warfare to wear down the adversary's airpower well before any aerial engagements ever take place. By integrating highly accurate missile forces, supported by sophisticated electronic

and information warfare capabilities, into their air operations, PLAAF commanders aim to utilize these weapons to seize the operational initiative at the onset of a conflict. Through intense first strikes executed by ballistic and cruise missiles aimed at an adversary's command and control centers, early-warning facilities, critical air bases (and especially the aircraft, ammunition, and petroleum, oil, and lubricant storage bunkers at these facilities), ground-based air defenses, electrical power grids, and field logistics centers, the PLAAF seeks to degrade its opponent's airpower on the ground so as to mitigate the shortcomings or amplify the advantages of its own aviation combatants prior to any other conventional air superiority operations.[6] A future Sino-Indian conflict, therefore, will certainly witness the IAF facing serious dangers on the ground in addition to all the challenges that now await it in the air.

PAKISTAN'S EFFORTS TO BOOST ITS AIRPOWER

As if the problems posed by China were not enough, Indian planners also have to reckon with Pakistan. The Pakistan Air Force (PAF) may be a weaker competitor than the PLAAF, but it is by no means a pushover. With more than 400 fighters in service, the PAF has, by dint of steady effort over the years and against all fiscal odds (thanks to U.S. assistance), managed to erode the IAF's desired margin of superiority. When the number of aircraft actually operational on any given day is accounted for, the IAF's numerical superiority over the PAF is less than two-to-one, way below the advantageous ratio necessary to underwrite the IAF's obligations against both Pakistan and China and representing a considerable degradation in comparison to the 1980s, when the IAF enjoyed close to a three-to-one superiority over the PAF.

Pakistan's overall military weaknesses have compelled its air force to take national air defense very seriously, and the PAF has sought to satisfy this objective by investing in conscientious pilot training, diversified early-warning capabilities to include new AWACS platforms (consisting of both the Chinese ZDK-03 and the excellent Swedish Saab Erieye), and a rationalized force structure. The latter is centered on late-model U.S. F-16s as the high-end fighter, with the new Chinese JF-17 light multirole aircraft as the eventual replacement for all the other lower-end combatants—the Q-5, the Mirage III/V, and the J-7—in its inventory today. With all PAF F-16s likely to be eventually brought up to the Block 52 standard and equipped with the C5+ version of the potent AIM-120 Advanced Medium-Range Air-to-Air Missile, the force will have acquired a formidable beyond-visual-range air combat capability.[7]

If the PAF's plans come to fruition with the acquisition of additional F-16s and new fifth-generation Chinese J-31s—something Islamabad is working frantically to procure—the Pakistani air arm could end up with a decent three-tier multirole force a decade or so from

now. Based on discussions taking place between Pakistan and China and between Pakistan and the United States, the PAF in the not-too-distant future could operate some 40 J-31 stealth fighters at the high-end; some 100 F-16s armed with among the best U.S. beyond-visual-range air-to-air missiles and other advanced air-to-ground munitions, and possibly complemented by a smaller number of Chinese J-10s in the middle; and as many as 250 JF-17s at the low end. The aircraft in all three classes would be capable of undertaking both air-to-air and air-to-ground operations as required.[8]

Even the least capable fighter in this lineup, the JF-17, is an effective combatant: it is capable of all-weather operations against both air and surface targets, its aerodynamic performance compares favorably with that of the Indian Tejas, and the later units of its class will likely be armed with advanced Western sensors, weapons, and defensive systems.

As a result of this potential upgrade, the weakest aircraft in the PAF inventory would also be fighters of consequence that IAF planners must factor into their force-sizing calculations. Admittedly, the proficiency of the best PAF squadrons in 2016 is not comparable to that of their Indian counterparts, certainly in the realm of air-to-air operations. But thanks to the recent intense F-16 air-to-ground missions along Pakistan's western border, PAF capabilities in air-land operations have modestly improved—with forward air controllers able to coordinate with their airborne strike elements, and the latter demonstrating better target acquisition and ordnance delivery. Given these trends, and the increasing number of exercises with foreign air forces, it must be expected that the best units of the PAF will be able to give a decent account of themselves in any future conflict.

INDIA'S CONTINGENCY PLANS FOR A TWO-FRONT WAR

Against this prospect of Chinese and Pakistani airpower improvements, the IAF's story in recent years has been one of steadily weakening end strength, even if specific components of its air warfare capabilities have undergone dramatic improvements. Although policymakers in New Delhi are conscious of the threats posed by the two dissimilar adversaries, China and Pakistan, Indian military planners still do not have effective solutions to the possibility of a full-fledged war on two fronts simultaneously.

Although all three Indian armed services have begun planning for such a contingency, their constrained budgets and sluggish acquisition programs compel them to operate as if a future subcontinental conflict will likely involve major combat against only one adversary, with the other serving principally as a threatening distraction intended to tie down Indian combat forces from being committed exclusively to the primary front, whichever that may be. Under such premises, the IAF intends to commit roughly 70 percent of its combat

squadrons to the main theater of operations, leaving the residual 30 percent as a contingency reserve to deal with any dangers that may be posed by the subsidiary threat.[9]

The PLAAF is likely to sport about 800 advanced fighters by 2020, with the PAF possibly fielding up to 200 modern aircraft. Given their likely evolution, the IAF is reported to have concluded some time ago that it would need about 60 combat squadrons to deal with the challenges posed by a serious two-front threat.[10] Although it is unclear whether this has been formally conveyed to the Indian government, it has been widely discussed in public forums because it represents, at least prima facie, a logical response to the evolving threat environment facing the country. As one Indian analyst, Vivek Kapur, concluded after an extended analysis, "For fighting a 1.5- or two-front war, the IAF would need [a] total of 33–43 (+20) = 53–63 fighter squadrons of fifth, fourth+ and fourth-generation fighters in 2032."[11]

> Indian military planners still do not have effective solutions to the possibility of a full-fledged war on two fronts simultaneously.

Since IAF fighter squadrons nominally consist of eighteen aircraft each (sixteen fighters plus two combat-capable trainers—with three additional airframes in storage as maintenance, attrition, or war wastage reserves), a 60-squadron force would muster 1,080 frontline fighters, drawn from an inventory of 1,260 aircraft, and would unquestionably provide India with the ability to defend its airspace, while supporting its ground and naval operations effectively in all but the most overpowering contingencies.

If this capability is composed of high-quality aircraft flown by better-trained pilots with superior combat support assets, it would satisfy the IAF's force allocation plans more or less adequately: under the assumption that 70 percent of the squadrons available are tasked to meet the most pressing contingency, namely a high-intensity Sino-Indian conflict, a 60-squadron force would permit the IAF to deploy somewhere between 750 and 880 Indian fighters against China's 800-odd advanced combatants, while still preserving 330 to 380 fighters in reserve—the residual 30 percent of the force—to deal with the secondary challenge that might be posed by Pakistan's 200-odd advanced aircraft (or its total force of about 400 fighters). If the primary threat turns out to be Pakistan, the existing allocation metric would bequeath the IAF a crushing air superiority over its Pakistani counterpart, while permitting it to maintain a much larger and more comfortable reserve vis-à-vis its Chinese opponent.

A 60-squadron force composed of sophisticated multirole aircraft would, thus, enable the IAF to secure the requisite air superiority necessary for operational success against both

adversaries for some time to come. To the degree that such force levels allow the service to secure a decisive edge over Pakistan while preserving effective parity with China, at least where the numbers of high-end aircraft are concerned, the logic of the 60-squadron requirement is understandable.

But it is possible that the IAF could remain an effective combat arm, capable of defeating both of its regional adversaries, even if it possesses a somewhat smaller force. This is because the PLAAF, irrespective of the projected numbers of high-end fighters in its future inventory, still cannot bring to bear the entirety of its combat aviation capabilities against India. Even if China's most pressing near-term threats—Japan, Taiwan, and the United States—were to be held in abeyance for purposes of argument, the still significant airpower infrastructure deficits facing China in the Chengdu and Lanzhou Military Regions, which abut the northern Indian frontiers, would prevent the PLAAF from committing the entirety of its advanced fighter force against its Indian opponent.[12]

CHINA'S INFRASTRUCTURE MODERNIZATION

Chinese military planners understand this problem entirely, but as long as Beijing's main threats were seen to emerge primarily from its east, infrastructure modernization on the Tibetan plateau and its environs were of lesser priority than preparations for a war with Taiwan and its regional supporters, the United States and Japan. Sometime in the past decade, however, it became evident to Beijing that the measures required to cope with growing Indian power could not be put off indefinitely, despite the fact that the Taiwan problem was unlikely to disappear anytime soon. Consequently, China began a serious program of modernizing its civilian and military infrastructure in the areas abutting the Indian border with the intention of advancing economic development and internal security goals as well as preparing prudently for conventional warfighting operations against India. This shift was part and parcel of a larger Chinese transformation that, as the *Telegraph* described it, focused on "push[ing] forward preparations for military conflict in every strategic direction."[13] This alteration in emphasis, signaled by China's then defense minister Liang Guanglie in an important interview in 2010, was reaffirmed in the May 2015 document "China's Military Strategy," which transparently declared:

> Due to its complex geostrategic environment, China faces various threats and challenges *in all its strategic directions and security domains*. Therefore, [preparation for military struggle] PMS must be carried out in a well-planned, prioritized, comprehensive and coordinated way, so as to maintain the balance and stability of the overall strategic situation. China's armed forces will make overall planning for PMS in both traditional and new security domains, and get ready to safeguard national sovereignty and security, protect the country's

> maritime rights and interests, and deal with armed conflicts and emergencies. To adapt to the upgrading of weaponry and equipment as well as changes of operational patterns, China's armed forces will further *optimize battlefield disposition and strengthen strategic prepositioning*.[14] [Emphasis added.]

Consistent with this new orientation, China has begun "preparing Tibet as [a] future war zone," as two Indian analysts, Brigadier (retired) Gurmeet Kanwal and Monika Chansoria, phrased it succinctly.[15] These measures encompass wide-ranging investments in road, rail, and airfield modernization, not to mention the development of substantial new logistics and communications facilities, at least some of which are being built underground. The air warfare infrastructure improvements have proceeded more slowly than their land warfare equivalents, but they have not been forgotten. The more deliberate pace in this instance might be explained by the bureaucratic weight of the People's Liberation Army (PLA) over the PLAAF, the PLA's traditional experience with fighting successful land wars even in the face of an adversary's air superiority, the considerable limitations of airpower in operations at high altitudes, or the absence, until recently, of genuine jointness in Chinese military planning.[16]

All this seems to be on the cusp of a major transformation. The PLA today has begun to internalize the lessons of the airpower revolution that has been under way since Operation Desert Storm, the combat phase of the U.S.-led effort in the 1990–1991 Gulf War. And Chinese President Xi Jinping has, more recently, been pushing the Chinese armed forces with an eye to securing greater loyalty to the party and increasing their operational effectiveness in an era of information warfare. Toward these ends, he has announced major reductions in PLA numbers, created a joint military command intended to bring all branches of the armed forces under one roof, reorganized China's strategic forces, dismantled four powerful military headquarters, and, of specific relevance to the discussion here, abolished the seven military regions and replaced them with five new theater commands.[17]

The entire Sino-Indian border is now encompassed by what China calls the Western Theater Command, which includes the old Lanzhou Military Region as well as those portions of the old Chengdu Military Region that previously abutted Nepal and eastern India.[18] In the areas near the border controlled by the Western Theater Command—if its demarcation as described in the best current Western analysis is accurate—there appear to be nine major airfields capable of supporting conventional military operations against India, in addition to several other helipads and forward landing sites. These airfields, which include PLAAF bases as well as joint civil-military aerodromes, are likely to increase in number as China continues with its airport expansion during the Thirteenth Five-Year Plan (2016–2020).[19]

By 2025, therefore, China could have as many as twelve airfields in the wider Tibetan region that could be pressed into service in a major Sino-Indian conflict. Although the routine PLAAF fighter presence at all existing facilities today is modest—a posture similar to that

maintained by the principal Chinese land formations earmarked for operations against India—Chinese planners appear to be emphasizing the creation of infrastructure rather than the forward deployment of major combat forces in peacetime on the assumption that the availability of prepared facilities would enable them to deploy large numbers of advanced aircraft into the theater during a crisis, if necessary. Most of the airfields that are notionally available for military operations against India today, however, have not been developed as effective air bases capable of supporting either numerous aircraft or high-intensity warfighting. These preparations will take many more years to complete, thus providing the IAF with some respite in the interim.

Even when the entire complement of Chinese facilities is ready, however, it is likely that the actual operational threats to the Indian air service will emerge from a smaller fraction of the more than 800 high-end Chinese fighters that will certainly exist in the PLAAF inventory by about 2025, and these at any rate will be subject to all the constraints that usually bedevil aircraft operating from high-altitude air bases. Some of these challenges can be surmounted by air-to-air refueling, despite the limited number of Chinese aerial refueling tankers today. But the binding constraint on the ability of the Chinese air force to bring combat aircraft to bear against the IAF will remain the number and quality of its air bases capable of supporting tactical air operations against India.[20]

If it is assumed—crudely—that during a major conflict with India in the post-2025 period each Chinese airfield could host on average a single air regiment consisting of 36 aircraft, the IAF would have to plan on confronting a force of anywhere between 324 and 432 Chinese fighters, depending on the number of facilities that are operational during that time. This total would include aircraft based routinely at the Tibetan airfields, crisis reinforcements (which could also comprise attrition replacements for PLAAF losses sustained in any conflict with India), and any other combat aircraft operating from rearward Chinese bases with tanker support and possibly recovering at border airfields. Whatever the internal composition of the deploying Chinese fighters may be, the IAF has little choice but to assume that, on the most conservative estimates, it could face an adversary force consisting of about three or four air divisions, or, in other words, 300 to 400 or more aircraft.

