SELF RELIANCE AND SELF SUFFICIENCY: EXPERIENCE OF THE INDIAN AIRCRAFT INDUSTRY

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ABSTRACT

The thesis addresses three major questions arising from the decision of the Government of India to set up an indigenous aircraft industry in the public sector. Firstly, the rationale behind such a decision. Secondly, the decision-making and execution of the various aircraft manufacturing programs undertaken in the country. And finally, following from the above, has the aeronautical industry in India been able to make any significant progress towards the proclaimed goals of self sufficiency and self reliance?

The creation of an aeronautical industry in India was the direct result of the Industrial Policy Resolution of 1956 which emphasised indigenous manufacture of aircraft in order to expand the technological and industrial base of the country as well as to lessen dependence on foreign suppliers. While short term import of combat aircraft was considered inevitable, the manufacturing policy envisaged the licenced production of aircraft in technical collaboration with foreign manufacturers in the initial stages. This would be followed by the creation of design, development and manufacturing facilities which would be geared towards fulfilling the requirements of the user agency, i.e. the Indian Air Force (IAF).

Implementation of this policy was exceptionally swift. Within a period of six years beginning from 1956, the Government of India had taken steps to manufacture as many as six different types of aircraft. Of these, two, the

HF-24 Marut and the HJT-16 Kiran were to be designed indigenously, and two, the Gnat and the HS-748 to be manufactured under licence from UK. Further, it was also decided to manufacture the MiG-21 fighter and Al-III helicopter under licence from the Soviet Union and France respectively. These projects however encountered serious problems at various stages of implementation. Firstly, the country lacked the trained manpower required for the execution of the manufacturing programs. Secondly, there were serious lapses in project planning and management. Even in cases where project reports were prepared with the help of overseas consultants, these were subject to arbitrary changes by decision-makers both at the Ministry of Defence and at Hindustan Aeronautics Limited (HAL). This resulted in considerable delays as well as low productivity. Further, there were considerable losses in terms of redundancy of parts and raw materials due to poor coordination between various sectors of the decision-making machinery. Finally, after more than 25 years of manufacturing experience, the country has not been able to evolve a cohesive aircraft procurement and manufacturing policy. As a consequence, not only is the industry facing a considerable problem of idle capacity in the near future but has also not been able to keep abreast of contemporary technology.

HAL is now undertaking a second round of transfer of technology from the West - a situation reminiscent of the late 1950s. After two decades of attempting to design and develop its own combat aircraft, it has finally decided to

license manufacture the Anglo-French Jaguar and the MiG-23. Thus, despite rhetoric to the contrary, a combination of poor planning and bad management have ensured that the aircraft industry in India is nowhere near the twin goals of self reliance and self sufficiency it had set for itself a quarter of a century ago.

CONTENTS

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INTRODUCTION

The period from 1954 onwards was of major significance for the aeronautical industry in India. This was also the time when the Second Five Year Plan was being formulated. The First Five Year Plan (1951-56) had neither attempted fundamental changes in the economy nor tried to initiate process of rapid growth. It was, as was officially admitted 'essentially a plan of preparation for laying the foundation for more rapid development in the future'.[1] On the other hand, the Second Five Year Plan (1956-61) had been drafted with an intention to achieve certain goals, especially in the industrial sector. It was made quite clear that basic industries like mining, iron and steel and machine tools would have immediate priority 'in order to provide for a constant increase of the country's "self-equipment"'.[2]

The Industrial Policy Resolution adopted by Parliament in 1956 stated that the manufacture of aircraft would be the responsibility of the public sector,[3] and the rationale for indigenous manufacture of aircraft was clearly stated by the Prime Minister Jawaharlal Nehru in a speech in Parliament on 21 March 1956:[4]

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[1] India. Planning Commission, *The First Five Year Plan*, New Delhi, 1953.

[2] For further elaboration refer: Charles Bettelheim, *India Independent* (London: Macgibbon & Kee, 1968), pp.246-247.

[3] Air Marshal M.S. Chaturvedi, *History of the Indian Air Force* (New Delhi: Vikas, 1978), p.198.

[4] *Jawaharlal Nehru's Speeches 1953-57*, Volume III (New Delhi: Publications Division, Government of India, 1958), pp.39-40, 41.

> The more technical armies and navies and air forces get, the more important becomes the industrial and technological base of the country. You import ... an aircraft ... and you may even teach somebody to use it, but that is a very superficial type of defence because you have not got the technological background for it ... If somebody from whom you bought it refuses to supply a part of it, it becomes useless, so that in spite of your independence you become dependent on others, and very greatly so ... The *real strength of a country develops by industrial growth, which implies the capacity to make weapons* of war for the army, the navy or the air force ... (emphasis added)

The overriding importance attached to the twin concepts of indigenous defence production and self reliance was further elaborated by Nehru in reply to a debate in Parliament 23 June 1962, when he stated:[5]

> ... I believe, as a practical proposition, that it is better to have a second-rate thing made in our own country than to rely on the first-rate thing which we have to import and which may stop functioning for lack of spare parts or something else.

Thus, the policy of the Government of India with regard to equipping the IAF had been clearly defined by 1956. Apart from the outright purchase of aircraft from overseas, facilities for indigenous production would be set up by following a policy of:

(a) licensed production of aircraft within the country in technical collaboration with overseas manufacturers.

(b) creating design, development and production facilities of the required type of aircraft.

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[5] *Jawaharlal Nehru's Speeches 1957-63*, Volume IV (New Delhi: Publications Division, Government of India, 1964), p.447. The IAF had no public reaction to this proposition.

To an extent, HAL had already acquired experience with the assembly of combat aircraft in its manufacture of Vampire jets under licence. But the uncertainties associated with the total reliance on UK suppliers for the Vampire powerplants clearly gave an added incentive to HAL to try and set up engine manufacturing facilities. Consequently, when an agreement to manufacture the Gnat was signed with Folland Aircraft (UK) in 1956, the Government also invited a technical team from Bristol Siddeley Ltd (UK), manufacturers of the Orpheus engine, to visit India and submit a project report for its indigenous manufacture. This resulted in the signing of an agreement in 1956 for the licence manufacture of the Orpheus engine.[6]

In addition, to licence manufacture of the Gnat, an Air Staff Requirement had been formulated for a multi-role combat aircraft suitable for both high-level intercept and low-level ground attack missions. There was also the requirement to design, develop and manufacture a basic jet trainer to replace the Harvard and the Vampire T. Mk 55. Despite the fact that the HAL design team possessed neither the capacity nor the experience[7] to take up these projects simultaneously, both were accepted for execution. This, it would appear was done more for 'political' and symbolic reasons rather than as a result of a careful assessment of

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[6] Air Marshal M.S. Chaturvedi, refer n.3, p.198.

[7] The only aircraft that had ever been designed by HAL was the piston engined primary trainer, the HT-2 which made its first flight on 5 August 1951.

HAL's ability to execute the two projects. The result was that Dr Kurt Tank and his Assistant Engineer Mittelhuber accompanied by a team of West German design engineers were invited to take charge of the design development of the combat aircraft, later designated the HF-24. Arriving in India in August 1956 Dr Tank 'spent his first few months ... creating, from scratch, a respectable design department and prototype shop'.[8] Meanwhile, Dr V.M. Ghatage and Raj Mahindra assumed responsibility for the basic jet trainer, the HJT-16. Work also began on the design of a turbojet the HJE-2500, which was intended eventually to supplant the Viper engine in the trainer.[9]

With regard to the communications and logistic support component it was decided to replace the aging fleet of C-47 Dakota aircraft with the Avro-748 (later known as the HS-748). The aircraft was expected to meet both civil and military requirements and a licence agreements to manufacture the aircraft and its powerplant, the Rolls Royce Dart-7 engine, were signed in 1959. The aircraft was to be ~~progressively~~ built at the Aircraft Maintenance Depot (AMD), Kanpur while the engines were to be manufactured by HAL, Bangalore.[10] While helicopters had initially been acquired by the IAF as early as 1954, their utilisation was limited to VIP transportation and casualty evacuation

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[8] William Green et.al. (ed), *The Indian Air Force and its Aircraft* (London: Ducimus Books Ltd., 1982), p.30.

[9] ibid. Ghatage and Mahindra had recently returned from the US and UK respectively.

[10] Air Marshal M.S. Chaturvedi, refer n.3, p.199.

tasks. However, in the late 1950s the increasing involvement of the Indian Army in the security needs of the northern borders resulted in the evaluation of various medium transport helicopters. Negotiations for an initial batch of 10 Mi-4s were finalised in Moscow in October 1960 and a further 16 were ordered in early 1962.[11] However, the IAF selected the Sud Aviation (France) Alouette III as its standard light utility helicopter and signed a contract on 4 June 1962 for its purchase and manufacture under licence.[12]

The late 1950s also witnessed the acquisition of F.86 Sabre day fighters by Pakistan from the US. Soon afterwards, India decided to opt for the manufacture of the MiG-21 and a licence agreement was signed with the Soviet Union in August 1962.[13] The aircraft was to be built by a new company that was set up for the purpose in August 1963, Aeronautics (India) Limited.

Thus, with a period of six years beginning from 1956 the Government of India had taken measures to manufacture as many as six different types of aircraft. Of these two were to be designed indigenously, two to be manufactured under licence from UK and one each from France and the Soviet Union. Apart from Hindustan Aircraft Limited (HAL),

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11 William Green et.al., refer n.8, p.50.

12 ibid., p.51.

13 *Committee on Public Undertakings (1967-68): Eighth Report (Fourth Lok Sabha)*, p.8.

Bangalore, by 1963 two new companies had been established in order to undertake this task. However, a year later, in October 1964, the three were amalgamated.

> ... with a view to conserving resources in a field where technical talent was limited and to enable the activities of aircraft manufacturing units to be planned and coordinated in the most efficient and coordinated manner.[14]

Given this background of the development of the aircraft industry in India the present study will attempt to examine the following aspects:

1. An assessment of the selection process. Given the fact that licence manufacture was decided on as a measure to diversify sources of supply as well as achieve a satisfactory level of self reliance, were the aircraft that were ultimately manufactured, selected for their technical and operational superiority/suitability or were political considerations the prime motivating factor? Or did the particular aircraft happen to be the only one of its type that was available for manufacture under licence?
2. Were the licence agreements with vendors from various countries comprehensive enough to ensure suitable technical and material help in the creation of assembly lines and manufacturing facilities?

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[14] Air Marshal M.S. Chaturvedi, refer n.3, p.199.

3. With regard to the indigenous design and development projects, had the Government undertaken any pre-planning exercise to determine India's capability in terms of technical manpower and resources to execute these programs successfully?

4. Implementation of the various manufacturing programs. This involves a detailed examination of the problems encountered in the actual assembly and manufacture of aircraft. Here again the emphasis will be on the organisational efficiency viewed in terms of running an efficient aircraft industry and will encompass the decision making machinery at the Ministry of Defence and the execution of such decisions by HAL. Is there any evidence of a comprehensive planning and coordination process that would ensure efficient utilisation of manufacturing facilities, manpower and materials?

5. The costs of self reliance. The domestic manufacture of aircraft has involved a fairly substantial financial outlay, for what have been rather limited production runs of each aircraft type. This would deny HAL any benefits that normally accrue from the economies of scale as aircraft production was primarily geared towards meeting the requirements of the IAF. Also, an attempt will be made to explore the argument that aircraft manufacture in India is cheaper because of its low labour costs.

6. Consequent on the above point, has the creation of the aircraft industry and the substantive costs incurred therein, had any beneficial effects in terms of spinoffs? Has it helped the development of ancillary industries in the small scale sector? Have there been any tangible benefits in terms of acquisition of advanced technology which have then helped modernise various sectors of Indian industry? These can be fairly wide ranging, from alloy and special steel technology on the one hand to advanced electronics on the other. A further question that shall be examined is whether such technology could ~~not~~ have been acquired if India had not decided to set up an indigenous aircraft industry. Also, has the creation of this high technology sector led to integrated industrial planning and development incorporating various other sections of Indian industry.

7. Finally, has India been able to achieve the goal of self reliance that formed the rationale behind the development of the aircraft industry or, has overt dependence, i.e. a purchaser-supplier relationship with various countries been replaced by a not so obvious dependence in terms of raw materials, components and spare parts? If the latter is true, have any real benefits accrued? As a corollary to this question a comparative evaluation of Indian experience with different collaborators UK, France and the Soviet Union will be made and an attempt made to point out the

long term advantages or disadvantages that helped (or hindered) HAL's drive towards self sufficiency.

Before embarking on a detailed analysis of the various aircraft manufacturing programs undertaken by Hindustan Aeronautics Limited (HAL), it should be pointed out that one of the major problems that confronts a researcher working on any aspect of Indian defence is that of paucity of *primary* sources. This includes the defence production sector for the simple reason that all relevant industries are under the administrative control of the Ministry of Defence, and as a consequence, beyond the purview of some of the provisions of the Indian Companies Act. For example, the 'Indian Aeronautical Industry' (i.e. HAL) is exempted from disclosing any purchases over Rs 10,000 ($1,000) that it makes from other public sector companies.[15] Further, over the years, there has been virtually no public debate on defence planning or the defence production sector. In this context it would be relevant to state that HAL is the largest company functioning under the Ministry of Defence, with a workforce of over 40,000. A major contributing factor in this regard has been the fact that no level of the defence production decision-making process is open to any form of scrutiny by the public or, to a large extent, by the Parliament. Reasons of National Security are the

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[15] *HAL Annual Report 1979-80*, p.59.

blanket excuse that has inevitably been used by the Government in its refusal to disclose any information that might open it to criticism.[16]

However, given the parliamentary system of government in India, some information is published in *unclassified* form by the office of the *Comptroller and Auditor General of India* in the form of an annual report. Although not available to the public, this report is provided to the members of the *Public Accounts Committee* (PAC) of Parliament. A mere statement of facts, this report *does* document various issues which are then taken up on a *selective* basis by the PAC for further enquiry. It is for this reason that this study relies *primarily* on the reports of the Comptroller and Auditor General and those of the PAC. Although the HAL itself does publish an annual report because of legal obligations, a careful perusal reveals that they have tended to become singularly uninformative over the last two decades.

So far as secondary sources are concerned, apart from the standard professional journals like *Air International*, *International Defense Review* and *Flight International*, the singularly *consistent and most helpful source* of reliable information has been *Milavnews*, a 'confidential' monthly newsletter published by Aviation Advisory Services, Stapleton Airfield, nr Romford, Essex, England.

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16 For a good study of the ineffective role of the Parliament in matters related to defence problems, see Cecil B. Jones Jr., *How the Indian Lok Sabha Handles Defense Matters - An Institutional Study*, The American University, 1975, PhD thesis (Unpublished).

CHAPTER I

INDO-BRITISH PROJECTS

A. GNAT/AJEET

Development of the single-seat lightweight Gnat fighter/interceptor was started by the (then) Folland Aircraft Ltd. (U.K.) as a private venture in 1951. The first Gnat MkI prototype powered by a Bristol Siddeley Orpheus (B Or.1) turbojet flew on 18 July 1955. The aircraft apparently did not meet the requirements of the Royal Air Force and was never introduced into service, though 6 Gnat MkI aircraft were subsequently ordered by the Ministry of Aviation (U.K.).[1] India, on the other hand undertook negotiations directly with Folland Aircraft and Bristol Siddeley Aero-Engines in 1956 to produce the aircraft and its powerplant, the Orpheus turbojet. A licence agreement was signed in September 1956[2] and it also covered the supply of 25 aircraft plus 15 sets of components.[3]

At the time of signing the agreement, the aircraft and engine were still under development. The first prototype Gnat MkI which flew in 1955 had been powered by the original version of the Orpheus engine (B Or.1) developing 3,285 lb thrust. The Orpheus 701 (B Or.2) powerplant which equipped the definitive versions of the Gnat was type-tested in November 1956, at a rating of 4,520 lb thrust, later improved

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1 *Jane's All the World's Aircraft 1963-64*, p.144. See also p.32.

2 *Keesing's Contemporary Archives* 1957, 15728C.

3 *Jane's All the World's Aircraft 1966-67*, p.158.

to 4,700 lb.[4] The IAF also knew that the manufacturers had not developed the Gnat completely[5] but chose it on the grounds that it was basically a good air defence aircraft that needed 'a certain amount of development'.[6]

Licence for the manufacture of the Gnat MkI was assigned to the (then) Hindustan Aircraft LImited (HAL) and construction of factory buildings was completed by 1959.[7] The first Gnat assembled in India from British supplied kits flew for the first time on 18 November, 1959. Also, most of the jigs and tools required for the manufacture of this aircraft were reported to have been fabricated indigenously by HAL.[8]

By 1960-61, the first two phases of progressive manufacture i.e. from kits and sub-assemblies, had been completed but the program suffered a setback in production of the aircraft from raw materials.[9] These problems contined to increase and a year later, in 1961-62, HAL admitted that it faced 'certain difficulties' in producing the aircraft as a result of which there had been a 'considerable' delay in the production schedule.[10] The snags encountered at this

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4 *Jane's All the World's Aircraft 1964-65*, p.476.

5 *Public Accounts Committee (1980-81) Thirty Third Report (Seventh Lok Sabha)*, para 1.29.

6 ibid., para 1.30.

7 *SIPRI. Arms Trade with the Third World* (Stockholm: Almqvist & Wiksell, 1971), p.751.

8 *Jane's All the World's Aircraft 1975-76*, pp.102-103.

9 *HAL Annual Report 1960-61*, p.5.

10 *HAL Annual Report 1961-62*, p.7.

stage were apparently a consequence of developmental problems with the Gnat MkI itself rather than of HAL's inability to absorb manufacturing techniques. This was clarified in 1962-63 when HAL announced that although a 'large' number of aircraft had been produced, deliveries had been held up because of technical difficulties beyond its control. It was further added that steps were being taken in conjunction with Folland Aircraft Ltd. to overcome them.[11] This certainly proved to be a time consuming process since although the first Gnat built fully at HAL flew on 21 May, 1962, it was not handed over to the IAF till over a year later.[12]

Manufacture of the aircraft had stabilised by 1963-64 when it was announced that production was 'progressing satisfactorily'.[13] The engine was also being progressively manufactured from sub-assemblies and the first Orpheus 701 produced from imported 'raw materials' and components was completed by late 1963.[14] At this stage, however, only the airframe was being fabricated in India from imported 'raw materials' and it was only in 1965-66 that HAL signed agreements for the licence manufacture accessories like avionics, wheels, brakes, undercarriage and hydraulic equipment with various British companies including Bendix, Dunlop and Dowty Rotol.[15]

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11 *HAL Annual Report 1962-63*, p.11.

12 *Jane's All the World's Aircraft 1975-76*, p.102.

13 *HAL Annual Report 1963-64*, p.4.

14 *HAL Annual Report 1962-63*, p,14.

15 *HAL Annual Report 1965-66*, p.12.

Also, as the aircraft entered squadron service with the IAF, the inherent weaknesses in the original design effort became more apparent. For example, during the 1965 Indo-Pakistan war, when the Gnat was used operationally for the first time, considerable difficulties were encountered with the 30mm Aden cannon as a result of which there was an inordinately high incidence of gun stoppages.[16] Other failures included those of brake seals and the VHF Radio Transmitter (RT) sets[17] but the most serious problems lay in a very critical area of aircraft performance i.e. failures associated with the flying control system and the hydraulic system of the aircraft.[18] In evidence before the *Public Accounts Committee* in 1980, the Chairman of HAL admitted to the serious deficiency that the Gnat suffered in this field, adding:[19]

> ... all the brains in the country and the scientists' organisations with the half of the original design of the aircraft, have been trying to cure it. The flying record of the GNAT shows that we had a number of fatal accidents, where we lost some experienced pilots which costs even more if we take into account the cost of training together with the cost of an aircraft, apart (sic) from the human aspect of it.

Air Headquarters, in evidence before the same Committee, elaborated on the matter and disclosed that the flying control

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16 *PAC (1980-81) Thirty Third Report*, para 1.28.

17 ibid., para 1.56.

18 ibid., para 1.28.

19 ibid.

system in the Gnat was a serious problem compared to an aircraft of the same generation - the Hunter:[20]

> Both have been in the Air Force with the same number of squadrons. If the yardstick of serious malfunctioning is taken as the number of fatal accidents then over the same period of 18 years of operation, of the two aircraft, we lost 4 pilots in Hunters and 19 in Gnats!

Problems with the Longitudinal Control System (LCS) of the Gnat MkI resulted in the formation of a Study Group headed by Air Commodore J.J. Bouche which submitted its report in April 1972.[21] During the course of its enquiry, the Study Group found that investigations into aircraft accidents involving the LCS had been unsatisfactory because of the lack of qualified investigators. Further, the findings of a large number of technical defect reports were not available either at HAL or at Air Headquarters.[22]

The net result of the various shortcomings in the Gnat was that it suffered from a very high accident rate. For example (according to available information), during the period 1965-1973, it was only in 1967-68 that the annual number of 'serious accidents' was less than 50. The accident rates for the remaining years are as under:[23]

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[20] ibid., para 1.33.

[21] ibid., para 1.34. The findings of this report were never made public.

[22] ibid., para 1.35.

[23] ibid., para 1.32.

Year	No. of Accidents
1965	66
1966	50
1969	61
1970	50
1971	51
1972	53
1973	59

Overall, from the time of its induction into the IAF in 1958-59 to 15 November, 1980, the Gnat had met with as many as 613 major accidents and a further 624 'incidents'.[24] Regardless of its high accident rate, the IAF 'did not lose faith or confidence' in the aircraft but 'only wanted deficiencies removed'.[25] In fact, by 1972, the aircraft was considered to have a good export potential because of its low initial and operating costs, simplicity of design and high transonic performance. Two Gnat MkI aircraft were displayed at the Farnborough Air Show (U.K.) in September 1972[26] and the export price was then quoted at about Rs 2.3 million ($300,000).[27] While no export orders were received, manufacture of the aircraft continued till 31 January, 1974[28] a total of 215 Gnat MkIs being manufactured by HAL.[29]

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[24] ibid.

[25] ibid., para 1.31.

[26] *Milavnews*, September 1972, p.15.

[27] *Milavnews*, August 1972, p.14.

[28] *Jane's All the World's Aircraft 1974-75*, p.104.

[29] *Jane's All the World's Aircraft 1975-76*, p.103.

Gnat MkII/Ajeet:

After examining the Report of the Bouche Committee (April 1972) as well as conducting various feasibility studies, HAL proposed to develop an improved version of the Gnat. This proposal was approved by the Government in September 1972 and the new version, designated as MkII, was to be developed at an estimated cost of Rs 9.9 million (foreign exchange: Rs 2.6 million). Development work was to be carried out in four stages over a period of three years and deliveries were expected to commence two years later i.e. by 1976-77.[30]

Broad parameters of the development effort were defined in the Air Staff Requirement (ASR)22 issued in May 1972. At about the same time it was also decided to undertake a retromodification program in order to extend the useful life of the existing fleet of Gnat MkI aircraft. An ASR to remove the defects and make improvements in the MkI aircraft was issued by Air Headquarters in November 1972. This was also expected 'to help the development' of the MkII aircraft.[31] While the development work got underway, in July 1973, the Ministry of Defence sanctioned the manufacture of about 70 Gnat MkII at a unit cost of Rs 5.127 million[32] involving a total outlay of Rs 360.4 million.[33]

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30 *Report of the Comptroller and Auditor General of India: 1978-79. Union Government (Defence Services)*, para 6, p.5.

31 ibid., pp.5-6.

32 *PAC (1980-81) Thirty Third Report*, para 1.81.

33 ibid., para 1.25.

Three months later, in October 1973, the Ministry of Defence sanctioned a retromodification program involving about 130 aircraft at an estimated cost of Rs 209.04 million. For this work, the MkI aircraft were to be made available to the HAL in a phased manner from 1974-75 onwards.[34] Thus, the retromodification program was expected to help in the development of the MkII version, which was to conform to the 'standard of preparation' to be specified after completion of the development work which comprised four stages. These were:[35]

Stage	Work	Planned Schedule/Actual For Completion (from time of sanction)	Completion
		Planned	Actual
I	Improvements to the Navigation and Communication Systems	8 months By May 1973	January 1973 April 1976*
II	Improvements to the Hydraulics Systems	18 months By March 1974	September 1974
III	Improvements to the Longitudinal Control System	36 months By September 1975	October 1979
IV	Improvements to the Fuel System (introduction of internal wing fuel tanks)	3 months By September 1975	April 1976

* This delay was due to additional tasks beyond the original proposal.

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[34] ibid., para 1.64.

[35] ibid., para 1.36.

However, even before the entire development program for the Gnat MkII could be completed, Air Headquarters issued a revised ASR-4 in June, 1974 which was also to be applicable to the retromodification program.[36] The revised ASR was apparently a clearer definition of the IAF requirements for the Gnat MkII. In evidence before the *Public Accounts Committee* in 1980, the Secretary of the Department of Defence Production explained:[37]

> The difference between ASR 22/1972 and ASR 4/1974 was not substantial to require any revamping of the project. It may however be added that the original proposal of HAL was not based on any ASR.

He further went on to add:[38]

> Some equipment were available later, and it was thought it would be better to use them and improve performance ... these improvements were considered and thought of between 1972 and 1974.

In fact, there was no difference between the two ASRs except regarding the radius of action and the weapons load that the aircraft was to carry.[39] Renamed the *Ajeet*, the aircraft was to be produced primarily for the tactical ground attack role, unlike the Gnat which had been designed as an interceptor.

Initially, two Gnat MkIs were converted for flight testing of the Ajeet's hydraulic and avionics systems while a Gnat airframe was subjected to static tests. The first

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[36] ibid., para 1.38.

[37] ibid., para 1.40.

[38] ibid., para 1.41.

[39] ibid., para 1.43.

prototype Ajeet, a Gnat MkI with less than the full range or modifications, first flew on 6 March, 1975 and a second prototype joined the flight test program on 5 November that year.[40] The modification program had, by this stage, been delayed considerably and the various changes to be incorporated in the Ajeet were in different stages of installation and evaluation:

1. Stage I: Navigation and Communication Systems: Improvements in these areas, according to the original HAL proposal would appear to have been minor in nature. They were planned for completion on one of the Gnat MkI aircraft and the work was completed by January 1973 - four months ahead of schedule. Nonetheless, the ASR of 1974 laid down certain specific requirements and changes to be incorporated in this area:[41]

(a) Due to the change over from the interception to the ground attack role, the Ferranti (U.K.) Airpass interception radar was to be deleted.

(b) Installation of IFF Mk-10 (BAT) - identification equipment.

(c) The TA/RA-22 VHF communications set, an item manufactured by Bharat Electronics Limited (a sister concern under the Ministry of Defence) under licence from Bendix (USA), had proved to have a very high

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40 H.P. Mama, 'Ajeet - the IAF's New Ground Attack Fighter', *International Defense Review* 6/1977, p.1088.

41 *PAC (1980-81) Thirty Third Report*, para 1.89.

failure rate.[42] It was therefore decided to replace the set by an imported V/UHF communications system manufactured by Collins (USA) as well as incorporate a standby VHF set (AH-3).

(d) Replacement of the Ferranti Mk8 gunsight of the Gnat by the Ferranti ISIS 195 (Integrated Strike and Interception System) two-axis rate gyro gunsight which would be licence-manufactured by HAL's Lucknow Division.

These modifications required a complete re-installation and a new wiring system for the avionics. The task could thus not be completed on a Gnat aircraft but had to be incorporated on one of the Ajeet prototypes. Improvements connected with this stage could thus be completed only by April 1976.

2. Stage II: Hydraulics System: Work in this area was connected with the longitudinal stability of the aircraft (see Stage III below) and was completed by September 1974. This was six months behind schedule and the primary reason for the delay was the incorporation of an Abex engine-driven variable delivery hydraulic pump[43] instead of the earlier constant delivery unit.

3. Stage III: Longitudinal Control System (LCS): Development work relating to improvements in the LCS with the modified Hobson actuator unit was completed 'in all

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[42] ibid., para 1.57.

[43] ibid., para 1.39.

respects' by October 1979[44] - nearly four years later than scheduled. The unit used in the Gnat had been designed and supplied by a British firm, Claudel Hobson, which had since been taken over by Lucas Aerospace (UK). As the HAL 'did not have the competence to undertake development of powered flying controls to improve longitudinal control',[45] it was decided to entrust the development of the actuator unit to Lucas Aerospace.

Design of the modified Hobson actuator unit encountered serious problems despite sustained efforts by the design engineers of Lucas Aerospace. According to the Chairman of HAL:[46]

> They made many trials; they gave us many options; they gave us many prototypes and made many improvements.
>
> ... So, we tried to persuade them and pressurise them to give us in absolute state of the art, [a] modern flying control with all the possible safety factors built into it. Admittedly, in getting these developments carried out, Lucas took longer than anticipated.

4. Stage IV: Fuel System: It had been originally planned to improve the fuel system by manufacturing a new wing with an integrally sealed tank and converting a Gnat MkI as an Ajeet prototype using this wing. This was done according to schedule and the first converted Ajeet prototype flew in March 1975. However, the ASR of 1974 spelt out certain

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[44] ibid.

[45] ibid., para 1.46.

[46] ibid., para 1.50.

refinements to be carried out in connection with the fuel system, including the introduction of an SPE 6210F MkI fuel booster pump. As a result, an additional time of seven months was taken to meet the requirements of the ASR of 1974.[47]

It is interesting to note that while the ASR of June 1974 affected all the four stages of development, it was more than a year later, in September 1975, that HAL approved.[48]

> ... a proposal to take up further work required concurrently with the work sanctioned earlier with a view to minimising expenditure.

While development work on the Ajeet apparently made progress, it took the Ministry of Defence another year to sanction an additional amount of Rs 5.4 million (foreign exchange: Rs 1 million) - this was done in July 1976. Development work was completed in '*almost* all respects' (emphasis added) by early 1976 and the 'standard of preparation' of the first and second production batch of aircraft was specified by Air Headquarters in February 1976 and July 1976.[49] In making preparations for manufacture of the Ajeet, HAL had earlier awarded a £120,000 contract to Automotive Products Ltd. (UK) for the supply of aileron power control units, landing gear retraction jacks, filters, flow restrictors, foot brake pumps and various types of valves.[50]

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47 ibid., para 1.39.

48 *C and AG Report: 1978-79*, para 6, p.6.

49 ibid.

50 *International Defense Review* 5/1975, p.766.

In March 1977, three years after having accepted the ASR of 1974, HAL expressed its 'inability' to comply with some vital requirements of the Ajeet as specified in the ASR. In the same month, Air Headquarters informed the Ministry of Defence that if HAL was unable to ensure aircraft performance 'close' to the ASR, it might be compelled to 'review' the entire acquisition program for the Ajeet.[51] Interestingly, by May 1977, within two months of presumably intense bureaucratic activity, views of the Air Headquarters underwent a radical change. In proposing a further development expenditure of Rs 4.05 million, Air Headquarters stated that while there were 'serious shortcomings' in the Ajeet, it was not planned to drop the project altogether, but it might become necessary to reduce the number of aircraft produced. Accordingly, in July 1977, the Ministry of Defence increased the development expenditure for the aircraft to Rs 19.35 million (foreign exchange: Rs 4.4 million)[52] - compared to the original estimate of Rs 9.9 million (foreign exchange: Rs 2.6 million).

Although manufacture of the Ajeet actually began on a small scale in 1976-77, the aircraft could not be delivered to the IAF due to a 'number of problems relating to development and production'.[53] It was only in March 1978, that about 20 aircraft were delivered. Of these six were

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51 *PAC (1980-81) Thirty Third Report*, para 1.44.

52 ibid., para 1.45.

53 *HAL Annual Report 1976-77*, p.6.

allotted to the Ajeet handling flight while the rest were handed back to HAL for storage and incorporation of additional modifications.[54] This was because, although theoretically these aircraft conformed to the 'standard of preparation' laid down by the IAF, substantial concessions had to be made while accepting aircraft for the handling flight. These included:[55]

1. Installation of the (old) Hobson tailplane actuator unit, HU type-145 in place of the modified HU type-1003 which was still under development.
2. Non-compliance of the camouflage painting scheme.
3. The aircraft were accepted without full night flying facilities.
4. A few 'minor' concessions to enable the use of Category 'B' (used) components, as Category 'A' (new) components were not available.

No aircraft were delivered to the IAF in 1978-79 because of the non-availability of the modified Hobson actuator units.[56] It is thus clear that the initial delivery of the Ajeet aircraft to the IAF was for purely ceremonial purposes rather than an effective contribution to its operational capability. Apart from the concessions mentioned earlier, initial IAF handling flights experienced several maintenance problems which included:[57]

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54 *PAC (1980-81) Thirty Third Report*, para 1.83.

55 ibid., para 1.54.

56 ibid., para 1.53.

57 ibid., para 1.57.

1. Fuel leaks from the integral fuel tanks in the wings: nine modifications had to be incorporated to rectify the problem.

2. Brake seal failures.

3. R/T failure: this was overcome by replacing the indigenously manufactured TA/RA22 VHF communications sets by V/UHF systems manufactured by Collins (USA).

By October 1978, Air Headquarters had made it clear that it was considering a reduction in the number of aircraft to be manufactured.[58] Production orders were reportedly reduced from the then planned total of 115 to 80 aircraft.[59] At the same time a Specialist Committee had been set up by the IAF to study the question of

> ... extended development efforts due to shortfall in radius of action and the design deficiency in the development of modified power control unit and the need to try the various armament stores.[60]

In other words, while the transition from the interceptor role of the Gnat to the ground attack tasks of the Ajeet had been an integral part of the ASR of 1974, the delay in development effort had made it impossible for weapons trials to be carried out. Accordingly on recommendations of the Specialist Committee of the IAF, a further sum of Rs 12.65 million was sanctioned for further development work.[61]

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58 ibid., para 1.56.

59 *Air International*, Vol.21, No.3, September 1981, p.105; also *Flight International*, 12 June, 1982, p.1555.

60 *PAC (1980-81) Thirty Third Report*, para 1.81.

61 ibid.

This work had not been completed till December 1979 when the aircraft was inducted into squadron service - nearly 20 months after the formation of the handling flight.[62]

By the end of 1980, HAL had been able to overcome the following problems:[63]

1. Radius of action: Against the radius of action of 108 nautical miles specified in the ASR of 1974, HAL had been able to achieve a range of 93 nautical miles in the first instance. Subsequently, with the installation of 2 x 33 gallon drop tanks, the Ajeet was able to acquire an additional range of 10 nautical miles. While the aircraft now had a range of 103 nautical miles 'with certain restrictions', it now had only two underwing hard points for weapons carriage, instead of four originally planned.
2. Carriage of Rocket Pods: As a result of the limitations imposed by the installation of drop tanks, the aircraft could not be cleared for the installation of four pods of 19 x 68 mm rockets. Instead, it had been cleared for two pods of 16 x 57 mm rockets and trials were being carried out for the use of two pods of 32 x 7 mm rockets.
3. Night flying capability: Development work had been completed.

