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AN INDUSTRIAL STRATEGY IN SUPPORT OF FIGHTER AIRCRAFT FOR INDUSTRIALLY DEVELOPING NATIONS

By

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About the Author

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INTRODUCTION

> It is an axiom today that there can be no defence without a sufficient industrial backing. A country which has not got that industrial background cannot fight a modern war or defend itself for any length of time, however big its army might be. The defence forces indeed are merely an extension of the industry of the country. When one thinks of defence, therefore, one has to think first of all of industrialisation on a vast scale.
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> Jawaharlal Nehru, 1947[1]

Although war is an extreme form of political expression, there can be no doubt that a nation's ability to pursue its interests is directly proportional to its military power. Before the turn of the century, military power was very much a function of how large an army one could raise. However, in the second half of the 20th century, technology has become more and more important, to the extent that it now plays a major role in the projection of military power. Indeed, a military force which is technologically inferior to its enemy needs significant numerical superiority to overcome its technological inferiority.

Nehru correctly saw not only the impact of technology but also the attendant problem with it, namely, that unless one's military equipment is home grown, then it makes one dependent on other countries who supply the equipment. The recent 'Pressler Amendment' which has led to the US refusal to provide spares support to Pakistani F16 aircraft is a case in point. It therefore follows that nations which wish to pursue a completely independent foreign policy without external influences need to be self-sufficient in the supply and maintenance of their military equipment.

Following World War II, the former Allies followed this principle, with the USA, USSR, UK and France successfully developing military technology along independent lines. Independent Sweden also followed this course. However, today the development of the latest technology, particularly in the very high technological areas of combat – aircraft and missiles has become too expensive, and one by one these countries have had to accept reality, so that now only the USA and perhaps Russia are capable of designing, building and maintaining the entire range of military equipment. Even then, the USA has preferred to buy some overseas designs where convenient, for example, the AV8B and Goshawk, which are respectively based on the British Aerospace Harrier and Hawk, and more recently, the selection of the Pilatus based Beech PC9 Mk II as the primary military training aircraft.

Meanwhile, other less industrialised countries, which are referred to in this paper as the 'industrially developing countries',[2] sought to develop industrial policies which might also lead them to self-sufficiency in military hardware. However, starting at a lower technological base, and with competing priorities for funds, their success has

[1] S. Gopal, ed., *Selected Works of Jawaharlal Nehru, Second Series, No. 2*, New Delhi, 1984, p 364.

[2] Commonly accepted usage f the term 'developing countries' refers to the so called Third World and excludes countries like Australia and New Zealand which, although considered to be 'developed', are still developing *industrially* as they attempt to reduce the dependence of their economies on primary produce. This paper has therefore introduced a new term, '*industrially developing countries*', so as to group countries like Australia and New Zealand with the commonly designated developing countries.

been notably less than the industrialised countries, in comparison to whom they have been steadily losing ground. For these industrially developing countries, and in particular the democracies, the ideal of self-sufficiency appears no longer realisable without the politically unacceptable neglect of the development of the nation as a whole and the welfare of its citizens.

Even a large nation such as India, which since Independence has been highly motivated towards a totally independent foreign policy, and which has consequently developed one of the largest and most diverse military industries amongst the industrially developing countries, has lowered its sights on the goal of self-sufficiency. According to the Stockholm International Peace Research Institute, 'Indian leaders and technology managers distinguish between self-sufficiency, which they have come to define as autarky and see as unattainable, and self-reliance, which implies more modest goals'[3] (notwithstanding India's persistence with its indigenous Light Combat Aircraft design). On the other side of the Indian Ocean, the official Australian position is that 'complete self-sufficiency in the logistics and other support of the [Defence] Force is neither practicable or affordable … Careful judgements are made on the balance between investment in combat capabilities and investment in their support, in order to achieve an optimum combination of combat strength and supportability'.[4]

This paper will contribute to those judgements by discussing the merits and problems associated with establishing and maintaining military aircraft industries, and in particular, the fighter aircraft industry. The reason for concentrating the discussion on fighter aircraft is threefold. Firstly, the fighter holds the key to the success of air power which itself is pivotal in most if not all modern war scenarios. Secondly, fighters are acquired in large numbers which involve substantial outlays and make indigenous production appear viable. Thirdly, fighters represent the top end of the scale in the leading edge of technology which offers challenge and reward for local industry in terms of technology transfer.

It must be noted from the outset that the paper does not specifically address the helicopter, which, like the fighter, is also used to support the land battle in both mobility and firepower, which is also being acquired in large numbers, and whose utility in modern warfare is also facilitated by high technology. Indeed, with its modern weaponry and manoeuvrability, it is becoming more of a fighter in the close air support role. However, despite these similarities, the helicopter has significant differences. For example the future requirement for helicopters is not as clear as for the fighter. As the noted Indian air power strategist Air Commodore (ret) Jasjit Singh points out, 'until the speeds of helicopters reach figures of 600 kph or more, they remain highly vulnerable to hostile air activity … Their effective employment, and in some cases their very survivability and employability will depend upon the degree of air superiority available'.[5] Helicopters also differ industrially in that much of the airframe, engine and systems are applicable to civilian applications. Therefore the helicopter manufacturing industry has another dimension to it vis a vis the purely military application of the fighter industry. Nonetheless, as long as these differences

[3] SIPRI Yearbook 1994, *World Armaments and Disarmament*, New York, 1994, p 344.
[4] *Defence White Paper: Defending Australia*, Canberra, 1994, p 52.
[5] Singh, Jasjit, *Air Power in Modern Warfare*, New Delhi, 1985, p 17.

are born in mind, much of the discussion found in this paper is equally relevant to the helicopter, as it is to other military equipment of a complex and technologically advanced nature. Indeed the higher the technology, the more the relevance.