Matching India's immediate adversaries one-to-one would then require the IAF to field some 800 combat aircraft to support a force of about 38 squadrons. If the quality of Indian fighters is pervasively superior to those in the Chinese and Pakistani inventories with operational excellence to match, the IAF could probably get by with a somewhat smaller force. But the technical quality of the entire Indian inventory will never be uniformly superior to that of all its opponents, nor will Indian pilots always be better than their adversaries. And no matter how effective the IAF as a whole might be, the possibility of tactical failures is ever present, even in an otherwise successful war. Given these realities, and the recognition that numbers have a quality all their own, the IAF has very sensibly pushed for an end strength of 42–45 squadrons by 2027.[21]

While a 60-squadron strength would undoubtedly enable the IAF to overlook Chinese basing constraints along India's frontiers and reach for parity with the PLAAF's high-end fighter force irrespective of location, it is certain to prove unaffordable based on current trends. When the infrastructure limitations afflicting Chinese airpower in the Tibetan region are taken into account, a smaller force of 42–45 squadrons would suffice to defeat both China and Pakistan as long as the IAF is not confronted by the need to prosecute a high-intensity conflict against both adversaries simultaneously. If the IAF's superior pilot quality and operational proficiency continue to persist, India can protect its security even with the smaller end strength for a while longer, provided that sophisticated aircraft constitute the bulk of its airpower inventory; that it systematically invests in increasing the IAF's stockpile of advanced munitions, enlarging the number of its combat support aircraft, and improving its physical infrastructure; and that the Indian air service maintains its advances in doctrine and concepts of employment.

Based on these assumptions, the IAF should be able to defeat its Pakistani counterpart convincingly, while being able to overcome the PLAAF in the northern Indian theater of operations—where India's political and military aims are deeply conservative to begin with. This judgment presumes, however, that the PAF would not suddenly benefit from any open-ended foreign assistance (especially from the United States, but also from China), which would enable it to dramatically improve its airpower capabilities. It also supposes that Chinese infrastructure modernization in the Tibetan theater will not experience revolutionary improvements beyond those anticipated today, or that the number of fifth-generation fighters in the PLAAF inventory suddenly increases because of exogenous pressures. And, finally, it simply hopes that the Chinese missile-, electronic- and cyberwarfare threats to Indian airpower will turn out on balance to be manageable. If these assumptions prove faulty, however, the number of combat aircraft (and other mitigating capabilities) required to deal with the challenges posed by India's adversaries would have to further increase.

Unfortunately for India, some of these premises could turn out to be tenuous: at a time when Pakistan seems likely to enjoy continued access to U.S. and Chinese combat aviation technologies, and China's aerospace modernization (including on the Tibetan plateau) continues purposefully, the diminishing number of India's fighter squadrons—in fact, the inability to sustain even today's authorized capability, let alone the most expansive force often advocated—cannot be good news for its civilian security managers or, for that matter, its air force.

A HEAP OF BREWING TROUBLES

IAF'S SQUADRON STRENGTH AT A DEFICIT

Against the aspirational 60 squadrons often advocated as necessary for dealing with the evolving Chinese and Pakistan threats, the Indian Air Force (IAF) today has an authorized end strength of just 39.5 squadrons. This number is supposed to increase to 42–45 squadrons by 2027. Even if this expansion takes place—an uncertain prospect—it will equip the IAF with a combat force that is still only comparable to, if not smaller than, even the number of fourth- and fifth-generation fighters likely to appear in the Chinese inventory at that time.

For operational reasons, this parity may not matter—or it might, depending on the state of Chinese airpower infrastructure modernization in Tibet over the next ten years. Nevertheless, the prevailing trends do not inspire any confidence that the IAF will be able to meet even its more modest declared target of 42–45 squadrons by 2027. Today, against the authorized total of 39.5 squadrons, the IAF can barely muster 32 squadrons of fighters. As a thoughtful Indian commentator, Air Marshal (retired) B. K. Pandey, detailed in 2015, the most capable components of the IAF force lineup consisted of ten squadrons of Su-30MKIs, three squadrons of MiG-29s, two and a half squadrons of Mirage 2000s, six squadrons of MiG-21 Bisons, five squadrons of Jaguars, and five squadrons of MiG-27s.[22] This total of 31.5 squadrons, to be exact, may in fact overstate the IAF's combat potential because it refers to the frontline units of the force without accounting for the actual number of combat-ready aircraft. When that aspect is considered, as the Indian Parliament's Consultative Committee on Defense did in April 2015, the IAF is supposed to have closer to

25 functioning squadrons because attrition, poor serviceability, and operational conversion have apparently taken a high toll.[23] By even the most liberal accounting, therefore—that is, ignoring operational availability and adding to the lineup the entirely obsolete five MiG-21 M/MF/bis squadrons (which Pandey has excluded from his summary)—the IAF today has only 36.5 operable squadrons against the already inadequate sanctioned strength of 39.5.

This deficit is rooted substantially in the harsh fact that the capital account of India's defense budget is quite constrained—and that the gap between overall resource requirements and actual allocations will increase in the years ahead. In his eye-opening commentary on the 2015–2016 Indian defense budget, the Indian scholar Laxman K. Behera has noted that despite the steady growth of Indian defense spending in recent years, the disparity between defense needs and governmental funding has widened since 2009–2010.[24] Moreover, the overall pressures on the nation's public finances and the steady increases in revenue expenditures in the defense budget—a trend that is likely to strengthen in coming years thanks to the government's recent acceptance of the "one rank, one pay" demand—implies that the defense capital account will either contract or at best hold steady, despite the need for accelerated procurement in diverse areas.

This reality has already taken a toll on the IAF's 2015–2016 acquisition budget, which, despite being the largest of the three services, has actually contracted. Although India is expected to remain one of the fastest-growing economies in the world for some time to come, the resources available for defense modernization are likely to be limited because of the overwhelming importance of development obligations in what is still a poor, yet robustly democratic, country. The likelihood is thus relatively low that the IAF will suddenly enjoy huge injections of additional funds that would enable it to meet its recapitalization objectives in the near future. This prognosis is bolstered by confidential private sector studies of India's 2012–2027 Long Term Integrated Perspective Plan, which suggest that the anticipated liabilities during this period already exceed the extant capital allocations by about 40 percent.

The IAF today has only 36.5 operable squadrons against the already inadequate sanctioned strength of 39.5.

The expected paucity of funds, therefore, should have prompted the IAF to reconsider its force structure today and in the future. But India's higher defense organization does not seem to permit the systematic planning that would allow resources, requirements, and threats to be reconciled in an orderly way. The Integrated Defense Staff undertakes such exercises regularly, but its ability to influence the final decisions of the ministries of defense and finance is questionable. The IAF's continuing deficit in numbers is thus certain to persist for a long time.

AIRCRAFT INVENTORY OVERLY DIVERSIFIED

The budgetary shortfall is bad enough, but it is exacerbated by the heterogeneity of the force. Benjamin Lambeth, a U.S. expert on airpower, described the problem politely when he characterized the IAF as being "unusually diversified," with "seven types of fighters, six types of helicopters, four types of airlifters, and three types of trainers, as well as tankers, new AWACS [airborne warning and control system] platforms, and a variety of remote piloted aircraft."[25] Even the Air Combat Command of the U.S. Air Force, which is much larger than the IAF, has a more rationalized force structure: it operates primarily two types of strike fighters: the F-15 and the F-16 in different variants for air superiority and multirole operations, with only the A-10 designed exclusively for ground attack. The fifth-generation F-22 now complements the F-15, since the decision to forgo the complete replacement of the F-15 seems well in place. The F-35, which is still being developed, is intended to eventually replace the F-16 and A-10 entirely. The fighter strength of the U.S. Air Force, which consists of close to 1,300 aircraft, is thus composed of four basic aircraft types and will likely remain so even after the F-35 is fully integrated because some F-16s might be retained, or an entirely new replacement for the A-10 could be funded, for close air support missions.

In contrast, the IAF, with a smaller combat force of 600 to 800 aircraft (depending on what is counted as frontline, operational, or potent) operates six types of fighters: the MiG-21, MiG-29, Mirage 2000, and Su-30MKI for air defense or as multirole platforms, and the Jaguar and MiG-27 for dedicated ground attack missions. Substantial elements of this diverse inventory are already obsolete: eleven squadrons of MiG-21 Bisons and MiG-27s will likely be retired before the end of this decade, and the five assorted squadrons of MiG-21 M/MF/bis should have been eliminated from the force years ago. The five Jaguar squadrons, originally acquired to fulfill the deep-penetration strike role since the late 1970s, are ineffective in the face of any meaningful opposition, but if they are upgraded with new engines and avionics—a program that has been delayed interminably—they could provide at least another decade's worth of service.

Even after these transitions are completed, however, the problems of inventory diversity will remain. If all the MiG-21 and MiG-27 squadrons are retired on schedule before 2020, the IAF would still have five types of strike fighters in its residual inventory, since the recently ordered 36 French Rafales would join the MiG-29, Mirage 2000, Su-30MKI, and Jaguar to equip a nominally 22.5 squadron-strong force consisting of about 400 frontline aircraft. If India chooses to purchase a fighter other than the Rafale to fill the remainder of the original Medium Multirole Combat Aircraft requirement—a distinct possibility today—the IAF could end up with seven types of combat aircraft, once the new selectee is added to the Tejas now scheduled to join the service as a replacement for the retiring MiG-21s.

Such diversity in a force consisting of a little more than 600 frontline aircraft fielded in about 33 squadrons is a guaranteed recipe for operational inefficiency. The logistics burdens of maintaining such a lineup in what is still a relatively small fighting contingent are

atrocious and will further drain the IAF of resources at a time when it is already strained. Stories about the maintenance problems caused by the multiplicity of aircraft fielded in such small numbers are already legion in the IAF and beyond, and for the service to continue justifying its persistent heterogeneity on grounds of avoiding "over-relian[ce] on any particular variety of aircraft," as journalists Jayanta Gupta and Pinak Priya Bhattacharya reported, borders on the absurd.[26]

GRAND AMBITIONS, MUDDLED PLANNING?

The honest truth is that, whatever the value of diversification might be, the IAF has ended up with an awkward force structure not simply for political or operational reasons. A prominent Indian defense commentator, Bharat Karnad, has charged that the IAF's force structure maladies are largely the result of its own prejudices, characterizing them as "grand ambitions, muddled planning."[27] While poor preparation has probably played a part—as it usually does in any complex organization—the blame cannot be laid exclusively at the IAF's door. Other factors remain important and relevant as well.

For starters, it demonstrates how the IAF, the most technology-intensive of the Indian armed services, continues to be a victim of the larger vagaries of the international aviation market because it has no domestic sources of supply where advanced combat platforms are concerned. Furthermore, it testifies to the weakness of India's higher defense organization because of its inability to formulate unified priorities and coherent responses to those requirements, and to the weakness of its lengthy and often frustrating procurement policies and processes, which prevent any expeditious acquisition of the necessary capabilities. And, finally, it highlights the problematic consequences of the disjuncture between national and service imperatives. Successive governments in India, seduced by the dream of making the country self-sufficient in regard to the production of cutting-edge military technologies, have pursued industrial policies that have yielded only modest successes in the conventional realm. Meanwhile, the Indian armed services, seeking to acquire the best fighting instruments irrespective of source—because those matter most where combat outcomes are concerned—find themselves struggling against domestic research and development organizations that invariably promise more than they can deliver.[28]

The unproductive interaction of all these factors accounts for many of the force structure problems bedeviling the Indian military as a whole. Where the IAF is concerned, these difficulties are manifested most acutely by its current and prospective three-tier air defense/multirole fighter force (see table 1)—in fact, a four-tier force when the dedicated ground attack contingents are factored in—at a time when fiscal pressures are inordinately stressing the service. The division of aircraft into these three tiers by weight is not intended to necessarily imply differences in sophistication; the differentiation merely reflects how the IAF thinks about its force architecture and is utilized here primarily for analytical convenience.

TABLE 1. Indian Air Force Air Defense/Multirole Fighter Aircraft by Weight, in Kilograms

≤20-TON AIRCRAFT	EMPTY WEIGHT	MAXIMUM TAKEOFF WEIGHT
Mikoyan/Russian Aircraft Corporation MiG-21F	4,600	8,500
Mikoyan/Russian Aircraft Corporation MiG-21bis (version 75A)	5,353	9,500
Mikoyan/Russian Aircraft Corporation MiG-21MF	5,843	9,800
Mikoyan/Russian Aircraft Corporation MiG-21 Bison (version 75B)	6,000	10,050
Hindustan Aeronautics Limited Tejas	6,560	13,500
Saab Group Gripen NG	8,000	16,500
Dassault Aviation Mirage 2000C	7,500	17,000
Mikoyan/Russian Aircraft Corporation MiG-29	10,900	19,700
≤30-TON AIRCRAFT	**EMPTY WEIGHT**	**MAXIMUM TAKEOFF WEIGHT**
Lockheed Martin F-16IN	9,466	21,772
Dassault Aviation Rafale	9,850	24,500
Eurofighter Jagdflugzeug GmbH Typhoon	11,150	23,500
Hindustan Aeronautics Limited AMCA	17,273	29,465
Boeing F/A-18E/F	14,552	29,937
≤40-TON AIRCRAFT	**EMPTY WEIGHT**	**MAXIMUM TAKEOFF WEIGHT**
Sukhoi Company Su-30MKI	17,700	38,800
Sukhoi Company/Hindustan Aeronautics Limited PAK-FA	18,500	37,000

Notes: The Tejas is a prospective addition to the Indian Air Force. Aircraft in italics are candidates for the residual Medium Multirole Combat Aircraft purchase.

Source: Jamie Hunter, *Jane's All the World's Aircraft: In Service, 2015-2016*, 21st ed. (Surrey: IHS Jane's, 2015); and Paul Jackson Fraes, *Jane's All the World's Aircraft: Development & Production, 2015-2016*, 104th ed. (Surrey: IHS Jane's, 2015).

THE LIGHTWEIGHT COMPONENT

THE SEARCH FOR A MiG-21 REPLACEMENT

All three tiers of the air defense/multirole force seem to be in trouble. The light component (aircraft weighing 20 tons or less) consists of roughly five squadrons of MiG-21 M/MF/bis fighters, six squadrons of MiG-21 Bisons, three squadrons of MiG-29s, and less than three squadrons of Mirage 2000s. The MiG-21s are the oldest serving air defense fighters of the Indian Air Force (IAF); more than 900 aircraft in different versions have flown in national colors since 1963. The MiG-21, a highly storied aircraft, is basically a point defense fighter and, until the Bison variant was inducted into the IAF, it was intended principally for air-to-air combat that occurred within visual range using short-range infrared homing air-to-air missiles. With the introduction of the Bison—and its new Phazotron Kopyo multimode radar capable of supporting the employment of the Russian active radar-guided AA-12 ADDER missile in addition to other older, semi-active, radar-guided weapons—the MiG-21 for the first time became capable of carrying out air combat operations beyond visual range. The MiG-21 force, accordingly, bifurcated into two components, the newer Bison squadrons focused on all-weather air combat at all ranges, and the older MiG-21 variants committed to primarily daylight air operations within visual range. The early models still have short-range air defense as their primary responsibility, but the IAF has frequently as-

signed them secondary ground attack missions as well, even though they are not optimized for that role and cannot carry the precision-guided munitions that the Bison can handle.