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62 ibid., para 107.

63 ibid., para 1.56 and para 1.59.

4. High rate of gun stoppages: Efficiency was being confirmed through intensive gun firing trials.

5. Invertor failures: The problem had been resolved by the introduction of an indigenously developed invertor.

Thus, by the end of 1980, while two Gnat squadrons (Nos.9 and 18) had been re-equipped with the Ajeet, HAL had only been 'able to acquire all the items for modifying the aircraft for carriage and delivery of 57 mm rockets. 'A limited number of aircraft were expected to be modified by June 1981, and the balance in due course. The aircraft had finally been cleared for operational service,[64] more than four years behind schedule.

The Retromodification Program:

As mentioned earlier, in October 1973, the Ministry of Defence had sanctioned the retromodification of about 150 Gnat MkI aircraft in a phased manner from 1974-75 onwards. However, due to the delay in development of the Gnat MkII/Ajeet, in November 1977, the number of aircraft to be retromodified was reduced to about 100.[65] This was because, given the number of MkI aircraft available, the remaining airframe fatigue life was very limited. Also a substantial number of aircraft had

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[64] ibid., para 1.58.

[65] ibid., para 1.67.

suffered from wastage.[66] In other words they had been written off, a fact not altogether surprising, given the high accident rate for the Gnat.

By July 1979, only seven Gnat MkIs had been retromodified and test flown. Even then, the delivery of these aircraft had been held up to facilitate the installation of the modified Hobson actuator unit which was still under development. Work on another three aircraft had not been completed 'for want of certain components to be supplied by the Air Force/foreign supplier'.[67] By November 1979 it had been decided to abandon the proposal for retromodifying the remaining 90 aircraft. The reason for this decision, according to the Department of Defence Production was that:[68]

> During the extended period of development, one of the likely adversaries of India had acquired a large number of very high performance (supersonic) aircraft and quick reaction surface-to-air missiles ... it was felt that the MkII aircraft would not be a viable weapons system well beyond the mid 80s because of its low survivability in such an environment. As such it was felt that the strength of the MkII force should be limited to four squadrons. Therefore, the initial order for MkII aircraft was curtailed ... and retromodification program was reduced ...

As for the 10 Gnat MkIs which were in the process of retromodification, it was only by late 1980 that 'all

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66 ibid., para 1.72.

67 ibid., para 1.68.

68 ibid., para 1.70.

components' required for the work had been received. Nine aircraft had been test flown after retromodification and accepted by the IAF while the remaining one aircraft was in the final stage of acceptance.[69] Given the delay in retromodifying the first 10 Gnat MkIs, it was clear that even if the work had not been restricted to this number, there would not have been enough MkI aircraft in IAF inventory with enough airframe fatigue life remaining, to make the retromodification program worthwhile.

Thus, after the cancellation of the retromodification program and a substantial reduction in the number of Ajeet aircraft required, the manufacturing program finally came to an end in March 1982 after the manufacture of 20 aircraft.[70] Also, as a result of this cancellation and short-closure of orders, there was a substantial amount of redundancy in components and materials required for manufacture. Details are as under:[71]

	Million of Rupees	
	Cost of Redundancy: Production/ Retromodification	Cost of surplus items: Development Program
Raw Materials	2.1	0.139
Standard Parts	0.8	
Castings and Forgings	0.05	
Proprietory Items	3.3	0.792
Hobson Units	5.08	0.037
Modification Kits	1.04	
Parts	0.73	
Components	6.984	
	19.964	0.968

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69 ibid., para 1.73.

70 *Flight International*, 12 June, 1982, p.1555.

71 *PAC (1980-81) Thirty Third Report*, para 1.78.

While the surplus items relating to the development program, valued at nearly Rs 1 million had to be written off as a net loss, some of the materials acquired for the retromodification and manufacture programs, it was later realised, could be used in other programs. HAL later decided that of the surplus materials (valued at Rs 20 million approximately), bought out components and parts could be used for the development/production program of the Ajeet Trainer aircraft while the raw materials could be used for materials worth Rs 9.5 million, about Rs 10.5 million had to be written off as losses in connection with the Ajeet manufacturing program.

Ajeet Trainer:

In 1975, while engaged in the development of the Ajeet, HAL also initiated studies for the design of a 2-seat trainer version and it was considered possible to develop the aircraft within three years of sanction.[72] Formal sanction was received in February 1976[73] and the aircraft was said to have been intended to be the long term replacement for the 12 Hunter T.66s and a similar number of single seat Hunters at the IAF's Operational Conversion Unit, as well as other operational trainers at squadron level.[74]

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72 *Milavnews*, November 1975, p.14.

73 H.P. Mama, 'Ajeet - the IAF's New Ground Attack Fighter', *International Defense Review*, 6/1977, p.1090.

74 *Milavnews*, May 1977, pp.12-13.

By late 1976, design of the tandem 2-seat trainer had been finalised and it was also reported in Western sources that two prototypes were to be built with the first one scheduled to fly in July 1978.[75] A fuselage mockup of the trainer had been completed by early 1977 and the design indicated that the aircraft would offer somewhat more room than the earlier 2-seat Gnat trainer (developed in UK and then in use with the RAF) there being sufficient room to instal Martin Baker GF4 ejection seats (common with the Ajeet) in place of the Folland/Saab Type 2G lightweight seats of previous Gnats.[76] But this was accomplished by the deletion of some of the fuel tanks - resulting in reduced endurance. The aircraft was to have a performance in some respects 'fairly close' to that of the H.S. Hawk, particularly in Mach number and rate of climb, at a considerably lower cost. In terms of life cycle costs, the Ajeet trainer was to be 'an unbeatable bargain'.[77]

Low speed tunnel tests were carried out at the National Aeronautical Laboratory, Bangalore, while high speed trials had to be conducted at establishments in UK. By mid-1977, the first flight of the two trainer prototypes to be built, had reportedly been rescheduled to late 1978.[78]

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75 *Milavnews*, October 1976, p.14.

76 *Milavnews*, January 1977, p.12.

77 H.P. Mama, 'Ajeet - the IAF's New Ground Attack Fighter'. Refer n.73.

78 *Milavnews*, May 1977, p.13.

There was no comment about the aircraft by the Ministry of Defence even in 1978, except for the mention that development work had 'progressed'.[79] This suggests that development of the aircraft had encountered significant problems.

It was only four years later, in 1982, that the first prototype could be completed. The first of the two prototypes came off the assembly line in September 1982 and carried out its first high speed taxiing trials on the fifteenth of that month,[80] followed by its first flight on 11 October.[81] Development of the aircraft was expected to be completed by 1984[82] and an initial IAF order for 12 2-seat Ajeet trainers had been announced.[83] However, the only prototype Ajeet trainer crashed in December 1982 while on a systemstest flight - within three months of its manufacture. By mid-1983, according to Indian media reports, the entire program was in jeopardy as the Ministry of Defence was said to have instructed HAL 'to stop all production activity and tooling for the Ajeet trainer'.[84] Although the Ministry of Defence later attempted

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79 Ministry of Defence *Report 1977-78*, p.62.

80 *Statesman*, 17 September, 1982.

81 *Indian Express*, 12 October, 1982.

82 N.N. Sachitanand in *Hindu* (Madras), International Edition, 29 July, 1978.

83 *Indian Express*, 22 September, 1982.

84 *Indian Express*, 9 May 1983.

to deny this report, it is significant to note that its clarification only mentioned the fact that 'work on the project' was being carried on and did not elaborate on the production plans for the aircraft.[85]

Thus, while the small size, low weight and quick reaction capability of the Gnat were the main factors in the IAF's decision to acquire and manufacture the aircraft, the decision seems to have been a hasty one. The aircraft did not satisfy Royal Air Force (RAF) requirements as an interceptor in the late 1950s, and the IAF made no attempt to co-ordinate its evaluation effort with that of the RAF, preferring to deal with the manufacturers directly.[86]

The RAF itself did not reject the aircraft altogether. A development order for 14 Gnat trainers was issued in 1958 and the first prototype flew for the first time on 31 August 1959 with the development series Gnat T MkI entering service with the RAF in February 1962. Delivery of the production models began in November 1962, barely four years after the decision to develop the trainer version. A total of 91 aircraft were delivered to the RAF Flying Training Command, replacing the Vampire T MkII at Advanced Flying Training Schools (AFTS).[87]

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85 ibid., 11 May 1983.

86 *PAC (1980-81) Thirty Third Report*, paras 1.30 and 1.31.

87 *Jane's All the World's Aircraft 1967-68*, p.165.

Also, the Gnat trainer had already incorporated certain modifications which were to be included by HAL in the Gnat MkII and Ajeet trainer nearly 15 years later. The Gnat T.MkI was fitted with wet wings and could carry about 450 litres (almost 100 gal) of fuel as compared to the 500 litre (110 gal) capacity of the Ajeet wings. As a result the aircraft also had the provision for four underwing attachments. Despite increases in tailplane and fin area, a larger wing and other modifications and improvements,[88] the Gnat trainer could hardly be described as a simple aircraft. According to an experienced RAF instructor

> ... the Gnat ... could hardly lay claim to simplicity. On the contrary, it was a demandingly complex little aeroplane, an engineering nightmare. The longitudinal control system in particular ... was the source of much difficulty...
> Some respected and experienced pilots never really mastered it; a few in the early days died trying. Most, who had only the fleeting association with the Gnat that the AFTS course brought, passed on to greater things still pondering the witchcraft of manual control in a dark and gusty circuit. Crosswind landings in manual control from the back seat gave rise to the original legend of the legless blindfolded epileptic one-armed paperhanger. Similarly, the mysteries of the fuel system were still being unravelled as the aeroplane passed out of RAF service.[89]

HAL on the other hand, did not incorporate any major modifications in the design of the aircraft and confined

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[88] H.P. Mama, 'Ajeet - the IAF's New Ground Attack Fighter', *International Defense Review* 6/1977, p.1089.

[89] Sqn. Ldr. Roy Gamlin in *Flight International*, 3 January, 1981, p.32.

its changes to minor improvements in cooperation with the IAF. Despite the inordinately high accident rate of the Gnat MkI, it is clear that HAL lacked the design capability necessary to improve the aircraft. It was only after observing the accident rate of the Gnat for more than six years operational service with the IAF, and more than a decade after having initiated progressive manufacture, that HAL could formulate proposals to improve its flight safety. This too was not a very comprehensive proposal because of the lack of any documentation on previous accidents and related causes - one of the major findings of the Bouche Committee (April 1972).*

Even on grounds of alleged simplicity of manufacture, HAL, it would appear, was not very efficient. While it could be that bureaucratic inefficiency was responsible for such a situation, the fact remains that the Accessories Complex at Lucknow began production nearly 10 years after the various pieces of equipment had begun to be used in domestic manufacture - five years after the licence agreements were signed.

The Ajeet itself was a result of an attempt by HAL to introduce modifications to improve the flying qualities of the Gnat MkI. This process itself began at a time when the production run of the Gnat was nearing completion. Thus, even by 1972, HAL had not been able to formulate proposals for a definitive MkII variant which would be a substantial improvement on the MkI. On the other hand, the modifications suggested seemed to be a combination of

* See p.15. f.n.21.

the changes introduced by the RAF in its Gnat trainer (i.e. a wet wing) and marginal improvements in its communication and navigation systems. No other design changes were sought, and the only major modification suggested was that of the Hobson tailplane actuator unit, i.e. improvements in the Longitudinal Control System. This again reflected the total dependence of HAL on Lucas Aerospace (UK), the manufacturers of the unit.

Consequently, while HAL claimed to have completed development work on the Gnat MkII/Ajeet 'in almost all respects' by 1976, a few months later in March 1977 it had to concede its inability to comply with some vital requirements as specified in the AST of 1974. This nearly led to the cancellation of the project. But, in what could only be described as bureaucratic pressure to keep the program going, in May 1977 Air Headquarters changed its stand and recommended further expenditure on development of the Ajeet. This again did not appear to have had any beneficial effect so far as the operational capability of the IAF is concerned. By the time the Hobson unit had finally been cleared for unrestricted operation in October 1979, IAF requirement for the aircraft had ceased to exist because of changes in its threat environment. Nor was it only the Hobson unit that created problems for the Ajeet. HAL had not been able to provide the required range of 108 nautical miles in the first instance, the aircraft having a range of about 93 nautical miles. Subsequent increase in the range to 103 nautical miles by use of drop tanks not only imposed certain

restrictions on the aircraft but also reduced the number of hard points available for carrying stores from four to two - thereby minimising its effectiveness as a weapons delivery platform.

Consequently, it would appear that HAL had no precise idea of the real nature of the development effort required. As a result, not only did the cost of development of the Ajeet go up from Rs 9.9 million to Rs 32 million, but there was also a delay of seven years in the completion of the project. This led to cancellation of orders for the aircraft as well as redundancy in materials and parts required in its manufacture; and by the time the aircraft finally joined IAF inventory in 1979-80, a decision had already been taken to phase out the Gnat[90] as part of a policy to replace all subsonic aircraft with supersonic planes.[91]

The Ajeet Trainer aircraft too demonstrated the inherent lack of design and development expertise at HAL. Sanctioned in 1976, development was expected to be completed within two years, i.e. by 1978. In fact it took more than six years for the first prototype to be completed. The first production aircraft was scheduled for delivery by 1984, but then again this was contingent on the assumption that no serious difficulties would be encountered in its development. The situation has altered somewhat

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90 *Times of India*, 7 June, 1980.

91 *Economic Times*, 15 April, 1982.

after the crash of the only prototype that was built. With flying characteristics more or less similar to that of the Gnat Trainer used by the RAF in the 1960s and 70s, it would seem unlikely that the Ajeet Trainer could be used for advanced flying and weapons training in the late 1980s and 1990s.[92]

Viewed in this context, the initial IAF order for 12 trainers appears quite adequate although, given past experience, bureaucratic pressures could possibly result in an extended production run. Also, given the lack of success in exporting the Gnat/Ajeet, the export potential of the trainer version would also seem to be quite marginal.

It would thus be reasonable to conclude that the Gnat/Ajeet/Trainer manufacturing program, while appearing to have been reasonably successful, did not actually turn out to be so. The significant losses, both human and material, suffered by the IAF because of deficiencies in the flight performance of the Gnat, do not sustain the argument about the simplicity and cost effectiveness of the aircraft. Attempts at improving these qualities and incorporating them in an improved version - the Ajeet, turned out to be a classic example of too little and too late.

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[92] Consequently, it would appear to be highly probable that replacement aircraft for the Hunter OCUs would have to be imported.

B. HS(AVRO) 748

The HS(Avro) 748 is the only transport aircraft to have been manufactured in India. It also happens to be the only aircraft which in the initial stages of its manufacturing program was the direct responsibility of the IAF.

On 20 May 1959, the Deputy Chief of Air Staff proposed that the Government should agree 'in principle' to replace the C-47 Dakota fleet (then consisting of approximately 100 aircraft), from 1960 by a total of 181 transport aircraft to meet Air Force requirements over the next 10 years. Of these, 29 were to be the passenger carrier version which included the Executive/VIP type (16) for the Communications Flight and Navigator/Signaller trainer variant (13). Two weeks, later on 4 June 1959, the Ministry of Defence prepared a paper on the subject which was submitted to the Defence Committee of the Cabinet (DCC) at its meeting on 9 June 1959. The DCC, while maintaining that it was 'desirable' to consider indigenous manufacture of a suitable transport aircraft, decided to appoint a committee under the Chief of Air Staff. The committee was expected to[93]

> ... consider the various offers from foreign manufacturers which had been received in the Ministry and to decide upon the suitable aircraft to replace the Dakota fleet in the Indian Airlines and the Indian Air Force.

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[93] *Public Accounts Committee (1972-73) Eighty Second Report (Fifth Lok Sabha)*, para 2.55.

Within a fortnight this committee had apparently considered all the submissions and had decided to recommend indigenous manufacture of the HS-748. This proposal was considered by the DCC at its meeting on 26 June 1959 and accepted. The entire process, which began with the proposal to replace the Dakotas to the time when it was decided to manufacture the HS-748, was thus completed in a record time of five weeks. But, there seems to have been a deliberate and successful attempt at misinterpretation of the suitability of the HS-748 for *all* the requirements of the IAF. This is because the paper which was put up to the DCC at its meeting on 26 June 1959, actually mentioned the suitability of the HS-748 in the following words:[94]

> ~~While~~ the Avro 748 would meet the Air Force requirements for their VIP and communication aircraft for which there is the requirement of 29 aircraft over a period of ten years.

In other words, there was no discussion of the suitability of the aircraft in the military freighter and transport roles for which there existed requirements of 56 and 95 aircraft respectively.[95] This, in any case, would have been impossible to evaluate since the aircraft itself was at the stage of prototype construction and the first prototype flew only on 24 June 1960,[96] a year after it had

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[94] ibid.

[95] *Committee on Public Undertakings (1967-68) Eighth Report (Fourth Lok Sabha)*, para 134.

[96] *Jane's All the World's Aircraft 1963-64*, p.134.

been decided to manufacture it. The decision would thus appear to have been made on the basis of the requirement of 29 aircraft with no consideration being given to the requirements of the (then) Indian Airlines Corporation (IAC), contrary to the guidelines given to the Chief of Air Staff Committee.

This contention is further substantiated by information from other sources. When the concept of indigenous manufacture of transport aircraft for the IAF and the IAC had been discussed in 1959, IAC had made its preference for the Fokker F.27 (Friendship) aircraft quite clear and had stated that the HS-748 Series I aircraft did not suit its requirements.[97] According to a former Chief of Air Staff[98] who was also a member of the Chief of Air Staff Committee, the Committee had decided that the HS-748 was a totally unknown design and was favourably inclined towards the Fokker F.27 as it was a proven aircraft. The then Chief of Air Staff, Air Marshal S. Mukherji, however, decided that the HS-748 would be the best plane for the IAF, that it should be manufactured indigenously, and that IAC requirements did not matter. Pressure, it would appear, was exerted by the then Defence Minister Krishna Menon on behalf of Hawker Siddeley Aviation Limited (HSAL), the manufacturers of the aircraft. The ground for this assumption is that the then Managing Director of HSAL, Sir Roy Dobson, needed

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97 *CPU (1967-68) Eighth Report*, paras 137-138.

98 Interview with the (late) Air Chief Marshal P.C. Lal at Air Headquarters, New Delhi on 5 February, 1981.

a 'patron' for the aircraft as it would be in direct competition with Fokker. He arrived in India in April/May 1959 (about the same time as the IAF formally proposed the replacement of its Dakota fleet) and Krishna Menon, who had known him earlier, according to the former Air Chief, is said to have made a 'promise' to favour the HS-748.

As regards other alternatives, it should be added that at about the same time, Lockheed Aircraft (USA) had put forward a proposal to help India design and develop a transport aircraft suited to Indian conditions. It would be powered by two Rolls Royce Dart turboprop engines (the same as those in the HS-748), and the design of the aircraft would be owned by India. The company had also offered to help set up a factory in India as well as to assist in worldwide sales of the aircraft.

Rejection of the Lockheed offer was later justified in Parliament by Krishna Menon on grounds that it had come at a rather late stage and the company had wanted 90 days to submit their report. As the question had been under consideration for a 'long time' and an early decision was necessary, the government had decided not to wait for another three months.[99] This was clearly a falsification of facts since the decision to manufacture the HS-748 had been taken barely five weeks after the initial proposal to acquire a new transport aircraft. In any case an agreement for the licence manufacture of the HS-748 was

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[99] *Times*, 9 August, 1959.

signed in July 1959[100] and that for the Rolls Royce Dart 6 engines in December 1959.[101] A feature unique to the manufacture of this aircraft was that only the engines were to be manufactured by HAL at Bangalore; the aircraft itself was to be built at the Aircraft Maintenance Depot (AMD) at Kanpur.

The project itself encountered several problems right from the time the agreement was signed in July 1959. Since it was still in the design stage, HSAL was not in a position to give an itemised price list for various components, but undertook to make it available within a year i.e. by July 1960. The only commitment that the company made was that unit cost of the aircraft would not exceed £158,000 at June 1959 price levels, subject to escalation based on the UK wage index.[102] 'Some sort of price list' which in effect was only for sub-assemblies was provided by HSAL in November 1960 but was not accepted by the Ministry of Defence. It was only four years later, in 1964, that an acceptable price list was finally forthcoming.[103]

As far as tooling up for production was concerned, in 1959, HSAL had quoted a figure of 1.9 million man hours for jigs and tools based on a production rate of five aircraft per month. Since the proposed production rate was subsequently

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100 *CPU (1967-68) Eighth Report*, para 135.

101 *Times*, 31 December, 1959.

102 *PAC (1972-73) Eighty Second Report*, para 251.

103 ibid., para 2.48.

reduced to three aircraft per month, the new estimate was 1.725 million man hours (man hours of direct labour were assessed by HSAL as 1 UK man hour = 2 Indian man hours, at an hourly wage of Rs 4). Based on this estimate, and including Rs 1 million as the cost of raw material for the manufacture of jigs and tools, the total cost of manufacturing tools was estimated at Rs 8 million.[104] AMD, Kanpur assessed 1 UK man hour as being equal to 1.5 Indian man hours and the man hour rate at Rs 3.60. Based on this, Rs 5.65 million was sanctioned for the manufacture of jigs, fixtures and tooling.[105]

By mid-1960, the first set of jigs had been set up at the AMD - at a time when the IAF requirement for the HS-748 stood at 180 aircraft.[106] HSAL had, by this time, developed a Series II version of the HS-748 powered by RR Dart 7 Mk531 engines. This version was evaluated by the IAF and it was decided to switch production to the Series II from the fifth aircraft onwards.[107] Initial orders for the HS-748 were placed after considerable delays as shown below:[108]

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104 *CPU (1967-68) Eighth Report*, para 148.

105 ibid., para 149.

106 ibid., para 133.

107 ibid., para 135.

108 *PAC (1972-73) Eighty Second Report*, para 2.54.

No. of Aircraft	Ordered
1	August 3, 1959
3	April 28, 1961
3	June 15, 1962
3	September 11, 1962
6	September 5, 1963

In fact, after the first seven aircraft had been ordered in 1962, the Ministry of Defence considered the possibility of having the remaining aircraft modified as navigator/signaller trainers. But it had little choice in the matter as HSAL had yet to finalise the design of this version.[109] On the other hand, there is evidence to suggest that the Ministry of Defence was forced by HSAL to order aircraft numbers 8 to 16. According to the Secretary of the Department of Defence Production:[110]

> ... we did not need even one aircraft of this normal version, but HSAL insisted that we must buy, otherwise they would not be able to give us for quite some time a design for modification (for the VIP/Executive version) and the subsequent aircraft.

Due to the drastic reduction in IAF orders for the aircraft and its unsuitability for IAC requirements, it was decided to re-assess the requirements for production facilities. The Executive Director of HSAL visited Kanpur in July 1964 and recommended that in view of the small number of aircraft to be manufactured it would not be

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109 ibid., para 2.58.

110 ibid., para 2.59. See pp. 45, 64.

economical to undertake tooling to manufacture the entire aircraft, so that work should be restricted to the fuselage stage only with the wing sets to be imported from UK. In October 1964 management of the Kanpur factory was transferred to HAL and the recommendation about reduced tooling was accepted three months later i.e. in January 1965.[111]

The tooling process itself encountered serious problems, including the lack of trained personnel and an overall underestimation of the extent of work required. By December 1966, the expenditure on tooling amounted to Rs 19.6 million as against the original estimate of Rs 5.65 million.[112] This included a sum of Rs 5.249 million on jigs and tools which were not likely to be utilised because of the decision to reduce the manufacturing effort. Even fuselage tools worth Rs 1.302 million were rendered useless because of the decision to manufacture the Series II version instead of Series I.[113] The entire effort seems to have suffered because of mismanagement. This becomes apparent keeping in view the fact that the first of the four HS-748 Series I aircraft assembled at Kanpur flew on 1 November 1961, but the second not until 13 March 1963. The first Series II aircraft flew a year later, on 28 January 1964.[114] It would thus appear that the first

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111 *CPU (1967-68) Eighth Report*, para 151.

112 ibid., para 150.

113 ibid., para 152.

114 *Jane's All the World's Aircraft 1966-67*, p.81.

few aircraft were not manufactured but merely assembled at Kanpur since jigs and tools for manufacturing purposes were still being installed . Also, it was only after the management of the AMD, Kanpur, was taken over by HAL that it was formally admitted that no detailed plans or estimates had been drawn up before the Ministry of Defence undertook the project. According to the Secretary of the Department of Defence Production, a team of IAF officers had been sent to UK and after the collaboration agreement was signed, in consultation with HSAL, they 'prepared a quick plan and the implementation was on the basis of that plan'.[115]

The project as a whole was reviewed in 1962 and a Special Committee appointed to enquire into its progress is reported to have made some adverse comments. According to the London *Times*, it was realised that the HS-748 would not be suitable for high altitude airfields and the Committee recommended that the DHC-4 Caribou, manufactured by De Havilland, Canada, should be manufactured instead.[116] In June 1963, the Emergency Committee of the Cabinet decided that only 29 aircraft for communication and training purposes should be manufactured, and that a decision on the Military Freighter (MF) version should be taken only after flight trials of the HS-748MF and the DHC-4 Caribou. These trials were completed only in 1964 and the HS-748 was found unsuitable.[117]

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115 *CPU (1967-68) Eighth Report*, para 141.

116 7 June 1963.

117 *Public Accounts Committee (1968-69) Forty Seventh Report (Fourth Lok Sabha)*, p.22.

Confronted with a drastic reduction in the number of aircraft to be manufactured, HAL/Ministry of Defence increased pressure on the IAC to order the HS-748. Consequently, a letter of intent for 15 aircraft (nine passenger and six freighter versions) was placed on HAL. But, after trials on its freighter routes in the Eastern region in April 1965 with the Series II version, the Letter of Intent for six freighter aircraft was withdrawn. The order for nine passenger aircraft was finally confirmed in Septmber 1965. In evidence before the *Committee on Public Undertakings* of Parliament, the Secretary of the Ministry of Tourism and Civil Aviation justified the orders as follows:

> ... it was naturally felt, in view of the fact that it is a very expensive business to manufacture aircraft and the plane was being manufactured in India under licence, that the Indian Airlines should also use the plane.[118]
>
> ... there was no escape from using that plane ... regardless of the fact that it might be a little more expensive.[119]

The first HS-748 was deliverd to the IAC on 28 June 1967[120] and, in the same month, another five aircraft were ordered,[121] bringing IAC orders to a total of 14. Deliveries were completed by 1970[122] and the IAC order made it clear

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118 *Committee on Public Undertakings (1972-73) Twenty Eighth Report (Fifth Lok Sabha)*, para 2.38.

119 ibid., para 2.7.

120 *HAL Annual Report 1966-67*, p.13.

121 *CPU (1972-73) Twenty Eighth Report*, para 2.3

122 *HAL Annual Report 1969-70*, p.12.

that the economics of manufacturing the HS-748 involved a substantial loss to HAL if the selling price of the aircraft was to be the same as that charged by HSAL.[123] While the IAF was required to pay an amount equivalent to 5 per cent of the cost of manufacture (later raised to 7½ per cent)[124] as profit to HAL, the price to be paid by IAC was computed at Rs 8.97 million per aircraft. Since the unit cost of production of the HS-748 was estimated at Rs 10.33 million, the Civil Aviation Department had to subsidise HAL to the extent of Rs 1.35 million for every aircraft delivered to the IAC.[125] This subsidy later had to be further increased when 10 additional aircraft were ordered in April 1970 at a unit cost of Rs 9.27 million.[126] Cost of production was now estimated at Rs 13.18 million[127] - involving a subsidy of Rs 3.91 million per aircraft.

Operationally, the HS-748 came under heavy criticism by pilots of the Indian Airlines (IA, as the IAC was now known). A Technical Committee was appointed by the Government in January 1971[128] to examine complaints

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123 *HAL Annual Report 1967-68*, p.32.

124 *HAL Annual Report 1968-69*, p.49.

125 *CPU (1972-73) Twenty Eighth Report*, para 2.17.

126 ibid., para 2.18.

127 ibid., para 2.19.

128 ibid., para 2.31.

about shortcomings in the climb performance of HAL-built HS-748s as well as its performance at high ambient temperatures (above 45°C). In its Report submitted in August 1971, the Committee pointed out that certain aircraft were 'slightly below form, but the average mean of the fleet were of the required standard'.[129] However, the Task Force which was set up to examine the Report of the Technical Committee in its Report submitted on 7 November 1971, made two recommendations.[130]

1. Regarding production models delivered to IA, it recommended that HAL and the Directorate of Aircraft Inspection, Civil Aviation Department, should not, in the future, accept shortfalls below the standards prescribed by the Director General of Civil Aviation (DGCA). It further recommended that in respect to these flight tests, HAL should adopt procedures already in practice with HSAL.
2. Performance of inservice aircraft was declared safe by the Task Force but it recommended certain procedures regarding engine power checks.

While the Indian Airlines tried to implement these recommendations, in actual practice 'considerable difficulties (were) experienced in obtaining the desired

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[129] ibid., para 2.35.

[130] ibid., para 2.32.

performance'.[131] The matter was taken up with HSAL, Rolls Royce and HAL which declared that modifications would be required to make the aircraft safe for flying under high temperature conditions. In March 1972, IA informed HAL that it would like 12 aircraft to be so modified - at a unit cost of Rs 40,000.[132]

A recently completed HS-748 was flown to UK for performance evaluation by HSAL at Woodford and was reportedly found to be upto specifications. But, before its return to India for further tropical trials its water/methanol system was modified.[133] As a result of these problems, not only did the IA have to restrict operations of the aircraft, but it also had to reduce the permissible maximum gross take-off weight from 44,495 lbs to 40,500 lbs.[134] At the same time, after having awarded a Certificate of Airworthiness to three of the 10 aircraft ordered in 1970, the DGCA apparently refused certification for a further batch of four which were ready for delivery.[135] Finally, on 23 March 1973, the Minister for Tourism and Civil Aviation informed Parliament that the performance of the HS-748 would be evaluated by a group of experts

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131 ibid., para 2.33.

132 ibid., para 2.39.

133 *Milavnews*, May 1973, p.15.

134 *Milavnews*, April 1973, p.14.

135 *Milavnews*, March 1973, p.14.

led by Satish Dhawan, Director of the Indian Institute of Science, Bangalore.[136]

As for the supply of HS-748s to the IAF, the 16 Executive/VIP versions were delivered in the second half of the 1960s. Further orders for an unspecified number of aircraft were placed in 1968-69[137] and deliveries of the Navigator/Signaller trainer types were expected to begin in 1970.[138] These, however, suffered from manufacturing delays due to non availability of indigenously manufactured audio control equipment and to some extent, initial difficulties experienced in ground and flight clearance of navigator trainer installations.[139] This was also a period of uncertainty so far as the future of the manufacturing program itself was concerned, because IAF's requirement for a suitable Military Freighter (MF) variant had still not been met. In 1968-69, for example, HAL announced that it was exploring the possibility of manufacturing 'some successor aircraft'.[140]

As early as 1965, after rejecting the MF version of the HS-748, the IAF had also tested the Breguet 941 (France) and the Caribou MkII (the prototype DHC-5D

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136 *CPU (1972-73) Twenth Eighth Report*, para 2.43.

137 *HAL Annual Report 1968-69*, p.15.

138 *Jane's All the World's Aircraft 1970-71*, p.116.

139 *HAL Annual Report 1970-71*, p.9.

140 *HAL Annual Report 1968-69*, p.15.

Buffalo) and concluded that the latter aircraft came close to meeting its requirements, but negotiations about its manufacture could not be held since the aircraft had not reached production status.[141] Meanwhile, in May 1966, HAL concluded a supplementary licence agreement with HSAL which provided for the manufacture of the MF variant of the HS-748. But no decision to manufacture any military freighter aircraft was taken for the next three years and it was only in 1969, after detailed negotiations with De Havilland Canada that the proposal to manufacture the DHC-5D was given up. More than a year later, in December 1970, the Government finally decided to 'explore the possibility' of developing and manufacturing the HS-748MF.[142] In June 1971, HAL placed a contract with HSAL for the supply of modification kits and related technical data at a cost of Rs 3.35 million.

It would appear that this was a decision taken at the administrative level without taking into account any specifications that would be required by the IAF. This is because it was HSAL which was to supply the technical data for modifying the HS-748, an aircraft which had earlier been rejected as being unsuitable as a military freighter. Accordingly, Air Headquarters issued detailed specificatons only in February 1972 after the modifications

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141 *PAC (1968-69) Forty Seventh Report*, p.34.

142 *Report of the Comptroller and Auditor General of India: 1975-75. Union Government (Defence Services).* Hereafter referred to as *C & AG Report: 1974-75.*

on the aircraft had already been carried out. Flight trials were carried out during the period March-June 1972[143] and what followed was a unique mixutre of bureaucratic pressure and inter-services difference of opinion.

In July 1972, after the first phase of trials had been completed; the Army expressed its reservations regarding the suitability of the aircraft. Air Headquarters on the other hand, insisted that the trials had been successful and justified its decision taken in March 1972 for orders to be placed on HAL. In fact, it had finalised plans for induction of the aircraft into squadron service by 1975-76 in June 1972,[144] a month before the Army registered its complaint. However, in order to appease the Army,Air Headquarters agreed to further trials with a modified HS-748 with a para dropping door on the starboard side. In the meanwhile, HAL was insisting that the Government place firm orders to 'minimise the consequences of a break in production'.[145]

The entire issue was reviewed at 'high level' in the Ministry of Defence in August-September 1972, and it was agreed that the HS-748MF was the 'only viable alternative'. It was also decided that:[146]

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143 ibid., p.12.

144 ibid.

145 *HAL Annual Report 1971-72*, p.14.

146 *C & AG Report: 1974-75*, para 7, p.12.

1. Initially, 48 HS-748MFs would be ordered to meet immediate requirements.
2. A Standing Group representing the Army, the IAF, the R & D Organisation and HAL would co-ordinate flight trials and produce improvements suggested by the Army.
3. An Army-IAF Study Group would undertake a one year study to decide further orders for this aircraft should be placed, or whether some other aircraft should be inducted to satisfy long term requirements.