AIM

The aim of this paper is to address, in broad terms, how the industry of industrially developing nations should be structured to support the vital and high technology fighter aircraft element of their defence forces.

INDUSTRIAL SUPPORT OPTIONS

The spectrum of industrial support options, which ranges from full design and production to simply carrying out the basic maintenance requirements on imported aircraft, can be reduced to four separate options which are discussed in the following section.

Indigenous Design and Production

Nehru's strategic thoughts on the link between defence and industry quoted at the beginning of this paper imply a goal of indigenous design and production. On the surface, the option to design and build one's own combat aircraft appears to afford the greatest degree of self-sufficiency, in that not only is the prime equipment manufactured locally, but maintenance and spares support are also readily available. But it should be noted that an indigenous design does not necessarily mean total self-sufficiency, as often the sub-systems in the design need to be imported. In Sweden's latest fighter, the Gripen, many of the critical technologies are produced under licence from foreign companies, with foreign content assessed as high as 40 percent. For example, the engine is a derivative of the General Electric F404 with only 40 percent manufactured in Sweden.[6] Indeed, only the USA, France and possibly Russia can boast of being totally self-sufficient in all their combat aircraft needs.

Another attraction of indigenous design and manufacture is the prestige of the undertaking. The ability to produce and export one's own aircraft is a sign of a 'coming of age' technologically. This is considered to be important, particularly in developing countries with a colonial background, because it indicates an ability to stand on one's own two feet and a need to be taken seriously. In Indonesia for example, the modernisation program of the late seventies and eighties included the creation of an aircraft manufacturing industry, with the production of the CN-235, a transport aircraft built in cooperation with the Spanish aircraft manufacturer CASA. Hal Hill, a senior research fellow at the Australian National University in Canberra, questions the financial viability of the project and suggests that it may have had more to do with State prestige and the personal ambitions of its sponsor, the Minister for Research and Technology Dr. B. J. Habibie, than with economics.[7] More recently,

[6] *Jane's Defence Weekly*, 10 June 1995, p 116.
[7] Hill, H., 'The World According to B. J. Habibie', *Inside Indonesia*, Northcote, Victoria, July 1988.

Dr. Habibie has been in Australia proposing the joint development of a regional fighter aircraft, similar in concept to the European Fighter Aircraft (EFA).[8]

A third advantage of the home grown design is that it is built with a particular indigenous requirement in mind. For example, both India and Australia need to have aircraft which can operate in conditions which are quite different to those which prevail in the USA and Europe. In Australia, the main area of interest is in the tropical north, while in India a combat aircraft needs to be able to operate in the heat of the Rajasthan desert as well as the high altitudes found in the north. One source suggests that the technical difficulties involved in operating aircraft in the Himalayas was one of the factors which led to the decision not to use IAF aircraft in ground attack missions in the 1962 war against China.[9] Air Forces which can have their aircraft built specifically to an air staff requirement do not need to accept compromises or have the aircraft specially modified to meet their needs.

Finally, economics must be considered. Modern fighter aircraft are very expensive items, with the flyaway cost[10] of an F16 around $US20 million, and that of the next generation of fighters reported to be anything between $US25 million and $US60 million.[11] Thus a reasonably modest buy of 50 imported fighters at the lower end of the scale would entail an outlay of around $US1.875 billion,[12] representing a significant outlay not only in government expenditure but more importantly in foreign exchange. As most developing countries can ill afford this sort of impact on their current account, local production becomes an attractive option. Moreover if the product turns out to be a good one, there are prospects for export. Thus, rather than a drain on foreign reserves, an indigenous design becomes a potential foreign exchange earner.

Paradoxically, the overwhelming drawback to indigenous design and development is also its huge cost. Aircraft, and particularly fighter aircraft, are very complex machines which operate in a difficult and unforgiving environment. Power plants need to be reliable throughout the manoeuvre envelope. To maximise payload, weight needs to be kept to an absolute minimum, resulting in the use of high technology materials and very small strength margins which need to be painstakingly verified. The quest for manoeuvrability in fighter aircraft has led to unstable designs which need computer based control systems to enable them to be flown. Development of the control software alone involves an enormous investment of time and money.

An indication of the expense involved is gained from a review of the development costs for a number of fighter aircraft currently in development. According to Jane's,[13] the F22, the most advanced of the modern designs incorporating stealth technology, is expected to cost $US20 billion to develop, the EFA $US14 billion and the French Rafale $US8 billion. The Gripen, which is technologically inferior to those aircraft,

[8] *The Australian*, 31 May 1995.
[9] Smith, Chris, *India's Ad Hoc Arsenal Direction or Drift in Defence Policy*, New York, 1994, p 77.
[10] Flyaway cost is the cost of the basic aircraft without support equipment, spares, documentation and training. Addition of these items will usually result in a project cost at least 1.5 times the flyaway cost.
[11] *Jane's Defence Weekly*, 10 June 1995, p 116.
[12] Calculated by multiplying 50 times $US25 million times 1.5 to get project cost.
[13] *Jane's Defence Weekly*, 10 June 1995, p 116.

cost a mere $US2 billion to develop, but much of the difference can be explained by the substantial import of technology. For the same reasons, Japan's FSX fighter program is reported to have absorbed $US3.75 billion to the first prototype stage,[14] and Taiwan's Chin-Kuo fighter (also called the Independent Defense Fighter) is estimated to have absorbed about $US4 billion.[15] The projected development costs for India's Light Combat Aircraft (LCA) are estimated by one source to be $US1.5 billion[16] and by another to be at least $US2 billion,[17] the comparatively lower cost reflecting not only the extent of technology import but also cheaper manpower costs.