Given that the aircraft, which was originally intended for high-speed, high-altitude air defense operations, proved adaptable enough for close air support and battlefield strike missions at medium and low altitudes as well, it is not surprising that the MiG-21 fleet served as the backbone of the IAF over the years. In the 1980s, the service began planning for the eventual replacement of the MiG-21 as the core of its light fighter force, but two other developments took place as this process evolved.

Alarmed by the Pakistani acquisition of the U.S. F-16 in the aftermath of the 1979 Soviet invasion of Afghanistan, the Indian government foisted upon the IAF two squadrons of French Mirage 2000s. This was presumably in the belief that the beyond-visual-range air combat capability of the Mirage 2000's semi-active radar-guided Super 530 air-to-air missiles would provide the necessary counter to the new F-16s, which lacked similar weaponry at the time.[29] This exorbitant, panicked purchase—its cost apparently exceeded the entire Indian defense budget in 1981, the year it was concluded—resulted in a procurement of 49 aircraft, a relatively small number, with ten more acquired about two decades later. The problems of acquiring such modest numbers were magnified because the IAF was also contemplating acquiring two squadrons of the newest Russian fourth-generation fighter then available, the MiG-29, which was designed to replace the older MiG-21s and MiG-23s in the Soviet inventory.

The hasty induction into the IAF by 1986 of two new light fighters, the Mirage 2000 and the MiG-29, certainly improved its air combat capabilities, primarily in the beyond-visual-range arena. But the small numbers of aircraft involved complicated the service's force structure considerably. Even as these developments were occurring, however, the IAF did not have a clear sense of what would eventually replace the MiG-21 force as a whole. The Indian government, driven by its own dreams of import substitution, was pulling in a different direction than its air force.

Acting upon the IAF's requirements for a MiG-21 replacement, the government initiated an indigenous development program for a Light Combat Aircraft in 1983, even as it was otherwise authorizing the piecemeal acquisition of small numbers of foreign fighters to beef up the IAF's air defense capabilities to cope with the emerging Pakistani threat.[30] For a country that had never before developed an indigenous fighter entirely through domestic resources, the Light Combat Aircraft symbolized the acme of hubris as Indian designers proposed to simultaneously create from scratch not only a cutting-edge airframe but also a high-thrust engine and an advanced multimode radar. The intent was to integrate all these capabilities and others into a lightweight platform that would stand comparison with the best in the world and thereby contribute toward enabling the IAF to maintain the airpower superiority it needed for successful deterrence against Pakistan and China.

The IAF leadership seemed skeptical about the ability of India's Defense Research and Development Organization to deliver such an advanced fighter, and the Light Combat Aircraft's troubled history appears to have justified this disbelief. As a stopgap, therefore, the service decided in 1993 to modernize, first, a segment of the MiG-21 fleet to bring it to the Bison standard. That entailed equipping 125 aircraft with a new radar, new beyond-visual-range active air-to-air missiles, new defensive avionics, and new cockpit displays, among other things.[31] Because this upgrade could be applied only to the newest airframes in the inventory, the Bison program could not serve as a comprehensive solution to the problem of replacing the MiG-21 force as a whole.

THE MIRAGE 2000 AND THE MiG-29

Still uncertain about whether the Light Combat Aircraft program would deliver the promised high-quality replacement, the IAF finally sought at the turn of the century to expand the Mirage 2000 inventory as a substantial, even if not a full, replacement for the non-Bison variants of the MiG-21 fleet. The Mirage 2000's superb performance during the 1999 Kargil War; its high levels of operational availability; its outstanding ergonomics, high-quality avionics, and decent weaponry; and its excellent flying qualities and instantaneous turn performance all combined to generate an IAF requirement for 126 new, late-generation Multirole Combat Aircraft (MRCA) aircraft (with possibly 74 to follow, for an even 200) as replacements for the older Indian MiG-21s and MiG-23s.[32]

The French manufacturer Dassault Aviation had kept open its Mirage 2000 production line until 2004 in anticipation of receiving an Indian order for more aircraft. Unfortunately for the IAF, by the time the Indian Ministry of Defense's lumbering decisionmaking process took off, Dassault Aviation had decided to exit the race when it was confronted by the Indian government's decision to pursue the MRCA acquisition through a multivendor competition. Dassault Aviation's departure and the prospect of considering other international fighters that were previously unavailable prompted the IAF to reconfigure the MRCA requirement into a Medium Multirole Combat Aircraft (MMRCA) competition. After much encouragement from both the French and Indian governments, that race enticed Dassault Aviation to offer its follow-on fighter, the heavier and far more sophisticated Rafale, which eventually won out after the associated flight evaluations were finally completed in 2009–2010.

The inordinate delays in conducting the MMRCA competition implied, however, that the Mirage 2000s already in the fleet were progressively aging, even as newer fourth-generation and more advanced designs began to enter the Chinese and Pakistani air forces. To manage this challenge at a time when the MMRCA acquisition process seemed all but interminable, the IAF embarked on an expensive stopgap effort to upgrade the relatively small numbers of Mirage 2000 and MiG-29 aircraft in its inventory. The operational logic for embarking

on these twin upgrade programs was understandable: they represented a desperate effort to modernize the IAF's best lightweight air combat fighters at a time when the regional air threat was increasing, the promised Light Combat Aircraft seemed nowhere near maturity, and the heavy fighters of the IAF—the Su-30MKIs—were paralyzed by poor operational readiness rates and significant avionics and engine problems.

Yet the price paid for this interim fix was exorbitant. The Indian defense correspondent Rajat Pandit reported, based on the former Indian defense minister's reply in parliament, that the upgrade for each Mirage 2000 jet cost 167 crore rupees.[33] In U.S. dollars, this is the equivalent of upward of roughly $25 million per jet, or a total cost of some $1.2 billion for the upgrades alone. The MiG-29 upgrade, while nowhere as expensive, is still estimated to have cost close to $1 billion for 62 upgraded fighters.[34] Although these investments have produced enormous increases in capability—thanks to the integration of new multimode radars, new defensive avionics, and new active radar-guided beyond-visual-range missiles—they are likely to have prolonged the service life of the Mirage 2000 and MiG-29 fleets for only about another fifteen years, twenty at best.

Consequently, it does raise the question of whether the IAF would not have been better off acquiring an entirely new lightweight fighter, such as the Gripen NG (for Next Generation)—with its easy maintainability, phenomenal situational awareness, diverse weapons load, better sustained maneuvering performance, true swing-role capability, and relatively low cost—as a straightforward replacement for all the existing aircraft in the Indian inventory that weigh 20 tons or less. A bold decision of this kind would have required forgoing all stopgap upgrades on the Mirage 2000s and MiG-29s already fielded and the prompt retirement of all the early model MiG-21s still in the inventory. The saved resources would be applied toward the acquisition of an entirely new 4.5-generation aircraft that would remain in service for thirty-plus years. Such an acquisition strategy might have been tenable if the IAF had been confident that the Indian government could actually procure a suitable replacement fighter quickly and in sufficient numbers. But there are good reasons for doubt on both counts—in no small measure because of the opposition emerging from the domestic research establishment, which feared the death of its Light Combat Aircraft program were a superior foreign fighter to be acquired. As a result, the IAF had perhaps no alternative but to settle for the expensive upgrade of a small number of older airplanes merely to maintain its combat capabilities at a time when the lightweight fighter segment was contracting in size and effectiveness. Moreover, the budgetary implications of procuring an entirely new line of fighters when the MMRCA acquisition had not yet been completed or satisfied may have pushed the IAF further toward the upgrade option.

All told, then, the modernization of the Mirage 2000s and the MiG-29s, though bestowing a dramatic increase in air combat capabilities, has still not resolved the dilemmas associated with MiG-21 replacement and the steady diminution in the IAF's end strength. Recognizing this problem, the Indian defense minister, Manohar Parrikar, speculated on one occa-

sion that India might consider "build[ing] another single engine [fighter] in India, which is possible . . . [as] a replacement for the MiG-21."[35] For a while, it was widely thought that the Gripen NG might in fact be selected as this MiG-21 replacement, when Saab, the aircraft's manufacturer, promised to shift the production line substantially to India.[36] Saab's proposal was both attractive and consistent with the "make in India" mantra of Prime Minister Narendra Modi's government. But it appears that the old dream of import substitution and the acute fiscal pressures of the moment combined to persuade the Ministry of Defense to press the IAF into accepting an improved version of the Light Combat Aircraft, dubbed the Tejas Mark 1 Standard of Preparation-2018 (SoP-18), as at least a near-term replacement for the oldest MiG-21s in the force.[37]

THE TEJAS MARK 1

For many years, the IAF resisted the notion that the Tejas Mark 1 was an adequate combat aircraft because of its myriad weaknesses. It accepted the lightweight fighter in small numbers only in test units with a series of waivers to its desired requirements. The many shortcomings of the aircraft are by now well-known: it was developed by civilian design bureaucracies—primarily the Aeronautical Development Agency in collaboration with Hindustan Aeronautics Limited—without any significant IAF input until very late in the engineering and manufacturing development phase.[38]

The net result was an aircraft that is overweight, possesses a suboptimal thrust-to-weight ratio despite the heavy use of composites, has poor energy addition and a limited top speed, and an egregious ergonomic design of the cockpit. Even the aircraft's remarkable instantaneous turn capability—superior to that of the MiG-21—does not compensate for the limitations of its compound delta wing design, which, like other aircraft with similar planforms, produces an extremely high airspeed bleed-off rate in any turning fight. As one Indian engineer, Prodyut Das, savagely concluded, "We have a fairly mediocre fighter somewhere between the Gnat F1 and the MiG-21 on our hands."[39]

For all of the shortcomings of the Tejas, what is perhaps most attractive to the government of India right now is its supposedly low cost. The Tejas Mark 1 is advertised as costing somewhere in the vicinity of $38 million apiece.[40] If the development cost of the program thus far—some $2.7 billion—is factored in, the unit cost of each aircraft rises to about $60 million, which if true would be about 72 percent of the price of the Gripen NG offered to Norway in 2008. The publicized price of the Tejas, however, must be taken with a grain of salt: senior Indian aerospace industry insiders expect that the aircraft will cost closer to $50 million each and that its unit cost would actually rise to about $80 million when its development bills are included. If true, the Tejas may end up being somewhat cheaper than the least expensive foreign competitor on the horizon, the Gripen NG.

But the critical question that is as yet unanswerable is how much cheaper it would be, an issue that bears fundamentally on the matter of cost effectiveness. Given the Gripen's impressive air combat capabilities, operational flexibility, and low operating and life-cycle costs, it would be hard to make the case that the Tejas is, even at the low end of the cost range, more than 72 percent as capable as its Swedish peer. That argument will become even more untenable as the expenses of the ongoing rectification initiatives are added to the overall development costs of the Light Combat Aircraft program. At $80 million per unit, the cost effectiveness of the Tejas as compared to the Gripen NG disappears almost entirely, leaving the IAF with a fighter in its inventory that is pricey, hard to maintain, and ultimately suboptimal for the swing-role mission.

In any event, the lure of lower costs, however marginal the difference, appears to have swayed the Modi government's decision in favor of the Tejas. This accountant's approach to force modernization may be understandable, given the fiscal pressures on the Indian defense budget, but it hardly meets the test of cost effectiveness, let alone mission superiority.

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Despite the fact that it is still not obvious whether the domestic manufacturer, Hindustan Aeronautics Limited, has the production capability to build the Tejas Mark 1 in the numbers required annually, the Ministry of Defense has obliged the IAF to acquire six squadrons of this improved version to replace the early model MiG-21s that will be retired in a few years. This translates into 126 aircraft, with 108 deployed in squadron service and the rest stored as maintenance, attrition, and war wastage reserves.

Because no other alternatives appear to be viable, acquiring some 100-odd upgraded Tejas Mark 1s seemed to be the best solution that the government of India could come up with at this point, despite the IAF's well-founded and continuing reservations about the aircraft's performance.[41] Some of the limitations of the Tejas will be addressed through specific fixes: it appears that the final production version will be equipped for air-to-air refueling; will have an Israeli active electronically scanned array (AESA) radar, the EL/M-2052, as its principal sensor; and will be equipped with an Israeli weapons suite, consisting of Python short-range infrared-guided and Derby long-range active radar-guided air-to-air missiles, besides various other free-fall and precision-guided air-to-ground munitions.

With such improvements, the Tejas Mark 1 could be transformed into a serviceable fighter, thirty years after its conception, but its aerodynamic deficiencies will almost certainly be harder to correct. The claims from early 2016, as reported in the Indian newspaper *Tribune*, that remediation engineering will produce an aircraft that is "1,000 [kilograms] lighter than the existing version" are simply laughable.[42] Consequently, it is still too early to declare, as one unidentified Indian defense official did in an interview with the *Times of India*, that the Tejas "will be more than able to outgun the similar JF-17, which Pakistan is acquiring with China's help,"[43] let alone surpass the Chinese J-10, which has also turned out to be an impressive lightweight fourth-generation combatant.

Whether the Tejas ends up being superior to such comparable adversaries will depend on many things, especially the aircraft's flight performance; the quality of the situational awareness enjoyed by its pilot, which hinges in substantial measure on its radar detection and tracking range and the effectiveness of its integration with other onboard and offboard sensors; the quality of its air-to-air weaponry, including their maximum kinematic range and, more important, the size of their no-escape zone, the effectiveness of their guidance systems, and their levels of electronic protection; as well as the sophistication of the aircraft's air-to-ground munitions and their associated targeting systems; and the sophistication of its defensive avionics suites.

There are reasons for concern in some of these areas. A detailed evaluation of the Tejas as an air-to-air fighter, both intrinsically and in relation to its rivals, cannot be undertaken here, but the following issues are worth considering. For starters, it is unlikely that the aircraft's thrust and maximum speed can be dramatically improved at this juncture because its General Electric F404 engine unfortunately cannot be replaced by the advanced General Electric F414-INS6 successor without major modifications to the airframe—and, by implication, without further delays in acquiring an aircraft that is unlikely to complete entering service before the first quarter of this century. A high top speed is irrelevant for close-in maneuvering, but it can make a huge difference in a fighter's ability to engage and disengage at will; a high thrust-to-weight ratio, meanwhile, is desirable, especially in maneuvering air-to-air combat, because it affects a fighter's climbing, acceleration, and sustained G performance, giving it great advantages especially in the vertical plane and allowing it to regain energy quickly after high-G maneuvers. The Tejas's limited top speed and thrust-to-weight ratio in particular will force the IAF to develop air combat tactics that minimize its vulnerabilities—the latter especially in regard to vertical performance—given that the aircraft will have to live with the General Electric F404 engine permanently. This is especially true given that the IAF has decided to drop the Mark 2 variant, which was supposed to be powered by the General Electric F414-INS6 engine; instead, all the Tejas fighters, in both Mark 1 and Mark 1A variants, will be powered only by the General Electric F404.