In October 1972, the Government authorised HAL to place a Letter of Intent on HSAL for 40 sets of parts and, in April 1973, formally sanctioned the manufacture of 48 aircraft at a unit cost of Rs 14.97 million. The decision was justified on the grounds that it

> ... took into account the imperative need for timely replacement of unserviceable/uneconomical aircraft as also the need to prevent a break in production at the manufacturing unit...[147]

What followed was a complicated series of events in which decisions were made, reversed and reversed again. During the period March-May 1973, foreign exchange worth Rs 107.3 million was provided to HAL which ordered items worth Rs 17.4 million and initiated price negotiations with HSAL. No further orders could be placed because in July 1973, HSAL announced a 'steep increase' in prices and

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147 ibid., pp.12-13.

Air Headquarters revived the alternative proposal for manufacturing the DHC-5D Buffallo under licence from De Havilland Canada. In August 1973, Air Headquarters issued 'revised and comprehensive' specifications for a military transport aircraft required for induction into service by 1974-75. This move received further support in October 1973 when the Army-IAF Study Group reported that the HS-748MF would not meet all requirements of the Army and that an aircraft similar to the DHC-5D Buffallo should be considered.[148]

Negotiations with HSAL on prices had, however, been continuing and were finalised in November 1973, with the offer being valid till December. In November, Air Headquarters too changed its views and placed a formal order for 48 HS-748MFs on HAL. But in December the Government instructed HAL to suspend procurement of supplies pending fresh review of the entire program.[149] It would appear that at least two factors contributed to this decision. Firstly, the move by Indian Airlines to ground all HS-748s which had flown more than 5,000 hours, following the discovery of fatigue cracks in ailerons and hinges of several aircraft which had logged around 8,000 flying hours.[150] The IAF too grounded its

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148 ibid., p.13.

149 ibid.

150 *Milavnews*, September 1973, p.11.

fleet as a precautionary measure.[151] Secondly, the Dhawan Committee which had been appointed in May 1973 to enquire into the safety and performance of the aircraft had not yet submitted its report.[152]

After another round of negotiations with De Havilland Canada, the proposal to manufacture the DHC-5D Buffalo[153] was dropped again, reportedly on grounds that adequate credits were not forthcoming.[154] In February 1974 it was decided to reduce the order for the HS-748MF from 48 to 30 aircraft and the decision was conveyed to HAL in March. Revised quotes received from HSAL valid till April (later extended to May) 1974 reflected an increase of 14.6 per cent over the prices negotiated in November 1973. During April-May 1974, Air Headquarters again expressed its misgivings about the HS-748MF, stating that it would 'not agree to a firm order being placed' and that it would 'have to evaluate afresh and assess the several options available'. Meanwhile, HSAL's offer lapsed.[155]

In June 1974, HAL conveyed to the Government its concern about the delay in the project since the original proposal of 1969 and the uncertainty encountered since

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151 *Milavnews*, October 1973, p.14.

152 *HAL Annual Report 1973-74*, p.12.

153 *C & AG Report: 1974-75*, para 7, p.13.

154 *International Defense Review* 5/1975, p.766.

155 ibid., p.14.

the Government sanctions of Defember 1972 and April 1973. It maintained:[156]

1. Continued increase in costs would adversely affect viability of the project apart from delaying delivery by 12-15 months.
2. Break in production because of lack of orders had resulted in a 'go slow' by workers, adding Rs 2.7 million per aircraft to the cost of aircraft manufactured for the IAF.
3. Even if a decision was taken by September 1974, gross idle time in the manufacturing unit, i.e. Kanpur division, would amount to 1.6 million man hours, equivalent to Rs 26.5 million.

This was because under the terms of the original agreement, HAL was to have produced 100 aircraft of which 70 were to have been from parts supplied by HSAL. Up to May 1973 only 43 had been completed and since then assembly was continuing at a rate of not more than 2-3 aircraft per year.[157] In any event, HAL again acquired fresh quotations from HSAL (representing an increase of 30.6 per cent over 1973 prices) valid till September 1974, which lapsed because no decision was taken.[158]

It was December 1974 before the period of inaction ended. A 'high level' meeting held that month accepted

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156 ibid.

157 *Milavnews*, June 1974, p.15.

158 *C & AG Report: 1974-75*, para 7, p.15.

that the 1972 decision (to manufacture the MF version) had been taken 'on merit' and 'after due deliberation and concurrence of all concerned'. It was further stressed that the decision 'was a sound one and should be implemented'. Consequently, it was decided to place an order for 30 HS-748MF.[159]

Once again the exercise of inviting quotations from HSAL was carried out in February 1975 and in June that year, a contract for the manufacture of 10 HS-748MFs was finally concluded. As a result of the inaction over a period of two years, the contracted base price was 35 per cent higher than that offered in November 1973 and was subject to further escalation. In January 1976, the Government finally authorised:[160]

1. Manufacture of 10 HS-748MFs at a unit cost of Rs 22.9 million.
2. Modification of 17 existing HS-748 trainer aircraft at an estimated cost of Rs 20.7 million.
3. Purchase of three of the seven unsold aircraft manufactured (for Indian Airlines) by HAL (1971-72 and 1972-73) after modifications - which would cost another Rs 47.55 million.

By February 1976, the unit cost of manufacture of the 10 HS-748MFs was estimated at Rs 28.84 million as compared to Rs 14.97 million in April 1973 and Rs 22.9

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159 ibid.

160 ibid.

million sanctioned a month earlier. In effect, the delay in arriving at a decision resulted in an extra expenditure of Rs 138.7 million for 10 aircraft besides delay in induction of the aircraft into squadron services.[161]

The Dhawan Committee, which finally submitted its report in 1975, cleared the performance of the HS-748. It concluded that the aircraft was 'continuing to meet current international standards of airworthiness and safety'.[162] The report, however, had no effect on the situation of the aircraft in India. Indian Airlines had already refused to take delivery of the last seven of the 24 aircraft it had ordered. HSAL was, at one stage, reported to be willing to buy back the seven aircraft but its proposed price of about Rs 11.2 million per aircraft would have resulted in an overall loss of up to Rs 30 million.[163] In any case, as mentioned above, three of the HS-748s were refurbished and transferred to the IAF and some of the remaining four were reportedly acquired by DGCA for Radio and Navigation Aid caliberation work.[164]

During the period 1972-76, capacity utilisation of the Kanpur division was very marginal as the Government attempted to find customers for the aircraft. According to HAL:[165]

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161 ibid., p.16.

162 *Milavnews*, December 1975, p.17.

163 *Milavnews*, June 1975, p.14.

164 *Milavnews*, August 1976, p.11.

165 *HAL Annual Report 1976-77*, p.6.

> Quest for utilisation of the available capacity at Kanpur Division has been engaging attention for the last few years. The management has been pursuing with the concerned authorities in government to obtain additional orders to make use of available resources ... also ... for an early decision on a new project ...

Possibly as a result of pressure from HAL a repeat order for 10 HS-748MFs was placed in early 1978 - enough to keep the Kanpur Division busy till 1980-82.[166] This, however, did not obviate the need for the sanction of a new project. This was conceded by HAL itself in 1978:[167]

> ... if orders for ... (the new project) ... are not finalised early, the dimensions of idleness will assume serious proportions in 1980-81 and increasingly thereafter.

While the IAF presumably had no further requirement for the MF version of the HS-748, a rear loading variant was also suggested to fulfil the longstanding requirement for a Medium Tactical Transport Aircraft (METAC) to replace the obsolescent fleet of Douglas C-47s and C-119Gs. But, cost escalation reportedly raised the price of the proposed HS-748 Rear Loading Tactical Transport (RLTT) to the same level as the DHC-5D Buffalo, the aircraft favoured by the IAF.[168] No decision was forthcoming even by 1979 although it was clear that one was long

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166 *Milavnews*, May 1978, p.15.

167 *HAL Annual Report 1977-78*, p.6.

168 *Milavnews*, May 1978, p.15.

overdue. By now contenders reportedly included the DHC-5D Buffalo, HS-748 (RLTT), Aeritalia G.222 and the An-32 from the Soviet Union.[169] By late 1979, plans for the procurement of the An-32 were reportedly finalised during the Moscow visit of Defence Secretary Dave. It was then planned to manufacture the aircraft at HAL's Kanpur division.[170] However, in 1980, it was announced that the An-32 would not be built in India but would be purchased directly from the Soviet Union.[171]

Meanwhile, HAL was expected to terminate production of the HS-748 in 1982-83[172] after having manufactured 89 aircraft, including 72 for the IAF.[173] But it would appear that the future of the HS-748 manufacture is still an open question. This is because while the Coastguarder version of the aircraft had earlier been rejected because the economics of its operation had been 'rather discouraging'[174], later reports claim that the aircraft is still one of the contenders for service with the Indian Coast Guard, although a decision has yet to be taken.[175]

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169 *Milavnews*, March 1979, p.13.

170 *Milavnews*, November 1979, p.17.

171 *Milavnews*, September 1980, p.19. Quoting Minister of State for Defence Production, C.P.N. Singh.

172 Minister of State for Defence Production, C.P.N. Singh's statement in Parliament, reported in *Times of India*, 19 June 1980.

173 *Milavnews*, July 1980, p.17.

174 *Times of India*, 29 May 1980.

175 Pushpindar Singh in *Asian Defence Journal*, 10/82, p.29.

In short, the manufacturing record for the HS-748 has been a total failure. To begin with, the decision to manufacture the aircraft itself was highly questionable. The aircraft was at the prototype construction stage so its performance could not be evaluated. Also, there is enough evidence to prove that there was a substantial body of opinion that did not favour its manufacture in India. Nonetheless, it was decided to manufacture the HS-748 - probably one of the quickest decisions made by the Ministry of Defence in the context of defence production in India.

Even then, the installation of manufacturing equipment proceeded in an ad hoc manner. Although the total IAF requirement had been given as 180 aircraft, this was scaled down to 27 soon afterwards. At the same time, no project report was prepared and the whole program proceeded on the basis of instructions received from HSAL. This is not to say that such a course of action was ~~not~~ inevitable. The Aircraft Manufacturing Depot at Kanpur had no experience whatsoever in aircraft manufacture. But, in the process in 1963, HSAL managed to sell nine more passenger aircraft than the IAF actually required.

Despite the IAF's reduction in orders and its preference for the DHC Caribou for military freighter requirements, the decision to manufacture the aircraft was not reversed. On the other hand, pressure was exerted on the (then) Indian Airlines Corporation (IAC)

to order aircraft for its passenger and freight carrying requirements - an order which was eventually placed, albeit very reluctantly. The very fact that HAL (which had taken over management of the AMD) had to be subsidised for the aircraft supplied to the IAC made it evident that the manufacture of the HS-748 was highly uneconomical, to say the least. Nonetheless, HAL had no such problems so far as the aircraft supplied to the IAF were concerned - it merely billed the IAF on a cost-plus-profit basis.

The question of acquiring an aircraft to meet the Military Freighter and paradropping requirements of the IAF was re-opened in the second half of the 1960s despite the fact that an agreement to develop a MF variant of the HS-748 had been signed with HSAL in 1966. This would indicate not only a continued preference of the IAF for the Caribou II (a development of the Caribou and later called the DHC-5D Buffalo) but also an attempt by HAL to pressurise the IAF to opt for the HS-748MF - a variant which had not been developed till then. The result was that no decision was taken on this matter for the next three years while negotiations with De Havilland Canada for the licence manufacture of the DHC-5D Buffalo continued.

While these negotiations were finally terminated in 1969, another year passed before the Ministry of Defence decided to 'explore the possibility' of manufacturing the

HS-748MF - a decision taken without considering requirements of the user services i.e. the IAF and the Indian Army. The result was five years of bureaucratic and inter-services infighting during which time no action could be taken as decisions were reversed soon after they had been made - a bad reflection not only on the quality of the decision making process but also on the aircraft under consideration.

The aircraft also came under severe criticism by its only civilian operator - Indian Airlines. Serious complaints about the aircraft began to emerge within a few years of its induction into service, culminating in the appointment of the Dhawan Committee in 1973 to enquire into specific allegations about performance and safety aspects of the HS-748. Although the Committee eventually cleared the aircraft the damage had already become clear. Indian Airlines initially suspended acceptance of the last seven of the aircraft it had ordered and eventually refused to take delivery of them at all.

The unwillingness of both the civilian and service users of the HS-748 to place further orders for it inevitably affected the economics of manufacture. As already mentioned, it cost more to build an HS-748 in India than to buy one from UK. By 1975, HAL had suffered a further loss of Rs 26.5 million - representing man hours lost due to lack of work.

By December 1974 the period of inaction appeared to have come to an end when it was finally decided that the IAF would acquire 30 HS-748MFs. Actually, the manufacture of only 10 HS-748MFs was sanctioned in 1976 although it was also decided to modify a further 17 of the existing trainer versions as well as three of the aircraft which had originally manufactured for Indian Airlines. This would also indicate that the IAF had originally acquired more trainer versions of the HS-748 than it actually required. In any case, a further 10 HS-748MFs were ordered in 1978, possibly as a result of bureaucratic pressure, since the IAF was already in the process of evaluating successor aircraft . Manufacture of the last batch of the MFs was scheduled to end in 1982 but there is no indication so far as to whether production of the aircraft itself would be terminated since the Coastguarder version is reported to be under evaluation.

The manufacturing history of the HS-748 is thus a classic example of an aircraft being selected for licence manufacture without being evaluated for suitability. Once production began, user agencies were coerced into placing orders and the result was one of the most inefficient production runs in the history of aircraft manufacture in India.

CHAPTER II

INDO-SOVIET COOPERATION: THE MIG-21 PROJECT

Various reasons have been given for the acquisition and manufacture of MiG-21 aircraft by India. These range from the position that they were acquired as a reaction to the US supply of a squadron of F-104 Starfighters to Pakistan in August 1961[1] and the subsequent unwillingness of Western countries to provide the IAF with aircraft of similar performance, to the argument that the Soviet supply of MiG-21s was acceptable to India because they were cheap and readily available, while the bureaucracy in India was dissatisfied with British collaboration in the manufacture of a powerplant for the Indian designed HF-24.[2] Another variation of the previous argument is that although the MiG-21 possessed no 'obvious advantage' over the Lightning (UK), Mirage III (France) and the F-104 (US), these aircraft were not available to India and 'manufacturing rights and rupee payment seemed to have decided the issue'.[3]

However, these explanations would seem to be incomplete when viewed in terms of the requirements of the IAF. The questions that arise are:

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[1] For example, see K. Subrahmanyam in *Times of India*, 24 November 1971.

[2] Raju G.C. Thomas, *The Defence of India: A Budgetary Perspective of Strategy and Politics* (New Delhi: Macmillan, 1971), pp.188-190.

[3] Maj. Gen. Sukhwant Singh, *India's Wars Since Independence: Defence of the Western Border*, Volume II (New Delhi: Vikas, 1981), p.295.

1. Did the IAF have a requirement for this type of aircraft?
2. What were the alternative types available, if any?
3. Given the then Defence Minister, Krishna Menon's emphasis on creating a domestic defence production base, was the MiG-21 the only type of aircraft available for indigenous manufacture?

To acquire a proper perspective on the background events that eventually led to the acquisition and subsequent manufacture of MiG-21 aircraft in India, it is necessary to note that the Soviet Union had shown its potential as a future supplier of military equipment as early as 1956. This was when the IAF had decided to purchase Canberra bombers from UK in preference to the Il-28s offered by the Soviet Union.[4]

In January 1961, it was reported that the Soviet Trade Commissioner in India, N.P. Shizyaev, had told a news conference in Calcutta on 9 January 1961,[5] that the Soviet Union had offered 'jet planes' to India for rupee payment and that his government was prepared to supply any number of 'jets' which were of the latest 'type'. He was further quoted as having disclosed that negotiations in this respect had just been concluded in Moscow and the Government of India's reply was now awaited.

Over a year later, while addressing a news conference, Prime Minister Jawaharlal Nehru gave reasons for the

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4 *Keesing's Contemporary Archives*, 1957, 15428:C.

5 *Asian Recorder*, 1961, 3761:INI:H.

Indian proposal to buy MiGs as well as to manufacture the aircraft in India with Soviet assistance.[6] The MiG was a 'stout and simple' aircraft he said, 'not sophisticated and complicated'. It would be easy to manufacture, cheaper than other comparable aircraft, and could be paid for in rupees. While production could start within two or three years, in the meantime it would be necessary to purchase some aircraft to bring the IAF up to strength. While reiterating that no final decision to buy the aircraft had been taken, he said that Britain and the United States had made enquiries about the proposal, but there had been no pressure. A few days later, while speaking in Parliament in June 1962,[7] Nehru elaborated on the background of the Indian interest in the MiG-21. A team of Indian engineers had gone to the Soviet Union to buy a few jet engines as well as to seek Soviet help to modify these for installation in the indigenously designed HF-24. While it was subsequently found that the engine could not be modified for use with the HF-24, the team had become interested in the MiG-21, made enquiries and submitted a report to the Indian government. Later, while replying to the foreign affairs debate in Parliament, he said he favoured the acquisition of guided missiles rather than costly aircraft which would be outdated in a few years.[8]

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[6] *Times*, 14 June 1962.

[7] *Times*, 21 June 1962.

[8] An Indian request for Sidewinder Air-to-Air missiles had been turned down by the US in 1961 although they were supplied to Pakistan along with the F-104s. *Times*, 5 July 1962.

Britain and the United States meanwhile made joint efforts to persuade India to buy Western aircraft.[9] The Commonwealth Relations Secretary, Duncan Sandys, visited New Delhi in June 1962, with a counter offer to supply Lightning fighters. Nehru confirmed that the Indian proposal to buy and manufacture MiGs in India had been discussed in his meeting with Sandys and that he had made it clear that India had made no final decision on the matter.[10] What the Sandys mission did achieve was an Indian promise to re-examine the entire question.

Accordingly, an IAF evaluation team led by Air Vice Marshal Harjinder Singh[11] visited Britain ostensibly to evaluate the Lightning. This could have been a purely formal exercise as Nehru had already made it clear on earlier occasions that India had compared the MiGs with similar Western aircraft and favoured the former because it was 'meant for rougher work ... easier to manufacture, not so sophisticated'.[12] Soon after the return of the IAF evaluation team, it was reported that a Soviet offer to supply MiGs and provide for their later manufacture in India had been accepted 'in principle'.[13] The deciding

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9 *Times*, 14 June 1962. These were reported to include US willingness to be a partner to any financial arrangements that would make the purchase of Western aircraft possible as well as providing the RAF with American aircraft if British production was diverted to India.

10 *Times*, 18 June 1962.

11 *Times*, 13 July 1962.

12 *Times*, 5 July 1962.

13 *Times*, 23 July 1962 quoting a report in the *Indian Express*.

factor, it was reported in the *Times*, was not the price but the complexity of Lightning aircraft.[14]

In the last week of July 1962, an Indian delegation led by Dr S. Bhagwantam, Scientific Adviser to the Ministry of Defence, left for the Soviet Union to negotiate for the licence manufacture of the MiGs in India,[15] returning to India in the second week of August for consultations.[16] It would thus appear that the main reason for the Indian acquisition of MiGs besides those of ruggedness and simplicity of operation, was not the acquisition of F-104s by Pakistan. Although this would undoubtedly have been a factor, the threat from Pakistan in Indian perception, would have increased ever since the supply of F-86 Sabres by the United States in the late 1950s. Neither would the unit cost have played any decisive role, since the Anglo-American offer had been made after considering India's foreign exchange difficulties. The prime factors influencing this decision would be as follows:

1. The decision to induct supersonic aircraft into the IAF.
2. Failure to find a suitable powerplant for the indigenously designed HF-24 in order to give it supersonic capability.

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14 *Times*, 30 July 1962.

15 ibid.

16 *Times*, 18 August 1962.

3. A decision to indigenously manufacture the aircraft that was selected for the IAF.

Thus, while the offer of the supply of Lightning aircraft was attractive in terms of unit cost, there is no evidence to suggest that Britain offered licence manufacturing facilities for this type in India. Also, at this stage India had started acquiring military equipment from countries other than its traditional supplier - UK. Consequently, a combination of political, economic and technical factors and a policy of indigenous manufacture of combat aircraft were instrumental in the decision to manufacture the MiG-21.

By the middle of August 1962, the official decision had been made and on 17 August Dr S. Bhagwantam returned to Moscow where an agreement was signed on 29 August.[17] However, this agreement was somewhat incomplete and not a comprehensive accord. Within a fortnight there were reports[18] of new doubts at the service and technical levels about the merits of the variant of the MiG-21 that the Soviets were offering. It was not the performance of the aircraft that was being questioned (although doubts in this context had already been expressed) but the type of equipment that the Soviets were willing to provide in the aircraft. For it was reported that the Soviet Union was

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17 *Committee on Public Undertakings (1967-68): Eighth Report (Fourth Lok Sabha)*, p.8.

18 *Times*, 13 September 1962.

not willing to sell the latest in its inventory and that the alternative equipment offered 'was not good enough to make the aircraft fully useful to India'.

That these problems took some time to be solved is also indicated by further reports quoting Indian officials that the Soviet Union had let it be known that MiGs would not be available after all while Soviet diplomatic circles maintained that the aircraft contracted for would be delivered on schedule and that the Government of India had been reassured on this count.[19] However, these reassurances could also have been necessary because of the conflict with China in October-November since in a speech on 9 November 1962, Nehru said that he had no doubt whatever that the Soviet Union would fulfil her commitment to supply MiG aircraft by December, adding that he had been assured that 'all promises of aid would be honoured by the Soviet Union'. He felt that the war between India and China had placed the Soviet Union in a 'great fix'. 'Despite this they have helped us in the past and I have no doubt they will keep their word of giving us the planes they have promised by December'.[20]

The same expectation was repeated by the Defence Minister Y.B. Chavan in Parliament on 4 December.[21] There had been 'some little difficulty' Nehru added in reply to criticism

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19 *Times*, 3 November 1962.

20 *Times*, 12 November 1962; *Asian Recorder*, 1962, 4925:INI:A.

21 *Times*, 5 December 1962.

that the deal might be in jeopardy because of the Sino-Indian border war, but this had 'nothing to do with China' but was due to 'the world situation becoming rather critical because of what happened in the Caribbean ... (the) ... main thing...' was that the Soviet Union would build a plant in India for the manufacture of the aircraft. As regards delivery 'a few MiGs are to come in December, a few next year, and a few in 1964', mainly for training purposes.[22]

The fact that the significance of the MiG agreement lay in its provision for indigenous manufacture under licence over a period of time and not in its immediate ability to strengthen the Air Force was emphasised by both India and the Soviet Union. Addressing a press conference later in December, Nehru stated that he expected the initial batch of aircraft to be delivered 'fairly soon' as they were 'supposed to have been shipped by the end of 1962 or may be January 1963'. Adding that the MiGs would be few in number he said 'they are really meant to help us to manufacture in this country this type of plane'.[23]

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[22] ibid. Also *Keesing's Contemporary Archives 1963*, 19194:A. Nehru's answer was in reply to questions by Opposition members who drew attention to a statement by Duncan Sandys made in the British House of Commons the previous day after his return from India and Pakistan that 'the Soviet Union did not feel it could supply the MiG aircraft at the moment' since India was involved in a dispute with a Communist power. The Indian Ambassador to Washington had, in a television interview, stated that he did not think India would be receiving any military aid from the Soviet Union.

[23] *Hindu*, 1 January 1962.

The same view was put forward by the Minister for Defence and Economic Coordination, T.T. Krishnamachari, who at a press conference in Wellington (New Zealand) insisted that it was entirely incorrect to say that the Soviet Union was committed to help India's defence program.

> In fact we are committed to buy plans and designs of a Russian MiG fighter and Russia is holding us to that commitment ... there is no suggestion that the Russians intend giving military aid.[24]

The Soviet Union too made it amply clear that the MiG deal was not an agreement for the supply of arms, as a consequence of the Sino-Indian border conflict. The Soviet news agency *Tass* published a clarification on 23 February, 1963 concerning reports in the foreign press about 'so-called Soviet deliveries of war material in large quantities to India'.

> In reality, the USSR will help India draw up plans and then build a factory for manufacturing fighter planes in the framework of Agreements on technical co-operation.

These agreements, it went on to say, also provided for the Soviet Union to furnish 12 MiG-21 airplanes, including six for delivery in 1963 and the rest in 1964.[25]

Despite Chavan's assertion in Parliament on 15 April, 1963 that the manufacture of the MiGs would commence in about 18 months to two years,[26] the actual progress from

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[24] Quoted in *Hindu*, 23 April 1963.

[25] *Asian Recorder 1963*, INI:5127:E.

[26] *Asian Recorder 1963*, INI:5235:M.

the project planning to the manufacture stage required over five years. A preliminary project report was prepared with the help of a team of Soviet technicians and submitted to the government in September 1963.[27] Even at this early stage, domestic politics had an important role to play with the economics of manufacture having a secondary role - a factor which has had its impact on the economic viability of the project even to this date.

A number of sites were surveyed and Nasik (Maharashtra) was found to be the most suitable for the airframe factory. As regards the engine factory, the emphasis was on a location having a temperate climate and the choice narrowed down to two: Koraput (Orissa) situated at an altitude of 3,000 ft and a distance of 1,500 km (900 miles) by road or 600 miles by air from Nasik. It was not well serviced either by road or by rail links and it was clear that engines manufactured here would take a week to reach Nasik by rail, a problem that would increase when overhauls began. The other site considered was near the industrial belt at Puné (Poona), close to Nasik.[28] Soviet experts' advice was that the presence of industry near Puné would shorten the time required for construction of the factory and mastering engine production techniques by a period of about 6-8 months. If, on the other hand, the intention was to establish an industrial centre to manufacture

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27 *CPU (1967-68) Eighth Report*, p.8.

28 ibid., para 28, 33. See f.n. 35.

engines with considerable expansion of production in the future, only then would Koraput be a viable alternative.[29]

However, the government had decided on Koraput even before the submission of the preliminary project report. As early as April 1963, the Deputy Minister for Defence, D.R. Chavan, had made an announcement in Parliament to this effect.[30] The manufacture of AA-3 missiles and associated electronics seems to have been only under consideration[31] and the announcement in August, 1963 of the formation of a state owned company - Aeronautics India Limited - also mentioned the (initial) construction of two factories, at Nasik and Koraput.[32] It was a few weeks after the submission of the project report that the decision to set up a guided missile and electronics factory at Hyderabad was announced, on October 18, 1963. The earlier optimism about the commencement of manufacture still prevailed and the factories were expected to go into production by 1965.[33]

By early 1964, construction of buildings at Koraput and Nasik had been sanctioned and the contracts entrusted to the Orissa and Maharashtra governments. While it was

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[29] ibid., para 32.

[30] *Asian Recorder 1963*, INI:5235:M.

[31] ibid. Statement of the Minister for Defence Production, K. Raghuramaiah.

[32] *Times*, 19 August 1963.

[33] *Asian Recorder 1963*, INI:5532:F.

realised that under normal circumstances it would take 3-4 years for works and shops to be commissioned, this project planned to commence production simultaneously with the construction of buildings.[34] Aeronautics India Limited, meanwhile, was a company that existed only on paper, since the MiG project was assigned to it only on March 30, 1964. The reason given by the Ministry of Defence for these steps was one of speedier implementation of the project.[35]

Although the project reports submitted a year earlier were in accordance with the agreement of August 1962, the preliminary nature of the agreement itself soon became obvious, and this had to be followed up by a second agreement which was signed on September 11, 1964 during the visit of the Defence Minister, Y.B. Chavan to Moscow. According to Chavan, the original agreement was 'based on certain presumptions which in experience were found to be rather imcomplete'. For it had originally been considered that India could manufacture its own jigs and tools, which was later found to be beyond its capability.[36] Under the

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[34] *CPU (1967-68) Eighth Report*, paras 38-39.

[35] ibid., para 40. That the entire civil works program involved bureaucratic as well as centre-state politics was clear when, in reply to a Calling Attention notice in the Rajya Sabha, the Minister of State for Defence told the House on March 19, 1968 of representations having been received from the Orissa government who said they would have difficulty in keeping the State Engineering cadre employed if work on Koraput was taken over by Hindustan Aeronautics Limited (HAL) (as the company was now known), para 60.

[36] *Lok Sabha Debates, Third Series*, Vol.XXXIV, 22 September 1964, Cols.3038, 3040.

supplementary agreements, the Soviet Union agreed not only to provide machinery, jigs and tools but also to provide Soviet technical teams to assist in preparing detailed working project and production schedules. Arrangements for the supply of major assemblies, sub-assemblies and raw materials were finalised, and the Soviet Union also agreed to provide addtional 38 MiG-21s (besides the 12 aircraft already contracted for), in order to enable the IAF to re-equip three of its fighter squadrons. The Soviet Union also agreed to provide loans amounting to $142 million (at 2% interest to be repayed over 10 years) covering technical assistance and machinery for the manufacturing units.[37]

Accordingly, another Soviet team came to Nasik in 1965 to assist Hindustan Aeronautics Limited (HAL) in the preparation of 'Working Project Details', completing its report by early 1966.[38] The production program of the MiG complex was finalised by June 1966 as follows:[39]

A. KORAPUT:

(i) Delivery of first engine after tesing: May 1968.

(ii) Manufacture from major assemblies: September 1968.

(iii) from imported components: April 1970.

(iv) from raw materials: January 1971.

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[37] Statement by Cahvan in Parliament, reproduced in *Asian Recorder 1964*, INI:6090:A. Also Thomas F. Brady in the *New York Times*, 22 September 1964.

[38] *CPU (1967-68) Eighth Report*, para 26.

[39] ibid., paras 63, 66.

B. NASIK:

(i) erection from fully equipped assemblies: January 1967.

(ii) assembly from detailed sub-assemblies: April-May 1968.

(iii) indigenous production from raw materials: July 1970.

C. HYDERABAD:

(i) production from fully equipped assemblies (i.e. testing): no date given.

(ii) production from sub-assemblies and testing: no date given.

By early 1968, the Nasik and Hyderabad divisions had completed Phase I of their respective production schedules and Hyderabad had also completed about 30% of the work associated with the (final) Phase II. In other words, HAL contribution at this stage was limited to testing of the avionics equipment at Hyderabad and limited assembly work at the Nasik factory. Although Nasik had become an earning division in 1966-67[40] and sales had increased by Rs 90 million in 1967-68, there was only a marginal effect on profits as HAL effort in assembly was rather limited.[41] Production at the Koraput factory was already behind schedule because of delay in finalising contracts for the supply of test equipment and the first engine was delivered after testing only in December 1968. As a result, the rest of the production program was already considered to be 6-7 months behind schedule.[42]

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40 *HAL Annual Report, 1966-67*, p.12.

41 *HAL Annual Report, 1967-68*, p.6.

42 *CPU (1967-68) Eighth Report*, para 64.

The economic viability of the project itself was not given any consideration at the project. Estimates of cost of production from sub-assemblies, details, raw materials and profitability had not been worked out for any of the three MiG factories nor had they been included in the project report. Supplies to the IAF were to be on a 'cost plus profit' basis and in early 1968 it was disclosed that the quantum of profit had not been decided since HAL had 'not been able to make any reasonably accurate estimate of production costs and financial results of the factories so far'.[43] In any case, financial estimates even of the imports of plants and other machinery had increased substantially in rupee terms because of its devaluation in June 1966.[44] There was a large increase in the amount of deferred credits because of imports and, as a result, an increase of nearly 200 per cent on interest in 1967-68 - Rs 31.7 million as compared to Rs 10.7 million in the previous year.[45] To further complicate the problem of economics of manufacture, no breakup value was available for imported components issued for the aircraft manufactured from sub-assemblies.[46]

The performance of the MiG manufacturing program of HAL came under rather severe criticism by the *Public Accounts Committee* of the Parliament and a report released

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[43] ibid., para 68.

[44] *HAL Annual Report 1965-66*, p.10.

[45] *HAL Annual Report 1967-68*, p.6.

[46] ibid., p.24.

in 1968 included the following comments:

> The Committee does not agree that distance between airframe and engine factories does not make any difference to defence production ... The entire program and schedule of construction is affected by distance ... (and) ... has its own financial, functional and time consuming disadvantages ...
>
> ... hope that unless strategic considerations are overwhelming, Government will pay due attention to economic considerations in the future ...
>
> There is, however, need for expeditious completion of railway link and provision of prompt and extensive post and telegraph facilities ... (at Koraput).[47]
>
> ... surprised to note that an essential item like the cost of production was omitted from the Project Report with the result that HAL, which took over the project at a later stage had no idea about the cost of production of this aircraft ... recommend that ... (this) ... should be worked out without delay ...[48]

Although originally scheduled to go into production by the end of 1965, the first MiG-21FL was delivered to the IAF only in January 1967. This, too, was part of an initial batch of 60 aircraft[49] that were assembled from kits. The pricing policy as announced in 1968 amounted to an ad hoc profit of Rs 100,000 per aircraft regardless

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47 *CPU (1967-68) Eighth Report*, paras 35-37.

48 ibid., para 69. Although in a formal sense, HAL had not been associated in the negotiations (having been formed in 1964), which were conducted on a government-to-government basis, the Ministry of Defence had appointed project teams from its own officers. The leaders of these project teams eventually became General Managers of the three factories. *CPU (1967-68) Eighth Report*, para 174.

49 Thomas F. Brady in the *New York Times*, 22 September 1969.

of the cost of production.[50] The next year this was further elaborated on as HAL manufacture progressed to production from sub-assemblies. A profit margin of Rs 150,000 per aircraft and Rs 2,000 on each missile assembled besides a 15 per cent profit on HAL effort in the supply of 'group sets of spares' was finalised.[51] Government approval for creation of overhaul facilities was also obtained and in September 1968 the Soviets offered a new variant of the MiG-21FL, the MiG-21M under licence.[52]

It would thus be seen that the progress towards indigenous manufacture of the MiG-21FL so far had been somewhat erratic. Various factors contributed to this state of affairs, including delays in deliveries of tooling and raw materials from the Soviet Union,[53] the documentation and technical literature into English.[54] On the Indian side there was a shortage of suitably qualified personnel not only at the managerial and supervisory level (despite secondment of officers to HAL both from the government and the IAF),[55] but also of apprentices.[56] Due to the inordinate delays in the manufacturing schedule, HAL by now was only at the stage of beginning to set up overhaul facilities for

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50 *HAL Annual Report 1967-68*, p.24.

51 *HAL Annual Report 1968-69*, p.49.

52 *PAC (1981-82): Sixty Sixth Report (Seventh Lok Sabha)*, para 13.

53 *HAL Annual Report 1968-69*, p.9.

54 *HAL Annual Report 1965-66*, p.10.

55 ibid.