While the lower development costs of the LCA appear to vindicate the project, it is not regarded as a success story. Conceived in the early eighties, it has had a turbulent history of development, starting with a problem with the indigenously designed GTX engine running many years behind schedule, and a consequent requirement to choose between an imported engine such as the GE F404, the Rolls Royce RB199 or the SNECMA M88. Problems also arose with the weight of the aircraft which grew from an originally conceived 5.5 tonnes to 8 tonnes, with associated cost increases. Cost estimates are now about $US10 billion for 200 units.[18]

These costs would make the LCA substantially more expensive than the comparable Gripen, and perhaps could even be underestimated considering the lower wage factor enjoyed by India. But even if the LCA is priced the same as the Gripen, India will have difficulty pitting the aircraft against its more experienced and reputed European and American competitors. Moreover, Chris Smith suggests that the LCA cannot expect a great deal of support from the Indian Air Force, who appear to favour Western technology over that which is home grown. Smith implausibly puts this down to a much wider trait of Indians whom he believes are rarely enamoured of indigenous products such as cars and electronics.[19] A more likely explanation is that professional military officers know the value of a technological edge over their potential enemy and thus demand the best affordable, home grown or not. A similar attitude has been seen in Australia with the lack of enthusiasm for local designs such as the Nomad light transport aircraft.[20]

The reason that the international market is so highly competitive is that the volume of fighters in inventories around the world is shrinking. Indeed Simon[21] believes from his discussions with aircraft manufacturers from Europe and the USA at the 1991 Paris Air Show that the replacement ratio for their fighter inventories will be one to three or even less for most countries. A report released by the American Teal Group Corporation suggests the ratio might be slightly better, around one in 2.3,[22] but both sources show a significantly decreasing market. In further consideration of the potential market for the Rafale, Simon has estimated a maximum export market of

[14] *Defence News*, 24-30 July 1995.
[15] *Far Eastern Economic Review*, 12 January 1995.
[16] *Defence News*, May 15-21, p 8.
[17] SIPRI Year Book 1994, quoting from *MILAVNEWS*, Vol. 30, No. 632, December 1991.
[18] Smith, n9, pp 169-177, who quotes costs from Karp, A., *The Light Combat Aircraft and the Insulation of Indian Weapons Procurement*, mimeo, Stockholm, January 1991, p 4.
[19] *ibid*, p 177.
[20] Lague, D., 'Widow Maker', *Sydney Morning Herald*, 18 March 1995.
[21] Simon, Y., 'Prospects for the French Fighter Industry in a Post Cold War Environment: Is the future More Than a Mirage?', *Rand Report RGSD-106*, 1993, p 72, note 9.
[22] Teal Group Corporation, World Military and Civil Aircraft Briefing, June 1995.

340, a number which includes the possibility of sales of 50 aircraft to each of Brazil and India and 60 to Taiwan, all of whom have fighter projects of their own.[23]

This shrinking market is due to a combination of the reduced perceived threats at the end of the cold war, especially in Western Europe, the vastly improved capabilities of the new aircraft technology which gives a force multiplier effect, and the very high costs of procurement and ownership. This in turn has led to the trend to extend the life of existing fighters by retaining the same airframe, albeit with some refurbishment, and replacing the avionics and engine with state of the art systems. An upgrade proposed for the Indian MiG 21, for example, is reported to offer a performance close to that of the latest fighters for a period of 10 to 15 years at a cost of about a fifth of that required to replace it with the MIG 29.[24] The RAF has ordered a similar upgrade for its Jaguars,[25] and in Australia, the F111 is undergoing a major upgrade to take it to 2020.[26] Thus the fighters of the fifties and sixties, which lasted only 10 to 15 years on performance considerations, have been replaced with aircraft which have a useful life, albeit with updates, of 30 years and beyond.

The net result is surplus capacity and a resultant fierce competition between the Europeans offering EFA, Rafale and Gripen; Russia, which needs sales to revive its well developed but currently bankrupt aircraft industry to earn desperately needed foreign currency; and a USA equally desperate to retain its export share against a decreasing home market. Despite President Clinton's promises to try to reduce the international arms trade, the US Government has committed itself to assisting arms exporters to secure sales.[27] Entry to such a competitive environment appears to be a high risk economic strategy for nations aspiring to industrial development.

Collaboration

When indigenous design and development is not a feasible proposition from an expense consideration, a number of industrially developed and developing nations have opted for collaborative ventures with allies. If allies can agree on the basic requirements and work share arrangements, then collaborative arrangements provide most of the advantages of indigenous design at a much reduced cost. Thus cost reductions are realised both in the shared development costs as well as lower individual aircraft costs facilitated by guaranteed orders and consequent longer production runs. For developing countries, collaboration with an industrially developed country has an additional benefit in technology transfer which would inevitably come with the project, for example, the AMX project involving collaboration between Embraer of Brazil and the Italian companies Aermacchi and Alena. India was also reported to be looking for partners to help defray costs in the LCA,[28] but perhaps too late in the project.