Complicating matters further, the performance of the Israeli EL/M-2052 radar, the successor to the EL/M-2032 that now equips the Tejas, is unknown because the system is still in

development. If the Tejas is to be able to pull off successful first-look, first-shot, first-kill air engagements against comparable opponents without airborne warning and control system (AWACS) support, its EL/M-2052 radar will have to perform significantly better than the EL/M-2032 radar does in comparison to KLJ-7 radar that equips all fourth-generation Chinese-origin fighters.[44] Of particular concern is the troubling report that the EL/M-2052 radar, which Elta is supposed to co-develop with India's Defense Research and Development Organization, might already have been transferred to (or stolen by) China—a development that, if true, could imply future transfers of some of its key capabilities to Pakistan.[45]

The decision to equip the Tejas with the EL/M-2052, rather than some alternative such as the U.S. Scalable Agile Beam Radar (SABR) or the Raytheon Advanced Combat Radar (RACR)—both AESA radar systems—was apparently reached because Elta offered the Defense Research and Development Organization the prospect of co-development. While it is hoped that this gamble will pay off over time, the fact remains that the EL/M-2052 is a developmental AESA radar that is not yet fielded on any combat aircraft, let alone on Israel's own fighters that are equipped largely, though not exclusively, with U.S. sensors and weapons.

In comparison, the Israeli weapons suite intended for the Tejas offers more promising prospects. The Derby active radar-guided air-to-air missile that will be the aircraft's primary beyond-visual-range weapon is excellent, with superb electronic protection features and a range of pulse repetition frequencies that provide high accuracy in the intercept endgame. But it is shorter-ranged than the comparable active missiles carried by Chinese fighters, the Chinese PL-12, and by Pakistani fighters, the U.S. AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM). The versions already in Indian employ do not have a data link, which presumably will be added as it is integrated with the Tejas's EL/M-2052 radar.

These limitations will matter less in short-range engagements, but in the AWACS-supported beyond-visual-range combat that will increasingly become the norm in southern Asia, they could turn out to be costly. The Python 4 within-visual-range missile that the Tejas is likely to carry, in contrast, outclasses anything India's adversaries can bring to a close-in fight, and the Israeli display and sight helmet (DASH) mounted sight will enable Indian pilots to target adversaries in the beam or in other difficult geometries without having to pivot the entire aircraft. Success in maneuvering combat, however—especially when it involves multiple adversaries—is as much a product of comparative pilot proficiency and luck as it is a function of technological superiority. The odds of success in this aerial combat regime, therefore, will increase greatly if the Tejas is gradually armed with the even better Python 5, a weapon with significant range and countermeasure advantages over all the short-range air-to-air missiles now carried by Chinese and Pakistani combatants.

Finally, the Tejas's defensive avionics will need appropriate improvement if the aircraft is to dominate the kind of combat to be expected in the future. The aircraft's electronic warfare

suite has the four basic subsystems—a radar warning receiver, a missile approach warning system, chaff and flares, and an automated countermeasures dispensing system—carried by modern fighters, except for an onboard self-protection jammer. The solution now settled upon seems to be a podded system, mostly likely the EL/L-8222, which is already carried by several other IAF fighters. The EL/L-8222 is an excellent narrowband digital radio frequency memory (DRFM) system. It is almost certainly superior to the Chinese KG300 DRFM-based jammer, which equips the JF-17; whether it surpasses the defensive avionics system on the J-10 is unclear.

In any event, coping with Chinese airborne electronic warfare capabilities will be the test facing the EL/L-8222, because although Pakistani capabilities are modest, the equivalent Chinese threat is not. China's airborne electronic warfare investments are enormous, with diverse and often high-powered systems equipping fighter aircraft, unmanned aerial vehicles, and dedicated standoff jammer aircraft; they have also historically profited immensely from both Russian and Israeli technology. A key component of Tejas modernization will, therefore, have to include focused investments in upgrading its electronic warfare suites to keep up with the Chinese fighters and combat support aircraft it is likely to encounter. The critical issue here, however, is not simply improving specific components such as the radar warning receiver or the missile approach warning systems or the self-protection jammer. More important, the entire defensive avionics suite needs to be sufficiently integrated with the new EL/M-2052 AESA radar to enable those jam-and-search, jam-and-track, and jam-and-shoot capabilities that would give it the upper hand in the face of its other maneuvering and energy state deficiencies in air combat.

The Indian government should be cautious about pushing ahead with plans to acquire more than the six squadrons currently authorized until the shortcomings of the Tejas are satisfactorily addressed.

All this adds up to the sobering conclusion that the Tejas has potential but that it is a mixed bag. Accordingly, the Indian government should be cautious about pushing ahead with plans to acquire more than the six squadrons currently authorized until the shortcomings of the aircraft as an aerodynamic platform and as a combat system are satisfactorily addressed. Of those two deficiencies, the combat system may be easier to fix: the IAF at least has the option of selecting the SABR or the RACR at some future point if the EL/M-2052 does not deliver according to expectations, and the U.S. government has released the AMRAAM for integration with the Tejas if India seeks to acquire this weapon in addition to the Derby. Such a shift, however, is likely to be both time-consuming and costly, and so one can only hope that the contemplated Israeli systems work as advertised. The

integration of any sophisticated AESA radar would transform the Tejas into at least a useful standoff air intercept platform, especially when operating over Indian territory or above the interstitial battlefields in southern Asia. Even with improvements, however, it is unlikely to ever become a sophisticated air superiority fighter capable of operating in depth or successfully against high-end opponents. But if its problems can be sufficiently corrected to allow its acquisition in larger numbers—say, twelve squadrons, a prospect with which the IAF is extremely uncomfortable, and for good reason—the shortcomings in the IAF's lightweight fighter force could arguably be mitigated, albeit with a compromise in capabilities in regard to the all-weather point air defense and strike missions.

Serious problems would arise, however, if efforts to improve the Tejas fail to yield a satisfactory outcome, because that would leave the service with a huge gap at the low end of the force, given the hopes that this aircraft could still come to serve as the IAF's principal short-range air defense fighter and the backbone of its light multirole component. In such circumstances, the IAF would be compelled to consider further expanding the medium (30 tons or less) and heavyweight (40 tons or less) segments of the combat aircraft inventory. Such an outcome would bring considerable increases in warfighting capability, but at much higher costs at exactly the time when the service is struggling to find the resources to fund its medium-weight aircraft requirements as well as its future heavy acquisitions.

CRUNCHING NUMBERS ON BOOSTING SQUADRON STRENGTH

The IAF holds out the hope of being able to field at least 42 fighter squadrons by 2027, a substantial increase from its nadir of 32 squadrons today. How exactly the gap will be closed is still an open question. If it is assumed that the service will certainly have thirteen Su-30MKI squadrons of heavyweight fighters, a nominal two squadrons of Rafales in the medium-weight category, and three squadrons of modernized MiG-29s, two and a half squadrons of modernized Mirage 2000s, and six squadrons of improved Tejas at the lightweight end of the air defense/multirole force (plus five squadrons of upgraded Jaguars for dedicated ground attack), the total of 31.5 squadrons still leaves a 10.5-squadron shortfall that must be filled. If the gap is filled by acquiring six additional squadrons of Tejas lightweight fighters, the shortfall appears more manageable: just 4.5 squadrons, which can be equipped with the 90 aircraft that India hopes to acquire to complete the original MMRCA tender for 126 aircraft that was aborted when the Rafale purchase was terminated after 36 aircraft were slated to be bought straight off the shelf.

If this solution comes to pass, however, the difference in numbers between the size of the IAF's high-end force and that of its adversaries even in 2020 will be significant. The IAF's most sophisticated fighters will not number more than 510 aircraft (272 Su-30MKIs, 62

MiG-29s, 50 Mirage 2000s, 36 Rafales, and 90 MMRCA follow-on fighters) against the 600 or so best Chinese and Pakistani fighters, namely the Su-35s, Su-27/30s, J-11s, and F-16s (with the J-10s left entirely out of the estimation). This comparison, moreover, presumes that the residual MMRCA component will be fully integrated into the IAF by the end of this decade, a quite optimistic assumption.

If the comparison is pushed out to 2025, when the IAF is perhaps within striking distance of its 42-squadron target, the ratio between the Indian air arm and its adversaries becomes even more unfavorable because China alone could have in its inventory some 400 fourth-generation fighters, 375 to 400 fourth-generation-plus fighters, and 200 to 300 fifth-generation fighters. Even excluding the fourth-generation fighters, China alone will possess 575 to 700 high-end multirole fighters—besides whatever else Pakistan can bring to the party—versus the IAF's smaller contingent of 500-odd aircraft that are all only fourth- or fourth-generation-plus (now that the service seems uncertain about rapidly inducting Russian fifth-generation aircraft into its inventory). The only meaningful constraints on Chinese airpower superiority in this scenario will be the state of its supporting infrastructure in Tibet, the number of its aerial refueling tankers, and the general state of Sino-Indian relations in the context of China's competition with its more important East Asian adversaries Japan, Taiwan, and the United States.

If the unfavorable prospects implicit in the 2025 prognosis are to be minimized, it is imperative that the Indian government hold the line at six Tejas squadrons at the lightweight end and expand the medium multirole force instead to ten full squadrons beyond the 36 Rafales already on order. This would permit the high-end balance in 2027 to approach something closer to numerical parity—some 600 Indian fighters to China's 575–700. Even so, the qualitative differences will be hard to bridge, given that fifth-generation fighters would constitute a substantial share (anywhere from 28 to 52 percent) of the Chinese total, in contrast to no comparable capabilities in the Indian inventory. Even if the size of the People's Liberation Army Air Force's (PLAAF's) fifth-generation fighter segment in 2025 is smaller than that anticipated here—say, only 100–200 aircraft—an IAF of about 600 advanced and continually upgraded multirole aircraft will be essential to cope with the growing Chinese air strength, assuming of course that the PLAAF's basing infrastructure in Tibet improves appropriately along the way.

Such growth in Indian capabilities will at any rate be required because, as noted, these 2025 comparisons still leave Pakistan's most capable fighters out of the reckoning entirely. When Pakistan's advanced combatants, however modest in strength, are factored into the force-sizing metric, the need for at least 600 sophisticated Indian fighters, which are far more capable than the 108 low-end Tejas aircraft entering the force, becomes almost self-evidently compelling. Adding the 95-odd Jaguars—the backbone of the dedicated ground attack segment that, it is hoped, will be modernized by then—to this total yields an end strength of some 800 aircraft. That translates into 38 squadrons of frontline aircraft plus

maintenance, attrition, and war wastage reserves. Although this capability is still some distance away from the 42–45 squadrons desired by the IAF—which would require between 882 and 945 aircraft in total—the fact that the largest share of the force could be committed without reservations to the air superiority mission should give Indian airpower the edge so long as China's aviation infrastructure in the Tibetan region is not transformed dramatically.

Indian policymakers should do their utmost to avoid concurrent conflicts with China and Pakistan, because the numerical balances in such a scenario—at least in the air—are not comforting.

The closer the IAF's high-end component approaches its Chinese counterpart, even in numbers, the better positioned the Indian air arm would be in dealing with a simultaneous two-front war, however unlikely such a contingency would appear today. Even with such capabilities, though, the IAF would face considerable risks. At the very least, therefore, the crude quantitative comparison attempted here suggests only that Indian policymakers should do their utmost to avoid concurrent conflicts with China and Pakistan, because the numerical balances in such a scenario—at least in the air—are not comforting. As policymakers seek to avert such a danger, however, they ought to be resolutely pursuing the objective of not just building up toward the strength of 42–45 squadrons that the IAF seeks by 2027, but actually ensuring that its high-end fighters come to constitute the largest proportion of this force.

THE MEDIUM-WEIGHT COMPONENT

THE RAFALE

Such a conclusion naturally refocuses attention on the Indian government's prospective decision in regard to filling out the medium segment of its air arm. The Indian Air Force (IAF), at least in its recent history, had no medium-weight combatants; its diverse fighter assets were clumped mostly at the lightweight end, with the Su-30MKI the sole representative at the heavy end of the spectrum. With the reformulation of the Medium Multirole Combat Aircraft (MMRCA) requirement—born out of the original effort to expand the lightweight Mirage 2000 force—the IAF began to review a series of twin-engine fourth-generation-plus aircraft such as the Rafale, the Typhoon, the F/A-18E/F Super Hornet, and the MiG-35 as well as lighter single-engine fourth-generation-plus fighters such as the F-16 and the JAS-39 Gripen. (The F-16 comes in just barely past the medium-weight mark, and the Gripen definitively subsists as a lightweight combatant even in its heavier NG guise.)

Given the evolving force ratios involving China and Pakistan, the IAF initially sought to acquire 126 aircraft under the aegis of its MMRCA competition, while holding out hope for 74 more aircraft later. The resulting purchase would have sufficed to equip close to ten squadrons with advanced fourth-generation-plus aircraft, whose distinguishing characteristics include high agility, reduced radar signatures, active electronically scanned array (AESA) radars, sensor fusion, high-capacity and secure data links, enhanced defensive avionics suites, and advanced air-to-air and air-to-ground weaponry. A single large acquisition

of this kind held the promise of simplifying the IAF's logistics and maintenance, allowing the force to focus on a single platform, rather than creating the congeries of aircraft that exist, for example, in its lightweight segment. With such ambitions, the IAF conducted a lengthy and detailed evaluation of six candidates before selecting the Rafale, with the Typhoon as a backup in case the contract with Dassault Aviation could not be concluded for any reason.