56 *HAL Annual Report 1966-67*, p.9.

the aircraft already in IAF inventory. These were finally completed by 1972-73 at the Koraput and Hyderabad divisions but those at Nasik were still not yet commissioned because of delays in supplies from the Soviet Union.[57]

Thus, the first indigenously manufactured MiG-21FL could be delivered to the IAF only by October 1970.[58] Even at this stage, capacity utilisation at the various manufacturing divisions was fairly low, either due to inability of HAL to find qualified personnel or to Soviet unwillingness to provide any detailed design or type approval data.[59] By 1969-70, the electronics division at Hyderabad was already suffering from a serious shortfall of work, to the extent that HAL sought government approval to manufacture TV sets.[60] It also took up a project to fabricate some industrial prototypes of transistorised gear controllers for *Vijayanta* tanks. Agreements were signed in January 1971 with Tesla (Czechoslovakia) and Selenia (Italy) for the manufacture under licence of Precision Approach Radars and Surveillance Radars and a Special Projects Team set up at Bharat Electronics Ltd.

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57 *HAL Annual Report 1972-73*, p.10.

58 *HAL Annual Report 1970-71*, p.9.

59 *SIPRI, Arms Trade with the Third World* (Stockholm: Almqvist & Wiksell, 1971), p.749. It is also said that 'requests for the supply of these from the Indian side have been turned down'.

60 *HAL Annual Report 1969-70*, p.12.

(another company under the Ministry of Defence) for the indigenous development of avionics equipment was transferred to the Hyderabad Division.[61]

Although in 1969-70, the engine factory at Koraput 'exceeded target of production',[62] it too was faced with the problem of spare capacity, especially in the foundry and forge divisions. This problem persisted in the following years despite its having obtained orders for the supply of castings and forgings to the Heavy Vehicle Factory, Avadi and the Vehicles Factory, Jabalpur.[63] Hence it would appear that the MiG complex of the HAL did not make any significant contribution in value terms or in the manufacture of the MiG-21FL variant,[64] 60 (or 63, according to another source)[65] of which were assembled from kits out of a total production run of around 190 aircraft which ended in 1974.[66]

Meanwhile, an agreement for the manufacture of a modified version of the aircraft, the MiG-21M, had already

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61 *HAL Annual Report 1970-71*, pp.11-12.

62 *HAL Annual Report 1969-70*, p.12.

63 *HAL Annual Report 1970-71*, p.11. See also *HAL Annual Report 1971-72*, p.12.

64 'FL' is the export designation for the versions built in quantity for the IAF by HAL including the MiG-21PF (Fishbed-D), the MiG-21PF-SPS and the later MiG-21PFM (Fishbed-F). See *Milavnews*, February 1973, p.15.

65 *Air International*, Vol.55, No.5, May 1982, p.211.

66 *Milavnews*, July 1973, p.14.

been signed in October 1969.[67] The MiG-21M was a simplified version of the MiG-21MF which was already being manufactured in the Soviet Union. Apart from an internal cannon (the MiG-21M being equipped with two 23 mm cannon in an underbelly pack) and numerous other detailed changes, the MiG-21MF used titanium components in its powerplants to gain 220 lb more thrust and an improved low level speed performance. However, in the initial stages, the Indian authorities are said to have decided not to include the improved powerplant on grounds that the additional cost of retooling for titanium components was not considered worthwhile.[68]

Under terms of the inter-governmental agreement, the Soviet Union agreed to transfer to India the licence and technical documentation for the manufacture of 'a certain number' (150) of aircraft on payment of a licence fee of Rs 50 million in five equal annual instalments (plus interest at 2 per cent on unpaid amounts). Terms, conditions and mode of payment for manufacture of aircraft beyond the specified numbers were to be determined separately. A good indicator of bureaucratic delays is the fact that the agreement was not assigned to HAL until nearly a year later, in September 1970.[69]

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67 *Public Accounts Committee (1981-82) Sixty Sixth Report (Seventh Lok Sabha)*, para 1.2.

68 *Milavnews*, October 1972, p.13. Also, *International Defense Review*, 2/1972, p.545.

69 Refer n.66.

The formal procedures notwithstanding, a contract for the supply of 30 aircraft in kit form had already been concluded in July 1970[70] with the aircraft scheduled to be delivered to the IAF 1972-73 onwards.[71] In this case also, the economics of manufacture under licence vis-a-vis outright import from the Soviet Union were not examined. The rationale behind this omission, according to the Ministry of Defence, was that the MiG-21M manufacturing program was considered to be an extension of the manufacture of the MiG-21FL. The project was considered to be economically viable on two grounds. Firstly, it would require only installation of certain additional plant and machinery and, secondly, would provide sufficient work for the three divisions for another 10 years and thus help stabilise production and update technology.[72]

An estimate of the cost of manufacture of the MiG-21 in India is, however, available. The initial unit cost of the MiG-21M - Rs 7.83 million (at 1971 prices) - was based on the unit cost of a fully imported aircraft while a revised unit cost of Rs 10.52 million was what it would cost to manufacture it from raw materials.[73] This figure underwent a further revision to Rs 11.5 million a few months later.[74]

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70 *PAC (1981-82) Sixty Sixth Report*, para 1.6.

71 ibid., para 1.5.

72 ibid., para 1.8.

73 ibid., para 1.21.

74 ibid., para 1.13.

Following approval by the Defence Committee of the Cabinet for the IAF to build up a force level of six squadrons of the MiG-21 MF by 1976-77, two orders for 48 and 102 aircraft were placed by Air Headquarters in September 1971 and May 1972 respectively.[75] Meanwhile there seem to have been some problems with the Soviet Union as the latter is reported to have demanded payments for licence fees in dollars instead of rupees as originally stipulated.[76] These problems seem to have persisted for quite a long time as reports about a cutback in the planned procurement of the MiG-21M persisted from 1972 to 1974.[77] The manufacturing program itself came under criticism and Western reports, quoting press sources in India, described it as a 'dubious success' giving the following reasons:[78]

1. The MiG-21 itself was criticised on grounds of inferior performance, especially its radius of action.
2. Inadequate numbers and excessive cost of indigenously manufactured aircraft. This was unofficially quoted (at 1973 prices) as being Rs 14.4 million or about twice the price of a direct import from the USSR.
3. That even as late as 1972, more than 50% of the components of the Indian MiG-21s were imported from

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75 ibid., paras 1.3 and 1.5.

76 *SIPRI Yearbook 1973*, p.363.

77 See for example, *Milavnews*, August 1972, p.12; *Milavnews*, September 1974, p.14.

78 *Milavnews*, November 1973, pp.14-15.

the Soviet Union i.e. the foreign exchange cost of the aircraft was the same as an aircraft bought off the shelf. In addition, the Soviet Union now required production licence fees to be paid in US dollars and was refusing to allow manufacturing rights for some of the most important and complex parts of the aircraft.

4. The program was allegedly three years behind schedule.

Other analysts, while making the same points also added that the MiG-21 manufacturing program would not provide any benefit to HAL in developing an indigenous design and development capability. On the contrary, they argued, it would enhance HAL's dependence on external suppliers.[79]

Such criticisms would be valid given the halting nature of progress not only towards indigenisation and self sufficiency in manufacture but also the slow pace of delivery of the aircraft itself. This is further substantiated by the recommendations of the Internal Review Committee headed by Air Marshal O.P. Mehra, the then Chairman of HAL.[80] In order to meet targets of production, overhaul, repair and delivery, it was suggested that HAL should:

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[79] Dennis Childs and Michael Kidron, 'India, the USSR and the MiG Project', *Economic and Political Weekly* (Bombay), September 1973, pp.1721-1728.

[80] *HAL Annual Report 1972-73*, p.24.

1. Ensure prompt delivery of supplies from the Soviet Union and other suppliers.
2. Improve communications with the government and arrange to speed up the process of implementation of decisions.

These two steps were clearly very necessary as the first MiG-21M, assembled at HAL, was delivered to the IAF in December 1972,[81] over three years after the agreement for their manufacture under licence was signed. Meanwhile, HAL is reported to have changed its views regarding the powerplant for the MiG-21M, deciding to opt for the R-11-S2S-300 or R-13 version[82] for increased low level performance after assembling three of the RD-11-300 models in early 1973. The switch over from powerplants for the MiG-21FL is said to have been made in record time with assistance from more than 150 Soviet technicians and the Koraput plant was scheduled to concentrate entirely on engines for the MiG-21M from 1974 onwards.[83] Deliveries of this version, however, were rather slow in 1973-74 with a total of only a dozen or so delivered by March 1974.[84] HAL itself maintained that MiG production in 1973-74 was satisfactory but admitted to 'some shortfalls in relation to the budget'.[85]

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81 *HAL Annual Report 1972-73*, p.10. This followed the delivery of seven MiG-21MFs from the Soviet Union earlier that year.

82 *Milavnews*, April 1973, p.14.

83 *Milavnews*, February 1973, p.15.

84 *Milavnews*, November 1973, p.15. See also Dilip Mukerjee in *Times of India*, 29 October 1974.

85 *HAL Annual Report 1973-74*, p.12.

Efforts at indigenisation were however kept up and in the same year a licence agreement for the manufacture of a range of accessories for the MiG-21M was signed.[86] These were to be manufactured at a new Accessories Factory to be set up at Lucknow, for which government approval had already been received.[87]

In a reassessment by Air Headquarters in February 1973, the requirement for MiG-21M was now estimated at about 308 aircraft instead of the original assessment of 150 because of problems of sustainability of force levels of some other types in IAF service. It was, therefore, decided to build a force level of 10 squadrons of MiG-21M by 1980-81 instead of the originally planned six squadrons. While these revised requirements were approved by the government in orders issued in November 1974,[88] a protocol for the manufacture of an additional 150 aircraft had already been signed in April 1973.[89] An additional licence fee of Rs 22.5 million was to be paid on the same terms and rate of interest as before.

The manufacturing program itself was proceeding rather slowly with a total of about 30 MiG-21Ms delivered by March 1975.[90] Since these aircraft had been manufactured

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86 *Ministry of Defence Report 1973-74*, p.63.

87 Refer n.86.

88 *PAC (1981-82) Sixty Sixth Report*, para 1.12.

89 ibid., para 1.14.

90 ibid., para 1.16.

against the first two orders and by IAF's revised estimates, an additional 150 aircraft (over and above the 150 already on order) would be required from 1973-74 onwards,[91] in April 1975. Air Headquarters proposed the outright purchase of about 90 aircraft over and above the total requirement assessed in February 1973. The main reason for such a step was the 'aging and obsolescence of a large number of aircraft and slippage in delivery' of MiG-21Ms by HAL.[92]

The Ministry of Defence 'partly attributed' these delays to 'delay in supply of raw materials from the foreign supplier, unforeseen technical problems and delay and shortcomings' at the HAL.[93] These problems were apparently discussed during the visit, in February 1975 of a Soviet military delegation. It was subsequently reported that, apart from selling Soviet equipment to India, agreement had been reached to expand the area of cooperation in the field of defence production.[94] The results of this were soon forthcoming when, on July 1975, deliveries of some 18 items of equipment from the

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[91] ibid., para 1.9.

[92] Refer n.90. In early 1975 it was reported that work at MiG divisions (as well as the Bangalore Complex) had averaged less than 20 per cent of installed capacity. See *Milavnews*, February 1975, p.10.

[93] *PAC (1981-82) Sixty Sixth Report*, para 1.17.

[94] *Milavnews*, March 1975, p.14.

Accessories Division at Lucknow, commenced about 10 months ahead of schedule.[95]

By the end of 1975, the Koraput division had begun the manufacture of complete R-13 turbojets for the MiG-21Ms from imported raw materials although there were reports of shortfalls in airframe production at Nasik.[96] The first MiG-21M built from raw materials was delivered to the IAF on 1 December 1975 and, having completed the production of the MiG-21FL variant, the MiG complex was concentrating entirely on the former.[97] The airframe division also sought to sub-contract many airframe and tooling components to private industry near Nasik as part of an integrated plan to concentrate only on specialist items requiring particular expertise or facilities.[98]

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[95] *Milavnews*, July 1975, p.12. These included wheels, hydraulic components, fuel pumps, pressure regulators, brakes, ejection seats and navigation instruments. Although this division had been licence manufacturing spares from France and UK, emphasis shifted to MiG-21 components because of the large number of aircraft in service with the IAF.

[96] *Milavnews*, October 1975, p.15. Meanwhile, reports that the IAF might take up a Rolls Royce offer to re-engine MiG-21s with *Spey* engines were discounted in India because it was considered that despite the advantages of improved performance and extended operational life, the investment made in the Koraput factory was too great to be discarded. Also, the cost and time scale of such a modification would be prohibitive. See *International Defense Review* 2/1976, p.308.

[97] *Times of India*, 2 December 1975. Also *Milavnews*, December 1975, p.17.

[98] *Milavnews*, January 1976, p.14.

Delays in the MiG-21M delivery schedule as well as the inability of HAL to develop the MkII version of the indigenously designed HF-24 Marut made it essential for the IAF to further review its long term requirements (up to 1987-88) for this type. In July 1975, it was decided that the total requirement of MiG-21Ms would be around 535 units. But, within two months i.e. September 1975 this had been scaled down to about 162 aircraft.[99]

The reason for this was that although the Soviet Union had offered the latest MiG variant, the MiG-21 bis in January 1975 for manufacture in India, the IAF had apparently not evaluated the aircraft to ascertain whether it fulfilled requirements. This was done only in August 1975 as a result of which requirements were changed and finalised a month later.[100] A delegation comprising officials from the Ministry of Defence and HAL visited the Soviet Union in October, 1975, and, as a result, preliminary cost details and budget estimates for manufacturing the MiG-21 bis were submitted to the Government in November 1975. Licence agreement for its manufacture was eventually signed nearly a year later in October 1976, and orders for the number of aircraft to be actually manufactured were issued in December 1976.[101]

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99 *PAC (1981-82) Sixty Sixth Report*, para 1.23.

100 ibid., paras 1.22 and 1.23.

101 ibid., para 1.26.

A preliminary project report was submitted by HAL in September 1977[102] and assembly of the MiG-21 bis was scheduled to begin at Nasik around 1979 after completion of the required number of MiG-21Ms. Western sources reported that the IAF required about 150 MiG-21 bis, production of which was expected to continue till 1983-84. Changes from the MiG-21M included installation of the R.25 turbojet,[103] the manufacture of which reportedly required an additional 1,500 personnel at the engine division at Koraput which already employed 3,800 workers,[104] A detailed Project Report was to have been submitted by December 1978,[105] but this could be achieved only by April 1980.[106] Government approval for the investment of capital and deferred revenue expenditure was finally granted in February 1981[107] - the entire process from the time the contract was signed taking over four years.

In the interim, a complicated set of bureaucratic manoeuvres in 1975 resulted in financial losses as well

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102 ibid.

103 *Milavnews*, October 1976, p.13.

104 *Milavnews*, September 1976, p.12.

105 This was based on the assumption that the Soviet Union would supply the relevant documents by March 1978. In fact, they were received only much later, in September 1979.

106 *PAC (1981-82) Sixty Sixth Report*, para 1.26.

107 ibid., para 1.27.

as over supply of raw material and spares for MiG-21M manufacture. As mentioned earlier, the Soviet Union had offered the MiG-21 bis for licence manufacture but this variant was not evaluated until August 1975. Meanwhile, in November 1974, the Ministry of Defence had already sanctioned the manufacture of an additional 124 aircraft and a formal order was placed on HAL in February 1975, deliveries being scheduled for the period 1978-79 to 1981-82.[108] By September 1975, while HAL had placed orders valued at Rs 167.5 million for the supply of raw materials and parts on the Soviet Union, it had been decided to reduce requirements for the MiG-21M to around 162 aircraft. This was due partly to direct import of MiGs from the Soviet Union and partly to the decision to manufacture the MiG-21 bis. But this did not prevent HAL from placing additional orders worth Rs 18.9 million a month later - the agreement being actually signed on 25 October 1975. Attempts made a few days later as well as in May 1976 to curtail supplies were unsuccessful as the Soviet Union argued that 'the equipment had already been manufactured and partly supplied'.[109]

The manufacturing program of the MiG-21M has not only been behind schedule but output has also been fairly low - approximately 9-10 aircraft per year as against a target capacity of 30 per year.[110] Shortfalls in MiG

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[108] ibid., para 1.48.

[109] ibid., para 1.52.

[110] *Milavnews*, December 1978, p.14.

manufacture in 1975-76 and 1977-78 were reported to have been attributed to 'organisational deficiencies' and labour problems respectively, by the Minister of State for Defence Production, Sher Singh.[111] Attempts at further indigenisation of the MiGs has been a constantly feature and in 1976-77 new plans were formulated.[112] A year later, in 1978, it was announced that the first phase (already underway) would be completed in four years, that a 'time bound' program had been drawn up for indigenisation of high value items.[113] In October 1978, a Soviet technical mission headed by the Deputy Minister of Aviation Industry, I.S. Silayev, visited India to discuss the entire question of collaboration in aircraft production.[114]

The Soviet team was reported to have promised to accelerate the indigenisation of the MiG program from the then existing level of 75 per cent. The Soviets were also said to have discussed with the Indian team led by the Defence Production Secretary, M. Menezes, the possible Soviet import of MiG spares manufactured by HAL and agreements relating to transfer of technology and supply of raw materials. Although the Soviet delegation was reported to be 'receptive' to the idea of offset

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111 *Milavnews*, August 1978, p.10. Also *HAL Annual Report 1977-78*, p.5.

112 *HAL Annual Report 1976-77*, p.7.

113 *HAL Annual Report 1977-78*, p.6.

114 *Milavnews*, October 1978, p.14.

purchases from HAL for its own MiG manufacturing program, nothing substantial seems to have been achieved as 'other aspects' of the MiG program were to be 'further explored' by a Soviet technical team scheduled to make a follow up visit a few weeks later.[115]

Along with the low output of the MiG-21M, in 1978 HAL also began the assembly of the MiG-21 bis from imported kits, although full scale production was not expected to begin till the completion of the MiG-21MF manufacturing program, sometime in 1980-81.[116] The question of transfer of technology was again discussed when an Indian delegation, headed by the Defence Secretary, J.A. Dave, visited Moscow in September-October 1979. The Soviet Union was said to view Indian defence production requirements with 'utmost sympathy' and the visiting delegation again discussed proposals for increasing the indigenous content of the output by MiG factories. Soviet sources were quoted as saying that India had 'a fair chance' of acquiring the latest in MiG technology.[117]

By early 1980, there were reports that the government was finalising arrangements to procure the MiG-23MF as a replacement for its MiG-21FLs and MiG-21Ms for air

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115 *Milavnews*, November 1978, p.17. Also *Hindu* (International Edition), 28 October 1978.

116 *Milavnews*, December 1978, p.14. Introduction of the MiG-21 bis program is also said to have resulted in abandonment of earlier IAF plans to develop the HF-24 Marut into HF-25.

117 *Milavnews*, November 1979, p.17.

defence roles and the MiG-23BN to re-equip the HF-24 and Su-7 squadrons for ground support tasks,[118] and that deliveries of an initial quantity of each variant from the Soviet Union would be followed by large scale production by HAL after the MiG-21 bis was phased out of production by 1982-83.[119] This would have been a very optimistic assessment of HAL's manufacturing capabilities since it had barely begun to manufacture the MiG-21 bis with its uprated R.25 engines and the last MiG-21MF was not scheduled for completion till late 1981 or early 1982.[120]

The transition from manufacturing the MiG-21MF to the Mig-21 bis turned out to be a fairly complicated procedure given the excess materials ordered for the former aircraft. Although the licence fee of Rs 22.5 million paid for the manufacture of the additional 150 MiG-21MFs was subsequently adjusted towards the licence fee payable for the manufacture of the MiG-21 bis,[121] the value of excess materials was assessed in July 1977 at Rs 167.3 million. It was not possible for HAL during the period 1976-79 to ascertain whether any of the excess supplies could be used in its MiG-21 bis manufacturing

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118 The MiG-23BN is generally similar to the MiG-23BN in service with the Warsaw Pact, but has no Air Intercept Radar.

119 *Milavnews*, January 1980, p.14.

120 *Milavnews*, February 1980, p.13.

121 *PAC (1981-82) Sixty Sixth Report*, para 1.15.

program, since detailed documentation for this aircraft had not been received.[122] This exercise was finally carried out in 1980 when it was concluded that the degree of commonality between the two variants was as follows:[123]

Parts: 39 per cent

Forgings and Castings: 44 per cent

Ready made equipment: 73 per cent

There was no commonality in the material pertaining to the systems division (Hyderabad) for which material worth Rs 5.74 million had been acquired. As regards the Aircraft division, supplies worth Rs 162 million had been received by June 1980, of which material costing Rs 18.9 million could be utilised for the manufacture of the 12 remaining MiG-21MFs. While the Soviet Union had agreed to cancel orders for supplies worth about Rs 5.2 million[124] and efforts were being made for a further reduction of orders worth Rs 5.9 million,[125] HAL, by its own reckoning, had been saddled with totally surplus material valued at about Rs 148.24 million.[126] Earlier, the Soviet Union had

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122 *Report of the Comptroller and Auditor General. Union Government (Defence Services), 1978-79*, para 37.

123 Refer n.121, para 1.34.

124 ibid., para 1.35.

125 ibid., para 1.38.

126 ibid., para 1.34A.

assured HAL that the excess materials procured could be used for manufacturing the MiG-21 bis and overhaul of the MiG-21M/MFs.[127]

These assurances seem to have been only partly true. In evidence before the *Public Accounts Committee* of Parliament in 1981, a representative of the Ministry of Defence stated that an estimated Rs 118.9 million worth of supplies could be utilised in the manufacture of the MiG-21 bis, overhaul purposes and fabrication of spares leaving a net surplus of only Rs 29.3 million.[128] However, on further questioning it, it was conceded that HAL was indeed considering the manufacture of an additional batch of 70 MiG-21Ms and this order, along with requirements for repair and overhaul, would 'absorb a great deal of the items procured'.[129]

Aircraft production itself had not stabilised even as late as 1970-80 when it was admitted that the MiG complex had earned a lower net profit 'because of lesser delivery and cost overruns in respect of certain projects'.[130] The order for a further 70 MiG-21Ms does not seem to have materialised either, as the last of the MiG-21MF was reported to have been completed on 11 November 1981. HAL is now said to be concentrating entirely on the MiG-21 bis, 150 of which are on order. Production is now reported

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127 Refer n.122.

128 *PAC (1981-82) Sixty Sixth Report*, para 1.34A.

129 ibid., para 1.38.

130 *HAL Annual Report 1979-80*, p.71.

to be at the rate of 2.5 to 3 aircraft per month which would imply that all the aircraft on order would be delivered by 1984.[131] This, if true, would mean that HAL has been able to increase its rate of production to almost thrice that obtaining in the late 1970s.

Meanwhile, uncertainty existed about the eventual manufacture of the MiG-23 and its R.29 engine as a follow on to the MiG-21 bis program. Agreement reached in 1979 for MiG-23 procurement was reported to have been scaled down in 1980, and acquisition of 80 MiG-23MFs in kit form from mid-1980s was shelved pending a comparative evaluation of this aircraft and the French Mirage 2000. Procurement of 85 MiG-23BNs, however, was advanced given the urgent necessity to re-equip the Su-7 and HF-24 squadrons. Originally scheduled to be supplied from mid-1982 onwards,[132] the first batch was acquired in December 1980-January 1981, and reports indicated that indigenous production might not be undertaken given the replacement schedule. The aircraft were supplied in crates and simply 'bolted together' on arrival.[133]

Recent indications are that agreement has been reached to licence manufacture the MiG-27 *Flogger-J* tactical strike fighter rather than the MiG-23BN as originally

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131 *Air International*, Vol.22, No.5, May 1982, p.211.

132 *Milavnews*, November 1980, p.17.

133 *Milavnews*, March 1981, p.7.

planned. An estimated 150 aircraft of this type would be manufactured after completion of the MiG-21 bis program.[134]

Overall, during its first decade the MiG-21 manufacturing program has not been very successful, which is not at all unusual considering the HF-24 and the HJT-16 experience. But, while the latter two aircraft were attempts at indigenous development, the MiG-21 manufacture was undertaken in collaboration with the Soviet Union. Evidence would suggest that the Soviet Union at least initially was not very forthcoming in providing India with detailed data, technical drawings and information. This, combined with the cumbersome bureaucratic processes of the Ministry of Defence and HAL, and lack of technical expertise in the early years has been responsible for constant slippages in the manufacturing schedule.

Electronics equipment in the Indian-manufactured MiGs would appear to have been predominantly Soviet supplied with very little indigenous content - the main reason why activities at the Hyderabad division were considerably diversified after the initial years. They would also seem to have been simplified versions of what actually equips Soviet MiGs or else not up to IAF requirements. This contention is borne out by the fact that IAF technicians, in cooperation with HAL, are reported to have successfully integrated Swedish Electronic Warfare (EW)

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[134] Refer n.131.

equipment with the avionics of the indigenous MiG-21s.[135] Later reports also mention equipment such as Inertial Navigation Systems and Nav/Attack systems from *Ferranti* and *Marconi* (UK) installed in IAF MiGs.[136] Decision is also reported to have been taken to replace the not very successful AA-3 missiles with the more contemporary Matra Magic missile (France) of which several successful launchings are said to have been conducted.[137]

As against an estimated capacity of 30 aircraft per year, output during the 1970s has varied between 9 and 15 aircraft per year.[138] Recent reports that the current annual production rate of the MiG-21 bis is around 30-35 aircraft[139] would mean either increased rate of assembly or that the production process has finally stabilised, some 15 years after it began. The latter could possibly be the case since it has been reported that in keeping with the drive for local production, the MiG-21M wing has been modified for use on the MiG-21 bis - the reverse engineering reducing cost and complexity. The earlier cost-plus-ten per cent pricing policy which had been

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135 These include AR-753 Radar Warning Receivers (RWR) and Pod mounted jammers manufactured by Scatt (Sweden) and Reconnaissance Pods from Bofors. See *International Countermeausres Handbook, 1977-78* (Palo Alto, California), p.198.

136 *Flight International*, 6 September 1980, p.957.

137 *Air International*, Vol.22, No.2, February 1982, p.55.

138 *Flight International*, 18 March 1978, p.756.

139 *Air International*, Vol.22, No.5, May 1982, p.211.

criticised both by the IAF and Parliament has also been changed. Aircraft costs are now said to be fixed annually, with a small reserve for overruns.[140]

The cost of production of the Indian MiG-21s itself is only an approximation because the Soviet Union does not provide itemised prices for materials supplied by it and these are accounted for on an estimated basis. Consequently '... the value of inventory of USSR materials is provisional, subject to adjustment at the end of the project'.[141] Another factor that contributes to lowering of HAL's manufacturing costs is that the interest on deferred credit and licence fees is reimbursed by the Government of India and is not included as expenses by HAL.[142] In spite of these indirect subsidies, the cost of production of the Indian MiG-21s is, according to a Ministry of Defence source, *at least* 15-20 per cent higher than the cost of a fully imported aircraft.[143] Although it has been admitted that the lower net profits by the MiG complex in 1979-80, for example, were due to 'lesser delivery and cost over-runs in respect of certain projects',[144] the main reason would seem to be the lower

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140 *Flight International*, 19 January 1980, p.142.

141 Notes forming part of Accounts. *HAL Annual Report, 1978-79*, p.66.

142 Accounting Policies. *HAL Annual Report 1979-80*, p.35.

143 Information given by a senior Ministry of Defence official. The source was, however, quick to point out that the 'finish' of the indigenously manufactured aircraft was far superior to those manufactured in the Soviet Union. [Interview with Dr D.N. Prasad, Joint Secretary, Department of Defence Production on 9 February 1981 at the Ministry of Defence, South Block, New Delhi.]

144 *HAL Annual Report 1979-80*, p.71.

productivity rate as well as volume of manufacture. When the project was being conceived, it was envisaged that the Koraput Division should be planned in a manner that would make it conducive to substantial expansion in the long term. The same would have been the case with the Nasik and Hyderabad Divisions.

In practice, what has actually happened is that while the Hyderabad Division diversified its activities soon after production began, the Koraput and Nasik divisions have worked well below capacity. Consequently, although the divisions would have a potential for expansion, it would seem improbable. It has been reported that a decision was taken in 1981 to licence manufacture the MiG-27 *Flogger-J* tactical strike aircraft rather than the MiG-23BN as previously planned.[145] By mid-1983, a large part of the tooling equipment and machinery for the production of the MiG-27 had arrived in India and the first Indian assembled aircraft was expected to roll out by mid-1984.[146]

Another factor that could perhaps be held responsible for the low volume of production is the quick succession of variants of the MiG-21 that have been introduced on the production line even before the manufacture of the existing model had stabilised. For example, agreement

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145 *Air International*, Vol.22, No.5, May 1982, p.211.

146 *Indian Express*, 7 June 1983.

to manufacture the MiG-21M was signed in October 1969 when the MiG-21FL production was still confined mostly to assembly from kits. Later, agreement for the licence manufacture of the MiG-21 bis was signed in August 1976 - about the time that HAL was making initial deliveries of the MiG-21M built from detailed assemblies and raw materials. But, it can also be argued that this would have only a marginal effect since both the MiG-21FL and M variants completed their planned production runs of about 196 and 160 aircraft respectively. The only effect that the induction of new variants would have had would be in terms of diversion of manpower to assembly of the latest version. This by itself would be beneficial in the long run in terms of acquisition of manufacturing skills.

Thus, it would seem that two major factors have contributed to the uneven progress of the MiG-21 manufacturing program. The first, and probably more significant, one has been that of problems with the collaborator i.e. the Soviet Union. Although the government has never officially admitted any difficulties in securing supplies from the Soviet Union, it has, as already discussed, had to face numerous delays in supply of both raw materials and documentation. This has also been the case in the creation of overhaul facilities and execution of overhaul work. In 1972-73, it was admitted that overhaul work at Nasik could not be

undertaken because of 'non-receipt' of materials from the Soviet Union.[147] In November 1974, the Minister of State for Defence Production, Ram Niwas Mirdha, insisted in Parliament that 'no difficulty is being faced in securing supplies from USSR for overhaul tasks' but admitted to 'cases of delays in receipt of supplies'.[148] A few days earlier, he had spoken of the 'steadily rising' output of MiGs being overhauled in India but also mentioned that aircraft, including some assembled in India had had to be sent to the Soviet Union for overhaul in order to clear backlogs.[149]

This situation could not have substantially changed in the later half of the 1970s as an increasing number of MiGs would have become due for major overhaul. In 1977-78, the Koraput division was facing the familiar problem of shortage of spares from the Soviet Union causing shortfalls in overhaul work.[150] The slow pace of indigenisation also ensured a continuous reliance on the Soviet Union.[151] It is only in recent years that there

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147 *HAL Annual Report 1972-73*, p.10.

148 *Lok Sabha Debates* XLVI (Twelfth Session, Fifth Series), 28 November 1974, Column 97.

149 ibid., XLV, 15 November 1974, Col.169.

150 *HAL Annual Report 1977-78*, p.5.

151 For example, although in 1978-79 the Nasik division purchased raw materials and stores worth only Rs 0.65 million and Rs 1.25 million, from Ancillary and Small Scale industries respectively, this amounted to 25% and 49.1% of total purchases from indigenous sources. Refer *Report on Industrial Dispersal: National Committee on Development of Backward Areas* (Government of India, New Delhi, October 1980), Table 8.3, p.54.

has been any substantial progress with regard to domestic manufacture of spares.[152] This would appear to have come at a time when the MiG-21 is no longer being manufactured in the Soviet Union and parts for the aircraft would be increasingly difficult to acquire either from the Soviet Union or from other East European countries.

Another significant problem encountered in the MiG manufacturing program has been the management of HAL. In evidence before the *Public Accounts Committee* of Parliament, the Ministry of Defence stated that apart from the delays in receipt of documentation, tooling and material from the Soviet Union 'there was a need to strenghen the production planning and management information system ... and improve the quality of managerial supervision'.[153]

Also, there have not been any visible spin off benefits in the form of development of design or manufacturing capability based on the MiG experience, which has been a closed one. The prospects of the program introducing new technology and manufacturing processes do not appear very bright either, as all the newer processes and techniques would probably be introduced in manufacture of the later generation and more sophisticated Jaguar strike aircraft.

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[152] In accordance with a five year plan finalised in May 1977, out of a total of 2,769 items, 2,533 items had been indigenised by March 1982. *HAL Annual Report 1981-82*, p.11.

[153] *PAC (1981-82) Sixty Sixth Report*, para 1.20.

CHAPTER III

INDO-FRENCH COOOPERATION: MANUFACTURE OF HELICOPTERS

A. AL-III ALOUETTE

In 1962, the Government of India signed a licence agreement with Sud Aviation (airframe) and Turbomeca (powerplant) of France for the manufacture of the SA-316 Alouette III helicopter in India. Two teams were sent to France to undertake the necessary pre-planning work.[1] The program drawn up by the Planning Team in consultation with Sud Aviation envisaged a gradual build-up of manufacturing capacity for the Al-III with the first batch to be constructed from imported major assemblies, sub-assemblies and details. The time-frame for production was estimated as follows:[2]

1. Testing of initial fly-away helicopters: 2 months.
2. Assembly from major components: 5 months.
3. Construction from sub-assemblies: 7 months.
4. Manufacture from details: 9 months.
5. Finally, after a 'certain stage', manufacture from raw materials i.e. details, sub-assemblies and major components would be made at HAL's Bangalore Division.

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[1] *HAL Annual Report 1962-63*, p.12.

[2] *Committee on Public Undertakings (1967-68): Eighth Report (Fourth Lok Sabha)*, para 99.

By 1965-66, progressive manufacture from wholly imported components was underway and a limited number of Al-IIIs had been delivered to the IAF.[3] Subsequent stages of the program, however, soon fell behind schedule. There were considerable delays in the fabrication of structure assembly jigs because considerable difficulty was encountered in getting the jigs made at Bangalore to conform to the precise specifications provided in the drawings from Sud Aviation.[4] Further problems arose from the fact that certain drawings were in French while others were received late. But the principal reason for delays was the limitations of the Tool Department itself, 'which was unable to cope with many demands made on it, especially by the HF-24 and the HJT-16 projects'.[5]

The Planning Team, after studying the time cycle for large scale manufacture followed by Sud Aviation, had recommended a longer time cycle for initial manufacture from raw materials at the Bangalore Division. Management at the Bangalore Division on the other hand reduced the time cycle by one-third - a move which was later conceded to have been 'arbitrary'.[6] The offshoot of this action was that an outside consultant had to be brought in to review the program.

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[3] *HAL Annual Report 1965-66*, p.14.