[23] Simon, 'Prospects for the French Fighter Industry in a Post Cold War Environment: Is the future More Than a Mirage?', p 259.
[24] *Business Standard*, New Delhi, 13 June 1995.
[25] *Jane's Defence Weekly*, 25 March 1995, p 35.
[26] *Australian Defence Annual Report 1993-1994*, p 151.
[27] *Sydney Morning Herald*, 31 May 1995.
[28] Smith, *India's Ad Hoc Arsenal Direction or Drift in Defence Policy*, p 175.

Notwithstanding these potential gains, collaborative arrangements are not without their problems. The European Fighter Aircraft (EFA) is a case in point. The EFA has its origins in a preliminary agreement reached in December 1983 between the chiefs of staff of five nations, Great Britain, France, Germany, Italy and Spain, for a single seat, twin-engine, multi-role fighter aircraft. However, disagreement soon emerged between the prospective partners on the detailed specification, and an argument also emerged between Britain and France over design leadership, work share and the choice of engine, the stakes being high for the respective engine manufacturers Rolls Royce and SNECMA. After five years of haggling the impasse between Britain and France could not be resolved, and with Germany taking the side of Britain, France opted out of the program to develop its own fighter, the Rafale.[29]

The parallel development of the two projects now makes for an interesting comparison. With both projects starting at about the same time, Rafale has finished ahead of the EFA at almost half the development costs. While much of this difference could be attributed to the lighter weight of the Rafale and the more ambitious nature of the EFA project, one suspects that the problems of coordinating the efforts of four partners, each with different native tongues and political agendas has also had an influence on progress. Indeed Johnston argues that 'joint European projects can result in higher total research and development costs by as much as an extra 30 percent due to duplications in organisations, delays, transport and travelling costs'.[30] However, there are still savings to the participating nations, even though they are not as large as one would at first anticipate.

In terms of self-sufficiency, collaborative programs achieve the goal, in that two or more countries become mutually dependent, thus each holds the key to each other's independence of action as far as military hardware determines it. However, like the design itself, some compromises may need to be given with respect to future sales of the aircraft to third parties, which will be influenced by the political considerations of the respective partners. Also, collaboration does not remove but only reduces (to varying degrees) the major drawbacks of indigenous design: technical risk, high cost and the competition of the market place.

Licensed Manufacture

If one cannot afford an indigenous design or a collaborative venture, then the next step down is manufacture under licence. A number of industrially developing nations have undertaken licensed production, and the activities of both India and Australia in this field are remarkably similar. In terms of fighter aircraft, Australia has manufactured under licence the F86 Sabre, its successor the Mirage III, and recently a more limited program on the F-18 Hornet at Aerospace Technologies of Australia, formerly Government Aircraft Factories (GAF). In India, Hindustan Aeronautics Limited (or its predecessor Hindustan Aircraft Limited) has undertaken local manufacture of the Gnat, MiG 21, MiG 27 and Jaguar, the most successful of which was the MiG 21 production which produced 500 aircraft in its various marques, the 'FL', 'M' and 'bis'.

[29] Simon, 'Prospects for the French Fighter Industry in a Post Cold War Environment: Is the future More Than a Mirage?', pp 7-22.
[30] Johnston, S.I., 'Is There a Path Off the Road to Military Absurdity?', *British Army Review*, No. 101, August 1992, p 66.

Licensed production appears to offer a number of advantages to industrially developing nations in comparison to direct import. Technology transfer, the saving of foreign exchange, job creation, cost saving, and achieving a degree of self-sufficiency in terms of further production, spares and maintenance support are, on the surface, compelling arguments for undertaking licensed manufacture as a worthwhile alternative either to in-house development or to direct import. However the arguments bear closer scrutiny, especially in the light of experience gained in such projects.

Of these advantages the most important from an economic viewpoint is the saving of foreign exchange, vis a vis outright purchase. Theoretically, these savings should represent a reasonable proportion of the total project costs, being equal to the manhour content that the original equipment (that is, aircraft) manufacturer (OEM) would have needed to build the aircraft, measured at the OEM's labour rates, plus the savings in materials procured locally, but minus the amounts paid to the OEM for tooling, licence fees and technical personnel and any mark up on imported materials, components and sub-systems. It is this last group of items which seems to substantially erode the other savings. According to Ball,[31] 'Analysts have calculated that the foreign exchange cost of producing the MiG 21 aircraft in India was roughly the same as or may even have exceeded the cost of importing finished aircraft directly from the Soviet Union'. She concluded that, 'far from reducing foreign exchange requirements of the defense sector, domestic production of arms may actually increase them, particularly in the short to medium term'. While this may not hold the same truth for equipment purchased from Western countries where the wage content is higher, it is reasonable to conclude that the foreign exchange savings, if they are realised at all, will be a small percentage of the total outlay.

Savings in foreign exchange are not the only economic consideration; overall project cost is also an important determinant in the decision to build under licence. This is because, whether the project is sourced overseas or locally, it still has to be financed from government outlays. If the cost of the locally sourced product is greater than that of the foreign one, then the money has to be found, either through additional borrowing (in all probability overseas) or by reducing the number to be acquired, or by foregoing some other government expenditure, such as social welfare or infrastructure. Thus, if local manufacture is undertaken at a premium vis a vis direct import, then any savings in foreign exchange may be eroded by the resultant increase in borrowings to meet the overall increase in government expenditure.