The selection of the Rafale as the winner of the MMRCA competition confirmed the suspicion of several well-placed Indian observers that the IAF in the end picked the aircraft it wanted in the first place: a French fighter as the preferred Western counterpart to its Russian aircraft, given the service's long and ultimately happy experience with the Mirage 2000.[46] Whether this conjecture is in fact true is hard to judge from the outside, but the IAF did conduct an elaborate contest among the contenders before short-listing its final choices. Unfortunately for the Indian air arm, however, the competition collapsed because, after long and frustrating negotiations between the Indian and French governments as well as between the IAF and Dassault Aviation, the Modi government aborted the original tender and settled for an off-the-shelf purchase of just 36 aircraft as a consolation prize for Paris, while declaring its intention to continue searching for an additional 90 aircraft on more favorable terms.[47]

The Rafale debacle, ultimately, occurred because the aircraft's extraordinarily high unit and life-cycle costs made it impossible for the Indian government to follow through on its original intent to purchase the entire complement of 126 aircraft. But the seeds of the problem lay in the two-step Indian acquisition procedure itself: requiring the IAF to first choose an airplane that met its technical standards without any formal information about costs, and then selecting the lowest-priced competitor—based on costs, technology transfer offers, and offset proposals—from only among those that survived the first-stage triage. In doing so, the Indian government and its air arm could neither judge the total expected costs of their selection against all the other rivals a priori nor assess whether their differences in marginal price were worth the trade-offs in technology and performance.[48] It is not surprising, therefore, that when the price data for the Rafale were finally revealed, sticker shock set in as the total cost proved much larger than the IAF or the Indian government could afford.

Confronted by this fact, the then defense minister, A. K. Antony, apparently tried to revisit the methodology that resulted in the Rafale's selection in the first place—after cost negotiations had already begun. That was the clearest indication of both a flawed procedure and a political attempt at second-guessing the IAF's technical judgment. But no exit from the impasse could be found.[49] Other complications also unhelpfully intervened: Dassault Aviation balked at plowing back 50 percent of the total costs as direct offsets, assuming the risks of co-production with Indian public sector partners, and transferring technology at the levels demanded by India—all requirements stated in the IAF's original request for proposals.

None of this should have come as a revelation. Information about the Rafale's high unit costs was freely available in the trade literature. And common sense at any rate should have suggested that amortizing the huge development expenditures—running into many billions of dollars—of a sophisticated fighter such as the Rafale over a very small number of platforms would have driven up the unit costs tremendously. Because Dassault Aviation is a relatively small original equipment manufacturer in the global fighter market, the unit costs of its aircraft are on average much higher than, for example, those of its American competitors with their larger production runs. Higher unit costs usually imply fewer sales; fewer sales imply less revenue; and less revenue, in turn, implies a greater unwillingness to part with the already modest profits by accepting higher offset obligations, assuming greater product liability, and transferring maximal technology.

The IAF, obviously, should have known all this before the MMRCA competition was initiated. But its desire for the latest and most aerodynamically agile airplane of known pedigree, combined with the Indian government's two-stage procurement procedure, permitted the service to downselect the two most expensive contestants at a time when cheaper alternatives would have enabled it to buy multirole fighters that were just as good, while saving resources to enable the transition to a fifth-generation combat force.[50]

In any event, the IAF unfortunately will soon have to cope with the challenge of integrating another small contingent of 36 Rafales in what is already an overdiversified fighter force, one that now includes a medium-weight segment in addition to the lightweight and heavyweight components acquired previously. Make no mistake: the Rafale is a superb multirole fighter that is still in the early stages of what will be a long, thirty-year operational life. Although it lacks an AESA radar and its MICA-series (the French acronym for interception, combat, and self-defense missile) air-to-air missiles are most capable at shorter ranges compared with similar U.S. and Chinese weaponry, these limitations will be rectified at some point. The French Air Force and French Navy, for example, are beginning to field a new AESA radar, the RBE2, on their Rafales, and it is likely that the Indian aircraft also will be equipped with a variant of this system.[51]

The IAF unfortunately will soon have to cope with the challenge of integrating another small contingent of 36 aircraft in what is already an overdiversified fighter force.

Mitigating the Rafale's heavy maintenance burdens will be more challenging, but Dassault Aviation historically has always come through where spare parts and depot-level support are concerned, albeit at a high price. The enormous costs of support seem to be preventing the Indo-French negotiations for the 36

aircraft from coming to closure, and while it is likely that the impediments will eventually be resolved, nothing will change the fundamental realities about the Rafale's high unit and life-cycle costs.[52]

This fact notwithstanding, when the envisaged upgrades are completed, the Rafale, an already impressive combat aircraft, will become even more imposing in its F3R variant, thanks to its superb sensor fusion and targeting capabilities, formidable defensive avionics, highly effective swing-role performance, and reduced radar signatures.[53] Beyond the nagging doubts about whether Dassault Aviation can quickly deliver the 36 aircraft contracted because of the limitations in its manufacturing capacity, the Rafale's biggest handicap obviously is its horrendous break-the-bank price.

Recent information suggests that the aircraft's unit costs have been negotiated to around $220 million, a reduction from the earlier price tag of approximately $300 million that killed the original MMRCA program, but still high nonetheless.[54] The most authoritative information available in the Indian press indicates that the total program costs of procuring 36 Rafales will be about $9 billion—close to one-fourth of India's 2015–2016 defense budget. If the Modi government's earlier allocation of $4.7 billion for the aircraft alone is any indication, the unit flyaway costs of the Rafale would still be remarkably high: about $131 million per aircraft in comparison to, for example, about $75 million apiece for a U.S. F/A-18E/F Super Hornet in 2014.[55] With support and other costs thrown in, the Rafale ends up closer to $250 million each.

ALTERNATIVES BEYOND THE RAFALE

Despite these sobering numbers, it would be a blessing if, deus ex machina, the IAF could somehow lay its hands on 90 more Rafales, because such an addition would mitigate its problems of a diverse inventory while at the same time increasing its combat capabilities considerably. Unfortunately because of the costs involved, this option appears unavailing. And the government of India, at any rate, has cast its net wide, seeking to procure the remaining 90 fighters from among any of the original contestants in the MMRCA competition. By all accounts, the Indian defense minister seems to believe that all these rival aircraft are more or less comparable in capability,[56] and hence he is focused on an acquisition that prioritizes low unit and life-cycle costs, transfer of technology, and above all the Make in India program. In fact, the cheapest airplanes that can be co-produced in India appear to be the object of the current search because these twin objectives simultaneously satisfy the nation's budgetary constraints and its industrial policy goals.

While the IAF is sympathetic to these objectives, it understandably has other interests as well: it still seeks the best multirole aircraft that the treasury can afford, but above all it wants the impending acquisition to support the indigenous development of the Advanced

Medium Combat Aircraft (AMCA), a stealth fighter that the service hopes will become the medium-weight mainstay of the IAF beyond 2025.

Satisfying these criteria will take the Indian Ministry of Defense over the terrain already plowed during the MMRCA competition. The MiG-35 would still be a poor choice because the IAF is adamant—and for good reason—that it needs a new line of Western equipment as a technological hedge, given the prevailing dominance of Russian fighters in the IAF. Furthermore, only Western aircraft can provide the IAF with the advanced counters required to cope with the Russian platforms, sensors, and weapons now appearing in the air forces of its adversaries.

The Typhoon would obviously meet this criterion, but its high unit costs place it in the same unfavorable position as the Rafale. What is equally problematic is that the Typhoon, although impressive for its acceleration, supersonic maneuverability, and high top speed, now lags behind the Rafale where new sensors and the diversity of weapons carried are concerned. This failure to maintain its originally intended schedule of improvements is partly due to its poor sales record abroad, its divided governmental sponsors and service customers, and the competition posed by the F-35, which has also been sought by many of the same European air forces now flying the Typhoon.[57] Finally, the Eurofighter consortium that makes the Typhoon has no experience in developing fifth-generation stealth aircraft and, consequently, its value to the IAF's AMCA program is minimal.

That leaves the Gripen NG, the F-16IN, and the F/A-18E/F Super Hornet as possibilities, and each has different strengths and weaknesses. The Gripen NG will be an impressive aircraft when operational, but even when it becomes mature technologically, it would remain a lightweight rather than medium-weight fighter. This is not necessarily a disadvantage, because the F-16IN is similar in this respect. The F-16IN is actually two aircraft in one, depending on its configuration. Without conformal fuel tanks, it remains one of the most agile air combat aircraft ever built, and its primary sensors and weapons outclass even those of the Gripen today. It will likely be cheaper than the Gripen, and although the version offered to India is far superior to that operated by Pakistan, the IAF still has reservations about acquiring an airplane that is in Islamabad's inventory. Nonetheless, the manufacturer, Lockheed Martin, is committed to transferring the entire F-16 production line to India if the aircraft is selected for procurement. This provision makes the F-16IN extremely attractive as a project for the Make in India program—an offer that rivals Saab's in this respect.[58] Beyond that, the prospect of helping to service the thousands of F-16s still operational worldwide would instantly make India pivotal to the global aviation supply chain, while ironically putting it in the odd position of possibly having to support future aircraft sales to its rival, Pakistan.

Boeing's F/A-18E/F Super Hornet, in contrast to the Gripen NG and the F-16IN, is a twin-engine, medium-weight aircraft and a formidable strike fighter whose greatest strengths lie

in the surface attack and beyond-visual-range air-to-air missions. Because the Super Hornet will continue to equip the U.S. Navy's carrier air wings until at least 2035, it is unlikely that Boeing's co-production offers for this aircraft would match those of Lockheed Martin's F-16IN for reasons relating to both corporate strategy and U.S. governmental restrictions. Even so, any manufacturing related to the F/A-18E/F Super Hornet in India would create new opportunities to build a network of secondary and tertiary suppliers, thus increasing India's integration into the international aerospace industry while simultaneously enlarging its industrial base.[59] The fact that the Super Hornet's costs are likely to be comparable to the Gripen NG should only make it more attractive to India's Defense Ministry from a financial point of view. And, finally, selecting the Super Hornet offers a further benefit: it opens the door to the Indian Navy acquiring and operating the same aircraft on its next-generation large-deck aircraft carriers.

All three aircraft, then, would satisfy India's cost constraints; all three are highly capable multirole fighters; all would surpass the IAF's expectations for advanced technology to counter its rivals; all will continue to enjoy growth potential, at least where their avionics and weapons complements are concerned; and all three can also be manufactured in India, with Saab and Lockheed Martin likely being more flexible than Boeing on this score. Only the two U.S. primes, however, have a clear edge where the rapid production of the fighters is concerned—an issue that should be of importance to the IAF but is perhaps not of equal urgency to the government of India.[60] As far as program costs and operational effectiveness are concerned, therefore, any of these three fighters would fit the bill, though if the Gripen NG is selected, the Indian government would in effect be jettisoning the medium-weight component of its air force in favor of a functional mix of mainly light and heavy aircraft.

TECHNOLOGY TRANSFER AND THE AMCA PROGRAM

Irrespective of the finalist chosen, then, the big imponderable remains technology transfer. If the Indian government and the IAF expect that co-production in India will automatically translate into a "full" divestiture of critical technologies in materials, sensors, weaponry, or software code—as opposed to production line capacities—they are likely to be disappointed.

The same goes for expectations of assistance in regard to stealth technology. Of the three original equipment manufacturers under consideration, Lockheed Martin, having been the prime contractor for both the F-22 and the F-35, possesses the deepest experience where comprehensive fifth-generation fighter aircraft design is concerned. Boeing also plays in this game, as demonstrated by its collaboration with Lockheed Martin on the F-22 and its experience in designing Joint Strike Fighter prototypes. Saab comes in a poor third where stealth is concerned: although the Gripen NG will have extensive radar cross-section reduction treatments, no European manufacturer has the capacity to design a sophisticated fifth-generation fighter with organic stealth capabilities.[61]

If it is therefore assumed that the Lockheed Martin proposal has an edge at least where future support for the IAF's AMCA program is concerned, Indian decisionmakers should think again. Despite Lockheed Martin's ample experience in designing and manufacturing stealth fighters, this expertise is tightly controlled by the U.S. government. Any assistance from an American company for the AMCA effort will therefore have to be negotiated subsequently by the two governments, and the record thus far has not been promising.

The South Korean KF-X program is a great case in point: The Republic of Korea, a close ally of the United States, set out in 2002 to build its own stealth fighter, similar to what India proposes to do through its AMCA program. Lockheed Martin was expected to support this endeavor as part of a package deal that involved the South Korean purchase of 40 F-35 Lightning stealth fighters. Although the company agreed to provide assistance within the limits of its commercial interests, the U.S. government has refused to transfer four critical technologies—the AESA radar, electronic-warfare systems, infrared search and tracking capabilities, and targeting pods. And it is still unclear whether Washington will permit integration of the 21 other technologies approved for transfer with the South Korean, European, or Israeli alternatives now being considered.[62]

The moral of the story should be clear: stealth technology remains among the most tightly controlled American capabilities because of both the clear combat edge it provides and the huge U.S. lead in this area. Any expectation that the AMCA program would therefore be able to access American expertise merely because India purchased the F-16IN earlier would prove to be unfounded. This does not constitute an argument against the purchase of the F-16IN, which is a formidable combat aircraft available at a great price and that would make India a significant player in the international aviation market. But it does require the IAF, and the Indian government more generally, to think carefully about the character of the AMCA program—because the alternatives here are fraught.

Clearly, the IAF needs a stealthy fifth-generation follow-on fighter if it is to cope successfully with the Chinese J-20 and J-31, at least one of which is poised to enter the People's Liberation Army Air Force (PLAAF) early in the next decade. The Indian effort at cooperating with Russia to develop a heavy stealth platform, the PAK-FA (Perspektivny Aviatsionny Kompleks Frontovoy Aviatsii), is in trouble and hence the need for the AMCA, a medium-weight alternative, becomes more urgent. The AMCA would have been essential even if the PAK-FA program had proceeded swimmingly because the steady shift toward fifth-generation combatants implies that the IAF would eventually need stealth fighters in both weight classes. The imperative of not simply having a large enough air force but, more important, possessing an air arm with the largest proportion of sophisticated aircraft makes the case for a second stealthy fighter more compelling. But the Russian experience thus far should reinforce the point that all foreign manufacturers, not just American, would be very loath to part with their stealth technologies, at least for the foreseeable future and not until more revolutionary cloaking capabilities, such as free space plasma, become fully mature.

Although India has boldly displayed models of a future AMCA design that includes a highly shaped fuselage and planform, the country's capacity to build a fifth-generation fighter indigenously from scratch is actually nonexistent.[63] India has, no doubt, been developing bits and pieces of stealth-related technology, pursuing research in areas such as low probability of intercept radars, radar absorbent coatings, canopy treatments, conformal antennas, and engine masking, but Indian aircraft designers are still not capable of producing those organic stealth designs that integrate highly shaped airframes, enclosed engines, embedded sensors, internal weapons, and low-emission radars in a unified package.[64] India's choices, then, consist of attempting to develop such capabilities domestically, with foreign assistance whenever possible, or simply purchasing complete stealth fighters from any willing sellers. Russia has already agreed to sell the PAK-FA to India, and the United States is open to entertaining Indian requests for the F-35, but neither country is likely to help India to develop indigenous stealth technologies—any protestations to the contrary notwithstanding—for understandable national security reasons.