[4] *CPU (1967-68): Eighth Report*, para 100.

[5] ibid., para 106.

[6] ibid., para 102.

The consultant was of the view that it was not possible to manufacture the Al-III from raw materials in the time cycle finalised by the management, and that a more realistic estimate would be a very much longer time cycle in the initial stages which could later be reduced. After a detailed study of the Bangalore Division's workshops, it was concluded that the manufacturing time cycle could be reduced in the initial stages, but only with the help of Sud Aviation engineers and technicians and with the outright purchase of certain components which the Division would not be able to manufacture for some time to come.[7]

Even this review of the program did not help organise the manufacturing schedule as further complications arose at the time of ordering supplies. HAL had placed indents on the Director General, India Supply Mission (ISM), London. But, the ISM was unable to locate the sources of supply for many items of raw materials and brought out equipment. It was only then that the Bangalore Division decided to place direct orders on suppliers.[8] Because of the delays in procurement, even the delivery programs of the manufacture of certain items of machinery from raw materials, had to be revised. There were further delays as the delivery of raw materials was 'below

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[7] ibid., para 108.

[8] ibid., para 103.

expectations' and, as late as 1967, for certain items even firm supply contracts had not been executed.[9]

Thus, by 1968 production of the Al-III was mostly confined to major assembly work although manufacture of smaller components had begun. A trial order for certain spare parts was received from Sud Aviation[10] and in 1969 it was announced that spares worth Rs 60,000 had been exported.[11] In 1970 a trial order for 15 Al-III airframes was executed and another trial order valued at Rs 65,000 for the supply of a small number of fuel pumps and diffuser assemblies for the Artouste engine was received.[12]

It was also in 1970-71 that manufacture of the Al-III from raw materials began. This would appear to have been on a limited scale since indigenously manufactured blades were scheduled to be fitted in Al-IIIs which were to be delivered from 1972-73 onwards. Also, the engine factory was still attempting to overcome problems associated with the manufacture of reduction gears for the Artouste powerplant.[13] Some progress was however made in the

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[9] ibid., para 104.

[10] *HAL Annual Report 1967-68*, p.8.

[11] *HAL ANnual Report 1968-69*, p.10.

[12] *HAL Annual Report 1970-71*, p.9.

[13] ibid., p.8.

indigenisation of raw materials as eight different types of Aluminium and Magnesium alloys began to be locally produced.[14]

By February 1975, a total of 219 Al-IIIs had been ordered of which 147 had reportedly been delivered, including three to civil users.[15] An armed version carrying four AS.11B Air-to-Surface wire guided missiles, known as Chetak, was also developed and preliminary firing trials had been successfully carried out by 1976-77.[16] Some 40 AL-III Chetak were eventually built for use by helicopter anti-tank units.[17]

Although 193 Al-IIIs had been manufactured by 1977, workload at the Helicopter Complex at Bangalore declined as HAL asked the Ministry of Defence for further orders.[18] An unspecified number of helicopters were apparently ordered and their manufacture scheduled to continue at least till 1980-81.[19] It would appear that the requirement for the Al-III had been fulfilled with 260 having been

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14 *HAL Annual Report 1971-72*, p.9.

15 *Jane's All the World's Aircraft 1975-76*, p.103.

16 *Jane's All the World's Aircraft 1976-77*, p.82.

17 William Green et.al. (ed), *The Indian Air Force and its Aircraft* (London: Ducimus Books, 1982), p.61.

18 *HAL Annual Report 1977-78*, p.6.

19 *Milavnews*, December 1978, p.13.

manufactured by 1982.[20] Nonetheless manufacture of the helicopter was still continuing albeit on a limited scale since the Helicopter Division was reportedly functioning at 40 per cent capacity utilisation.[21] In late 1982, it was also reported that the Soviet Union was to acquire eight Al-IIIs and the sale of six Al-IIIs to Liberia was under negotiation.[22]

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20 *Air International*, Vol.24, No.1, January 1983, p.3.

21 S. Sapru in *Indian Express*, 28 June 1982.

22 Refer n.20.

B. SA-315B LAMA/CHEETAH

Design of the Sud Aviation (France) SA-315B Lama began in late 1969 initially to meet a requirement announced by the IAF for a high-altitude helicopter. Basically, the SA-315B combined features of the Alouette Al-II and III, having the airframe (with some reinforcement) of the former and dynamic components, including the Artouste powerplant and rotor system of the latter. A prototype was flown for the first time on 17 March 1969 and French certification was granted on 30 September 1970.[23]

It was also in September 1970 that the Government of India transferred to HAL two agreements with Aérospatiale:[24]

1. The manufacture of the SA-315B Lama (renamed Cheetah) under licence.
2. Cooperation in the design and development of an Advanced Light Helicopter (ALH) as a successor to the Cheetah and the Chetak.

Although the Cheetah was to be initially assembled at the Helicopter Division of HAL's Bangalore complex, its manufacture was later scheduled to be taken up at a new Helicopter Factory which was to be established with a capital expenditure of Rs 34.4 million.[25]

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23 *Jane's All the World's Aircraft 1971-72*, p.42. During demonstration flights in the Himalayas in 1969, the SA-315 carrying a crew of two and 308 lb (140 kg) fuel made the highest landings and takeoffs ever recorded, at a height of 24,600 ft (7,500 m).

24 *HAL Annual Report 1970-71*, p.12.

25 ibid.

The overall program reportedly called for the completion of 140 helicopters of which the first 40 were to be completed from components and sub-assemblies imported from France. The remaining 100 were to be built from raw materials and the delivery of these was scheduled to begin in 1976.[26] The first Indian-assembled Cheetah flew for the first time on 6 October 1973 and by early 1974, six had been delivered to the IAF.[27] Although a 'serious setback' in the Bangalore Complex Engine Division affected the performance of the Helicopter Division in 1973-74,[28] it would appear that in subsequent years, production stabilised and deliveries continued as scheduled.

In 1975, it was reportedly decided that all fixed wing liaison aircraft operated by the Indian Army were to be replaced by helicopters. As a consequence, its inventory of 63 HAOP-27 Krishak high wing light planes now began to be supplemented by the locally built SA-315B Cheetah.[29] Production of the helicopter from raw materials began in 1976-77 and by late 1977 about 16 were scheduled for completion, making a total of over 50 helicopters that had been assembled/manufactured till that time.[30]

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26 *Jane's All the World's Aircraft 1973-74*, p.103.

27 *Jane's All the World's Aircraft 1974-75*, p.105.

28 *HAL Annual Report 1973-74*, p.12.

29 *Milavnews*, January 1975, p.15.

30 *Jane's All the World's Aircraft 1977-78*, p.83.

By early 1981, a total of 133 helicopters had reportedly been delivered[31] and production of the Cheetah was continuing well into 1982. But, this would appear to have been on a limited scale since the helicopter division was said to have been working at 40 per cent of its installed capacity.[32]

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31 *Jane's All the World's Aircraft 1981-82*, p.89.

32 S. Sapru in *Indian Express*, 28 June 1982.

C. THE ADVANCED LIGHT HELICOPTER (ALH)

In September 1970, the Government of India concluded a 10-year collaboration agreement with Aérospatiale (France) for the design, development and production of a helicopter to meet the requirements of the Indian armed forces in the 1980s. Assigned to HAL the same month, the agreement provided for the training of Indian personnel for which a payment of US $750,000 (Rs 5.459 million) was to be made in 10 annual instalments and a further US $20,000 per year for any extension beyond 10 years, if any.[33] Under the terms of the agreement, Aérospatiale was to provide the following services to HAL:

1. Assistance in creation and development of a design base for the ALH.
2. Assistance in the field of personnel training in France as well as by sending Aérospatiale engineers and pilots to India. Training was to be imparted up to a maximum of 26 man months and 60 man hours of developmental flying and included design, testing and maintenance fields as well as incorporation of 'specific techniques' in the selected design.

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[33] Unless mentioned otherwise, details about the attempt to design and develop the ALH have been derived from *Report of the Comptroller and Auditor General: 1974-75. Union Government (Defence Services)*, para 8; and *Report of the Comptroller and Auditor General: 1979-80. Union Government (Defence Services)*, para 6.

3. Provide not only facilities to Indian technical personnel but also access to all design, flight development and technical data required for the program.

Based on a feasibility study conducted jointly by Aerospatiale and HAL, Air Headquarters issued an Air Staff Requirement (ASR) in May 1971. A year later, in April 1972, HAL sought Government approval to a detailed project report and cost estimates for setting up of the required development facilities.[34] No action was taken on the project report for the next two years and in July 1974, the ASR of 1971 was modified on the basis of the report of an Inter-Services Team which was submitted in March 1974. While the project still awaited Governmental approval, the capital cost of establishing design facilities, estimated in 1972 at Rs 88 million (foreign exchange: Rs 41 million), was revised in 1974 to Rs 113 million (foreign exchange: Rs 65 million) and again to Rs 136.9 million (foreign exchange: Rs 78.5 million) in August 1975.

Also, by the end of 1974, while 116 man months of training had been availed of, other services envisaged in the agreement remained 'largely' unutilised in absence of a final decision on the project. Meanwhile, as agreed

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34 *HAL Annual Report 1971-72*, p.9.

Rs 4.418 million in foreign exchange had been paid to Aérospatiale in addition to Rs 2.621 million (foreign exchange Rs 0.46 million) spent by HAL on training its personnel.

Lack of any decision on the project came under severe criticism in a *Report of the Comptroller and Auditor General* in 1974-75. It was only after this that the Ministry of Defence conceded (January 1976) that the delay in sanction was due to budgetary constraints. When the project was finally sanctioned by the Government in February 1976, the cost had increased from Rs 230.4 million (1972) to Rs 273.6 million for development and from Rs 88 million to Rs 136.9 million for establishing the design facilities. Also, due to the delay in sanctioning the project, the first prototype was not expected to fly until 1981-82 instead of 1978-79, and production was to commence in 1984-85 i.e. four years beyond the period of the collaboration agreement, which expired in September 1980.

According to Western sources[35] the ALH was to be powered by a single Turboméca Astazou XX engine and would apparently resemble the Alouette with a semi-monocoque fuselage housing a crew of two and up to five passengers but with a 4-bladed semi-rigid main rotor. Two versions were to be developed - one for

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35 *Milavnews*, January 1977, p.13.

the Army and the IAF with landing skids and a naval variant with a non-retractable tricycle undercarriage and provision for folding blades and Anti-Submarine Warfare (ASW) equipment.

However, in April 1977 before any significant progress could be made on the project, Air Headquarters proposed to replace the single-engine design by a twin-engine configuration. The proposal, reiterated in August 1977, was said to be based on the experience gained by the IAF during the 1971 operations in Bangladesh, and that of various countries involved in the Middle East War of 1973. This was clearly a case of late realisation and inefficiency in decision-making since the original ASR had been 'modified' in March 1974 without any reference to a change from a single-engine to a twin-engined design.

In any case, a revised ASR (draft) was issued by Air Headquarters in February 1978. In April 1978, HAL stated that the revised specifications would cause a delay of about 15-18 months in the development schedule and that prototype flight testing and manufacture would be possible by 1984 and 1987 respectively. Further, it would require continued assistance from Aérospatiale whose helicopters were equipped with engines manufactured by Turboméca.

Further complications arose when a Technical Group constituted in May 1978 recommended two alternative engines manufactured by Rolls Royce (UK) and Pratt and

Whitney (Canada). The Technical Group also assessed that the design change would result in a redundancy of stores worth Rs 5.4 million, further increase the cost of development by Rs 60 million and entail a delay of 15-18 months in the final induction of the helicopter. A proposal to change the scope of the project at a revised cost of Rs 359.7 million-Rs 375 million (an increase of Rs 86.1 million-Rs 101.4 million) was submitted to the Government in October 1978. The question whether HAL should extend its agreement with Aerospatiale or negotiate with 'other firms' was left open. This rather ambiguous proposal was approved by the Government in January 1979.

This decision clearly reopened the entire question of collaboration in the design and development of the airframe as well as the choice of a powerplant. Nearly two years later, by November 1980, neither had the collaboration agreement with Aerospatiale been extended nor had a suitable engine been selected. The only activity that had taken place was that HAL was 'holding discussions with some firms in this regard'. In the meanwhile, HAL had incurred a capital expenditure of Rs 38.4 million on buildings, machinery and equipment and a development expenditure of Rs 44.9 million up to June 1980. Thus, nearly a decade after the collaboration agreement for the design and development of the ALH

was signed, the project had made virtually no progress. On the other hand, cost estimates had escalated very sharply as is shown below:

	1972		1976		1979	
	(Million Rupees)					
	Total	(FE)	Total	(FE)	Total	(FE)
Design Facilities	88.0	(41.0)	136.9	(78.5)	-	-
Development	230.4	(61.0)	273.6	(87.3)	375.0 to 395.7	(126.1 to 140.0)
Unit Cost of Manufacture	3.5		4.5		7.0 to 8.0	(3.5 to 4.2)

Also, the change to twin engine configuration rendered an expenditure of Rs 5.4 million. Of this, a sum of Rs 3.693 million and Rs 0.533 million had been spent on helicopter and engine installation design - work which would be of dubious value since the entire design concept had been revised. Also, the only concrete result of all these years of work was the construction of test specimens, a wooden mockup and two wind tunnel models at a total cost of Rs 1.204 million.[36]

The project once again was severely criticised by the *Comptroller and Auditor General* in 1979-80 in reply to which the Ministry of Defence gave the following reasons (November 1980) justifying the progress (or lack

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36 *Public Accounts Committee (1981-82) Seventy Sixth Report (Seventh Lok Sabha)*, para 1.40.

of it) in the design and development of the ALH:

1. When the collaboration agreement was signed in 1970, the concept of the role of the helicopter was still evolving and changes in the ASR had to be made to provide for the desired capability in the changing operational environment.
2. Considerable expertise in the field of helicopter design and development had been acquired and this would be utilised in future development work.
3. The final decision regarding selection of a powerplant and collaboration with foreign manufacturer 'would be taken shortly and a modern technology helicopter would be sucfessfully designed and developed in about 7 years' time'.

By now a number of major western companies were competing to collaborate in the ALH project. For the powerplant in the twin engine configuration there were Rolls Royce (UK), Pratt and Whitney (Canada) and Turboméca (France) while Aerospatiale and Messerchmitt-Boelkow-Blohm (FRG) were contenders for collaboration in airframe design. A six-member delegation led by A.B. Malik, Secretary of the Department of Defence Production visited the establishments of Aérospatiale

and MBB in May 1981 and reportedly recommended design collaboration with either of the two companies! No decision regarding the choice of the powerplant was made but both Aérospatiale and MBB were required to suggest three different designs incorporating Rolls Royce, Pratt and Whitney and Turboméca engines respectively.[37] Both companies reportedly submitted in June/July 1981 their proposals which were then said to have been under consideration by a 'high-level team'.[38]

The entire issue of collaboration was still unresolved even by 1983 and there was no official indication as to when a decision would finally be made.

Summarising, although the program for the manufacture of the Al-III was finalised in collaboration with (the then) Sud Aviation of France, not much attention was paid to the limitations of HAL to manufacture the helicopter. These included lack of trained personnel as well as shortcomings in the tool fabrication department. To add to the problems, the management of HAL made arbitrary changes in the manufacturing schedule, which had already been finalised on a very optimistic basis.

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[37] Prabhu Chawla in *India Today*, 16-30 June 1981.

[38] Jagan Chawla in *Indian Express*, 14 May 1982.

This is because the original plan provided for HAL to start manufacture of the Al-III from raw materials within two years from the time assembly of the helicopters began. This time frame was reduced even further by HAL and the resulting situation was rectified only when an outside consultant advised that the time required to manufacture the helicopter from raw materials would be even longer than that visualised in the original project report. Even the revised schedule could not be adhered to because of organisational limitations and bureaucratic inefficiency within HAL and the Ministry of Defence. As late as 1967, five years after the licence agreement had been signed not only had contracts not been awarded for the supply of certain materials required for manufacture of the Al-III but, in some cases it had not been possible even to identify the suppliers for some items.

Thus, it was only in the early 1970s, nearly a decade after assembly began, that the manufacture of the Al-III from raw materials got underway. It would appear that production had finally stabilised by the mid-1970s and has continued since then without any serious problems.

Manufacture of the SA-315B, on the other hand, did not encounter any significant problems for two reasons:

1. It was essentially a derivative of the Al-II representing technology developed in the late 1950s and early 1960s. Also, by the time manufacture of this helicopter was taken up, HAL had already acquired a certain amount of experience in manufacturing the Al-III.
2. It was powered by the Artouste, the same engine used in the Al-III. Consequently, HAL did not have to encounter the difficulties usually associated with the absorption of new technology.

As a result, the various stages in the manufacture of the Cheetah proceeded according to schedule.

According to original plans, the manufacture of both the Al-III Chetak and the SA-315B Cheetah was scheduled to continue till 1980-81 after which it was intended to manufacture the ALH to fulfil IAF and Army requirements for the 1980s and beyond. But, since the ALH project did not make any significant progress, manufacture of the two helicopters was still continuing in 1982 - albeit on a very limited scale apparently due to lack of orders.

The agreement for collaboration in the design of the ALH was fairly comprehensive. It not only provided for access to design and other technical data but also included provisions for the training of HAL personnel

in helicopter design - an indication of the fact that although HAL had been manufacturing the Al-III, its capacity for designing helicopters was non-existent. Another interesting aspect of the attempt to design and develop the ALH is that although the agreement was signed in September 1970, an ASR was not issued by Air Headquarters until nearly nine months later, in May 1972. Thus, it would appear that the broad parameters for the ALH were not based on any ASR as is the usual practice. On the other hand, the ASR was formulated after Aérospatiale and HAL had given an indication about the type of single engined helicopter that was to be designed.

The project came to a virtual standstill soon after. Although the project report and cost estimates were submitted to the Government for approval in April 1972, no action was taken for the next four years. In the meanwhile the ASR was 'modified' in March 1974 as a result of the report of an Inter-Services Team. Officially, the delay was attributed to financial constraints. But, this would not appear to be the only reason considering the fact that the total amount involved in 1972 was Rs 318.4 million, which had gone up to Rs 410.5 million by 1976. Also, the time lapse between the signing of the agreement, when presumably there were funds, and that of the submission of the project report was considerably less than two years.

It would thus be difficult to conceive of a situation in which the financial picture would change so considerably in so short a time span. In any case, the annual payments to Aerospatiale continued to be made as per the terms of the collaboration agreement.

After it was finally sanctioned in February 1976, it took the project just over a year to become irrelevant for all practical purposes. This was because in April 1977, Air Headquarters decided that its requirements were for a twin engined helicopter instead of a single engined one as had been proposed earlier. A draft of a revised ASR incorporating a twin engined configuration was formally issued in February 1978 and subsequent years witnessed an increased interest by Western manufacturers not only in the context of design collaboration but also as potential suppliers of engines.

Since then, over four years elapsed and the Ministry of Defence, instead of having decided on a suitable collaborator appeared to have been overcome by inactivity. No decision had been taken by late 1983 although in the interim many Technical Groups and Expert Committees had been appointed to decide on the matter. Consequently, even if a decision on the choice of a collaborator was made in the near future, it would be only by the late 1980s that the first prototype could be expected to be flight tested.

It would thus be at least the early 1990s before the ALH would finally go into production - a decade later than the original schedule. In the meanwhile, it is difficult to visualise the future of HAL's Helicopter Complex except for an extended period of inactivity. This is not only because no domestic orders have been forthcoming but also since export markets for helicopters based on technology which is over 20 years old would appear to be virtually non-existent.

CHAPTER IV

INDIGENOUS VENTURES

A. HF-24 MARUT

Design and development of the HF-24 by the (then) Hindustan Aircraft Ltd, was approved by the Government of India in 1956.[1] Design effort was taken up under the direction of Dr Kurt Tank[2] and a team of eighteen German engineers, three Indian senior design engineers and about twenty-two other Indian engineers with design experience.[3] The time for development was initially estimated at four years and, according to the project report, the first prototype would be ready for flight trials by January 1960 and the second by July 1960.[4] Developmental costs were estimated at Rs 10.9 million.[5]

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1 *Report of the Comptroller and Auditor General of India 1974-75. Union Government (Defence Services)*, para 10.

2 Former Technical Director of the Focke-Wulf organisation who designed the F.W. 190 fighter and the Kondor maritime bomber.

3 The Indian complement eventually increased to more than 100 engineers. *Committee on Public Undertakings (1967-68): Eighth Report (Fourth Lok Sabha)*, para 78.

4 *Public Accounts Committee (1977-78): Second Report (Sixth Lok Sabha)*, para 2.34.

5 Refer n.1.

Initial plans called for the use of two Orpheus 703 turbojet engines for the interim transonic MkI version and a single Orpheus 12 turbojet for the definitive supersonic MkII variant. The latter was being developed by Bristol Siddeley (UK) for the NATO competition, and its completion was subject to its acceptance by NATO countries.[6]

While the prototypes were under construction, slow speed handling characteristics of the design were studied by testing models at the wind tunnel of the Indian Institute of Science, Bangalore. An unpowered full scale wooden flying model of the HF-24 was flight tested for the first time on 21 March 1959.[7] The first prototype made its first successful test flight on 17 June 1961,[8] more than a year after it was originally scheduled. By 1962, work on a second prototype for destruction tests had been completed[9] and a third model (the second flying prototype) flew successfully for the first time on 4 October 1962.[10]

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6 *SIPRI. Arms Trade with the Third World* (Stockholm: Almqvist & Wiksell, 1971), p.745.

7 *Jane's All the World's Aircraft 1963-64*, p.75.

8 *HAL Annual Report 1960-61*, p.3.

9 *HAL Annual Report 1961-62*, p.4.

10 *HAL Annual Report 1962-63*, p.7.

Plans for acquiring the Orpheus 12 powerplant menawhile, were facing difficulties. NATO interest in the development of the engine ended and Bristol Siddeley was now faced with the prospect of either financing development of the engine exclusively for the IAF or abandoning the project altogether. The company was initially reported to have asked for £1,500,000 to develop the engine for Indian requirements - an amount that was later said to have been substantially reduced - to £300,000.[11] Not only was this offer turned down but India reportedly showed no interest in an offer by a French firm, Snecma, of the Atar 9 turbojet (used by the Mirage III and V)[12] and decided to seek a powerplant of Soviet manufacture.

A team of engineers was sent to the Soviet Union in the last week of July 1961, to evaluate the suitability of the centrifugal-flow Klimov VK-7 and the RD9-F axial flow turbojets which the Soviets had offered.[13] It was reported from Moscow on 8 August 1961 that the RD9-F engine was technically sound, but that the HF-24 airframe, and to an extent the engine, would have to be

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11 *Times*, 1 June 1962.

12 Lorne J. Kavic, *India's Quest for Security: Defence Policies, 1947-65* (Berkeley and Los Angeles: University of California Press, 1967), p.134.

13 *CPU (1967-68), Eighth Report*, para 242.

modified to permit installation. Accordingly, a contract for the purchase of six engines was signed on 18 August 1961.[14]

A Soviet technical team arrived in Bangalore on 29 November 1961 to study the modifications required on the engine and airframe. Certain suggestions were made and HAL sought Soviet assistance to carry out the necessary modifications at the Bangalore factory itself[15] so that the engine could subsequently be taken up for manufacture. The Soviets informed HAL that licence agreement for manufacture of these engines would have to be concluded on the understanding that provision was made for the assistance of Soviet experts to carry out the necessary modifications. Nonetheless, the Soviet team made it clear that they saw no possibility of 're-fixing' the engine in the manner suggested by Indian experts since, according to them it would amount to producing a new engine.[16]

However, during the visit of another Indian team to the Soviet Union, the latter agreed to undertake the modification work by Soviet design engineers in the Soviet Union and not in India as had earlier been envisaged, but it was made clear that the Soviets could

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[14] ibid.

[15] ibid., para 243.

[16] ibid., para 244.

not write into the agreement, any guarantee of performance beyond Mach 1.4,[17] and, that the production of the RD9-F was expected to cease by 1962. Since the Soviet Union had no requirement for the modified version, they wanted to know HAL requirements so that suitable arrangements could be made for their continued manufacture. As a result, even though the first six engines were yet to be modified and tried in the HF-24, another agreement was signed in July 1962 for the supply of additional engines and components.[18]

The interest in a Soviet powerplant for the HF-24 also led to Indian interest in the MiG-21 aircraft, for which the Soviets offered to help set up manufacturing facilities. Agreement to manufacture the MiG-21 in India was signed within a few weeks of the purchase of the additional engines.[19] This, along with the fact that the RD9-F was no longer being manufactured apparently led to a decline in interest towards any development effort on it. Not much effort seems to have been put in towards the engine modification program because a year later, in September 1963, the Soviet Union was again requested to develop the RD9-F to Mach 2 capability. The Soviets replied that this was not possible and the maximum speed that could be achieved was Mach 1.4-1.6

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[17] ibid.

[18] ibid., para 245.

[19] This aspect is discussed in the Chapter on MiGs.

and possibly Mach 1.7.[20] It was only after the Soviet Union itself had expressed its inability to develop the powerplant to the standard demanded by HAL, that the latter accepted the fact that given the existing resources and technical knowhow, it would not be possible to develop the RD9-F in India either. Meanwhile, Rs 23.9 million had already been spent on this futile exercise,[21] and the agreement with the Soviet Union was foreclosed in February 1964.[22]

Search for an alternative engine, however, continued as India sought assistance from Britain and the United States. Representatives from Rolls Royce[23] and experts from the USAF Research and Development Centre at Dayton, Ohio visited India in July 1964, to suggest ways to improve the performance and rate of production of the HF-24.[24] It was apparently concluded that the project would require substantial western expertise, tooling and finance to bring it to the planned performance standards.[25] Officially, it was stated that 'certain

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20 *CPU (1967-68) Eighth Report*, para 246.

21 ibid.

22 *PAC (1977-78) Second Report*, para 2.54.

23 Lorne J. Kavic, *India's Quest for Security*, refer n.12, p.205.

24 India, Ministry of Defence, *Report 1964-65*, p.40.

25 *Times of India*, 17 August 1964.

suggestions' made by the American team were being 'taken into account' in overcoming developmental problems.[26]

By early 1963, while experiments with the Soviet engines were still being contemplated, it came to be known that Egypt too, was engaged in the development of a supersonic engine. Development of this engine, the E-300 turbojet, was proposed in three stages with the first scheduled for completion in 1965. Technical teams of the two countries exchanged visits, and based on the information provided by Egypt, it was decided to explore the possibility of incorporating the E-300 in the HF-24 airframe. Without waiting for the results of the first stage of development of the E-300, which would have been available within a few months, HAL sought and obtained approval of the Emergency Committee of the Cabinet and a collaboration agreement was signed with Egypt in September 1964.[27]

The hasty decision was later justified on grounds that not only there was 'no payment involved', but also that 'it was considered advantageous from a political angle to get into a relationship' with Egypt.[28] An HF-24 IBX airframe was handed over to Egypt along with

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[26] Refer n.24.

[27] *PAC (1977-78) Second Report*, para 2.55.

[28] ibid., para 2.59.

services and two Orpheus turbojets, the latter valued at Rs 2.2 million.[29] In all, the total expenditure amounted to about Rs 9.43 million.[30] It was only when progress of the joint project was reviewed in 1968, that it was realised by HAL that the E-300 was designed for optimum performance at high altitudes, i.e. in an interceptor role, and was not the ideal powerplant for the HF-24 which was meant to be a ground attack aircraft. Moreover, it would have taken several years for development of the HF-24 fitted with the E-300, which itself was in the process of being developed, and, by the time such an aircraft came into squadron services, the design would be outdated. The collaboration agreement was formerly foreclosed in 1968,[31] after four years of futile effort. Thus ended HAL's search, at least for the 1960s, to find a suitable powerplant for the HF-24 MkII supersonic aircraft, it having in the process acquired manufacturing rights for the supersonic MiG-21 instead.

The manufacturing program for the HF-24 MkI Marut did not proceed according to schedule either. HAL's Bangalore division had had very little experience in production planning methods, development and tooling for

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[29] ibid., para 2.57.

[30] ibid., para 2.62.

[31] ibid., para 2.62.

indigenously designed aircraft before 1960. Prior to this it had mostly undertaken licence manufacturing programs for which data for production planning, process sheets and tool drawings used to be provided by the licensor. With the HF-24 project, HAL committed itself to manufacturing the required number of aircraft in the late 1950s without sufficient information or experience to enable reliable production plans to be prepared. When the first order for 18 pre-production HF-24 MkI Marut aircraft was accepted by HAL, even prototype tooling had not been completed, and final assembly of the first prototype had just begun, in 1960, when the second order was placed.[32]

A production engineering department for the HF-24 was finally established in November 1960. Requirements for planning staff were met mainly by recruiting diploma holders in engineering who had no previous experience.[33] The other source usually utilised for obtaining methods engineers, i.e. the shops, did not exist since there were hardly any academically qualified personnel in the shops. Hence, changes required for production could not be indicated when drawings were being prepared. It was quite some time after the flight of the first prototype before the methods engineering personnel could make

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[32] *CPU (1967-68): Eight Report*, para 82.

[33] ibid.

worthwhile recommendations for drawing changes to facilitate production. A similar situation existed in the tool design department. The result was that tools fabricated according to the drawings frequently encountered snags at the proving stage and were not available for production until they had been modified.[34]

Average man hours for the manufacture of the 18 pre-production aircraft were assumed to be 110,000 whereas 900,000 man hours were required for construction of the two flying prototypes alone. Three million man hours had been seen as the requirement for the full-range of production tooling, whereas 1.1 million man hours had been expended for limited prototype tooling alone. Excluding the latter, seven million man hours had been devoted to production tooling by 1967.[35] As a consequence, there were frequent delays in delivery schedules and revision of production targets and developmental costs.

The time for development was initially estimated at four years, and the cost at Rs 10.9 million. The cost of development was revised to Rs 14.4 million in 1959, Rs 45 million in 1961, Rs 55.6 million in 1965, Rs 70 million in 1967 and an additional expenditure of Rs 7 million was authorised in March 1973. By March

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[34] ibid.

[35] ibid.

1975, Rs 81.2 million had actually been spent.[36] As against an estimated time for development of four years in 1956, the first prototype was flown in 1961. The first of 18 pre-production Maruts (HF-24 MkI) flew in March 1963[37] and a token delivery of two aircraft was made to the IAF on 10 May 1964.[38] By 1967, 12 more pre-production aircraft had been handed over to the IAF, with the remaining four being used for test and development purposes. The latter included one aircraft, designated HF-24 MkIA for trials in 1966[39] with an afterburner fitted to its Orpheus 703, the first phase of design and development of which had been completed by 1965.[40] First flight of the series production Marut, ordered in 1960 for delivery by 1964,[41] could take place only on 15 November 1967[42] and the aircraft was finally inducted into squadron service with the IAF in 1968.

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36 *PAC (1977-78) Second Report*, para 2.28.

37 *Jane's All the World's Aircraft 1973-74*, p.745.

38 *Report 1964-65*, p.56.

39 *Jane's All the World's Aircraft 1975-76*, p.101.

40 *Report 1964-65*, p.67.

41 *PAC (1977-78) Second Report*, para 2.29.

42 Refer n.37.

Development of the reheat variant of the Orpheus 703 was a direct consequence of the non-availability of a more powerful engine for the proposed HF-24 MkII. Trials in 1960-61 with the first prototype had made it clear that the Orpheus 703 powered HF-24 MkI fell considerably short of operational requirements then in force. Interest had then been generated by the Soviet RD9-F engines. At the same time, in July 1962, the Gas Turbine Research Establishment (GTRE) of the Defence Research and Development Organisation (DRDO) finalised a feasibility study of the reheat variant of the Orpheus 703 and the development project was sanctioned in January 1963.[43] Cost of the project was initially estimated at Rs 1.4 million for building one 'demonstrator engineering system', and the variant was conceived as a temporary engine and thereby improving the performance of the HF-24 MkI. Installation of the Orpheus 703 reheat engine as an interim solution was approved by the Emergency Committee of the Cabinet in April 1964.[44]

In February 1965, a Technical Study Group, headed by Air Commodore Moolgavakar reported that although the reheat engine would meet the then existing operational requirements, it would have 'some deficiency in the radius of action'. The Study Group nonetheless, accepted

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[43] *PAC (1977-78) Second Report*, para 2.63.

[44] ibid.

the reheat variant as 'the only expeditious solution',[45] and in July 1965, a decision was tkaen that the HF-24 MkIR 'be proceeded with on a priority basis'.[46] However, in March 1966, it was realised that the performance of the HF-24 MkIA,[47] (the initial developmental version), was inferior even to the HF-24 MkI in dry climb and cruise due to problems of base drag although the reheat system, as designed by GTRE was stated to have 'met the full specifications in respect of thrust, specific fuel consumption, etc.'[48]

Formal 150 hours of developmental testing on the Orpheus 703 with its 1700°K reheat system was completed by May 1967, four years after development began. The main reason for subsequent delays was that flight trials with only one prototype aircraft covering the entire range of developmental work on both airframe and engine was a time consuming process. In order to accelerate developmental work, a second prototype was built in late 1969. It crashed in January 1970 after only nine flights, resulting in the death of HAL's Chief Test Pilot. Developmental work on the original prototype, however, continued 'although at a somewhat reduced tempo'. Flight testing of the reheat engine were completed by

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[45] ibid.

[46] ibid., para 2.63.

[47] HF-24 MkIA after development was referred to as MkIR.

[48] Refer n.46.

October 1970, and in June 1971, Air Headquarters accepted the HF-24 MkIR with the Orpheus 703 reheat (1700°K) engine.[49]

Although initial flight testing of the Orpheus 703 reheat engine had been completed, by 1970-71,[50] type approval testing was completed 'provisionally' in December 1971,[51] when two more engines of this standard were delivered to HAL for further flight trials.[52] It is clear that, at this stage, the IAF had accepted the aircraft even before the reheat engine had been accorded provisional type certification although the 'Requirement Standard I of 1973' was not issued until January 1972. The Orpheus reheat engine is said to have met this standard.[53] Cost of development of the reheat variant, initially estimated at Rs 1.4 million in 1963 was revised many times, the final revised cost being Rs 7.85 million in 1974. Total outlay on the project amounted to Rs 20.2 million[54] but this amount included the development of 11 reheat systems instead of one as origianlly planned, as well as the cost of engines (on loan from HAL and to be returned) and the establishment costs of GTRE.[55]

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49 *PAC (1977-78) Second Report*, para 2.68.

50 *Report 1970-71*, p.72.

51 Refer n.49, para 2.70.

52 *Report 1971-72*, p.106.