In Australia, where labour rates are high, it is virtually impossible for licensed manufacture to be achieved for less than the direct purchase price. A simple example is found in the local production of the Steyr rifle carried out for the Australian Defence Force by the Lithgow Small Arms Factory, which cost 79 percent more than the purchase price from the original Austrian manufacturer.[32] The Hornet project was also undertaken at a premium; a cost benefit analysis carried out by the Defence Department showed that the premium paid for the limited work program undertaken

[31] Ball, N., *Security and Economy in the Third World*, London, 1988, p 378.
[32] *Canberra Times*, 10 June 1995.

in Australia could have been as high as $A713 million, adding about 20 percent to the program cost.[33]

On the other hand, licensed manufacture in a country such as India, which enjoys a considerable wage advantage, should in theory be cheaper. Indeed, Hindustan Aeronautics (HAL) believes the cost of licensed manufacture in India to be somewhere between 50 and 80 percent of the overseas purchase price.[34] However, this figure does not accord with that determined by SIPRI, which estimated the cost of producing the MiG 21 in India to be 193 percent more than its imported cost.[35] Although the SIPRI figure dates back to 1971, it seems to tie in with Ball's conclusion cited above and casts considerable doubt on whether licensed production in India, or any other developing country, is achieved at any saving to the exchequer.

The third advantage and indeed an oft stated reason for licensed production is the prospect of technology transfer, sought by developing countries to spur their industrialisation programs. As pointed out by Jasjit Singh, 'air power intrinsically operates at a level of technology significantly higher than that obtaining or operating in the rest of the country'.[36] However, Ball sees some problems with the technology transfer reasoning on four counts. First of all, she argues that, rather than military technology flowing to the civil sector and creating new industries, it is the other way around, stating that 'no Third World country can hope to support arms production of any magnitude if it does not already possess a reasonably strong, diversified industrial sector'.[37] Secondly, the high technology associated with military equipment (and particularly aircraft) is usually capital intensive as opposed to labour intensive. Therefore, investing in arms production is not the most effective way of increasing employment. Thirdly, the high technology needs to be absorbed rather than simply purchased. The growth of the so-called Asian Tigers for example has not been led by any investment in high technology military industries, which from the outset need highly trained people who are capable of understanding the technology. In fact, defence industries importing the latest technologies tend to draw away highly trained people from the civil sector where their skills are needed to adapt imported technology to local requirements.

Finally, the aircraft industry is not one that is renowned for its steady workload. A locally produced fighter aircraft may create a substantial workload for the period of production, typically five to eight years. However, if there is no following program, then labour needs to be laid off. Even the USA with its well established industry has this problem, which is overcome by having flexible labour laws and a resultant mobile workforce. However, this is not the case in many industrially developing countries which have no social security safety net. Thus governments, who typically own the industries, exhibit a reluctance to lay off workers. Such is the case with HAL which is currently overmanned as a result.[38] Ball summarises the problem succinctly when she states: 'no one, not even the most ardent supporter of defense industries, would

[33] 'The Cost of the F/A 18 Industry Program', Department of Defence, Canberra, May 1993, p 13.
[34] Interview with Mr A. V. Singh, Joint Secretary HAL.
[35] Smith, *India's Ad Hoc Arsenal Direction or Drift in Defence Policy*, p 158, quoting Almqvist and Wiksell, *The Arms Trade with the Third World*, SIPRI, 1971, p 742.
[36] Singh, n5, p xvii.
[37] Ball, *Security and Economy in the Third World*, p 358.
[38] From an interview with Mr A. V. Singh, Joint Secretary HAL.

deny that the industrialisation process would be better served by investing directly in the civil sector'.[39]

While not all these arguments are applicable to the more advanced of the industrially developing countries such as Australia and India, it is instructive to review the results of the Australian Hornet program, which introduced a number of new technologies to Australia. The Department of Defence has stated that, while a significant amount of technology was transferred into the Australian Aerospace Industry, best use does not appear to have been made of opportunities to commercialise these technologies and that the ongoing benefits were less than originally anticipated.[40] Thus, while technology transfer can be regarded as a legitimate spin-off of local manufacture, the shortcomings outlined by Ball and the Australian experience do not make 'technology transfer' a compelling argument for licensed production.

The last argument advanced for licensed manufacture is that of self-reliance, that is, the freedom to manufacture more equipment as and when desired and the ongoing support automatically provided to the Air Force over the life of the equipment, both in terms of spares and the availability of a maintenance facility with readily trained people. But here again the advantage is often overstated. Licensed manufacture seldom if ever means 100 percent local manufacture. For example, in the Australian Mirage and Macchi projects, in which the airframes were totally built in Australia, the major forgings were imported. Thus there will always be the potential for restrictions to be placed on further production, and a degree of dependence on the original equipment manufacture (OEM) or his vendors for spares.

Maximum self-reliance will be achieved if the high usage spares are selected for local manufacture at the beginning of the program, but this is not easy to do early in a new aircraft program, especially if the original aircraft manufacturer wants to retain the manufacture of high usage spares in-house as a future income earner.

The Australian Hornet program makes an interesting case study in this regard. With a requirement for only 75 aircraft, an extensive licensed manufacture was not economically feasible. The work was therefore divided into two parts, 'designated work' and 'offsets'. Designated work was defined as work 'of strategic significance which would not otherwise have been undertaken in Australia', in other words, licensed manufacture of some parts of the aircraft. Offsets are addressed later in the paper.