Consequently, the IAF is faced with the choice of accepting an indigenous product that is likely to be inferior in combat capability or purchasing a cutting-edge stealth fighter that will advantage it in conflict but will provide few benefits in terms of technology transfer and could come with significant technology security protection obligations. If India chose the latter route, the U.S. F-35 would be a perfect fit for the AMCA requirement: the unit costs of the aircraft have already come down to somewhere in the region of $100 million apiece, rivaling the Rafale, and the U.S. Air Force variant in the eighth low-rate initial production lot is targeted at $95 million each. The F-35's stealth, sensors, and weapons are unmatched in the air-to-ground role for which it is optimized, and its extremely low frontal signatures give it immense advantages in the air-to-air role as well. Finally, the aircraft's overall worth seems to be confirmed by the international aviation market, since F-35s are expected to constitute more than 60 percent of all the new Western combat aircraft sold during 2016–2020—a trend that is likely to persist as the aircraft is further upgraded over time.[65]

None of this may prove to be sufficiently persuasive to the IAF or to the government of India, given their deep-rooted desire for an indigenously produced follow-on medium-weight stealth fighter. But that only deepens the old dilemma confronting the air service: how does it balance the national (and sometimes its own) demand for self-sufficiency with its imperative for operational superiority over its adversaries? If the inclination to produce a stealthy AMCA indigenously wins out, India would enjoy some technology gains overall, but the end product is likely to resemble a Tejas redux.

Successfully building a stealth fighter requires an enormous depth of research and design expertise—not to mention excellence—in diverse areas, such as materials, electronics, and engine technology. It also entails possessing deep experience in systems integration, a capability developed only though the clear and uninterrupted progression of ever more complex aircraft production programs, in addition to nurturing highly specialized capabilities in the

specific technology areas required to produce a platform that synergizes very low observable stealth with advanced fighter performance. And it imposes extraordinary demands on manufacturing capability because stealth aircraft are fabricated to incredibly tight tolerances in the face of finicky materials and difficult geometries, not to mention the high maintenance demands that inevitably follow.

India's record on all these counts is not impressive—and that is putting it charitably. Consequently, the expectations entertained in the Indian defense research and development establishment about its ability to produce not simply a stealth combatant but one that can overwhelm comparable adversaries in combat are likely to fall terribly short, with disastrous consequences for the air force. If, after all the effort and investment, India finally manages to produce indigenously nothing more than an expensive but substandard stealth fighter, the national gains in technology progression will not have been worth the cost in potential losses of lives and material in combat. Given these realities, the Indian government ought to consider carefully the strategy underlying its AMCA program. It should start by honestly assessing what any foreign partnership might provide in support of its goal of building an advanced stealthy platform. Then it must consider whether the IAF—and the nation at large—is better served by the outright purchase of a capable combatant or yet another Sisyphean effort at producing an anemic simulacrum at home.

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Pretending that the advent of counterstealth capabilities would free the Indian government from making a choice here is not tenable either. For starters, it is simply not clear whether the current efforts at detecting stealth aircraft will succeed. Even if they only progress, it implies that the competition between stealth aircraft and counterstealth capabilities will further intensify, leaving nonstealthy combat aircraft at a distinct disadvantage when facing stealthy adversaries. Consequently, the IAF will have to move toward acquiring stealth fighters at some point—especially as the Chinese J-20 begins to enter the PLAAF in substantial numbers—with the only question being whether India acquires superior counterparts from a foreign source or settles for inferior combatants developed indigenously.

THE HEAVYWEIGHT COMPONENT

THE Su-30MKI

Until very recently, this quandary did not implicate the heavy segment of the Indian Air Force (IAF). Recognizing the necessity of acquiring the most sophisticated fighters possible to service the objective of maintaining regional air dominance, India simply ordered the first batch of 40 Su-30MKIs (a variant of the Su-27K) in 1996 as a prelude to the eventual, phased assembly of the Su-30MKI at home. The importance of possessing a high-end multirole fighter that was superior to the Chinese Su-27 and Su-30MKK variants then entering Beijing's inventories did not leave India the choice of cobbling together a homegrown alternative. The imperative of ensuring that its numerically smaller high-end segment would yield disproportionate operational benefits compelled the IAF to develop specifications for what would be, until the advent of the Su-35S, the most advanced Flanker design anywhere in the world. This Su-30MKI standard would incorporate Western and domestic components and be assembled in India under license from the Russian Sukhoi aircraft manufacturer's Irkutsk division.

As of 2016, the Su-30MKI is the largest single aircraft type in the IAF's inventory after the MiG-21, equipping ten squadrons and likely to further increase somewhat in number over time. The aircraft is a heavy multirole platform, capable of performing diverse missions

such as air superiority, surface attack (to include nuclear delivery and the suppression of enemy air defenses), escort jamming, buddy refueling (thanks to a huge 9,400-kilogram internal fuel capacity), and theater reconnaissance. The Su-30MKI's excellent integrated avionics, consisting of the N001M passive electronically scanned array radar, the decent but not superlative OLS-30 infrared search and track system, and a sophisticated defensive avionics suite (which incorporates an Indian radar warning receiver and an anti-radiation missile targeting system), along with other supplementary subsystems, gives the aircraft a substantial first-look advantage over its Chinese counterparts and any Pakistani opponents it may encounter.[66]

This edge may not always translate into first-shot leverage, because the aircraft's principal beyond-visual-range air-to-air missile, the active radar-guided AA-12 ADDER, has a shorter maximum kinematic range than either the Chinese PL-12 or the U.S. Advanced Medium Range Air-to-Air Missile. Still, the IAF calculates that the Su-30MKI's thrust-vectoring engines and its pilots' superior training and resultant air combat proficiency, in combination with the formidable SAP-14/SAP-518 self-protection/escort jamming systems, would allow the aircraft to deny its opponents a hard kill while closing range with them sufficiently to enable the effective use of its own air-to-air missiles. Because the SAP-14/SAP-518 jammers constrain the aircraft's aerodynamic performance in many ways, the IAF has often used the EL/L-8222 self-protection jammer with the Su-30MKI, while continuing to look for smaller, but more advanced, systems. The aircraft's overall capabilities also enable it to be used for cooperative targeting, in which some fighters illuminate the opponent while other, unseen, cohorts fire their missiles from radically different headings or altitudes, or for passive targeting, in which the Su-30MKI fires its missiles based on track data generated by the nonradiating infrared detection sensor on board. The heavy and diverse payload the Su-30MKI is capable of carrying, its excellent self-defense capabilities, and its extended operating radius thus make it a superb strike fighter capable of carrying out a range of offensive and defensive missions—both air and surface—either in small formations or in larger force packages.

The IAF's decision to invest in a large number of Su-30MKIs as the mainstay of its heavyweight end was undoubtedly a smart one, as it enabled the service to enjoy substantial technological advantages over its immediate adversaries while reducing the numerical edge otherwise enjoyed by China in respect to the fourth-generation and beyond combatants in its inventory. Not surprisingly, then, the Su-30MKI has developed a devoted following both in and out of the IAF, and many prominent Indian commentators have often argued that the service ought to acquire even more such aircraft in lieu of the expensive Medium Multirole Combat Aircraft (MMRCA) component with the eventual goal of moving toward a simple high-low mix of two or, at most, three kinds of air defense/multirole aircraft (Su-30MKI and Tejas, supplemented perhaps by the MiG-29s or Mirage 2000s) in the force. The fact that the unit flyaway cost of the Su-30MKI is relatively low makes such invocations seem more reasonable.[67]

For all its virtues, however, the Su-30MKI also has some shortcomings that have made the IAF leery of pursuing a substantial expansion beyond the planned force of 272 aircraft (approximately thirteen squadron-equivalents eventually). For starters, the aircraft are not as inexpensive as is often imagined. Although the unit flyaway cost of the Su-30MKI—estimated at anywhere from $45 million to $95 million—is cheaper than that of many aircraft of comparable capabilities, its maintenance and life-cycle costs are enormous, in fact much higher than similar Western aircraft.[68] This burden is compounded by the necessity of having to import all the major components and associated raw materials from Russia, which, as all the Indian armed forces can attest, has never been a reliable supplier of after-sales parts and services. In this regard, the Su-30MKI is no different from other Russian-origin aircraft: the mean time between the failure of its key subsystems is much lower than that of its Western counterparts, with its engines and its avionics proving particularly burdensome. This lowers the aircraft's readiness rate on any given day while raising its life-cycle costs considerably, which even in the normal course usually dwarf the original unit cost of the fighter itself.

The poor quality of the aircraft assembled at Hindustan Aeronautics Limited only exacerbates this problem: the Indian-built fighters cost more than those directly imported from Russia, and the standard of manufacturing at the Nashik plant is poor. That reality should give some pause when the more ambitious plans for building stealth aircraft domestically are bandied about.[69]

Not surprisingly, then, the Su-30MKI has become a hangar queen in recent years. In a scathing 2015 report, the Comptroller and Auditor General of India, the national statutory auditing body, found that the aircraft's overall availability rate hovered at 55–60 percent against the desirable level of at least 75 percent. Significant failures were identified in its engines, flight control systems, and defensive avionics that led to reduced monthly flying hours and, by implication, lowered combat readiness.[70]

During Indian Prime Minister Narendra Modi's December 2015 trip to Moscow, the problems of Russian after-sales support was high on the agenda. Although the visit concluded with several agreements intended to resolve those issues, only time will tell whether the remedies supposedly put in place will improve the IAF's Su-30MKI squadrons' in-service rate compared to past norms.[71] Given the historical record, however, it is not surprising that the IAF is wary of pursuing a runaway expansion of the Su-30MKI force, even though the aircraft itself is highly valued for its capabilities as an air dominance platform. Because the only useful fighters for a combat force are those that can actually get airborne on any given day, the IAF would still prefer to fill out its MMRCA contingent with an advanced Western platform whose reliability and sophisticated sensors and weapons provide not only insurance against the possibly reduced availability of the Su-30MKI but also a technological hedge when facing opponents that increasingly operate similar Russian-origin fighters and weapons.[72]

THE CHINA COMPLICATION

The latter challenge has suddenly become more acute for the IAF. Russia has maintained a substantial arms sales relationship with China for many years—a partnership fueled equally by the economic necessity of securing Chinese revenue to sustain Moscow's defense industrial base as it is by the political objectives of thumbing Russia's nose at the United States, maintaining influence in important regions of interest, and pursuing Moscow's ambitions as a great power.

But all the while, Russia's security managers traditionally were careful never to sell Beijing their best military equipment.[73] This reluctance was motivated partly by the still strong residual suspicions of China as a long-term strategic threat to Russian interests and partly by the justified fears of Beijing's terrible record in regard to protecting Russian intellectual property as far as defense equipment was concerned. After all, China's blatant reverse engineering of the Su-27 to produce the J-11 now in the People's Liberation Army Air Force (PLAAF) inventory, along with various other engine, sensor, and weapon systems, provided ample reasons to give Moscow pause when Chinese requests for the most advanced Russian weapons came over the transom.[74]

The traditional Russian disinclination to sell China its best weaponry served India well insofar as it enabled New Delhi to field certain cutting-edge capabilities—even if only in smaller numbers—that enhanced its security vis-à-vis Beijing. Maintaining India's advantage in this way was supposed to be one of the cornerstones of the Indo-Russian strategic relationship, the other being Moscow forswearing an arms relationship with Pakistan. For almost two decades now, the Su-30MKI represented the best manifestation of the Indian understanding that Russia would not arm China with combat capabilities superior to those transferred to India. The Su-30MKI possesses superior aerodynamic maneuverability, more advanced sensors and defensive avionics suites, and better electronic attack capabilities than either the Su-27 or the J-11, making it highly effective against those fighters in the Chinese inventory.

This advantage has now been whittled away as Russia seems to have resolved its old dilemma—"arming China or arming India,"[75] as the political scientist Thomas W. Zarzecki once phrased it—largely in favor of the former. This conclusion, which has been defended articulately by the foreign policy researchers Stephen Blank and Edward Levitzky in a 2015 essay, bodes ill for New Delhi.[76] Together with Moscow's recent overtures toward Islamabad, it appears to be corroborated by the latest $2 billion Russian sale of 24 Su-35Ss to China.[77] The Su-35S is a dramatically improved version of the Su-30MKI: it incorporates new upgraded thrust-vectoring engines, a new flight control system, and a new Irbis-E state-of-the-Russian-art passive electronically scanned array radar coupled with all new secondary sensors. It also has increased fuel carrying capacity and focused radar cross-section reductions.[78] All told, the Su-35S represents a substantial upsurge in PLAAF capabilities, and as a weapon system it simply outclasses anything the IAF has in its Russian-origin inventory today.

Obviously, 24 new Su-35Ss will not by themselves change the Sino-Indian air balance, but the sale presages a further deterioration in an already precarious equation because it is highly likely that China will pilfer key technologies pertaining to the AL-41F1S engine, the radar, and the other sensors and slowly incorporate them into its other combat aircraft, thereby raising their overall quality and effectiveness to India's further disadvantage.[79] Given these risks, Indian officials engaged their Russian counterparts in prior conversations seeking to ward off the sale. The fact that these parleys were unsuccessful only increases the operational burdens on the IAF at a time when the lightweight and medium-weight segments of the force are already struggling with issues of quality and diminishing numbers.

It is not surprising, therefore, that the Indian chief of the air staff, Air Chief Marshal Arup Raha, has insisted that the residual MMRCA segment be filled out not by more low-end Tejas fighters or more high-end Su-30MKIs but by advanced Western combat aircraft for all the reasons discussed earlier. As Raha has correctly argued, "It is important we have an MMRCA. I would not [necessarily] say Rafale, but we need to have [some equivalent] in the quickest possible time." Specifically addressing the possibility of acquiring additional Su-30MKI fighters in lieu of the MMRCA—a notion floated by Defense Minister Manohar Parrikar and advocated by some Indian defense analysts—Raha emphasized, "They are different types of aircraft and cannot replace each other; they only complement each other."[80]

Irrespective of how this debate is resolved in the future, it highlights the fact that even the heavyweight segment of the IAF—the one component that had always enjoyed technological and operational advantages over its regional rivals—is not free of afflictions. At the very least, therefore, the IAF will need to upgrade its Su-30MKI force much faster than it might have done otherwise, perhaps beginning the process even before all 272 aircraft have entered squadron service. Given the latest Russian sale of the Su-35S to China, the IAF's incorporating a new radar, new defensive avionics, and in general upgrading the Su-30MKI's fire control system, as well as fielding newer Russian active radar-guided air-to-air missiles, such as the AA-12 ADDER follow-on weapons being developed for the PAK-FA, might prove to be more urgent than initially imagined.