53 *PAC (1977-78) Second Report*, para 2.63.

54 ibid., para 2.70.

55 ibid., para 2.71.

Thus, the allocation of the project to the GTRE instead of HAL had more to do with bureaucratic politics of the DRDO and the Ministry of Defence rather than the facilities available at the GTRE. When the task of developing the reheat system was assigned to it, GTRE was utilising the workshop[56] and testbed facilities (for development testing of engines) of HAL. The latter also provided manufacturing facilities and such specialised facilities as process shop, automatic welding equipment, standards rooms and laboratories.[57]

More than 60 HF-24 MkI Maruts had been manufactured by August 1972. By this time development work on the GTRE reheat system for the Orpheus 703 had been largely completed except for a full exploration of the after-burning envelope. Thrust augmentation was reported to be restricted to about 25 per cent because of compressor limitations, but the system gave an 'all around improvement in performance apart from a 50 nautical mile reduction in radius of action'.[58] While the Orpheus 703 reheat (1700°K) engine was considered to be the most obvious choice for powering the HF-24 MkII, some consideration was also reported to have been given to the development of the aircraft with Rolls Royce/ Turboméca Adour turbofan engines.[59]

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[56] ibid., para 2.64.

[57] ibid., para 2.72.

[58] *Milavnews*, September 1972, p.16.

[59] *Milavnews*, August 1972, p.14.

It was also in 1972 that a HAL Review Committee under the then Chairman, Air Marshal O.P. Mehra, 'redefined' corporate objectives which now included:[60]

(i) Design and development of HF-24 MkII within 5 years from 'go'.

(ii) Advanced Technology Aircraft (ATA): (a) design and develop a prototype of the ATA within 10 years. (b) design and develop avionics within 6-8 years. (c) design and obtain type certification of engine within 10 years. (d) design and develop aircraft systems including equipment and accessories within 10 yeras.

While the Review Committee made no reference to the proposed HSS-73 or Marut MkIII variant, a more radical development had been proposed for this aircraft. It was unofficially reported by Western sources that a Messerschmitt-Boelkow-Bolhm (MBB) team of scientists led by Dr Kurt Tank[61] had, by early 1973, completed design studies of re-engining the Marut with two Rolls Royce/Turbo Union RB.199 advanced turbofans to give it a Mach 2 performance. Extensive re-design was said to be necessary to accommodate the two RB.199s including revised intakes, a completely new rear fuselage and the resultant aircraft was expected to have a low-altitude radius of action of about 350 nautical miles.[62]

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60 *HAL Annual Report 1972-73*, p.24, Annexure I.

61 Dr Tank and his team of German engineers had left India in 1967 and the HF-24 project had been the responsibility of an all Indian team led by S.C. Das. See *Jane's All the World's Aircraft 1975-76*, p.15.

62 ibid. Also *Milavnews*, March 1973, p.15.

In 1973, Air Headquarters formulated a long-term re-equipment plan based on many assumptions, including:[63]

(a) 'Deep strike' aircraft would be purchased in limited numbers and additional requirements would be met by the HF-24 Marut MkIII aircraft.

(b) 'To ensure maximum economy' Marut MkII, which would substantially be the same as Marut MkI, would be inducted so that 'the existing assets' could be utilised and 'improved versions produced'.

(c) 'Induction of an Advanced Technology Combat Aircraft (ATCA) I had been proposed for the 1980s. Another aircraft ATCA II would be introduced as successor to Gnat MkII and Marut MkII.'

At about the same time, in February 1973, Air Headquarters suggested that HAL abandon the project for manufacturing the 'HF-24 MkI with reheat engines' i.e. MkII[64] on grounds of financial stringency. Instead, it was proposed that the MkI aircraft already in service with the IAF be 'retromodified'.[65] By March 1973, HAL had submitted 'the time frame and cost implications of the Air Headquarters proposal as well as two additional

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63 *PAC (1981-82), Sixty Sixth Report*, para 19.

64 The MkII version also incorporated fully powered and duplicated Dowty hydraulic controls without the manual reversion of the MkI and production was scheduled to start in 1975-76. See *Milavnews*, September 1972, p.16.

65 *PAC (1977-78), Second Report*, para 2.77.

alternatives[66] envisaging development of variants', one by HAL and the other by GTRE.[67]

The result was that in May 1973, Air Headquarters 'suggested' that the project (limited to retromodification) with the Orpheus 703 reheat engine be held in abeyance. Two reasons were given for this decision.[68]

1. Although Air Headquarters had accepted the development of HF-24 MkII (Orpheus 703 reheat version) as per their requirement standard I of 1972, 'lessons learnt from the Indo-Pak conflict of 1971 indicated the need for an aircraft having a longer range' than the one prescribed. There was no possibility of increasing the range of this variant.

2. The alternative proposal submitted by HAL, involving development of the aircraft powered by 'another engine'[69] seemed more attractive. It appeared that this variant could easily be developed and would meet the improved performance requirements.

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[66] These were reported to be the installation of two Rolls Royce Adour turbofans (MkII), uprated by about 20 per cent to 8,400 lb. thrust or, a single 15,873 lb. Snecma Atar 09K-50 turbojet. See *Milavnews*, April 1973, p.13.

[67] *PAC (1977-78), Second Report*, para 2.79.

[68] ibid., para 2.80.

[69] This would have been either the Snecma Atar 09K-50 turbojet or the Adour GTX-G which was based on project design work carried out between Rolls Royce and GTRE, Bangalore. The GTX-G design was an uprated version of the reheated Adour Mk811 (8[illegible],400 lb thrust) incorporating a GTRE designed LP compressor and a RB.199 type reheat system developing a thrust of 11,450 lbs. See P.H. Young, 'Some Themes on Rolls Royce Military Engine Technology'. Paper presented at the *British Aviation Seminar and Exhibition*, 1981, New Delhi, 17-19 March 1981.

Almost simultaneously, the APEX Planning Group (the highest decision making body) of the Ministry of Defence, accepted the Air Headquarters proposal (of February 1973) for retromodification of the MkI aircraft, allocating Rs 104 million for development and Rs 594 million for retromodification. Formal government approval was also given immediately. This series of decisions was taken during the same month when Air Headquarters had requested that its earlier proposal be held in abeyance, i.e. May 1973.[70] It was only in July 1973, that the proposal to modify the HF-24 with the alternative engines was considered at a meeting convened by the Minister for Defence Production.[71] The prevailing view at this meeting was that development of the HF-24 with the Orpheus 703 reheat engine, with a view to retromodifying the aircraft, should continue. The Department of Defence Production subsequently justified this decision, stating[72]

> ... if the project had not been pursued, Government would have been open to criticism for not continuing and preserving the development of (the) reheat system ... a view was also taken that the expenditure incurred should be regarded as on 'competence building' ...

The IAF reiterated its requirement for an increased radius of action and, in September 1973, also made it clear that it should be possible to complete the

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[70] *PAC (1977-78), Second Report*, para 2.81.

[71] ibid., para 2.82.

[72] *PAC (1978-79), Ninety Sixth Report*, para 1.8.

development of the (alternative-GTX) engine on a time frame so that the MkII version of the aircraft could be inducted into service by 1978-79. While the original program of manufacture of a large number of HF-24 MkIIs (with Orpheus 703 reheat engine) had been reduced, in May 1973, to retromodification of a small number of aircraft, it was now realised that the design and development of the 'alternative engine' proposed by HAL 'was not as simple as it appeared'. Also HAL lacked the resources required to complete the project within an acceptable time frame of about five years.[73] This argument was also relevant to the ultimate cancellation of the retromodification program for the following reasons:[74]

1. The reheat system development cost was about Rs 65 million compared to Rs 25 million added on to the engine proposed by HAL and about Rs 56 million added on to the engine proposed by GTRE (the GTX-G). The difference in costs was due to the cost of modifying the airframe - installation of the Orpheus 703 reheat system requiring a fairly substantial amount of engineering work.

2. It was realised that, given the overall financial situation, the APEX Committee would permit the allocation of about Rs 100 million only. This amount was enough for retromodification of 'a number' of HF-24 aircraft 'then held' by the Air Force.

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73 ibid.

74 *PAC (1977-78), Second Report*, para 2.89.

3. The time required for implementation of one of the alternatives was as follows:

   (a) engine proposed by HAL: 'about 5 years'.

   (b) engine proposed by GTRE: 'about 5 years and a few months'.

   (c) Orpheus 703 reheat variant: 'about 4 years and 9 months or so'.

It is thus quite clear that the change in IAF requirements regarding increased radius of action notwithstanding, HAL was not in a position to deliver the MkII Orpheus 703 reheat version in the time frame desired by IAF. As far as the retromodification program was concerned, the Department of Defence Production conceded that 'if we waited for any of these schemes, the number of aircraft held by the Air Force would have come down'.[75]

By this time, i.e. late 1973, type certification tests on the Orpheus 703R-1700°K reheat system had been completed and tests with the Orpheus 703R-2000°K reheat system were in progress.[76] In other words, HAL had still not achieved its objective of a 36 per cent increase in thrust for the Orpheus 703 to give it around 6,600 lb thrust. The 27 per cent or so then attained was insufficient to give the HF-24 MkII its design performance of Mach 1.3-1.5.[77] It must be pointed out

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75 ibid.

76 *Report 1973-74*, p.91.

77 *Milavnews*, April 1973, p.13.

however, that the Orpheus 703R-2000 K reheat project was not taken up as a direct requirement for aircraft installation and was not specifically related to development of the HF-24 MkII. This was sanctioned by the Aeronautics R&D Board in March 1972 and

> The aim was to study the feasibility of incorporating a high degree reheat system and actual engine as is required in high technology engines. The task envisaged ... was to design and develop the system upto demonstrator stage to establish technical feasibility.[78]

At about the same time, the Technical Committee in its draft report (December 1973) recommended that the two new engine 'variants' be taken up for development. But bureaucratic opinion favouring incorporation of the reheat system was very strong and in February 1974, the Aeronautics R&D Board asked the Technical Committee to 'submit its report taking into account the final type approval since accorded to the reheat engine'.[79]

This was clearly not acceptable to the IAF and, on 3 August 1974, Air Headquarters repeated its earlier assertions (July/September 1973) and observed:

> (a) the HF-24 fitted with the Orpheus-703 reheat engine would not satisfy operational requirements;

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[78] *PAC (1977-78) Second Report*, para 2.100. A total amount of Rs 3.5 million was sanctioned up to February 1976.

[79] *Report of the Comptroller and Auditor General of India 1974-75. Union Government (Defence Services)*, para 10.

(b) the alternative proposals for engine development (with high costs and gestation periods) were not justified in the context of the then limited requirement of retromodification.

Considering these factors, it was recommended that the retromodification program should be given up.[80] A month later, in September 1974, Air Headquarters recommended that further efforts to develop an improved version of the HF-24 be abandoned. (Regardless of this, however, formal government orders 'closing' the project to develop the MkII version had not been issued by the Ministry of Defence even as late as 1977-78.)[81] Meanwhile, the Technical Committee, in its final report submitted in December 1974, reiterated its earlier recommendation (December 1973) that the proposed development of the engine 'variants' by GTRE and HAL, at a cost of Rs 40 million and Rs 9.3 million respectively, be approved and 'suitable monitoring committees be set up to review the progress of the projects'.[82]

Some attempts were also said to have been made to seek Soviet assistance in the development of the successor aircraft as well as to explore the possibility of acquiring Soviet alternatives for the proposed Deep

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80 *PAC (1977-78), Second Report*, para 2.88.

81 ibid.

82 Refer n.79.

Penetration Strike Aircraft (DPSA) requirement.[83] Interestingly enough, at the Annual General Meeting of the HAL in 1974, the then Chairman, M.M. Sen, is said to have 'agreed with some questioners ... that the advent of the MiG-21 might have relegated the HF-24 to the background'.[84]

Total expenditure on the development of the HF-24 and further development of the engine variants amounted to Rs 214.6 million by the end of March 1975.[85] Despite the various attempts by HAL and various committees of the Ministry of Defence, no further orders (beyond the 18 pre-production and 107 production HF-24s initially ordered) were forthcoming from the IAF and manufacture of the HF-24 Marut MkI finally ended in 1976-77.[86]

The production models of the HF-24 MkI themselves had various shortcomings in both performance and safety. As a consequence, a sum of Rs 10.2 million was sanctioned by the government in July 1976 to 'carry out essential improvements and modifications in the Marut fleet' then in service.[87] By March 1978, about Rs 7 million had

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83 *Milavnews*, September 1974, p.15.

84 *Milavnews*, October 1974, p.14.

85 Refer n.79.

86 *Milavnews*, May 1975, p.14 and S. Sapru in *Indian Express*, 28 June 1982.

87 *PAC (1977-78) Second Report*, para 2.90.

been spent on improvements and modifications although spinning trials had not been carried out. Although the 'gains of this development effort' were officially stated in the 'field of safety, better flight panel, instrumentation display, better fuel capacity, better aircraft handling etc.', it is the list of various 'tasks attended to' that actually brings out the crude nature of the original development effort. These included:[88]

1. Modification of Trim Circuit and reduction of sensitivity of the aileron trim tab.
2. Fixing of integral fuel tank leaks, installation of wing fuel transfer indicator and trials with 150 gallon drop tanks.
3. Installation of SFENA Artificial Horizon and SFIN Gyro Compass.
4. Firing trials with 430 mm Aden cannons.

The entire modification program was scheduled for completion by 1979-80.[89] But its effectiveness with regard to the deployment and operational capability of the HF-24 was considerably reduced by the fact that in 1980, it was decided to replace the aircraft by MiG-23BN (Flogger) imported from the Soviet Union. The first of

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[88] Department of Defence Production D.M. No.48/42/10/78/D dated 20 June 1978, reproduced in *PAC (1978-79) Ninety Sixth Report*, pp.35-36.

[89] ibid.

the MiG-23BNs arrived in India in mid-December 1980 and by mid-1981, two squadrons (Nos.10 and 230) had already converted from HF-24 to the MiG-23BN, with a third (and last) squadron scheduled for conversion by 1982.[90]

Development of HF-24 MkI Trainer:

According to the time schedule indicated by HAL in August 1963, development of the trainer version of the HF-24 MkI would take three to four years assuming 'no serious difficulties' were encountered.[91] The project was formally approved in May 1964, and involved an estimated expenditure of Rs 7.8 million, revised to Rs 37 million in May 1971. Actual expenditure on the project amounted to Rs 32.7 million and the first prototype made its first flight in 1970, more than two years behind schedule.[92] An order for 25 HF-24 MkI-Ts[93] was placed in November 1970 with the aircraft scheduled for delivery from January 1972 onwards.[94]

However, various problems were encountered both during the development and manufacturing stages and the first production HF-24 MkI-T was delivered to the

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90 *Jane's All the World's Aircraft 1981-82*, p.90.

91 *PAC (1977-78) Second Report*, para 2.35.

92 ibid., para 2.30.

93 S. Sapru in *Indian Express*, 28 June 1982.

94 *PAC (1977-78) Second Report*, para 2.30.

IAF in March 1975.[95] Two further orders for an unspecified number of trainer aircraft were placed in September 1971 and July 1972. But, in 1974, when the IAF recommended the cancellation of the retromodification program for the HF-24 MkI, it was decided that, as a consequence, the additional number of trainer versions were not required and that the two orders should be cancelled. This was done nearly two years later, on 24 March 1976.[96] The result was that materials, Tooling and Development expenditure worth Rs 36.4 million were declared redundant.[97] This included materials worth Rs 17.7 million (the balance being Tooling and Development cost) of which, it was subsequently realised, materials valued at Rs 2.8 million could be utilised in other projects.[98]

In other words, while the total outlay on the development of the HF-24 MkI and MkI trainer was estimated at Rs 114 million in March 1975, the loss sustained because of the inability of the aircraft to meet service specifications amounted to Rs 33.6 million. Also a further amount of Rs 10.2 million had to be sanctioned in 1976 to incorporate modifications in the

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95 ibid.

96 ibid., para 2.40.

97 ibid., para 2.41.

98 *PAC (1978-79) Ninety Sixth Report*, para 1.5.

existing fleet. But, this was not the only expenditure incurred by HAL on the ill-fated project. A substantial amount of money was spent on the development of different types of airframes to suit the reheat engine as well as other engines under consideration. The actual expenditure on different projects undertaken by HAL is as follows:[99]

(Million Rupees)

	Expenditure as on 31/3/76
HF-24 MkIA	9.902
HF-24 MkII-Old	0.817
HF-24 MkII-New	2.966
HF-24 MkIB	1.962
HF-24 MkIBX	9.429
HF-24 MkIR	31.258
HF-24 MkII/Adour	0.112
HF-24 TS-16	0.052
Total	56.498

This is not to say that the project had not been subject to a critical evaluation at any stage. In 1969, when initial deliveries of the aircraft were underway and the trainer version was still in the prototype stage, the Aeronautical Committee* appointed by the government reviewed the HF-24 project and

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[99] *PAC (1977-78) Second Report* para 2.46.

* The Committee was headed by Mr C. Subramaniam, a former Cabinet Minister. Details of membership of the Committee were not released.

> ... assessed that in the aircraft and its variants there existed an aircraft with promise and that the basic design should be stretched to full capacity and the matter pursued vigorously during the next two-three years.[100]

A further attempt to monitor the HF-24 project was made by the Aeronautics Committee in February 1971, when (in keeping with its earlier recommendation of 'vigorously' pursuing the program for 2-3 years), it constituted the Aeronautics Research and Development Board. The task before this Board was to make a detailed examination of every major development project before it was approved by the government as well as to review their progress from time to time.[101] After an evaluation of the progress of the HF-24 project, the Study Group subjected the former to very severe criticisms. Major observations included:[102]

1. The magnitude of work had not been properly appreciated nor had the elements of material and labour costs been reasonably allowed for while preparing the initial estimates.

2. The Indian design staff lacked experience to make any effective contribution in the earlier years. While this was a serious handicap, no allowance had been made in the estimates of cost and time.

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[100] ibid., para 2.105.

[101] Department of Defence Production O.M.F. No.48/12/16/78/D (HAL/MDN) dated 20 June 1978 reproduced in *PAC (1978-79) Ninety-Sixth Report*, pp.46-47.

[102] *PAC (1977-78) Second Report*, para 2.106.

3. The government not only failed to critically examine the project reports submitted by HAL in 1957 and 1960, but also did not monitor the progress in the development of the HF-24.

4. The management organisation in HAL for the project was inadequate.

5. The organisation in the Ministry of Defence responsible for monitoring development projects was inadequate.

6. The methodology followed; manufacture of a small number of prototypes followed by a comparatively large number of pre-production aircraft had given unsatisfactory results. The experience of aircraft manufacture in UK, France and USA proved that the alternative of production of a larger number of prototypes followed by regular manufacture would yield better results.

7. The decision to relate the development of the HF-24 to the 'successful completion of an engine under development abroad was not wise'.

8. Throughout the history of development of the HF-24, policy changes regarding choice of the engine were made - each requiring considerable design effort. This diverted resources from the development of the HF-24 MkI. Also, while engaged in developing the HF-24 MkI, HAL had been involved in building and supporting the flight development of several versions, including the HF-24 MkI with airpass, HF-24 MkIA, HF-24 MkIBX and HF-24 MkIR.

This criticism notwithstanding, it must be pointed out that, as mentioned earlier, it was its authors who had, in February 1974, asked the Technical Committee of the project to submit its report, keeping in view the fact that final type approval had been granted to the Orpheus 703 reheat system. In other words, despite

the fact that the entire exercise would have resulted in an aircraft not meeting the operational requirements of the IAF, attempts were made to generate bureaucratic pressure that would have resulted in the MkII project being sanctioned. This act would, by itself, have been in direct contradiction with one of the major recommendations of the Aeronautics Committee.

In its report submitted in 1969, the Committee had recommended the development of an advanced technology aircraft around a proven (and therefore obviously imported) engine along with the simultaneous development of an indigenous advanced technology engine. With regard to bombers, the Committee had made it quite clear that India's limited requirement did not justify their domestic manufacture.[103] In other words, replacements for the aging Canberra's were to come from abroad. There are three points to be made in this context:

1. While the IAF had not been very vocal about the suitability (or lack of it) the HF-24 MkI in terms of its operational requirements, the proposed MkII with the Orpheus 703 1700°K reheat engine reduced the radius of action even further. Besides, it not only entailed substantial design changes to the airframe but even then, would have failed to provide the aircraft with a Mach 2 capability.

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[103] Summary of the recommendations published in *Times of India*, 16 May 1969.

2. It was only when the IAF had reacted favourably towards a MkII version fitted with an imported i.e. Adour engine, that it was conceded by HAL that it was not in a position to deliver the aircraft within the time frame required by the IAF.

3. Finally, and perhaps an important reason for a decline in IAF interest in the HF-24 MkII was the induction of the SU-7 and the MiG-21MF from the Soviet Union. The HF-24 was primarily intended for ground support requirements and the SU-7s had been used in the same role in the 1971 war. Additionally, acquisition of the MiG-21MF after the war provided the IAF with an increased close support capability.

In evidence before the *Public Accounts Committee*, a representative of the Air Force stated that this

> ... injected in the HF-24 project some element of imponderables. We did not really anticipate before that we would at that point of time go in for these two aircraft which would do the same job as (the) HF-24 was doing.[104]

Consequently, the project for the development of the HF-24 can hardly be called successful. From its very inception, the project,which was viewed as the forerunner of a program for the manufacture of indigenously developed combat aircraft, relied on foreign resources - both in terms of expertise and technology. While this was to be expected since India did not have an established aeronautical industry nor the requisite technical manpower, there is little

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104 *PAC (1977-78) Second Report* , para 2.78.

evidence to suggest that this handicap was taken into consideration. Production as well as cost estimates always tended to be optimistic, perhaps based on the experience of Western manufacturers, without realisation of the fact that HAL lacked not only manpower, but also a technological base and organisation.

While the time for developing the HF-24 MkI was initially estimated at four years, the first prototype did not make tis first flight until five years after development work began. Deliveries of the production version of the aircraft, scheduled to begin by the end of 1963, were delayed by five years, actually beginning in 1968 when the HF-24 was formally inducted into squadron service. Fatigue testing had to be undertaken to *increase* the airframe life to 2,500 hours - representing 10 years of operational flying. Despite this, the aircraft was in operational service for about 12 years from the date of first deliveries, and about five years after production ended. In comparison, the Hunters, representing the same generation of aircraft, have been operational with the IAF for about 20 years.

The trainer version of the aircraft required nearly six years of development effort. It made its first flight in 1970 and while deliveries were expected to begin by 1972, they were delayed by another three years. Consequently, when the HAL did finally begin to deliver the HF-24 MkIT to the IAF in 1975, it was at a

time when the production run of the MkI itself was nearing completion. Hence, whether the trainer aircraft made any substantial contribution to IAF conversion programs to the HF-24 becomes highly questionable. Also, as mentioned earlier, the nature of modification tasks undertaken by HAL on the HF-24 as well as the trainer version make it amply clear that the effectiveness of the aircraft under combat conditions would have been very limited, to say the least.

As far as the MkII version of the aircraft is concerned it never really materialised - not altogether surprising considering the manner in which HAL tried to develop it. The HF-24 airframe had been primarily designed to be powered by the Orpheus 703 turbojet, to be developed later into a MkII version using the Bristol Siddeley Orpheus 12 turbojet then under development. Bristol Siddeley terminated its development plans for the latter partly as a result of unsuccessful negotiations with HAL directed at developing the engine exclusively for the MkII version. HAL then decided to use a Soviet powerplant, the RD9F, which ended in a waste of time and resources as HAL tried to persuade the Soviet Union to modify the engine to provide a level of performance which the latter claimed was beyond its capacity. Even then, it is not certain whether the engine itself could have been accommodated in the existing airframe without design changes.

Yet another unsuccessful attempt was made in collaboration with Egypt and it was after three years that it was realised that the E-300 engine being developed by the latter was optimised for high level interception tasks rather than low level ground support duties.

Parellel to these experiments the attempt by GTRE to develop a reheat system for the existing Orpheus 703 powerplant, while understandable in terms of requirements, seems to have become more of a status symbol in later years, i.e. the 1970s. Considering the fact that the first prototype powered by the reheat variant crashed on its tenth flight as early as January 1970, further development efforts can only be understood in the context of what the Ministry of Defence referred to as 'competence building'. But this was not the opinion that prevailed at the Ministry of Defence, HAL and GTRE. While GTRE secured final type approval for the reheat variant only in December 1973, Air Headquarters was persuaded of the operational capability of the aircraft as early as June 1971 - six months before the engine was accorded *provisional* type approval. It thus seems likely that the 'Requirement Standard I of 1972' issued by Air Headquarters in January 1972, was based on theoretical data on the performance of the aircraft rather than extensive flight trials.

The Aeronautics Committee (1969) had recommended that every effort be made to ensure that the aircraft with the reheat engine became available by early 1973, and its 'further improved version' by 1975-76 at the latest'.[105] It was only in August 1974 that the HAL and GTRE were able to provide a time frame for the manufacture of aircraft powered by the reheat variant, the Adour engine and a third alternative. The estimated period of five years that was suggested would hardly have been satisfactory to the IAF in the context of their re-equipment programs. Moreover, not only did the Adour and the other alternative engine options involve a smaller financial outlay, but the aircraft performance with either of these engines was closer to IAF requirements than that available by using the reheat engine.

Thus, the sole motivating factor behind the HAL's inclination to favour the reheat engine was one of prestige in that it involved an 'indigenously' designed airframe and powerplant. For example, in 1974-75, the Ministry of Defence stated that studies on 'improving' the performance of the HF-24 (MkI) were continuing and that this would 'call for a good deal of development effort and consideration is being given to the problems involved'.[106] In 1977-78, it was admitted that HAL

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105 *PAC (1977-78) Second Report*, para 2.11.

106 *Report 2974-75*, p.71.

had faced some technical problems regarding HF-24 engines which had been successfully overcome.[107] The same year, in evidence before the *Public Accounts Committee*, the Ministry of Defence had praised the HF-24 as being a 'good weapon platform', having 'good structural integrity' besides having 'growth potential'.[108]

While still trying to resolve the problems associated with the HF-24, HAL also attempted to provide an indigenous alternative to the DPSA requirement of the IAF. As mentioned earlier, a design study was carried out for the proposed aircraft (designated HF-73) by Dr Kurt Tank in the early 1970s. This proposal seems to have been given up in later years, but was replaced by a less ambitious program for the development of a successor to the HF-24. In August 1977, the government sanctioned an extended feasibility study for the development of an aircraft designated the HF-25, intended for a tactical air support role.[108]

Apparently based on the HF-24 design, it was to be equipped with a laser range-finder, a large electronics bay and completely re-designed air intakes.[109] Once again the problem was one of finding a suitable powerplant. According to a Western source citing Indian press reports,

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107 *Report 1977-78*, p.61.

108 *HAL Annual 1977-78*, p.6.

109 *International Defense Review*, 4/1978, p.490.

in 1978, the Soviet Union had offered the 16,535 lb Tumansky R-25 engine, derived from the MiG-21 bis for the HF-25 project which was then scheduled for production by the mid-1980s.[110] Introduction of the MiG-21 bis into the IAF and its manufacture by HAL, according to the same source, resulted in an abandonment of the plans for development of the HF-25.[111] Thus ended the long drawn attempt by HAL to indigenously design and develop a combat aircraft for the IAF.

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[110] *Milavnews*, October 1978, p.14.

[111] *Milavnews*, December 1978, p.14.

B. HJT-16 KIRAN

Design and development of a jet trainer, the HJT-16 Kiran according to IAF specifications was approved by the government in November 1959. A month later, in December 1959, the Ministry of Defence sanctioned the development of two prototypes and one shell for flight trials and structural tests at an estimated cost of Rs 2.7 million (including Rs 0.8 million in foreign exchange). The prototypes were expected to be ready for flight trials by December 1962 and June 1963 respectively.[112] Conflicting priorities, however, caused substantial delays right from the inception of this project. This was the first attempt at design and development of a jet aircraft by a team of Indian design engineers under V.M. Ghatage assisted by Raj Mahindra who was the senior design engineer for the project. By 1961-62, development of the aircraft was already six months behind the original schedule since only 60 per cent of the design work had been completed.[113] Reasons for this delay included:[114]

1. Non availability of design personnel and machine capacity in the shops.

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112 *Report of the Comptroller and Auditor General: 1975-76. Union Government (Defence Services)*, para 6, p.6. Hereafter referred to as *C and AG Report: 1975-75*.

113 *HAL Annual Report 1961-62*, p.5.

114 *C and AG Report: 1975-76*, para 6, p.6.

2. Pre-occupation of shop capacity with the production of other aircraft, namely the Folland Gnat and the HF-24.

3. High priority given to the design and development of the HF-24.

As a consequence, the first prototype did not make its first flight until 4 September 1964,[115] while the second prototype flew for the first time only in August 1965[116] - about two years behind schedule. The delay in flight trials however did not prevent HAL from taking measures to manufacture the aircraft as early as 1963-64 or the Ministry of Defence from placing an order for the manufacture of 24 pre-production aircraft.[117] By 1965-66 flight testing and development of the aircraft were continuing along with the 'manufacture of pre-production aircraft'[118] with deliveries planned for 1966-67.[119] But, due to further delays in development of the HJT-16, the first of the pre-production aircraft could be delivered to the IAF only by March 1968 and seven more were manufactured by December 1969 - an average of four aircraft per year.[120]

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115 *Jane's All the World's Aircraft 1964-65*, p.79. According to the *Ministry of Defence, Report 1964-65*, pp.41, 56, the first prototype flew in October 1964, while it made its 'first inaugural flight' in December 1964.

116 *C & AG Report:1975-76*, p.6.

117 *HAL Annual Report 1963-64*, p.4.

118 *HAL Annual Report 1965-66*, p,24,

119 *Report 1965-66*, p,46.

120 *C & AG Report: 1975-76*, p.7.

Deliveries against the initial contracts for the supply of 24 pre-production (August 1963) and 36 series production (April 1965)[121] aircraft thus took nearly nine years and were completed by March 1974, by which time it was claimed that production was finally stabilised. Meanwhile, two further orders for the HJT-16 had been placed on HAL in March 1968 and September 1970 respectively.[122] There was thus a substantial cumulative shortfall in aircraft deliveries by 1974.

The HJT-16 itself had been designed with a view to powering the initial production run of 60 aircraft by the (then) Bristol Siddeley Viper 11 turbojet developing 2,500 lb thrust, later models being powered by the indigenous HJE-2500.[123] A decision to design and develop a powerplant (the HJE-2500) was taken in February 1960[124] after rejecting an earlier proposal to use a derated version of the Orpheus engine on grounds that it would be too powerful for the aircraft.[125]

The project for the development of the HJE-2500 powerplant was a result of the Board of Directors of the

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121 *Jane's All the World's Aircraft 1969-70*, p.107.

122 *C & AG Report: 1975-76*, p.7.

123 *Public Accounts Committee (1977-78), Second Report (Sixth Lok Sabha)*, para 1.21.

124 ibid., para 1.8.

125 ibid., para 1.42.

HAL convincing the government, i.e. the Ministry of Defence, about the viability of the program. Air Headquarters on the other hand, had a non-committal attitude regarding the project right from the planning stage. According to a note prepared for the Committee of Directors' Meeting held on 13 February 1960, Air Headquarters had informed HAL that

> ... they have no comments at this stage except to suggest that the delivery schedule of this engine should be speeded up ... so that there is no delay in the production of the Basic Jet Trainer ... also added that since Government have approved the development... (of the HJT-16) ... proposals regarding the development of the engine should be sent to the Government direct.[126]

Since Air Headquarters had underlined the necessity of speeding up development of the engine to avoid delay in the manufacture of the HJT-16, HAL decided to commence design work 'in anticipation of the approval of the Government of India'.[127] In a subsequent letter to the Ministry of Defence, the then Managing Director of HAL justified this decision on two grounds:[128]

1. An engine of this thrust range was required for the HJT-16.

2. The design and prototype manufacture of this engine would establish a design and development team in India to meet future needs.

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[126] ibid., para 1.9.

[127] ibid.

[128] ibid., para 1.10.

As a result, when the HJE-2500 development project was sanctioned, the cost for development of four prototypes was estimated at Rs 3.5 million including a foreign exchange component of Rs 1.7 million. This estimate also included an expenditure of Rs 0.6 million on flight development tests and the project was scheduled for completion in three years.[129] Accordingly, the Board of Directors of HAL sanctioned Rs 0.5 million in December 1962.[130]

Given the low financial estimate for the development of the HJE-2500 as well as the meagre amounts involved in the first two sanctions by HAL, it is quite clear that the company had no idea about the effort involved in the design and development of a new engine. This was subsequently admitted by the Secretary, Department of Defence Production during evidence before the *Public Accounts Committee*. The following reasons were advanced for the 'sketchiness' of the initial estimates:[131]

1. HAL had not understood the development processes involved in the HJE-2500. Estimates for man-hours required for engine fabrication were based on 'the best guesses' of the process involved.

2. Since the Gas Turbine Research Establishment (GTRE) of the DRDO was in its early stages of establishment, it was not possible to cross-check the estimates provided by HAL.

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[129] ibid., para 1.9.

[130] ibid., para 1.8.

[131] ibid., para 1.11.

Also, not only did the engineers at HAL lack practical experience in engine design, but HAL itself lacked basic facilities. Although 'certain test facilities' were available, it was only at this stage that HAL had established an engine factory at Bangalore[132] to manufacture variants of the Bristol Siddeley Orpheus engines for the Gnat and HF-24 aircraft. The design scheme for the HJE-2500 had thus come from an organisation which itself had only theoretical knowledge about aircraft engines. But this did not deter HAL from undertaking the project since it was operating on the 'philosophy' of 'learn as you go'. While the failure to obtain the necessary test facilities and other equipment was attributed to the meagre grant of Rs 0.5 million in 1960[133] there is no evidence available to show that HAL asked the government for additional funds during the first four years of the project, i.e. between 1960-64.[134] In fact, it has been admitted that 'the Government did not take a conscious decision to proceed rapidly in this direction'.[135] Also, that there was no monitoring of the progress of the project during 1960-72 apart from occasional reviews.[136]

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[132] ibid., para 1.12.

[133] ibid., para 1.14.

[134] ibid., para 1.17.

[135] ibid., para 1.13.

[136] ibid., para 1.14.