The stated objectives of the industry program were, firstly, 'to provide in industry the capability to undertake required engineering, maintenance and spares provision support for the aircraft, its systems, equipment and support facilities, during the service life of the aircraft', and secondly, 'to establish, maintain or enhance the defence industry capabilities in general and provide a balanced stable on-going workload using the opportunities presented by the F/A-18 project'.[41] While the report concludes that these objectives were substantially achieved, it laments the lack of follow-on work to industry, with the resultant loss of capability.[42] For example, the

[39] Ball, *Security and Economy in the Third World*, p 357.
[40] Review of the F/A-18 Industry Program, Department of Defence, Canberra, March 1994, p 56.
[41] *ibid*, pp 21-22.
[42] *ibid*, p 8.

capability to manufacture the designated work components for the engine has been lost because of a lack of orders from either the RAAF or the USA.

The reasons for the lack of sales of parts to the USA were examined by Kentish,[43] who explains that a combination of 'buy American' pressures, other customers' mandated offset programs (such as Korea's new fighter) plus a reluctance on the part of US licensees to create competitors in the market place, were all factors working against the Australian supplier. As far as local sales are concerned, the lack of orders for spares from the RAAF has more to do with the original selection of the items than anything else. A review of the list of designated work indicates that few of the items represent high usage spares.[44] The absence of aircraft tyres from the list is illustrative. The resultant low volume of local demand therefore makes the local item uncompetitive compared to the imported item, even after the government's preferential pricing policy is applied.

With respect to the maintenance support argument, the Australian Department of Defence Report also queries whether licensed manufacture is of any great benefit when it comes to maintenance support. It states that maintenance activities 'require different equipment and skills from those employed in manufacture', and points out that 'you do not need to be able to build something in order to support it', using the motor car as an illustration.[45] Any number of aviation examples are also available, such as the support of commercial transport aircraft by airlines.

Summary of Manufacturing Options

The foregoing discussion of indigenous design, collaboration and licensed manufacturing options indicates that the main goals of in-country production have two major thrusts, one pertaining to self-sufficiency, the other to do with the national economy. Leaving aside the self-sufficiency arguments for the time being, the economic considerations themselves divide into three objectives: one to do with the preservation of foreign exchange, another which seeks to transfer technology for the purpose of future economic development, and the third to do with increasing employment. With respect to the former, this paper has described how licensed production of aircraft saves little in foreign exchange, and indeed in some cases, such as the Australian Hornet project, can result in an outflow which is larger than the direct purchase price. Indigenous design and production may fare better with respect to direct foreign exchange expenditure, especially if the final product can be exported to other countries. However, the fierce competition of the fighter aircraft market makes this a high risk economic strategy, and if sales are not forthcoming, the resultant very high cost burden on the government budget itself has an adverse effect on foreign exchange. Finally, from the technology transfer consideration, the sort of technology which accompanies modern fighter aircraft is not always readily transferable to the civil sector and in any case is not the optimum for developing countries in terms of promoting economic growth.

[43] Kentish, J.E., *Commercialisation of the Technologies Transferred to Australian F/A-18 Fighter Aircraft Industry Participants*, Thesis, M Bus., University of Southern Queensland, January 1990.
[44] Review of the F/A-18 Industry Program, n 40, pp 25-27.
[45] *ibid*, pp 57, 58.

Thus little if any economic advantage will actually accrue to industrially developing countries from the indigenous manufacture of fighter aircraft; indeed, in all probability, the economic effect will be negative. Accordingly, governments would be better off importing aircraft and spending the savings on other imperatives such as infrastructure or developing industries which generate exports and/or large scale employment. However, the thought of spending so much foreign exchange without seeing some economic benefit accrue is abhorrent to governments. One answer to this problem is offsets.

Offsets

Offsets are a form of counter trade between countries whereby the selling country agrees to make associated purchases to a specified value (commonly 30 percent of the purchase cost) from the buying country to offset the substantial foreign exchange outlay incurred by the latter. The competition in the international market place has forced suppliers to offer attractive inducements which can be in two forms, one directly linked to the project and which involves the manufacture of components in the customer country for export to the original equipment manufacturer (OEM), the other involving some other economic activity which is not related to the equipment being purchased or even in many cases to the military.

While project related offsets have some strategic advantage, they suffer from the same disadvantages outlined above, namely, a reluctance on the part of OEMs to agree to any more than the letter of the offset agreement, thereby avoiding the creation of competitors. On the other hand, the 'non-project related' schemes which generate ongoing growth to the economy are more likely to find favour with the overseas firm because they do not create this competition. A notable example in the Hornet project was the collaboration arrangement between the Australian company Hawker de Havilland and McDonnell Helicopter Company (MHC), involving the MDX helicopter project, for which McDonnell Douglas was permitted to acquit some of its offset obligations. The offset obligation placed on the American company undoubtedly helped persuade MHC to select an Australian partner over others such as Korea, Indonesia or India.[46]

Non-project related offsets are now starting to find favour both with recipient countries, which have realised the problems of relating offset work directly to the equipment, and the providers, who can see benefits other than simply meeting an offset obligation. For example, in the United Arab Emirates, one of the offset projects undertaken by the French firm Giat (which supplied the UAE with its Leclerc tanks), was to set up an engineering company specialising in air conditioning equipment.[47] No doubt the success of this project will return long term benefits to both the UAE and Giat. In another example of schemes to recoup foreign exchange, Northrop undertook to generate $US2 billion in Finnish exports in return for a $US3 billion aircraft purchase. Thus from an economic viewpoint, perhaps the industrial involvement sought with a new aircraft acquisition should be oriented towards the civil sector. However, this ignores the self-reliance considerations around which defence industrial policies are formed.