PROBLEMS WITH THE PAK-FA

Even as the Indian air arm considers the improvements necessary to preserve its operational edge where the Su-30MKI force is considered, it still has to figure out its options with respect to its other major heavyweight investment, namely, its participation in the Russian fifth-generation PAK-FA fighter program (dubbed the Prospective Multirole Fighter by the IAF). India and Russia had signed an intergovernmental agreement to co-develop and co-produce the Sukhoi/Hindustan Aeronautics Limited PAK-FA in 2007: the agreement included an Indian contribution of $295 million toward preliminary design work, an understanding that India would receive 25 percent of the workshare (in exchange for

eventually contributing 50 percent of the program development costs, then estimated at $10.5 billion), and a preliminary commitment by New Delhi to order 214 aircraft (some ten squadrons' worth consisting of 166 single-seat and 48 twin-seat fighters) when the final, mutually agreed design entered production.[81]

The discussions that led up to this agreement began in 2002 when Sukhoi urgently needed resources to develop a fifth-generation fighter that would enable the Russian aviation industry to compete with the U.S. F-35, since matching the U.S. F-22 Lightning was judged to be beyond reach in the near term. The aim of challenging the F-35—then, and still, the market leader among stealth fighters—would shape both the PAK-FA design and the economics of the program, with future consequences for Indo-Russian collaboration. The logic of an Indian partnership with Sukhoi was impeccable, from New Delhi's point of view. Even if the Su-30MKI had been an entirely trouble-free aircraft, the IAF would have still needed a fifth-generation follow-on fighter, given that its most challenging adversary, China, was already simultaneously pursuing two stealth programs, the J-20 and the J-31. The prospect of collaborating with Sukhoi on the PAK-FA, then, offered India the promise of quickly adding an advanced stealth fighter to the IAF inventory, acquiring expertise in stealth fighter design (which New Delhi intended to apply toward the development of its own indigenous Advanced Medium Combat Aircraft, or AMCA), and co-developing a platform that would also be tailored to India's own unique requirements. Of special interest to India was the twin-seat configuration that would enable the IAF to implement its "mission commander" concept developed in the context of Su-30MKI operations, while sharing the higher cockpit workload that was likely to materialize in more complex warfighting scenarios.

Unfortunately for the IAF, Sukhoi appeared to have had other ideas. It needed Indian resources, but not much else; accordingly, it went ahead with its PAK-FA development activities more or less independently. This was only to be expected because the systems engineering design had been completed well prior to the 2007 intergovernmental agreement—a fact confirmed by the initial taxi tests of the first prototype occurring barely two years after the bilateral accord was concluded. Given Sukhoi's decadelong work on the PAK-FA even before the first Indo-Russian conversations in 2002, it should not have been surprising that by the time India entered into the co-development effort, so much of the preliminary work was well under way. Namely, the PAK-FA's basic design had been validated and frozen, the construction of the early prototypes had begun, the AL-31F thrust-vectored supercruising engine was almost ready for integration, the active electronically scanned array (AESA) radar was in laboratory development, and the first flight test of the initial prototype was only three years away. India's contribution to the program, accordingly, was destined to be minimal—an outcome made certain by the fact that India's expertise in the functional areas that distinguish a fifth-generation platform—stealth shaping, supercruise propulsion, airframe embedded sensors, and network-centric warfare—are at best modest.

For all these reasons, the joint development of the PAK-FA never finally materialized in the ways that India sought since the earliest conversations in 2002. This, in turn, raises the obvious question of whose fault it was: Sukhoi's for being disingenuous from the beginning, or the IAF's for being blind to the obvious? At any rate, unilateral Russian decisions later to reduce the Indian workshare to 13 percent, reciprocated by the Indian decision to reduce the initial order from 214 aircraft, including 48 twin-seat fighters, to just 127 single-seat aircraft, only added to the mutual discomfort with the program and the real risk that India's larger access to the PAK-FA might itself be imperiled. Prime Minister Modi's December 2015 visit to Moscow appeared to salvage the collaboration but on radically different terms from those originally envisaged: apparently, India will now contribute $3.7 billion for the technological know-how and for three prototypes of PAK-FA fighters, presumably in support of future assembly of the aircraft in India.[82]

The IAF, it appears, is still uncomfortable with the PAK-FA because of its conviction that, among other things, the aircraft's supercruise engines and its stealth capabilities do not match those of the best Western airframes.[83] On both counts, the Indian air arm is correct, but especially where low observability is concerned, it ought to be recognized that Sukhoi had never set out to develop an ultra-stealthy aircraft like the U.S. F-22. Its ambition was to create a "balanced" design, with maximum attention paid to reducing the aircraft's frontal (vice the all-azimuth) radar cross-section and incorporating other fifth-generation features, such as supercruise engines and airframe embedded sensors. Most important, however, the Russians sought to develop a fighter that would incorporate broad—but not necessarily matchless—performance improvements combined with maximum cost control because of their benefits for penetrating a stealth fighter market that was already dominated by the F-35 in the West. The radar cross-section reduction goals of the PAK-FA program were consequently kept relatively modest, and the company was content to wait for maximum non-afterburning performance to arrive with the follow-on engine that is intended to replace the AL-31F.

The IAF's failure to appreciate Sukhoi's intentions, both technological and programmatic, thus led to its frustrations with the PAK-FA project, but it would still be a mistake for the service to reject the aircraft out of hand. Of the three non-Western stealth fighters out there—the PAK-FA, the J-20, and the J-31—the PAK-FA is certain to be the stealthiest, even if not by an order of magnitude, and will carry far more capable air-to-air and air-to-ground weapons than its Chinese counterparts. Since the IAF needs a fifth-generation fighter in its inventory to cope with the emerging Chinese capabilities, it would behoove Indian defense planners to avoid foreclosing the option of acquiring the PAK-FA in the future. Thus far, the IAF has been a tad cavalier: noting that the PAK-FA is a fifth-generation fighter aircraft (FGFA), Air Chief Marshal Raha declared, "If the FGFA [PAK-FA] comes through it is fine, otherwise the Indian FGFA—that is the AMCA, the advanced medium combat aircraft—we still have over 15 years to work on it before the MiG-29 upgraded

aircraft retire, before the Mirage 2000 upgraded ones retire, as well as Jaguar upgraded ones retire in another 15 years."[84]

While this cold shoulder is understandable, the calculation it conveys hinges heavily on the assumption that India will be able to develop the AMCA with operational capabilities that exceed both the PAK-FA's performance specifications and its cost. At least where the former is concerned, the Tejas experience does not offer many consolations. And while the IAF and the Defense Research and Development Organization have certainly learned from that experience, developing the AMCA will be far more challenging because it is intended to deliver a genuine fifth-generation combatant with advanced subsystems of the kind that India, at least thus far, has demonstrated no capability to produce indigenously. Some form of collaboration with a Western prime contractor or falling back on the PAK-FA technological know-how acquisition may thus turn out to be the only recourse, with the prospects for the former quite uncertain because of larger governmental constraints on the transfer of stealth capabilities.

All told, then, it would be quite unfortunate if the future of the IAF's heavyweight combat segment were to be placed at risk by an Indian decision to reject the acquisition of the PAK-FA when the prospects for its AMCA ambitions are still fundamentally unproven. The health of the heavyweight segment matters more than ever today because it remains the one component of the force that can compensate for the many operational limitations of the lightweight combat squadrons and, depending on which aircraft is selected for the residual MMRCA requirement, might have to back up many medium-weight combatants as well. Given the unfavorable trends overall in the regional air balance, putting the IAF's heavyweight component at risk would be a fateful blunder for both the Indian air service and the nation at large.

THE IAF'S STRENGTHS

While this discussion indicates that even the strongest component of Indian airpower faces considerable present and future risks, the strengths of the IAF cannot be overlooked. For starters, the professionalism, quality, and training of its pilots are simply superb. As numerous exercises with foreign air forces have revealed, the air combat skills of its fighter pilots now compare favorably with those of most first-world air forces. IAF pilots, especially in the elite squadrons, put in flying hours that match those in the West. They are proficient in basic fighter maneuvering and train in diverse formations and packages in both the aerial- and surface-attack regimes. They are aggressive and adaptable, and for the most part today they can—at least in squadrons flying advanced fighters—operate with minimal ground control intercept support. Yet, they are still not as proficient as their best developed country counterparts in all air warfighting regimes and in many cases still do not use their advanced

fighters to the limits of their capacity. These deficiencies, however, will disappear over time as the IAF exercises more extensively with its foreign counterparts and as it develops the tactics, techniques, and procedures that will enable it to exploit the new technologies entering the service.

Beyond pilot proficiency, the IAF is advantaged by its heavy emphasis on electronic warfare. This competency is shared by few of its peers outside the West, Russia, and China and was first revealed to the United States during the Cope India 04 air exercise when IAF pilots used their EL/L-8222 jamming pods to great effect.[85] The IAF continues to invest heavily in airborne electronic warfare, nurturing a substantial domestic development program while partnering with Israel, Italy, and Russia to acquire a variety of advanced podded and internal electronic warfare systems for all of its combat aircraft. The profusion of electronic warfare capabilities throughout the force has permitted it to maintain its confidence about defeating even the longer kinematic-ranged weapons in its adversaries' arsenals: by denying enemy fighter radars the ability to produce weapons-quality tracks at their longest detection ranges or by generating deceptive cues that induce enemy weapons to lock on to false targets, IAF fighters expect to close in to their targets unscathed until they can be attacked with their own, often shorter-ranged, weaponry. All IAF fighter training now includes extensive use of electronic warfare assets, and the best aircraft in the force are capable of utilizing advanced techniques such as jam-and-shoot besides being able to conduct a modest level of standoff jamming as well.

What especially enhances the IAF's warfighting advantages is the presence of its combat support capabilities, especially space-based imagery and communications assets, air refueling tankers, airborne intelligence, surveillance and reconnaissance platforms, and airborne early-warning and control aircraft. Unfortunately, none of these systems exists in sufficient numbers, both in absolute terms and relative to the IAF's operational needs. When the service has attempted to correct the deficiency in numbers, however, it has succumbed to its old failing, namely, increasing the diversity of aircraft types despite the common mission. Thus, for example, the IAF is likely to end up with two types of aerial tankers and two types of airborne early-warning aircraft, even though these contingents will remain on balance small in numbers. There are also some other conspicuous gaps—the absence of a dedicated standoff jamming aircraft will be particularly significant, primarily in the context of warfighting contingencies involving China.

Despite these shortcomings—which should be corrected purposefully—the great strength of the IAF's combat support aircraft is their quality, and the service's A-50E/I airborne early-warning and control system represents the perfect exemplar. Although the Indian defense specialist Bharat Karnad has charged that the Indian A-50E/I "is 30 percent less powerful compared to a similar item with the Chinese Air Force"[86] (presumably the KJ-2000 MAINRING), this claim is questionable. The surveillance capabilities of the two aircraft are at worst comparable, with the Indian version—which carries the Israeli PHALCON

radar as opposed to the supposedly indigenous variant on the Chinese aircraft—possessing some advantages. And the Indian airframe is actually superior, with its better turbofan engines enabling higher operating altitudes and longer unrefueled times on station.

The three Indian A-50E/I aircraft, however, are utterly insufficient relative to the IAF's needs, and, once again, India appears intent on diversifying the types of airborne warning and control system (AWACS) platforms it operates by adding less capable EMB-145 airborne early-warning platforms rather than simply acquiring the A-50E/I in larger numbers. It has been reported that the IAF intends to procure at least fifteen airborne warning and control systems by 2022. This objective is sensible, but the service should standardize its procurements and settle for large jet platforms because their higher operating altitudes provide them with a larger surveillance envelope, and they enjoy endurance advantages to boot.[87] The biggest limitations hampering the effective employment of AWACS capabilities in India currently are neither surveillance capabilities nor performance. What limits the AWACS's utility is the IAF's propensity to use the aircraft simply as a flying ground control intercept platform rather than as a full-fledged battle manager. It does that partly as a consequence of the absence of secure data links connecting the airborne sensor with all existing Indian fighters. And that, in turn, makes it important to complete the IAF's operational data link program and introduce AWACS operations into all IAF exercises, including those with foreign air forces. Because China, in particular, has undertaken huge investments in electronic attack directed at AWACS platforms, it is important that the IAF prepare for airborne battle management under contested conditions, a challenge that it can usefully train for in collaboration with its foreign partners, especially the United States.

Finally, what closes out the IAF's strengths is its excellent physical infrastructure. India possesses a very large network of airfields—more than 300 in number—some dating to the Second World War. These include everything from major operating bases managed by and exclusively for IAF use to joint civil and military use aerodromes to other small reserve airfields dispersed throughout the country. The IAF today routinely uses more than 75 airfields, including the austere advanced landing grounds in close proximity to the front, and nearly one-third of these facilities lie within 300 miles of the Chinese and Pakistani borders. The IAF, therefore, has a superb basing structure capable of supporting high-intensity combat operations with its two principal regional adversaries. Recognizing the growing threats, however, the service began several years ago an ambitious effort to modernize its airfield infrastructure. By upgrading some 30 IAF facilities in the first phase, followed by other IAF, navy, and coast guard airfields in the second stage, this renovation was intended to extend runway lengths to 11,000 feet, incorporate advanced radars and all-weather navigation equipment, and integrate automated air traffic management systems so as to permit flexible operations by all modern IAF fighters. In addition, civilian aircraft will be better supported in all joint use aerodromes, during day and night operations.[88]

This modernization will increase the IAF's effectiveness considerably: it will enable the force

to deploy squadrons flexibly as required by combat necessities, and it will enhance both survivability and force generation potential by enabling even diverse aircraft types to use common facilities capable of supporting all-weather operations. As this program continues toward completion, the IAF must now bring it to a logical conclusion by systematically improving the passive defenses uniformly at all its airfields, while upgrading the active defenses at the major operating bases. This will require ensuring that the modernized airfields have the requisite number of blast pens or aircraft shelters, that various types of petroleum, oil, and lubricants as well as munitions for diverse combat aircraft are available and stored underground, and that backups are available in case of damage to the primary command and control systems. Better active defenses, especially at the primary airfields, are also long overdue: the SA-3 and SA-8 systems traditionally used by the IAF for airfield defense are long obsolete, and the capabilities of the Akash, the indigenously developed medium-range mobile surface-to-air missile system, are suspect. Consequently, the replacement Spyder or Barak surface-to-air missile systems should be inducted expeditiously. The need to equip Indian air bases with new global positioning system jammers should also be considered, given the threats posed by coordinate-seeking weapons present in the Chinese and Pakistani inventories.