However, as a result of inter-organisational politics, the project did come to the notice of the DRDO of the Ministry of Defence in August 1964. The reason behind this was not the progress made on the project, or the lack of it. But, the point in question was whether HAL was entitled to work on the project. According to the Scientific Adviser to the Ministry of Defence, such long range development projects involving 'higher contemporary levels of competence should initially be handled at GTRE'.[137] The fact that until 1963, the only work done at GTRE was related to a 'certain number of individual components' and the first major engine project was the development of the reheat system for the HF-24,[138] did nothing to add substance to the Scientific Advisor's request that HAL should incur no further expenditure on the development of the engine till the matter was re-considered by its Board of Directors. HAL did not react favourably to this proposal and, in September 1964, made a representation to the Department of Defence Production that it be allowed to carry on with the HJE-2500 project for the following reasons:[139]

1. In countries like the UK and USA, design and development of aircraft/ aeroengines were entrusted to manufacturing companies and not

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[137] ibid., para 1.15.

[138] ibid., para 1.13.

[139] ibid., para 1.15.

handled by R & D Organisations. The latter carried out theoretical analysis to assist the Air Force in formulating Operational Requirements or undertook wind tunnel testing of models and evaluated the performance of components.

2. Research organisations, including GTRE, did not have design personnel, machinery or equipment for the manufacturing of components and test equipment. Without such facilities, it was not possible to manufacture prototypes nor was it worthwhile to establish duplicate facilities.

3. HAL, on the other hand, had a design group with a separate prototype shop which could also be supplemented by the available spare capacity in other manufacturing shops.

4. According to the existing schedule for the manufacture of the HJT-16 and the HJE-2500, there was a requirement for only 50 additional Viper 11 engines. The balance could be met by the HAL built HJE-2500 which would also have the additional advantage of locally manufactured spares.

GTRE's lack of facilities as well as HAL's insistence that it could provide the powerplant in a satisfactory time frame ensured continuation of its work on the HJE-2500 development. At the same time, although there were no firm proposals to manufacture the Viper 11 under licence, 'the matter was not pursued, presumably, consequent to the reversal of the earlier decision to suspend further expenditure by HAL on HJE-2500'.[140]

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[140] ibid., para 1.18.

The episode had no effect on HAL's efforts to develop the engine since a firm decision on the issue was taken in a matter of weeks. Nevertheless, compared to the original (1960) time frame of three years for the development of four prototype engines, the first prototype was test run only in September 1966, and even then, its performance did not satisfy specifications.[141]

In the meanwhile, development of the HJT-16 Kiran airframe itself had been considerably delayed with the first aircraft being delivered only by 1967-68, very few delivered till 1970-71. But this delay in airframe development in no way helped dovetail the engine and airframe manufacturing programs. As admitted by the Department of Defence Production, given the required facilities, HAL could have developed the engine between 1960 and 1967, 'but that would have required a type of effort which HAL was not in a position to mount at that point of time'. The reason was HAL's philosophy of engine development itself. According to standard practice, components are first developed, tested and then assembled. HAL assembled the engine, put it to test and when it did not come up to expectations, reversed the process.[142] The result was an inordinately prolonged development cycle. HAL's approach to engine design was severely

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[141] ibid., para 1.17.

[142] ibid., para 1.19.

criticised by a team of Rolls Royce engineers who called it 'an example of how engine development should not be undertaken' - an observation which was later endorsed by the Aeronautics Committee in April 1969.[143]

It was only by July 1967, that HAL could provide a tentative time frame by which the HJE-2500 would be available. It was also realised that the engine could be used in approximately 54 HJT-16 Kiran. In addition approximately 40 per cent of the reserve engines i.e. 20, could be supplied - making a total requirement of about 75 engines. The balance of the requirement would have to be met by the import of Viper 11 engines since the HJE-2500 would not be available before May 1971. Accordingly, the Board of Directors of HAL was asked to approve the manufacture of six prototypes at an estimated (revised) expenditure of Rs 14.5 million with a foreign exchange complement of Rs 1.5 million.[144] These estimates were subsequently scaled down to include the development of only four prototypes and in October 1967, HAL asked the government for a development grant of Rs 10 million including Rs 1.2 million in foreign exchange.[145] By this time it was also realised that only about 50 engines would 'ultimately be required'.

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[143] ibid., para 1.34.

[144] ibid., para 1.21.

[145] ibid., para 1.20.

On this basis, it was calculated that amortisation of tooling and development costs alone would be about Rs 325,000 per engine which would make the entire proposal uneconomical. Consequently, it was decided that the project be 'considered as an educational project'.[146]

Even the requirement of 50 engines soon turned out to be theoretical. While considering the request for the development grant of Rs 10 million, the government concluded in February 1968, that by the time the HJE-2500 had entered the manufacturing stage, the entire requirement of engines for the HJT-16 would have been met through imports. In these circumstances, it was officially decided to treat the development of the HJE-2500 as an educational venture.[147] Apart from this decision, no action was taken regarding the request for funds by HAL. Over a year later, in April 1969, the project again claimed official attention when the Aeronautics Committee recommended that it be pursued to completion as a development project regardless of its end use. The history of the development of the HJE-2500, commented the Committee, was a good lesson for the future. But, it nonetheless recommended further development on grounds that the experience in competent development and manufacture would considerably help the 'major engine project', i.e. the

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[146] ibid., para 1.21.

[147] ibid., para 1.23.

Orpheus 703 reheat engine, which it had recommended. Referring to the two design and development establishments viz. that of the HAL and the GTRE which was a part of DRDO, the Committee maintained:[148]

> The existence of two separate teams was an impediment to the sanction of the expenditure; acceptance of our recommendation for the merger of the two teams should remove this impediment.

As is discussed below, no decision on either of the two recommendations of the Aeronautics Committee was taken for the next three years. In the interim in May 1970, HAL submitted another revised proposal for the development of the HJE-2500. Development costs for the engine were now estimated at Rs 15 million with Rs 4 million in foreign exchange. Compared to the 1967 time frame it was now admitted that a further 62 months of development activity was required. In other words, the engine would not be available before July 1975. Factors responsible for the changes in financial estimates included rise in labour costs, increase in prices of 'bought out items' and raw materials besides increase in the estimated cost of fabrication of castings and forgings - the latter based on the expenditure gained in the manufacture of Orpheus engines.[149]

The new time schedule of 62 months was based on the difficulties encountered during the initial test bed

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[148] ibid., para 1.24.

[149] ibid., para 1.26.

running of the first prototype. After nearly four years of testing, upto 1970, 'it had not been possible to run the engine at the desired speed'. It was now accepted that there were serious problems involved in developing major components (such as the turbine, combustion chamber accessories) on the engine itself as originally planned. It was then decide to test and develop these components individually on separate test facilities.[150]

Since it had now been officially decided to classify the HJE-2500 project as an educational exercise, decision regarding further funding took over three years from the time of the Aeronautics Committee's recommendations in April 1969. In June 1972, it was decided to sanction the amount requested by HAL. According to the Secretary, Department of Defence Production, the delay ...

> ... was apparently due only to discussions with the Ministry of Finance and others as to where the funds would come from ... The question was whether it should be from the Aeronautics Research and Development Board. Ultimately Government sanctioned [the funds] from its own sources and not from the board.[151]

As regards the second recommendation of the Aeronautics Committee about amalgamation of the engine design departments of HAL and GTRE, the proposal was eventually rejected despite its 'acceptance in principle'. The DRDO disclaimed any responsibility regarding the delay

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[150] ibid., para 1.27.

[151] ibid., para 1.28.

in development of the HJE-2500 on grounds that the project had been handled entirely by HAL. In July/August 1972, it was decided by the Ministry of Defence that there was 'general agreement' on the respective roles of HAL and GTRE. In order to give 'practical definition' to this agreement, a work schedule for 1972-73 was drawn up to ensure co-ordination between the two agencies.[152]

During subsequent years, the engine project was consistently downgraded in priority. The Aeronautics Research and Development Board (ARDB), set up on the recommendations of the Aeronautics Committee had approved the HJE-2500 project at its meeting on 8 January 1972.[153] In May 1972, the ARDB set up a Technical Committee to assess various projects for propulsion systems including the HJE-2500. But, in its report submitted in December 1974, the Committee did not deal with the project at all, for two reasons:[154]

1. Consideration of the alternative power-plants for the HF-24 was of immediate importance at that time.

2. It was not possible to complete the proceedings within the stipulated time frame 'because of the pre-occupation of the Chairman of the Committee in his very many responsibilities as well as that of the members.

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[152] ibid., para 1.25.

[153] ibid., para 1.32.

[154] ibid., para 1.33.

Final testing of the HJE-2500 was conducted in April-May 1974,[155] nearly eight years after the first test-run. Since the HJT-16 manufacturing program had experienced considerable slippages, in July 1974, HAL decided to actively pursue the development program of the HJE-2500. Soon afterwards, a Monitoring Committee including the Director of Development and Design (HAL) probed into development manufacturing aspects of the program and made the following observations:[156]

1. An estimated 91,000 man hours per annum were required for the manufacture of prototype engines. There was no capacity available in the prototype shop of the Egnine Design Department and the Engine Division lacked spare capacity to undertake the work.

2. A new fuel system was acquired for the engine. Although Lucas Aerospace Ltd and Dowty Fuel Systems Ltd (both of UK) had shown some interest in the matter, the expenditure quoted for development work was too high.

3. Weight of the existing prototype was 20 per cent higher than specifications. Any reduction in weight involved 34 components which would require considerable time and effort.

4. There was no commercial value in the project since it could not be produced in time for the HJT-16 Kiran which was going to be further developed as an armed version requiring an engine of greater thrust.

HAL subsequently had little choice but to accept the recommendations of the Monitoring Committee to foreclose

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155 ibid., para 1.36.

156 ibid., para 1.35.

the project specially when it was made clear that production models would not be available before 1980. This was done in April 1975, barely nine months after the decision to actively pursue the project. Government sanction, for foreclosure of the project, was received 15 months later, in July 1976. Total expenditure on the HJE-2500 amounted to Rs 8.2 million.[157]

A direct consequence of this unsuccessful attempt at developing a powerplant for the HJT-16 was that the question of licence manufacture of the Viper 11 turbojet was never seriously consdered. The entire requirement for engines was met by imports at a total cost of Rs 111.2 million, at a unit cost which escalated from £17,936 (1966) to £33,700 (1971) and £42,614 (subject to escalation) in 1976.[158]

Manufacture of the HJT-16 itself, as mentioned earlier, had fallen considerably behind schedule because of development problems and slippages in production. This also affected the unit cost of aircraft. Against initial orders, this was estimated at Rs 1.27 million (foreign exchange Rs 550,000) in August 1963, and at Rs 1.047 million (f.e. Rs 603,000) in April 1965. Unit cost (including profit) was estimated at Rs 2.81 million (f.e. Rs 789,000) while the cost of those

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157 ibid.

158 ibid.

aircraft which were ordered in 1968-70 rose sharply to Rs 3.181 million (f.e. Rs 1.093 million). This estimate underwent yet another revision and the actual unit cost that was finally sanctioned in July 1967 amounted to Rs 4.013 million (f.e. Rs 1.439 million).[159]

A second effect of the substantial shortfall in HJT-16 deliveries in the early 1970s was that the IAF began to explore overseas markets to replace the Howard and Vampire T.55 trainers. By late 1974 unofficial reports stated that the Indian defence ministry was showing interest in placing an order with Czechoslovakia for about 100 Aero L-39 turbofan powered trainers.[160] By this time production is said to have stabilised at about 25 aircraft per year and attempts were being made to accelerate it so as to meet IAF's new training requirements which needed about 130 HJT-16 Kirans - almost double the quantity delivered till that time.[161]

This situation arose about three years after a review of requirements by Air Headquarters in October 1971, when it had been planned that the total requirement of trainer aircraft would be met from indigenous production. But production slippages (mainly prior to (1973-74) made a fresh review necessary. This exercise

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159 ibid.

160 *Milavnews*, September 1974, p.15.

161 *Milavnews*, January 1975, p.14.

was completed by Air Headquarters in February 1974 and it revealed a much larger requirement which justified a substantial import of additional aircraft. As HAL could not fulfill this additional requirement in the time frame required by Air Headquarters, in September 1974, the Ministry of Defence approved the import of a 'substantial' number of aircraft (estimated cost Rs 137 million) for delivery between September 1975 and March 1976.[162] Accordingly, about 50 Polish WSK-Mielec TS-11 Iskra-100 jet trainer aircraft equipped with a 7.62 mm nose cannon and four underwing hard points were ordered and deliveries completed by 1976.[163]

Meanwhile, two months after the Air Headquarter's review of its requirements and five months before the Ministry of Defence's approval for import of aircraft, in April 1974, on 'anticipation' that Rs 5 million for expansion of facilities to double the stabilised rate of production. Given the past experience in creating manufacturing facilities for this aircraft as well as the urgency of the IAF requirements, this move was clearly unwarranted and short-sighted. Because as it turned out, after the imports from Poland, even the then existing manufacturing facilities of HAL (i.e. prior to

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162 *C & AG Report: 1975-76*, para 6, p.10.

163 *Milavnews*, May 1975, p.14, also *Jane's All the World's Aircraft, 1977-78*, p.151.

expansion) were not likely to be utilised for the manufacture of the HJT-16 Kiran. Apparently, bureaucratic oversight was not only responsible for the initial sanction but also could not prevent the expansion from taking place since three years later in April 1977, the Ministry of Defence stated that the 'additional capacity set up would be, depending on requirements, used for the manufacture of other jet aircraft.[164]

By early 1975, approximately 75 HJT-16 Kiran jet trainers had been delivered out of a total IAF/Indian Navy (IN) requirement of 180 aircraft.[165] The 68th and subsequent Kirans had undergone slight modification and incorporated a single hard point beneath each wing for external stores[166] so that the aircraft could also, to a limited extent, be used for weapons training. But these modifications, it would appear were not given final clearance after flight trials and testing till late 1977. This is because the 119th and subsequent aircraft were designated HJT-16 MkIA and six aircraft of this version are reported to have been manufactured by 1 January 1978, bringing the total number of aircraft manufactured by that date to 125.[167] Since then, production has continued

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164 *C & AG Report: 1975-76*, para 6, p.10.

165 *Jane's All the World's Aircraft, 1975-76*, p.102.

166 ibid., also *Milavnews*, January 1975, p.14.

167 *Jane's All the World's Aircraft, 1978-79*, p.73.

at the rate of approximately 20 aircraft a year. By 1 January 1981, a total of 180 MkI/MkIAs had been manufactured and production was reportedly being slowed down in 1981 in favour of the HJT-16 Kiran MkII.[168]

HJT-16 Kiran MkII:

A proposal to use a derated Orpheus 701 turbojet to power the HJT-16 was considered at the inception of the Kiran development project in July 1958, but was rejected on grounds that the engine would be too powerful for the aircraft. The proposal was examined once again in 1970[169] at the initiative of the HAL Design Bureau but was once again turned down by Air Headquarters for two reasons:[170]

1. Incorporation of this power-plant would require extensive structural changes in the airframe.

2. The delays and costs involved in such modifications were unacceptable to the IAF.

The project was revived once again in 1975 when the IAF had mofified the design requirements for a trainer aircraft. It had also been decided to arm the HJT-16 Kiran for training and counter-insurgency tasks. Accordingly, the proposal was accepted by the Board of

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168 *Jane's All the World's Aircraft, 1981-82*, p.87.

169 *PAC (1977-78), Second Report*, para 1.42.

170 *C & AG Report: 1975-76*, para 6, pp.11-12.

Directors of HAL in August 1975. In December 1975, Ministry of Defence sanctioned development of the MkII version at an estimated cost of Rs 20.8 million within a time frame of three years.[171] The uprated MkII was to be equipped with a derated Orpheus 701 turbojet (developing 3,500 lb thrust) and incorporate an improved hydraulic system, avionics and weapons carrying capability with four underwing stations.[172] Range, with two underwing drop tanks fitted as standard, would be the same as that of the MkI but the new powerplant would give the MkII an improved maximum speed, climb and mnaoeuvrability.[173]

The prototype HJT-16 Kiran MkII flew for the first time on 30 July 1976 - two months ahead of schedule,[174] but flight testing was suspended later that year following problems with the engine intakes. These problems were apparently resolved by early 1977 and flight trials resumed by January/February 1977.[175] By December 1978, work on the MkII had progressed to completion of its spinning trials[176] and a second prototype was test flown for the first time in February 1979.[177]

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171 *PAC (1977-78), Second Report*, para 1.42.

172 *Milavnews*, October 1975, p.16.

173 *Jane's All the World's Aircraft 1977-78*, p.80.

174 *HAL Annual Report 1976-77*, p.6.

175 David A. Brown, 'India's Aircraft Industry Grows', *Aviation Week & Space Technology*, 17 January 1977, p.16. Also *Milavnews*, January 1977, p.12.

176 *Milavnews*, December 1978, p.14.

177 *Jane's All the World's Aircraft 1981-82*, p.88.

Soon after approval of the MkII development project, in March 1976, the Ministry of Defence had sanctioned a sum of Rs 551 million for Air Headquarters to place orders for the aircraft.[178] This however was not done despite HAL's request for orders in 1977-78, prompted by the dwindling workload at the Bangalore Division.[179] It was only in mid-1981, after the HJT-16 Kiran MkII had completed its development flying, that an IAF order for 24 aircraft was announced. Deliveries are scheduled for early 1983[180] and a total of 90 MkIIs are expected to be built for the IAF and Indian Navy.[181]

In all, the design, development and manufacturing program for the HJT-16 has not been very successful. There was a 3-7 year delay in initial delivery and completion of the first two orders for the aircraft. This was primarily attributed by HAL to lack of experience and of design personnel as a result of which the initial estimates tended to be highly unrealistic. At the same time, there seems to have been a remarkable degree of optimism, especially with regard to HAL's decision to develop a powerplant, the HJE-2500, for the HJT-16. The development of the engine itself took place on rather

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178 *C & AG Report: 1975-76*, para 6, p.12.

179 *HAL Annual Report*, p.6.

180 *Jane's All the World's Aircraft 1981-82*, p.88.

181 David Vellupillai, 'Hindustan Aeronautics: India's Aerospace Giant', *Flight International*, 5 November 1980, p.1179.

unconventional lines, i.e. an attempt was made to develop the HJE-2500 as a complete powerplant rather than the routine that is normally followed - that of developing components and then testing the complete engine. Also, HAL was not able to decide whether to treat the project as being completely educational in nature or as one which would eventually come into operational use. Opinion on this question seemed to fluctuate from time to time for over eight years, until 1978, when it was formally decided that development of the HJE-2500 was an educational project.

One major effect of the lack of a clear policy was that the proposal for the licence manufacture of the Viper 11 turbojet was never seriously considered. This would appear to have been in contradiction to the espoused policy of developing a trainer aircraft which would be indigenous to the extent possible. Further, the prolonged delay in development of the airframe for the HJT-16 resulted in the IAF having to extend the use of the Harvard trainers as the initial deliveries of the Kiran were used to replace the Vampire T.55 trainers then in service.[182] From the time of initial deliveries in 1968, more than five years are reported to have elapsed before the 50th aircraft came off the assembly line in late 1973.[183] Subsequently,

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182 *Milavnews*, September 1972, p.16.

183 *Milavnews*, January 1975, p.14.

because of accumulated shortfalls in deliveries of the HJT-16, the IAF was forced to seek replacement aircraft overseas.

Operational availability of the HJT-16 Kiran MkI, at least upto the mid-197-s, was far from satisfactory. Initially, the aircraft was expected to be utilised for 40 hours per month, but in July 1973, this was scaled down to 30 hours per month. The actual availability of the aircraft for flying operations during the period 1970-76 was as follows:[184]

	Serviceability (%)	Utilisation (Hours/Month)
1970	43	15
1971	36	10
1972	50	12
1973	34	19
1974	49	23
1975	45	24
1976	41	20

It is thus clear that the average serviceability of the HJT-16 over a period of seven years was about 45.6 per cent while the utilisation rate was about 17.6 hours per month, far below the revised expectations of the IAF. Many factors contributed to this low rate of availability. These included frequent modifications that had to be undertaken, lack of interchangeability of parts, shortfalls

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184 *C & AG Report: 1975-76*, para 6, p.11.

and delays in supplies of spares and ground and test equipment. On the other hand, the average serviceability of the Polish Iskra trainers in their first year of service with the IAF in 1975-76 was about 73 per cent and their utilisation about 18 hours per month as against the planned 30 hours per month.[185] The lower rate of utilisation of the Iskras was, however, not because of technical reasons, but, because of reorganisation of the IAF training program which resulted in the intake of trainees being about half of what had been originally estimated. This reorganisation of the training program is also reported to have resulted in an unforeseen surplus of HJT-16 Kirans during 1977-78, so that some of them were placed in storage.[186]

Apart from attempting to meet the requirements of the IAF, attempts were also made to seek export orders for the HJT-16, the aircraft having being displayed at the Farnborough Air Show as early as 1972.[187] In 1977, it was reported that Indonesia was evaluating the possibility of purchasing the aircraft[188] but no orders resulted. In 1980, there were further reports that India had initiated negotiations with 'several countries' in

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185 ibid.

186 *Milavnews*, August 1978, p.10.

187 *Milavnews*, September 1972, p.15.

188 *International Defense Review*, 5/1977, p.980.

Africa and Latin America and negotiations were said to have been in the 'final stages' with at least one African country.[189] This again has not resulted in any firm orders although, according to Western sources, negotiations under way between India and Liberia in 1982 could result in the sale of the HJT-16 to the latter.[190] However, while the aircraft has eventually met the training requirements of the IAF, it would not seem to have worthwhile export potential. While the HAL might be able to provide the aircraft at a lower unit cost, than some of its competitors, given past experience, it would not be in a position to provide the necessary back-up support and servicing facilities in an as efficient and organised manner as its competitors from UK and France.

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189 *Times of India*, 5 May 1980.

190 *International Defense Review*, 1/1982, p.93.

C. HPT-32

In November 1965, Air Headquarters proposed the replacement of its primary trainer, the HT-2 (inducted into service in April 1953) by a new generation aircraft and suggested that HAL undertake a feasibility study for its design and manufacture.[191] A formal Air Staff Requirement (ASR) was issued in May 1969 and 10 months later, HAL submitted a feasibility report, envisaging the development of an improved version of the HT-2, equipped with a more powerful engine. Unit cost of the new generation primary trainer was then estimated at Rs 230,000 and the development process was expected to be completed over four years.

In the meantime, the Aeronautics Committee had also studied the proposal for a new primary trainer. In its report submitted just over a month later, in April 1969, the Committee, while observing that the prospects of designing a piston engine basic trainer aircraft that would meet both civil aviation and IAF requirements were 'not bright', recommended that the matter deserved a 'careful study' before the HAL was allowed to develop a new aircraft. The reason behind this recommendation was that the Indian Institute of Technology, Kanpur had developed a two-seat basic trainer, the Revathi (MkI)

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191 Unless mentioned otherwise, details about the background and manufacturing history of the HPT-32 have been derived from *Report of the Comptroller and Auditor General: 1979-80 Union Government (Defence Services)*, para 7, pp.9-14.

intended for use by civil flying clubs. The aricraft flew for the first time on 13 January 1967, and had been Type Certificated by January 1969,[192] three months before the Aeronautics Committee submitted its report.

As a result of the recommendation of the Aeronautics Committee,HAL's proposal was 'temporarily set aside' and the question of having a common basic trainer was taken up for consideration jointly by the Ministry of Defence and the Ministry of Civil Aviation. To complicate matters, in May 1969, barely a month after the Aeronautics Committee had submitted its report, HAL made 'certain changes' in its feasibility report. In the Director General, Civil Aviation (DGCA), which then requested Air Headquarters to give its specifications for the *ab initio* trainer - a request made on grounds that civil aviation already had a primary trainer which met its requirements.

After updating the ASR of 1968 to accommodate 'contemporary changes in the pattern of pilot's training' Air Headquarters communicated their revised ASR to the DGCA in May 1971. The entire process, initiated by the recommendations of the Aeronautics Committee, thus took over two years. HAL, in keeping with the then prevailing opinion, informed Air Headquarters that, 'with a view to avoid duplication', it would undertake a feasibility study only if the results of evaluation of the Revathi (MkI) were not acceptable to the IAF. At the same time,

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192 *Jane's All the World's Aircraft, 1969-70*, p.105.

it should be emphasised, no joint feasibility study vis-a-vis the Revathi (MkI) had been undertaken by the IAF and the DGCA.

During this period, a MkI version of the Revathi was under development by the DGCA. Modifications included metal wings and an increased fuel capacity and the aircraft flew for the first time on 20 May 1970.[193] In November 1971, the DGCA was entrusted with a study of the feasibility of modifying the Revathi MkII, to meet IAF requirements. In its report submitted a month later, in December 1971, the DGCA informed Air Headquarters that after providing for certain characteristics desired by the latter, the Revathi MkII had been designed to 'meet more demanding requirements'.

As a result, extensive flight tests were carried out by the Aircraft and Systems Testing Establishment (ASTE) of the IAF between February and September 1972. Although the Revathi MkII was subsequently Type Certificated on 31 October 1972,[194] the IAF concluded that its performance fell short of the ASR and could not be improved without 'major' modifications. In response to the IAF recommendations, the DGCA informed the IAF in December 1972 that the required modifications and improvements could be carried out in about two years.

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193 *Jane's All the World's Aircraft, 1977-78*, p.78.

194 ibid.

A year later, in November 1973, the DGCA suggested that the IAF should consider inducting the Revathi MkII in its existing form as it met 'most' of the requirements excepting that of cockpit layout and climb and cruise performance. In December 1973, the DGCA indicated that it had no plans to incorporate any of the major modifications suggested by the IAF. Minor modifications including the replacement of original wooden flaps and ailerons by metal components were however carried out and the modified Revathi MkII resumed test flying in April 1974.

The impasse between the IAF and the DGCA lasted for more than six months till July 1974 when a joint evaluation of the Revathi MkII by the IAF in association with representatives of the DGCA was undertaken. This exercise again served to emphasise the difference of opinion about the aircraft that prevailed between the two organisations. The IAF repeated its earlier assertion that the aircraft in its 'current state of development' fell short of the ASR of 1971 in several respects. The DGCA on the other hand, insisted that it had the basic flying and performance qualities to be able to provide *ab initio* training both for IAF and civil aviation purposes. To strengthen its case for the Revathi MkII,

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195 ibid.

the DGCA added that once the IAF took a decision in principle that the aircraft was acceptable, it would develop the prototype and equip the aircraft with the required instrumentation and cockpit layout.

Consequently, nearly a decade after the IAF had initially communicated their requirement for a new trainer aircraft, the selection process was nowhere near completion. In fact, the decision making process seemed to have been brought to a standstill as a result of the exchanges between the IAF and the DGCA. In September 1974, HAL was once again given the task of examining the feasibility of the design, development and manufacture of a trainer aircraft as per the ASR of 1971. The aircraft was to be inducted into service from 1977-78 onwards in order to avoid any disruption in pilot training in the late 1970s.[196] In October 1974, Air Headquarters formally recommended the rejection of the Revathi MkII as it did not appear likely that the DGCA could carry out any significant improvements to its performance.

At the same time, Western sources reported that the government had approved a licence production plan for a selected foreign aircraft. After rejecting the Revathi II, the IAF was said to be evaluating the main international

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[196] This was because, as early as May 1973, HAL had informed the Ministry of Defence that the supply of spares for the HT-2 could continue only up to 1976-77. After this, retooling would be necessary and the progressive import of raw materials and rotables would pose a major problem.

primary trainers including the MBB Flamingo (Germany), Fuji FA-200 (Japan), NZAI CT-4 Airtrainer (New Zealand), SAAB/MF1-15 and -17 (Sweden) and the Scottish Aviation Bulldog (UK). The only demonstrator to have visited India, however, was reported to have been the NZAI CT-4.[197] But, funding problems persisted and by late 1974, HAL was reported to have progressed with the design of a light two-seat military trainer as a HT-2 replacement. Designated HPT-32, the aircraft would be powered by a 260 HP Lycoming engine and was said to have a target unit cost of Rs 600,000 (foreign exchange: Rs 76,000).[198]

According to the feasibility study submitted by HAL in April 1975, the design and development cost of the HPT-32 was estimated at Rs 1,608 million (foreign exchange: Rs 1.2 million) and the unit cost, exclusive of profit, about Rs 630,000 at 1974-75 price levels. By this time, Air Headquarters decided that it was necessary to incorporate 'further improvements' to its ASR of 1971. A revised ASR was issued in February 1976, and at the same time, the Ministry of Defence sanctioned the development of the HPT-32 on the basis of the feasibility report submitted by HAL a year earlier. The first aircraft was scheduled to be manufactured and delivered in five years, i.e. by February 1981. Along with the design of the aircraft,

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197 *Milavnews*, July 1974, p.14.

198 *Milavnews*, October 1974, p.14.

studies were also reported to have included the development of an indigenous piston engine, designated the HPE-4, intended both for the HPT-32 and the Basant agricultural aircraft which was also under development.[199] A prototype HPE-4 developing 400 HP had been test run by HAL for the first time in 1975.[200] The first HPT-32 prototype made its successful first flight on 6 January 1977, three months ahead of schedule,[201] but its performance would appear to have fallen far short of expectations. The grounds for this belief are that the second prototype was not flown until more than two years later, on 12 March 1979.[202] Even before the flight testing of the second prototype in March 1978, HAL insisted that deliveries of the HPT-32 could commence in 1981 only if a production order was immediately placed. Air Headquarters on the other hand, indicated (May 1979) that if development of the aircraft was not accelerated, the only alternative would be to replace the HT-2s (by then being maintained only at high costs and accident risks) through import of a suitable aircraft.

Phasing out of the HT-2 had now been re-scheduled and the trainer was to be in service till 1982 instead of 1977-78 as had earlier been planned. Air Headquarters again stressed (March 1979) upon the Ministry of Defence,

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199 *Milavnews*, October 1975, p.16.

200 *Milavnews*, January 1977, p.13.

201 *Report 1977-78*, p.62.

202 *Jane's All the World's Aircraft 1981-82*, p.89.

the need for induction of the HPT-32 by 1981-82 in order to avoid disrupting the pilots' training program. It was also clarified that in the absence of any guarantee about the performance of the HPT-32, no production orders could be placed on HAL.

The second prototype of the HPT-32 had incorporated many modifications, including landing gear, canopy and wing tip changes. This and the third prototype were also said to have been the subject of a weight reduction program.[203] The third prototype, an improved version, substantially lighter in weight and with aerodynamic refinements was finally test flown on 31 July 1981,[204] more than two years after the initial flight of the second prototype, and four and a half years after the first prototype.

Although the HPT-32 had been developed at the Bangalore Complex of HAL, it was decided to transfer the manufacturing facilities for it to the Kanpur division because of the idle capacity available there. An initial batch of 24 HPT-32 primary trainers was finally ordered in mid-1981[205] and service entry was reported to be scheduled for 1983-84. Eventual IAF procurements is expected to total 160 aircraft,[206] capable of additional roles including reconnaissance and light strike/weapons training.

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203 *Milavnews*, December 1978, p.14.

204 *Jane's All the World's Aircraft, 1981-82*, p.89.

205 *Air International*, Vol.21, No.2, August 1981, p.56.

206 *Air International*, Vol.20, No.2, February 1981, p.84.

As a result of problems and delays encountered in the development of the aircraft, the estimated development cost of Rs 16.8 million (April 1975) was expected to increase to Rs 37.7 million (excluding profit). In March 1978, HAL had indicated a revised unit cost of the production models of the HPT-32 at about Rs 850,000-900,000 (at 1977 price levels) as against the 1974-75 estimated cost of Rs 640,000 and the original estimated unit cost of Rs 230,000 (1968).

Thus, by the time the HPT-32 is inducted into service in 1983-84, it would have been more than 18 years since the IAF initially indicated its requirement for it. In the interim, the IAF had to satisfy its requirement for a primary trainer aircraft by extending its use of the HT-2 well beyond normal limits of economy and safety. The HT-2 was finally withdrawn in 1982 and pending delivery of the HPT-32, the IAF is using an Interim Training Plan which provides all-through jet training on the HJT-16 Kiran.[207]

The initial delays were caused by the recommendation of the Aeronautics Committee (1969), as a consequence of which HAL's proposal to design and develop a suitable replacement aircraft was shelved and the IAF was required to evaluate the Revathi - an aircraft designed primarily to meet civil aviation requirements. This joint evaluation

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207 *Air International*, Vol.23, No.2, August 1982, p.102.

program, besides resulting in inter-departmental politics also proved time-consuming; it lasted for over five years. As a consequence, when HAL was once again required to carry out a feasibility study in 1975, not only had there been an escalation in development costs, but, in keeping with the changes in IAF training programs, the ASR itself had to be revised. This in turn caused further delays in the development of the HPT-32, with the HAL requesting and the IAF refusing to place any orders for production versions of the aircraft till the prototypes had been developed to required standards. Estimated cost of development of the aircraft also escalated from Rs 16.8 million (1975) to Rs 37.7 million (1979) as did the estimated unit cost, rising from Rs 640,000 (1975) to Rs 900,000 (1977). These again are estimates that were calculated 3-4 years before the third prototype of the HPT-32 completed its flight trials in mid-1981 and would, in all probability, have to be revised again by the time the first production models are manufactured by the Kanpur division.

It is thus a poor reflection on the decision making and coordination activities in the Ministry of Defence, the DGCA and HAL (the latter because of the inordinate delays experienced in the development program for the HPT-32). In fact, the powerplant for the aircraft, the HPE-4 which was said to have been test run for the first time in 1975, is presumably still under development, as

none of the three prototypes flown so far has been equipped with it, even though it is reported that the production aircraft will use it.[208]

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208 *Jane's All the World's Aircraft, 1981-82*, p.89.

CHAPTER V

LESSONS FROM THE PAST

As mentioned at the outset, the decision to undertake indigenous manufacture of aircraft was the result of an effort to achieve self reliance and diversify sources of procurement. The first combat aircraft to be manufactured under licence was the Folland Gnat. Its light weight, simple design and high manoeuverability were the main factors in its favour. However, the decision to manufacture the Gnat would appear to have been a hasty one; the aircraft turned out to have serious problems of longitudinal instability. There is no evidence to suggest that in signing the licence agreement the Government of India stipulated inclusion of any clauses regarding further development work in order to improve the performance of the aircraft. In any case there were no serious hurdles in the process of setting up manufacturing facilities for the Gnat at HAL's factory at Bangalore. Inherent design deficiencies were the main factor behind the high accident rate of the aircraft while in operational service. During the first decade of its manufacture HAL lacked the design capability to improve its performance, and only in 1972 was HAL able to suggest some definite modifications that would improve the performance of the aircraft - which was now designated Gnat MkII. These modifications by themselves were not of a substantial nature with one exception which proved beyond the R&D capability of HAL and had to be

entrusted to its original manufacturers, Lucas Aerospace (UK). Later, Air Headquarters suggested a change in its operational role from an interceptor to a ground support aircraft and as a result the protoype incorporating the modifications and subsequent aircraft were designated Ajeet.