[46] *ibid*, p 28.
[47] *Jane's Defence Weekly*, 18 March 1995, p 54.

SELF-RELIANCE

As stated earlier in this paper, Nehru's concept of self-sufficiency, as applied to the manufacture of fighter aircraft, is not a practicable proposition. Instead, judgements need to be made on the amount of national resources which must be invested in support of the combat force to become self-reliant. To this end, it is instructive to look at what the military commander requires of his industrial support base, because even the latest and most capable hardware in the world will be of little use without adequate logistics support. Logistics support is fundamental to self-reliance.

When hostilities start, the first logistics requirement of combat aircraft will be to replenish those items which have been expended during the previous mission. This includes fuel, oil, oxygen and weapons. The next need of the operating unit is an ability to repair any battle damage to the aircraft and any systems necessary for the mission that have failed through normal processes. As hostilities progress, an Air Force also needs to be able to have the aircraft quickly modified to correct any deficiencies which have shown up in combat experience. Finally, the commander needs to have any aircraft lost in combat replaced (together with the crews).

The industry involvement in the replenishment of fuel and oxygen is outside the scope of this paper. However, the roles of industry in the provision of weapons, maintenance support, engineering and replacement aircraft are relevant, and will now be addressed in the reverse order of importance.

Replacement Aircraft

The supply of replacement aircraft for those lost or battle damaged has been afforded the lowest priority because, even if the aircraft is totally locally sourced and does not rely on overseas supply of components, the lead times needed to manufacture complete aircraft are prohibitive. A study carried out by the United States Air Force with respect to the capacity of industry to surge production of the F16 revealed that it would take three years to produce an aircraft beyond those already in the pipeline.[48] Given this order of lead time and the destructive power of modern weapons, attrition would ensure a cessation of hostilities long before any newly manufactured hardware could be brought to bear on the conflict.

Accordingly, the ability to produce aircraft will not influence the immediate outcome of hostilities, unless ample warning time has been given and has been acted upon to increase the number held in attrition reserve. As history tells us that this is unlikely to be the case, future conflicts will basically be a 'come as you are affair', with the manufacturing ability of the local industry not playing a significant part, at least in the short to medium term. Thus, while an indigenous production capability may impart a warm feeling to government, it provides no benefit to the force commander.

[48] Hallion, R.P., 'The Future of Air Power' in Stephens, A. (ed.), *The War in the Air*, 1914-1994, Canberra, 1994, p 358.

Ability to Modify

On the other hand, the ability to modify an existing design to adapt aircraft to local conditions or extract maximum performance is important. The latest technology with its emphasis on computer systems for flight controls and mission support lends itself fairly readily to modification. In particular, an ability to modify the onboard electronic warfare (EW) suite is seen as one of the highest priorities to counter changing electronic threat scenarios in the battlefield. The Israeli ability to develop electronic counters to Egyptian and Syrian surface-to-air missile (SAM) threats in 1973 and 1982 showed the advantage, if not the necessity, of possessing this capability.[49] In peacetime, a country also needs an ability to modify the combat aircraft to correct any deficiencies found in-service or to accommodate any weapons which have either been indigenously designed and developed or which have been sourced in a country different to that of the aircraft vendor.

Clearly, modifications to both hardware and software are best performed by the original designer of the aircraft. However, it is not essential to return the aircraft to the designer, provided that skilled people are available and that the engineering data have been bought as part of the original purchase. With respect to the former proviso, an ongoing support program needs to be introduced to ensure skilled people gain experience with the aircraft and in their profession. While this will involve considerable ongoing expense, it will be orders of magnitude less than the cost of developing a total design and development capability.

The second proviso is also significant because companies are frequently reluctant to part with engineering data. The problem is not insurmountable as long as careful attention is paid to this aspect during contract negotiations. But even in the absence of engineering data, the Israelis have shown that reverse engineering of foreign designs is not beyond the realms of possibility. For example, Israeli Aircraft Industries (IAI) has carried out upgrade modifications to Russian fighters without having operated them or manufactured them under licence.[50] Thus while a country needs an industry which is capable of engineering modifications to its aircraft, and that industry would be in a better position to provide that support if it had indeed been involved in the original design, it is not a pre-requisite.

Repair and Maintenance

Of vital importance to the commander is an ability to repair aircraft and aircraft components which have suffered battle damage or which have simply become unserviceable. As much of this work needs to take place in forward areas, it has traditionally been a function retained by air forces rather than industry, although Australian industry is now undertaking maintenance on the RAAF's main operating bases, and consideration is being given to using industry support in forward areas. Either way, it is a vital function which needs high priority. In August 1940, when RAF Fighter Command was being stretched to breaking point, it still had one-third of its inventory of Spitfires and Hurricanes in maintenance.[51] Given that these aircraft

[49] Glover, P.G., 'Air Supremacy, the Enduring Principle' in Mason, R.A., (ed.), *War in the Third Dimension – Essays in Contemporary Air Power*, Oxford, 1986, p 61.
[50] *Business Standard*, New Delhi, 13 June 1995.
[51] Brown, N., *The Future of Air Power*, London, 1986, p 24.

were much simpler than their modern counterparts, the maintenance challenge facing today's air forces cannot be overstated.

Industry involvement in deeper maintenance of the aircraft and its repairable items is also common in many countries, and is certainly preferable to relying on other countries for maintenance support. The Pakistani experience of returning F16 components for repair in the USA is illustrative. To this end, the initial decision not to set up depot level support for the Indian Air Force's Mirage 2000 was difficult to understand, given the demonstrated technical competence of the local industry.