The Dedicated Ground Attack Force

Although air defense/multirole squadrons have traditionally formed the largest component of the Indian Air Force (IAF), the service has maintained, since at least the late 1970s, a substantial force of dedicated ground attack aircraft. The necessity for such specialized capabilities derived from the fact that third-generation and early fourth-generation combat aircraft were invariably optimized for either air superiority or surface strike. With the advent of new aerodynamic designs, advanced materials, digital flight control systems, and modern avionics, the distinction between the two roles has blurred, allowing new multirole fighters to perform both missions with more or less equal felicity. Because the IAF has always been, as former Air Chief Marshal S. Krishnaswamy once proudly declared, "a totally offensive force,"[1] maintaining a dedicated ground attack component prior to the arrival of the true multirole fighter was entirely logical, and, until recently, this segment was composed of MiG-23BNs, MiG-27s, and Jaguars, all acquired and operated primarily for air interdiction at the theater level.

The retirement of the MiG-series ground attack combatants has left the IAF with about five squadrons' worth of Jaguar interdiction-strike aircraft, a small number of which is committed to the maritime strike mission. Although these aircraft have been

in service since 1978, their airframes still have probably close to two more decades of life left. Consequently, the IAF has embarked on a substantial modernization program that involves upgrading the Jaguars with new avionics (to include an advanced multimode radar and defensive avionics suites), new mission computers, new multifunction head-up displays, new navigation systems, new hands-on throttle and stick controls, new air-to-air and air-to-ground weaponry, and new engines.

Unfortunately, this upgrade program—and especially installing new engines—has been subjected to interminable delays.[2] As Air Marshal (retired) B. K. Pandey ruefully noted, "Hopefully, the IAF does not end up in a situation where with its efforts to re-engine the Jaguar fleet not having fructified, it is compelled to adopt the . . . option of retiring the fleet prematurely. Given the debilitating bureaucratic and financial grip on the procurement process, this possibility cannot be ruled out at this point in time with any degree of certainty."[3] Even if Pandey's worst fears do not materialize and the upgrade is completed only a decade from now, as seems likely, the aircraft will have been modernized just when it was approaching the onset of its retirement—a deplorable ending to an effort that was intended to transform the Jaguar into virtually a new aircraft other than its airframe.

Even if this upgrade had been completed expeditiously, however, it still would not fill the gaping hole left in the IAF's surface strike repertoire. A deep-penetrating aircraft like the Jaguar is ideal for attacking high-value targets, such as air bases, command and control sites, logistics nodes, and transportation hubs, at great distances behind the front. But it is too expensive and not particularly optimized for providing close air support to ground forces that are already in contact with the enemy.

The IAF, like many other air forces, has never given close air support the priority it deserves. It has understandably been reluctant to commit its costly multirole aircraft for interdiction operations against an adversary's ground forces because of their vulnerability in the low-level attacks that are usually necessary for successful close air support. Instead, it has thrown into the fray its older air defense fighters, such as early model MiG-21s, whose intrinsic design and inability to carry the appropriate ordnance make them ill-suited for this type of combat.

The IAF has failed to invest in specialized close support aircraft—platforms that are designed to be survivable in the face of substantial ground fire, have high endurance that enables them to loiter "on call" in proximity to the forward edge of the battle area, are relatively slower speed but highly maneuverable to permit repeated turns on a fluid battlefield, are capable of carrying large ordnance loads designed especially to kill armored vehicles, and have the capacity for acute target discrimination, acquisition, and precision engagement.

More important, the IAF's failure to plan for successfully prosecuting the close air support mission leaves the Indian Army to fend for itself by using terrestrial firepower as a substitute for reliable IAF backup or by laying claim to possessing its own attack helicopters. The Indian government has now accepted the idea that the IAF's attack helicopter squadrons, which will operate the formidable AH-64D Apache, will be employed under the army's direction, but the deficits in close air support will nonetheless persist, among other things, because of the small number of Apaches that India has thus far acquired. Even the most sophisticated attack helicopters, at any rate, are not adequate substitutes for fixed-wing close air support aircraft because only the latter can carry diverse munitions in substantial tonnage.

Recognizing this reality, Air Marshal (retired) Raghu Rajan has argued that "a transonic fighter with adequate payload and endurance such as the A-10 Thunderbolt needs to be acquired so that this gap in the IAF's capability is [filled]."[4] Whether this solution can satisfy the IAF's need for precision strike capabilities in the Himalayas deserves further scrutiny, given the aircraft's 13,700-meter (around 45,000-foot) service ceiling, but the Thunderbolt obviously would suffer no comparable constraints in the airspace over the plains. Where operations on the Himalayan battlefields are concerned, therefore, the IAF may end up relying on its multirole aircraft as it did during the 1999 Kargil War. But planning for such operations would require revamping its terminal attack control capabilities and increasing the size of its precision munitions stockpile, both of which have never received the attention they warrant.

If the IAF can allocate about four squadrons of effective fighters dedicated to the close air support mission, as it builds to an end strength of 42–45 combat squadrons in the years ahead, it would have made a signal contribution toward advancing the prospects of success in any future ground campaign in southern Asia.

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CONCLUSION

THE INDIAN AIR FORCE (IAF) IS, undoubtedly, a superb warfighting force. It is statutorily responsible for protecting India's airspace, and it concurrently contributes to peace and stability through its role in ensuring conventional deterrence, while extending India's influence through its budding capabilities for power projection. In this context, the air defense/multirole components of the force form the core of its warfighting capability—and it is unfortunate that these elements today are beset by serious risks and disquieting uncertainties. The numbers of combat aircraft, whether measured by plated airframes or squadron strength, are inadequate to the evolving threat and, even worse, are likely to remain stagnant for a while (if not drop further), despite the persistent promises of a future improvement in force strength. The viability of the current force structure, divided as it is into three separate weight classes with differing levels of heterogeneity in each, is questionable, especially for an air force with little promise of growing rapidly in size in the near future. The technological superiority of the air defense/multirole force, which is a prerequisite for successful deterrence of the nation's adversaries, is no longer as patently obvious as it was some two decades ago. And the current trends suggest that protecting the IAF's residual advantages will require significant additional resources that are nowhere in sight.

While poor planning has played a part in producing these maladies, the larger problems are in fact structural and go beyond the IAF itself. They also derive from the fact that the Indian nation, bombast to the contrary notwithstanding, still does not have the indigenous

capacity to produce advanced fighter aircraft that are superior to those in its competitors' inventories. At a time when the Indian state and its armed services have still not made the decisive leap toward procuring U.S. (or other Western) combat equipment on a substantial scale because of limited access to their best systems, the relatively higher prices of Western-origin equipment, and fears about both supply reliability and governmental constraints, the IAF—like the other Indian armed services—is forced to make do with equipment sourced from other countries that are often viewed as a second best. Inevitably the IAF becomes a victim of the vagaries of the international aviation market, having to bank on unreliable suppliers such as Russia or on polygamous subsystems producers such as Israel, which for purely commercial reasons end up doing business with New Delhi's adversaries even as they continue to supply critical military capabilities to India.

India still has major shortcomings in the quality of its academic achievements, the resources committed to research and development, and the competence needed to develop advanced militarily critical technologies and to integrate complex systems.

India's poor higher defense management only exacerbates these problems: the presence of a civil bureaucracy that is all-powerful but not well-versed in defense issues; the existence of a political leadership that, with few exceptions, has little interest in strategic matters; and the absence of a capacity for systems analysis either in the armed services or in the defense procurement processes combine to prevent the kind of planning that might otherwise have provided coherent solutions to what are obviously complex predicaments implicating international politics, domestic budgetary constraints, and indigenous weaknesses in science and technology.

In such a challenging environment, many in the political and bureaucratic leadership, in the Indian military, and in the opinion-making elites have converged on the notion that the solution to effectively equipping the armed forces requires producing all major weapon systems at home. In its most ambitious conception, this solution entails not merely the co-production of advanced foreign weapons in India, but also the development, manufacturing, and integration of entirely indigenous systems in the service of larger national self-sufficiency. This vision is, undoubtedly, appealing. If India were to be capable of domestically developing sophisticated weapons superior to those possessed by its adversaries, it would simultaneously incur tremendous economic, technological, and geostrategic advantages. But the evidence suggests that the country remains far from reaching this pinnacle. Partly because of poor national policies, India today still has major shortcomings in regard to the

quality of its academic achievements, the resources committed to research and development, and the competence needed to develop advanced militarily critical technologies and to integrate complex systems.[89]

In the field of aviation in particular, Indian capabilities beyond maintenance, repair, and overhaul are concentrated in design engineering and information technology solutions, where the nation's best-qualified, but low-cost, scientists and engineers are often hired by multinational corporations to service their in-country research and development centers. These establishments, for the most part, are focused on developing incremental innovations to existing products or new products that are often not central to realizing larger Indian ambitions in the aerospace sector. Some exceptions obviously exist, General Electric and Boeing being among the most prominent. But even their outstanding work in India cannot compensate for the deficits that otherwise mark the Indian aviation sector.

Other Indian private entities involved in this field usually concentrate on computer-aided design, components testing, and information technology solutions for business operations and product life-cycle management. Where manufacturing is concerned, most Indian private companies are tier 3 component suppliers—producing castings, power components, or aircraft interiors—with some tier 2 purveyors of hydraulic, electrical, and avionics components. But as yet no private entities have the capacity for integrating critical systems, such as engines and flight control and wing assemblies, let alone serving as prime integrators for complete aircraft. To the degree that something resembling the capacity for comprehensive integration exists, it can be found only in the public sector—in entities such as Hindustan Aeronautics Limited, or the National Aerospace Laboratories, or the Defense Research and Development Organization. But the record of achievement here, at least where combat aviation is concerned, has not been particularly striking.[90]

These weaknesses highlight the central problem facing Indian security managers where the IAF is concerned: how do they resolve the tension between securing self-sufficiency in the production of advanced weapon systems and the need to maintain technological superiority over the nation's adversaries for the purpose of successful deterrence? If India were capable of developing and manufacturing potent combat aircraft and their associated weaponry as well as the sophisticated combat support aircraft needed, this dilemma would naturally dissolve. But given that this is not the case, Indian policymakers have to tread carefully because any policies that assert the priority of technological autarky over technological superiority run the risk of undermining the nation's security where it matters most—in battle.

This is particularly relevant for the IAF because air warfare, more than perhaps any other form of combat, hinges disproportionately on technological advantage for success. Small differences in technological capability can produce a huge difference in warfighting outcomes, other things being equal. Moreover, because air dominance is essential not only for the effective protection of Indian airspace but also for the success of both ground and naval

operations, it is essential that Indian leaders prioritize the maintenance of such supremacy, both IAF and naval, even if this objective appears to run counter in the first instance to the goal of defense self-sufficiency.

The problems of dependency in any case cannot be resolved through quick fixes, much less arbitrary decisions to promote some domestic aircraft programs because they embody the seductive hope of import substitution. Reducing reliance on foreign military equipment requires—as is often overlooked in Indian commentary today—more than solutions pertaining to procurement. It also entails longer-term investments in improving India's academic attainments (especially in science and technology), increasing the allocations to research and development nationally (including in the private sector), opening the defense sector comprehensively to private producers (both Indian and foreign), refocusing the national defense research and development organizations toward mainly the development of strategic systems (which cannot be procured by any means on the international market), and steadily raising India's technological proficiency by progressively embedding it into the global supply chain for the production of military goods (which, in turn, requires the abolition of restrictions on foreign direct investment in defense). Concertedly implementing such initiatives would take India down the path of self-sufficiency faster than any forced efforts at procuring some indigenous aircraft, which may serve merely to subvert the Indian control of the air necessary for successful deterrence in southern Asia.

Strengthening the IAF with American resources represents an investment in advancing U.S. strategic interests in the wider Indo-Pacific region.

The imperative of maintaining the air superiority that the IAF has enjoyed in the regional context since 1971, and which is at risk of dissolution especially in regard to China over time, requires Indian policymakers to treat their air arm with the attention that befits its strategic importance. The IAF is not just the nation's air force; it is the country's quick reaction force par excellence. At a time when the principal near-term threat to India consists of subconventional conflicts under the shadow of nuclear weapons, the IAF alone embodies the capability for rapid, lethal, and discriminate response. Hence, its ability to prevail in both the air-to-air and the air-to-surface arenas must be protected and enhanced.

Over time, as projectable Chinese capabilities mature in complexity and expand in geographic presence, these distinguishing characteristics of Indian airpower will only grow in importance and with it the necessity of investing in their success. This, in turn, implies that the increased capital expenditures essential to strengthen Indian airpower cannot be put off

for very much longer if the IAF is to secure its operational superiority and grow toward the 60-squadron strength eventually required to prevail in the high-intensity two-front wars that India might face over the long term.

Until that moment is reached, however—when the full weight of Chinese airpower can actually be brought to bear in its southwestern quadrant—the need for investing in a force of 42–45 squadrons is compelling, especially if the IAF is to secure confident victories with minimal losses to itself and the least exposure of Indian national assets to enemy action. Achieving these twin goals will not only require the Indian government to fund the end strength it has committed to maintaining by 2027 but also necessitate ensuring that high-performance fighters come to populate the bulk of this inventory.

The responsibility for accomplishing these goals lies fundamentally with India. But the United States can help New Delhi in important ways. The U.S. government has already released critical combat aviation technologies for sale to India, such as the active electronically scanned array radar and active radar-guided air-to-air missiles. The licensed co-production of fourth-generation-plus aircraft too has been approved, and advanced airlifters have begun to form the mainstay of India's tactical and strategic transport fleets. U.S. policymakers have also expressed their willingness to consider sales of fifth-generation fighters to India, should the IAF seek to pursue this option, and a joint working group on jet engine technology has already begun reviewing the possibilities of co-developing and manufacturing a new-generation power plant for India's Advanced Medium Combat Aircraft.

Whether a collaborative effort to design and build this fighter is viable deserves serious consideration by both governments, but in the interim, the United States should proceed to release many of the advanced air-to-surface munitions that India requires to equip its Western-origin multirole and strike aircraft as well as the armed unmanned aerial vehicles that New Delhi has requested. Training IAF personnel in key functional specialties such as airborne warning and control system operations and close air support might be logical next steps as bilateral airpower exercises grow in complexity and sophistication. However such cooperation evolves, it bears remembering that strengthening the IAF with American resources represents an investment in advancing U.S. strategic interests in the wider Indo-Pacific region and, as such, warrants ambitiously expanding the collegial aerospace partnership that has materialized since the beginning of this new century.

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