The local manufacture of spare parts is also a distinct advantage, although clearly this cannot be achieved for the whole aircraft inventory of spares. Thus high usage spares need to be identified at the beginning of the acquisition project, not always an easy task. However, local industry shortfalls can be compensated for by stockpiling, and ultimately some degree of spars shortages can be overcome by cannibalisation. Thus the local manufacture of spares does not have quite the same priority as the final set of logistic support requirements – weapons.

Weapons

Of highest priority to the commander, or at least as high as an ability to maintain the aircraft, is the resupply of weapons. These can either be imported or manufactured locally. If imported they need to be stockpiled according to an anticipated usage rate and resupply lead time. Such a policy clearly involves some risk in the short to medium term with respect to assessing quantities required and the reliability of the source; thus local manufacture has strategic benefits. However, it is interesting to note that few countries which undertake the manufacture of combat aircraft for reasons of self-reliance also manufacture the weapons they carry. A review of SIPRI data reveals that, of the industrially developing countries, licensed manufacture of air-to-air missiles is undertaken only by China which produces the PL-9 (a version of the Israeli Python III missile), Egypt, manufacturing the Sidewinder AIM 9P, and India, which makes the Russian AA-8 Aphid (Indian designation Astra).[52] Australia does not completely manufacture any operational ordnance for the F/A 18 or F111.[53]

The lack of high technology armament manufacture in the industrially developing world is probably due to a combination of a reluctance of missile and laser guided bomb (LGB) manufacturers to grant licences and the reticence of nations to press for this capability. The former is understandable; manufacture by the vendor will always be preferable to the sale of a licence. The restriction of licences would also be favoured by the vendor's government.

Nonetheless, licenses have been granted to the countries mentioned above as well as to a number of industrialised countries: Germany, Japan and the UK all manufacture air-to-air missiles of American origin.[54] Of course the practice carries the same disadvantages as licensed aircraft manufacture. However, because the project is smaller, the problems in achieving self-sufficiency are smaller. Importantly, self-

[52] SIPRI Yearbook 1993, pp 483-518.
[53] Discussion with GPCAPT W. McDMayne, President Australian Ordnance Council.
[54] SIPRI Yearbook 1993, pp 483-518.

sufficiency in weapon manufacture is directly relevant to the conduct of combat operations; but as pointed out, self-sufficiency in weapon platform (that is, aircraft) manufacture is not. The reluctance of industrially developing countries to pursue weapon manufacture for combat aircraft is therefore puzzling.

If licensed manufacture cannot be achieved because of restrictions in technology transfer then, from a self-sufficiency perspective, there is a strong case for indigenous design. Israel, South Africa and Taiwan all produce indigenous designs.[55] Like the aircraft case, this has drawbacks in terms of cost, however, the smaller nature of the project limits that expense. In this regard the Israelis seem to be showing the way. The Lavi project was cancelled because of the financial inability of Israel to proceed alone after the USA withdrew financial support. However, the Israelis have still retained their missile and EW design and manufacturing capability. This is because they believe they will always be able to find someone to sell them a platform; real self-reliance with respect to manufacturing lies in the ability to adapt the design, especially with respect to the electronic warfare suite, and in weapons production.

CONCLUSION

The options available to acquire defence equipment are either to import or to manufacture in-country, the latter being undertaken through indigenous design, collaborative design or license agreements. In-country manufacture appears to have a number of advantages in terms of strategic self-sufficiency, national status, technology development and/or transfer to industry, job creation, and saving of foreign exchange. In essence, these issues reduce to two considerations: strategic (or self-reliance) and economic.

Taking the economic consideration first, this paper has shown that indigenous design and production is a very expensive business, so much so that the industrialised world is adopting the cheaper option of collaborative design, even with the attendant disadvantage of surrendering some measure of self-reliance. In this way, member countries attempt to reduce the unit price with the combined objectives of reducing their own defence costs as well as competing on the extremely competitive world market. Industrially developing countries attempting to enter this competitive market place on their own have little chance of success.

With respect to licensed production, industrially developing countries with low wage structures have, in theory, an advantage and should be able to produce overseas designs cheaper than buying them. However, the evidence is not conclusive; at best, the savings would appear to be minimal. Countries contemplating undertaking licensed production projects need to estimate their project costs carefully and realistically to determine whether any savings will actually accrue.

If there is no financial advantage then local production should not proceed. Instead, maximum value should be extracted from the competitive international market place to secure offset deals which will be of maximum benefit to the national economy.

[55] *Jane's Weapons Systems 1986-87*.

While it is natural to look for offset deals in the aircraft industry, these may not represent the best option economically, and thus a wider perspective should be taken.

The reason for this emphasis on economics in what is supposed to be a strategic consideration is that the ability to produce fighter aircraft indigenously confers little advantage with respect to self-reliance. Even if the aircraft can be totally sourced in-country, the lead times to produce modern aircraft are simply too long to have any bearing on the short to medium term sustainability required in modern warfare. Thus Nehru's goal of self-sufficiency in defence production is virtually impossible to achieve by developing countries with respect to fighter aircraft. On the other hand, establishment of capabilities for repair and maintenance of the aircraft, for engineering changes, in particular to the electronic warfare suite, and for manufacture of weapons and high usage spares, are vital to the conduct of combat operations. These areas of industrial involvement demand a far higher priority than the local manufacture of the platform, which represents just one of the reusable parts of the total weapons system.