The second aircraft to be produced in collaboration with a British manufacturer was the HS-748 - the only transport aircraft manufactured by HAL. The selection process and early manufacturing record of the HS-748 was certainly unique in many different aspects:

1. The aircraft was selected for manufacture without any prior evaluation.
2. In the selection process the government rejected the preference of the IAF and Indian Airlines for the proven Fokker F.27. At the same time, it also turned down an offer by Lockheed to design and develop a transport aircraft suited to Indian conditions, even thought the Lockheed offer included not only help in constructing manufacturing facilities in India but also assistance in seeking worldwide sales for the proposed aircraft.
3. The process of decision making itself was probably one of the quickest ever undertaken by the Ministry of Defence. The entire process took only five weeks.
4. In an apparent attempt to speed up the implementation of the project, HAL, as a potential manufacturer, was not consulted at all.

Thus, the selection of the HS-748 would appear to have been based entirely on 'political' considerations by the then Minister of Defence, Krishna Menon, rather than on technical considerations of the aircraft's suitability.

The decision to manufacture the MiG-21 was preceded by a fair amount of controversy. The aircraft was favoured for its rugged and simple construction as also for the fact that the Soviet Union was willing to allow its manufacture under licence in India.

Although Indian interest in the MiG-21 resulted in pressure from UK and the United States to buy Western aircraft, the decision to acquire and manufacture the MiG-21 was made for the following reasons:

1. Although not so sophisticated as contemporary Western aircraft, it was credited with having a comparable performance.
2. The Soviets were willing to accept payment in Indian Rupees.
3. The Indian Ministry of Defence decided that given the level of existing technology in India, the MiG-21 would be easier to induct into service and to manufacture than the British Lightning.
4. The Soviet offer was consistent with the then Defence Minister Krishna Menon's commitment towards creating a substantial defence production sector in India and diversifying arms acquisition.

Thus, the decision to manufacture the MiG-21 would appear to have been made because of a combination of technical, economic and political reasons in its favour.

On the other hand, the decision to manufacture the French Alouette Al-III under licence involved no such complicated factors. As the United States has traditionally not permitted manufacture of its equipment in third countries the only other possible sources of supply were the Soviet Union, France and the UK. Although India had acquired some Mi-4 helicopters from the Soviet Union from 1960 onwards, it declined an offer for their manufacture under licence on grounds that the numbers required by the IAF did not justify their manufacture in India. The two British helicopters, Westland's Wessex and Wasp were under development and were not expected to go into production till about 1962. Consequently, the only helicoper that was both in production and available for manufacture under licence was the Alouette Al-III, an agreement for which was signed in 1962.

The next question that needs to be examined is the terms and conditions of the licence agreements that India concluded with manufacturers in various countries. Although it has not been Government policy to make this information available to the public, an analysis of the various manufacturing programs gives some insight into the quality and nature of the various agreements on the transfer of technology. For example, the agreement for the manufacture

of the Gnat was concluded in 1956, at a time when the aircraft was still under development. Thus it would not have been possible for the IAF or the Ministry of Defence to have any alternative but to rely on performance data provided by the manufacturer. In fact, since the acquisition of the Gnat was not based on any detailed ASR issued by the IAF but on a general requirement for a fighter, it could be argued that the IAF not only accepted the aircraft once it had been type-tested but also had no performance requirement which had to be fulfilled by the manufacturer. However, within these limitations, it would appear that the Gnat manufacturing program did not encounter any serious problems attributable to lack of cooperation with Folland Aircraft Ltd.

The agreement with Hawker Siddeley to manufacture the HS-748 was concluded at an even earlier stage. As a consequence the licence agreement was extremely sketchy. The licence agreement for the manufacture of the HS-748 was based entirely on the assumption that the aircraft would be granted a certificate of airworthiness and would enter production, and the agreement itself ensured a sufficient amount of initial orders to make it economically viable for Hawker Siddeley to set up a production line for the HS-748. On the Indian side no detailed plans or estimates could be formulated because of lack of information and, as a consequence, the project proceeded entirely on the basis of instructions issued by the supplier.

With regard to indigenous design and development of aircraft, the HF-24 was the first major project undertaken as a response to an Air Staff Requirement for a multi-role combat aircraft. At that time HAL not only lacked competent design engineers but also had neither R&D facilities nor prototype workshops. As a result the project was entrusted to Dr Kurt Tank and his team of West German engineers who had to initiate the setting-up of R&D facilities before they could begin any design work. Nonetheless, it would appear that the 'political' advantage in India designing its own fighter aircraft outweighed any technical arguments that could have been made against such an undertaking. This is because the project was expected to result in an aircraft of the same generation as the highly successful Hawker Hunter - an aircraft which the IAF purchased in substantial numbers. The only positive aspect to the whole exercise could have been in terms of HAL acquiring experience in designing combat aircraft. But then again it could be argued that this was an expensive if not extravagant way of gaining such expertise, dependent as it was on foreign personnel. In any case, flight testing of the interim HF-24 MkI began only 1-2 years behind schedule - a fairly impressive achievement by HAL standards.

The definitive HF-24 MkII variant was dependent on the successful development of the Orpheus 12, then being developed for the NATO competition. After it became clear that NATO would not be interested in this engine, the Government of India refused an offer by the manufacturers

to develop it to Indian requirement. This decision would appear to have been a short-sighted one, since subsequent efforts to use a Soviet powerplant were unsuccessful entirely for technical reasons.

The HJT-16 Kiran jet trainer project was even more ambitious in nature. Not only was the development of this aircraft undertaken entirely by Indian design engineers but the intended program included development of both the airframe and a powerplant. Inevitably, development of this aircraft suffered delays.

Development of the HPT-32 primary trainer suffered delays not because of lack of resources or competent design personnel but because of one of the longest inter-departmental controversies in the history of the Indian aircraft industry.

Although the project for the design and development of an Advanced Light Helicopter (ALH) was not entirely indigenous, it nonetheless is a striking example of continued shortcomings in the planning process in the Ministry of Defence even in the 1970s. The collaboration agreement with SNIAS (France) was fairly comprehensive, but the design concept was not based on any detailed ASR issued by Air Headquarters. The 10 year design collaboration agreement resulted only in a substantial waste of time and resources, and it was only in July 1984 that the Ministry of Defence was able to finalise its choice for a collaborator on the ALH project.

With regard to the manufacturing programs, it is evident that HAL did not encounter any serious problems in the manufacture of Gnats. Initial difficulties were more due to problems with the aircraft itself rather than HAL's inability to absorb manufacturing techniques and technology. The experience with the HS-748, however, was quite different. Mismanagement of the entire project during the early years was pointed out by a Special Committee appointed in 1962, which also recommended that the DHC-4 Caribou should be manufactured instead of the HS-748. Nonetheless, bureaucratic pressure ensured not only continued manufacture of the HS-748, but coercion of Indian Airlines into ordering it.

The MiG-21 manufacturing program also originated in a haphazard manner. When the project reached the execution stage, a supplementary agreement had to be concluded in order to ensure that the work could actually begin. Even then, both the project report and working details had to be compiled by Soviet experts and technicians and further complications arose when it was discovered that all the documentation was in Russian.

The manufacturing program did not proceed smoothly either. In consequence, a substantial number of MiG-21s had to be imported directly from the Soviet Union. Later the decision to manufacture the MiG-21 bis instead of the MiG-21M resulted in redundancy of materials and parts worth about Rs 148 million. The manufacturing record of the MiG-21 thus stands out as an example of inefficiency and poor planning.

Production of the Alouette Al-III helicopters also encountered similar problems in the early stages. Manufacture of the SA-315B Cheetah, on the other hand, suffered no serious setbacks both because of the experience acquired in manufacturing the Al-III and because the two helicopters used the same powerplant.

Manufacture of the HF-24 seems to have proceeded in conjunction with development activities to improve the performance of the aircraft, but the aircraft did not prove very successful, and attempts to improve its performance failed.

The HJT-16 also had a very low production rate; during the first five years an average of only about 10 per year was produced. This, coupled with a prolonged delay in development, resulted in the IAF having to import Iskra trainers from Poland. The quality of production versions of the HJT-16 also appears to have been substandard, at least till the mid-1970s, resulting in a low rate of aircraft availability. As far as the HPT-12 primary trainer is concerned, although it finally entered production, deliveries of this aircraft have yet to begin, so it is not possible to comment on its manufacturing record.

It can thus be observed that the manufacturing programs for the various aircraft were undertaken with an undue degree of optimism and without considering the actual limitations that HAL had to contend with. These included lack of suitably qualified personnel as well as appropriate tools and machinery. Quite often the advice

of overseas experts and consultants from the collaborators was disregarded for no obvious reasons - only to be followed after a substantial loss of time and money.

Since neither HAL nor the Government of India releases any information about the cost of production of various aircraft, no definite conclusion can be reached as to whether these programs have been economically viable or have been sustained only as a result of government grants and subsidies. This is because till a few years ago, there was no system of a fixed selling price for aircraft manufactured for the IAF: all aircraft were supplied on a 'cost-plus' basis, meaning that the IAF paid HAL the actual cost of production, and a certain percentage of surcharge which represented HAL's profit margin. The reason for this arrangement was twofold. Firstly, production tended to stabilise only about 5-10 years after a particular aircraft had entered production. Secondly, HAL's accounting policies and procedures were relatively outdated and it normally took a few years of production before it could offer fixed quotations for any particular aircraft. Materials for the aircraft manufactured under licence were acquired under bulk contracts and the suppliers were under no obligation to provide itemised price lists. This situation appears to have changed over the last few years, as far as most suppliers are concerned, but purchases from the Soviet Union remain virtually unaffected by the new arrangements.

Nonetheless, according to a study carried out in the early 1970s,[1] the foreign exchange cost of production of

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[1] *SIPRI. Arms Trade With the Third World*, p.739.

the MiG-21 was 192.5 per cent of the imported cost of the aircraft. Estimates for the Gnat and Alouette were reckoned at 147.1 and 55 per cent respectively. It further went on to add that in the West typical labour costs varied from 10-15 per cent of total production costs compared to 1-5 per cent in India. On the other hand the share of material costs in total production costs in India varied from 40-80 per cent compared to 35-40 per cent in Western countries. This is not only because the import of parts tends to be more expensive than import of complete aircraft, but also due to the fact that other overheads including transport costs and customs duties increase prices further. Then, development and manufacture of specialised parts, like the Hobson actuator unit for the Ajeet, for example tend to be fairly expensive ventures because of the limited market for them. The subsidy provided to Indian Airlines by the Civil Aviation Department to purchase the HS-748 is another example. While the first batch of aircraft purchased by the airlines received a subsidy of Rs 1.35 million per aircraft (representing the difference between the unit cost of an imported aircraft and that manufactured by HAL), this was increased to Rs 3.91 million per aircraft for the second batch. In other words, the cost of manufacture of the HS-748 by HAL had increased from 13 per cent more than that of Hawker Siddeley to nearly 30 per cent. Later the extra costs involved in procuring modification kits for the Military Freighter variant would have increased costs even further.

Thus, there is enough circumstantial evidence to suggest that the costs of various aircraft manufactured in India have been substantially higher than those of imported units. While indigenisation would reduce this price differential, it should be noted that substantial indigenisation in almost all aircraft manufactured by HAL has been achieved only near the end of the production runs. Given the low production rates that have characterised aircraft manufacture at HAL, the benefits of indigenisation would appear to have been extremely marginal, if there have been any at all.

Another factor that has contributed to high costs is the location of the various divisions of HAL. The engines and airframe/assembly factories in the MiG complex, for example, are located approximately 1,500 km apart from Koraput and Nasik respectively, while the Kanpur division, manufacturing the HS-748 and the HPT-32 is located about 2,000 km from the Engine division at Bangalore. The accessories complex at Lucknow while only 80 km from Kanpur, is also about 2,000 km from the main centres of aircraft manufacture at Bangalore and Nasik. These locations were chosen not because the areas were industrially developed, but because they were categorised as industrially backward. While this was a good political gesture from the Government by way of appeasing the various States, it cannot in any way be justified on economic or technical grounds. Not only have basic facilities like roads and communications had to be created but there have also been

substantial difficulties in recruiting suitable trained manpower. This policy, however, has not been changed despite HAL's three decades of extensive manufacturing experience. The new electronics factory is going to be located at Korwa in Uttar Pradesh, in an industrially backward district.

CHAPTER VI

SELF RELIANCE AND SELF SUFFICIENCY

Based on past experience, the issues that need to be examined are whether the creation of an aircraft industry has had any beneficial effects on other sectors of Indian industry and whether it has contributed towards self-reliance and sufficiency. Viewed in terms of transfer of technology, there has been very little benefit, if any. The biggest single handicap in this regard has been the comparative backwardness of other industries. Unlike Western manufacturers, HAL has been relatively unsuccessful in its efforts to create ancillary and small scale industries. Apart from the lack of a sufficient technological base, the other problem has been that of a limited market. Manufacturers have been unwilling to invest in an industry with no export potential and where the only customer would be the HAL. As a result, by 1981-82 there were only 23 ancillary units established at Bangalore, Hyderabad, Koraput and Nasik which supplied goods worth Rs 5.3 million, and purchases worth Rs 11.7 million were made from small scale industrial units in 1981-82;[1] the total, Rs 17 million is extremely low considering that the total consumption of indigenously produced raw materials components and spare parts by HAL during the year was Rs 408.4 million approximately.

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[1] *HAL Annual Report 1981-82*, p.15.

HAL has thus been faced with the problem of having to produce components which would normally be supplied by other manufacturers in Western countries. Not only has this entailed extra investment by HAL, thereby increasing costs, but has also resulted in dependence on foreign suppliers till such time as production commenced. One beneficial effect of this situation has been that HAL is now in a position to provide components and equipment required by other defence industries as well as civil users. It has been supplying radars and other equipment for the three services.

Nonetheless, it would be seen that these efforts have been on a rather limited scale and some of them could also have been carried out by other Government-owned industries. This would suggest that HAL initiated work in some areas primarily because of idle capacity or bureaucratic empire building. A good example in this context is the latest efforts at 'diversification'. HAL is now engaged in R&D in the use of renewable sources of energy, primarily to utilise renewable biomass fuel. It can thus be said that although industrial backwardness has hampered HAL's efforts to transfer technology to other sectors of industry there has been some progress in this direction.

The final question that needs to be examined is that of self reliance and self sufficiency. As explained in the beginning, Nehru's concept of national defence went beyong just the acquisition of arms - it included the capability to manufacture such equipment. This concept

was certainly justified during the Indo-Pakistan conflict of 1965 when the major suppliers, US and UK, placed a total embargo on the supplies of arms and spares to the sub-continent. A similar situation occurred during the 1971 war when the US once again embargoed the supply of arms. The impact of the 1965 embargo was substantial since with the exception of some helicopters and about six MiG-21s the entire IAF inventory consisted of aircraft purchased from the West, but this situation had changed considerably in 1971 when the Soviet Union had emerged as the major arms supplier to India. But, even then there would have been considerable problems in the event of a Soviet embargo, since the MiG manufacturing program was still in its initial stages and India was totally dependent on the Soviet Union for spares and support equipment.

Since then more than a decade has elapsed and HAL has made considerable progress in its indigenisation efforts, having set up repair and overhaul facilities for almost all the aircraft in IAF inventory. But, while the overt dependence on foreign suppliers has been reduced to a bare minimum, there has been virtually no change in the no so obvious dependence in terms of raw materials, components and spare parts. For example, approximately 80% of the total consumption of these items during 1979-81 was met through imports.[2] Nonetheless, this dependence is not so acute since raw materials like special steels and alloys

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[2] *HAL Annual Report 1980-91*, p.35.

could always be acquired from alternate sources in the event of a supplier refusing to meet contractual obligations.

Also, in this context it would be relevant to note that while initial manufacturing costs of different types of aircraft may have been higher than the unit cost of imported types, their life cycle costs have probably been much lower. This is because, over the years, HAL has managed to create the facilities to overhaul virtually all types of aircraft in IAF inventory, and maintenance of aircraft domestically has resulted in savings in foreign exchange. Also, given the facilities as well as the trained manpower that now exist within the country, it would also be likely that this has had a favourable affect on the operational efficiency of the IAF.

The other substantial and less visible benefits that have accrued because of the domestic manufacture of aircraft have been of a political nature. Apart from the prestige attached to the fact that an underdeveloped country like India is capable of meeting most of its air force requirements, it has also ensured a low key but sustained expansion of the IAF. For example, had India been importing all its requirements for combat aircraft from the West, it is a moot point whether the US would have been so reluctant to meet Pakistan's demands for more aircraft, the 1981 agreement for the supply of 40 F-16s notwithstanding. Another aspect of this situation has been that acquisitions from the Soviet Union have not received so much publicity as they have invariably been part of larger arms agreements

involving the supply of equipment to the army and the navy as well.[3]

Another advantage of the licence agreements has been that they gave HAL the opportunity to acquire technology in the late 1950s and early 1960s. In this respect there has been no substantial difference in India's experience with the various collaborators, viz. UK, France and to an extent the Soviet Union. Both UK and France not only agreed to a complete transfer of technology but were also instrumental in helping HAL to create manufacturing facilities. Also, there is no evidence of any political concessions that India might have had to make as a price of such transfer. Although there is unconfirmed evidence that the Soviet Union did appear to be uncooperative, especially in the early 1970s, it did not have any adverse impact on the manufacturing program. In any case, by the early 1980s the MiG complex appeared to have been doing very well as compared to other divisions. Also, the Soviet willingness to allow the manufacture of the MiG-21 bis and subsequently the MiG-27 makes it quite clear that Indo-Soviet cooperation in aircraft manufacture will continue well into the 1990s.

However, while HAL has had no difficulties in acquiring foreign technology, the main problems the company has faced have been largely internal. Because of government protection and lack of competition within the domestic market there was

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[3]For example, the decision to acquire the Jaguar and Mirage 2000 aircraft attracted far more publicity both domestically as well as overseas than the induction of the MiG-23 and the MiG-25 into the IAF.

no incentive to attain cost effectiveness or strive towards specialisation. Limits to design improvement proposed by HAL were not generally determined by the lack of funds. While the system was slow in making decisions, there is evidence to suggest that the handicaps were technological.

Only once was an attempt made to study the problems of the aircraft industry and to suggest guidelines for future action. This was done by the Subramaniam Committee on Aeronautics which submitted its report in 1969. Although the report itself has never been made public, the Committee, keeping in view the limitations of the industry, had made two recommendations:[4]

1. A new advanced technology aircraft to be built around a proven engine (obviously imported).
2. Indigenous design and development of an advanced technology engine to be undertaken simultaneously, to replace the proven engine eventually.

Three years later, a HAL Review Committee formulated even more ambitious 'corporate objectives' which included the development of the HF-24 MkII within five years and an Advanced Technology Aircraft incorporating indigenously developed airframe, engine and avionics within 10 years.[5] The only result of this activity was that in October 1978 it was decided to acquire and licence-manufacture the

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[4] *Times of India*, 16 May 1969.

[5] *HAL Annual Report 1972-73*, p.24, Annexure I.

Anglo-French Jaguar. HAL thus ended up manufacturing a proven aircraft instead of merely a proven engine.

Another major R&D project which appears to be destined for eventual failure is the GTX - a locally designed demonstrator turbojet under development at the Gas Turbine Research Establishment at Bangalore. This engine has been under development for the last two decades during which radical developments in engine technology abroad have resulted in turbofan jet engines. Hence, the chances that it will be adopted would appear to be very slim indeed.

A similar situation occurred with the project to design and develop the ALH. Although it had been decided as early as February 1978 to design a twin engine helicopter, no decision on a powerplant for it had been taken by late 1984.

In fact, apart from success in the indigenous development of minor items like radio altimeters, brake pads and engine components, HAL has had very little success in its R&D efforts. Figures for the last four years amply illustrate this situation:

	1978-79	1979-80	1980-81	1981-82
R&D Expenditure	16,582,287	13,151,339	16,227,294	11,730,711
Amortised	1,956,000	1,304,000	-	-
R&D Expenditure Written off	11,974,351	-	-	11,730,711

Source: *HAL Annual Reports 1978-82*

It can thus be seen that while a total sum of Rs 57.7 million was spent on R&D during the 1978-82 period, an expenditure of approximately Rs 22.8 million was written off during the same time while only Rs 34.9 million would appear to have been put to any production use. At the same time by 1982, there was an amount of Rs 56.7 million[6] in the R&D reserve, indicating that either HAL still lacked the infrastructure to undertake substantial research projects or that planning and coordination in this field were lacking. This becomes clear when the R&D expenditure of about Rs 11.7 million in 1981-82 is compared to an expenditure of Rs 16.5 million on travelling or Rs 12.5 million on foreign technicians' fees and expenses.[7]

Planning failure is apparent in HAL's manufacturing programs as well. Despite the ongoing MiG manufacture and the initiation of the phased manufacture of the Jaguar, the overall capacity utilisation of HAL in 1981-82 was only 70%. Value of production on the other hand was Rs 2,750 million - an increase of about 74% over the previous year.[8] This increase, however, is quite misleading in that it is not entirely due to an increase in the output of aircraft. This became apparent when the composition of sales by HAL is analysed:[9]

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[6] *HAL Annual Report 1981-82*, p.27.

[7] ibid., p.38.

[8] ibid., p.10.

[9] ibid., p.45.

(Million Rupees)

	1979-80	(%)	1980-81	(%)	1981-82	(%)
Finished Goods	1,068.7	(70)	1,181.6	(71)	1,323.2	(58)
Repair & Overhaul	245.9	(16)	242.1	(15)	527.3	(23)
Spares Supply	151.4	(10)	149.2	(9)	291.1	(13)
Development	41.7	(2)	50.5	(3)	78.3	(4)
Miscellaneous	46.3	(2)	39.0	(2)	46.5	(2)
Total	1,554.9	(100)	1,662.4	(100)	2,266.4	(100)

As the table shows, sales in the category of finished goods (predominantly aircraft) accounted for only 58 per cent of total sales in 1981-82 as compared to about 70 per cent for the two preceding years. This figure is bound to decline substantially in the next few years as various manufacturing programs come to an end. With the termination of the manufacture of Ajeet, the future of this program is also highly doubtful. While the Cheetah and Chetak helicopter manufacturing programs are likely to continue at least in the near future, they would do so at a much reduced scale since service requirements would appear to have been largely met. Even if an immediate decision was taken on the ALH project it would be at least 1990 before the development of the helicopter was completed and manufacture could be initiated. Hence, HAL might be forced to keep the helicopter assembly lines open if only in order to avoid retrenchment of trained personnel who would be difficult to recruit at a much later date.

In this connection, it would perhaps be relevant to compare the Indian experience with that of another Third World country which, over a period of less than two decades, succeeded in establishing a fairly successful aircraft industry - Brazil.[10] Founded in 1969 Embraer started with the design and development of a light transport aircraft - the Bandeirante which first flew in August 1972 and deliveries to the Air Force began in February 1973. Over 460 of this successful aircraft have been built so far.

Meanwhile, in May 1970, an order was placed for the Aermacchi MB-326 GB trainer which came to be known in Brazil as the Xavante. The licence built aircraft first flew in September 1971 and deliveries of 182 aircraft were completed in February 1983. In August 1974 an agreement was also signed with Piper Aircraft (US) for the licence assembly of various models of commercial aircraft. While the Xavante agreement involved little transfer of technology, an agreement in 1974 with the Northrop Corporation for the production of F-5E Tiger II vertical fins, wing and centre fuselage weapons pylons gave the company experience in honeycomb technology and bonded metal structures.

However, Embraer possessed virtually no military aircraft design experience when it signed a development contract for the EMB-312 Tucano basic trainer on 6 December 1979. The first Tucano was handed over to the air force in September 1983 when an agreement worth $181 million for

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[10] Details of the industry are based on 'Embraer: The Brazilian Phenomenon', *Air International*, Vol.28, No.2, February 1985, Vol.28, No.2, pp. 66-73.

120 aircraft (+ 60 options) was signed with Egypt. This agreement has not only been sold to Honduras and Venezuela but a coproduction agreement has been reached with Short Brothers (UK) where the aircraft is short-listed for the RAF AST-412 requirement.

Meanwhile Embraer also owns a 29.7% share, along with Aeritalia and Aermacchi for the design and development of the AMX Battlefield support and light attack aircraft and is responsible for the development testing and manufacture of wings, air intakes, horizontal stabilisers and fuel tanks. It is also involved in engineering for the aircraft electrical system, navigation system, avionics integration and some aerodynamic testing. In 1984, the company signed an agreement with the Sikorsky Corporation (US) for the transfer of technology for the design and manufacture of composite material parts.

The development of the Brazilian industry thus stands out in sharp contrast to that of India. It began with the development of a civilian aircraft and took on other projects in a systematic manner. The Xavante program did not involve any substantial transfer of technology but it did provide the company with manufacturing experience. Meanwhile, the company acquired advanced technology with its agreement with Northrop for the manufacture of F-5E parts. Apart from launching other transport aircraft the Tucano trainer was its only venture in the field of military aviation. Recognizing its limitation in the design and development of combat aircraft, its partnership

Aeritalia and Aermacchi for the development of the AMX aircraft will not only provide Embraer with experience in this field but also provide valuable design and manufacturing experience for planning the next generation of combat aircraft.

On the other hand, HAL took on a series of manufacturing programs at a time when there was no available expertise in project planning and execution and there was an acute shortage of trained manpower. Also, HAL has the singular distinction of initiating the manufacture of combat aircraft without any experience in the manufacture of civilian aircraft, a route not taken by any other manufacturer. While Embraer's planning strategy can be viewed at two levels, i.e. manufacture of aircraft and acquisition of new technology and manufacturing techniques as exemplified by its agreements with Northrop and Sikorsky for the manufacture of parts for export, there is no evidence of any such integrated planning by HAL.

While on the one hand, HAL has been having problems of idle capacity especially in the 1970s there is no evidence to suggest that HAL made any serious efforts to manufacture components for Western manufacturers, the direct benefit of which would have been threefold. Not only would HAL have acquired access to advanced technology required for this purpose, it would also have increased its capacity utilisation and productivity besides earning foreign exchange - an important consideration given the country's chronic shortages.

THE FUTURE

Consequently, HAL is at the crossroads. Its various manufacturing programs based on technology developed in the 1950s and to some extent the 1960s are coming to an end. Due to lack of perspective planning, the company has not been able to utilise the benefits of advances in aviation technology. Hence, it was inevitable that if it was to continue to satisfy IAF and other service requirements it would have to undertake another round of complete transfer of technology - a situation reminiscent of the 1950s and early 1960s. This is now underway.

Despite the poor track record of HAL's manufacturing activities in the past, it would appear that the 1980s might see a consolidation of its experience in aircraft manufacture and an improvement in its performance. The first indicator in this direction would be the Jaguar manufacturing program, an agreement for which was signed with British Aerospace on 21 October 1978.[1] Valued at Rs 13,000 m (₤816 m) the contract provided for the outright purchase of 40 aircraft and the local assembly of 45 aircraft. The Jaguars were to be manufactured at a new assembly plant set up at Bangalore at a cost of Rs 25 m (₤3 m) approximately.[2]

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[1] *Flight International*, 4 November 1978, p.1630.

[2] *International Defense Review*, 2/1980, p.279.

In order to save time, it was decided to purchase the tools and jigs directly from BAe. The initial HAL assembled Jaguars were to have an indigenous content of about 10 per cent, being equipped with HAL developed radio altimeter V/VHF communication and IFF systems[3] and licence manufactured undercarriage, wheels and brakes, hydraulic system, air condition fuel system, ejection seats in subsequent models.[4] A subsequent agreement provided for the local manufacture of 31 additional aircraft.[5]

The first Indian assembled Jaguar flew on 31 March 1982 as per schedule with a total of three scheduled for delivery by the end of 1982.[6] Although by 1980 it seemed to have been accepted that the degree of indigenisation would be considerably less than that envisaged earlier, the indigenous content after the assembly/manufacture of the first 45 aircraft was likely to be about 30 to 40 per cent in the airframe but higher in the engine and equipment.[7] By 1982 HAL was entering phase III of the Adour engine manufacture under which 20 per cent of the engine would be made from imported raw materials by 1984. The ultimate

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[3] *International Defense Review*, 1/79, p.127.

[4] *Hindu*, 12 March 1982.

[5] *Air International*, Vol.23, No.6, December 1982, p.260. Also, *Statesman*, 19 October 1982.

[6] *Indian Express*, 1 April 1982. Also *Economic Times*, 8 March 1982.

[7] Interview with Alan Keys, Executive Director, British Aerospace, India, New Delhi, 7 February 1980.

goal of indigenisation by the final stage of the program being about 80 per cent.[8] A total of eight Jaguars were to be assembled in 1983 with another 15 scheduled for delivery in 1984.[9]

Although the Jaguar program will not match the MiG manufacturing program in terms of numbers, it is extremely significant to the HAL because it has introduced the company to modern manufacturing techniques such as the use of computer numerically controlled (CNC) machining, integral milling of skins and honeycomb bonding. New techniques are also being introduced at the Engine Division at Bangalore. Manufacture of the Jaguar's Adour Mk811 powerplant again requires CNC machining and use of titanium alloys. This upgrading does not apply only to airframe and engine manufacture. A new factory being set up at Korwa (in Uttar Pradesh) at a cost of more than £20 million (Rs 305 m approx.) will manufacture the Jaguar's navigation and weapons aiming computers, head up displays and other electronics equipment under licence from Western manufacturers. Based on this, the company hopes to develop CRTs, head up and head down displays, optics and inertial navigation platforms for use in future projects. Also included for development are data recording and other digital electronic equipment and components requiring precision mechanical engineering. The

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[8] *International Defense Review*, 11/1982, p.1608.

[9] *Indian Express*, 6 July 1983.

company is also spending another $10 million (Rs 100 m approx.) on five major computer systems which will be used in computer-aided design (CAD) work, programming of CNC machines as well as production planning and inventory control.[10]

Consequently, given the progress with the Jaguar manufacturing program so far, it is reasonable to conclude that HAL has come a long way from the muddled, ad hoc arrangements that typified its activities in the 1960s and to an extent, the 1970s. Not only has the project been proceeding on schedule but the technology acquired is expected to make a substantial contribution to future projects. But one area where HAL has failed to make any significant progress is in the field of aircraft design. While HAL designed HPT-32 and HJT-16 Kiran MkII are now in production, the fact remains that they are the efforts which date back to the 1960s. The ALH agreement with MBB will provide valuable experience to HAL engineers in the field of helicopter design since it involves collaboration right from the project definition phase. In the field of combat aircraft, although HAL has tinkered with various projects in the past, none of them actually materialised. It would appear that HAL has finally realised its limitations in this regard. Included in a 15 year corporate perspective

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[10] For details of the new round of the transfer of Western technology to HAL, refer Chris Kjelgaard, 'HAL Spools Up' in *Flight International*, 18 December 1982.

plan drawn up by the HAL in 1980-81 are, apart from the ALH and a turbo-prop version of the HPT-32, a light combat aircraft (LCA).[11]

The LCA project includes the design and developemnt of a high performance, multi-role combat aircraft that will meet the requirements of the IAF in the 1990s and beyond. A sum of Rs 5.5 billion has been sanctioned by the Government for the first stage of the project and Indian experts have held discussions with representatives of British Aerospace (UK), Dornier and MBB (FRG) and French aircraft manufacturers for possible collaboration in the program, the entire cost of which will be borne by India.[12]

Thus, Indian planners have not only finally realised the futility of 'going it alone' but also seem to have accepted the fact that programs for design and development of modern aircraft involves a fairly substantial degree of interdependence. Althoug neither the ALH nor the LCA will be operational before the mid-1990s, the two programs will provide the HAL with valuable design experience of both helicopters and combat aircraft, an experience which it has lacked so far, with the singular exception of the not-so-successful HF-24. The 1980s will also witness a greater consolidation of manufacturing programs with the main

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11 *Hindu*, 4 December 1981.

12 S. Sapru in *Indian Express*, 8 December 1983.

manufacturing activities being confined to the MiGs, the Jaguar and the Light Transport Aircraft. With improved production planning manufacturing techniques and inventory control it seems very likely that during this decade, the Indain aircraft industry i.e. HAL will succeed in achieving Nehru's vision of self-reliance and self-sufficiency - a goal towards which substantial progress has already been made.

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APPENDIX

HINDUSTAN AERONAUTICS LIMITED (HAL), BANGALORE

The Hindustan Aircraft Limited was established in December 1940 as a limited company owned jointly by the Government of Mysore and Walchand Hirachand. The Government of India joined in as a shareholder by purchasing the entire interest of the latter in 1941. Its original program was the assembly of Harlow trainers (August 1941) and Curtiss Hawk fighters (July 1942), but during the Second World War the factory was transformed into a Repair/Overhaul Base and aircraft production was suspended. In 1948, the company took up the design and development of the Basic Trainer HT-2, completing it in 1953, and besides other projects, also undertook the assembly of Vampire Fighters and Prentice Trainers. In 1957, the manufacture under licence of Gnat fighters and Orpheus engines was taken up, and in 1959 that of Dart engines for the HS-748 transport aircraft being manufactured by the Aircraft Manufacturing Depot at Kanpur (set up in 1959).

In August 1953, Aeronautics India Limited, a public sector company, was formed to establish and manage the three factories for the manufacture of the MiG-21 aircraft.
In an attempt to streamline the aircraft industry, Hindustan Aircraft and Aeronautics India were merged on 1 October 1964, and the new company redesignated as Hindustan Aeronautics Ltd (HAL) which also took over the Aircraft Manufacturing Depot, Kanpur. Also, the Railcoach Division of Hindustan Aircraft Ltd

was separated and transferred to the management of Bharat Earth Movers Ltd. w.e.f. 1 January 1965.

After a recent restructuring, HAL now consists of three complexes:

1. Bangalore Complex: which comprises the Airframe and Aircraft Assembly Unit, Aeroengine Factory, Design Complex and the Helicopter Division.
2. The MiG Complex: consisting of the Nasik, Koraput and Hyderabad Divisions.
3. Accessories Complex: Lucknow and Hyderabad Divisions. Also, a new Avionics Factory is under construction at Korwa.

Each of these complexes is headed by a separate Managing Director. Besides these, there is the Kanpur Divison which manufactures the HS-748 and HPT-32, under a General Manager who reports directly to the Chairman.

Pursuant to an agreement signed in 1978, the Bangalore complex has also been involved in the assembly of British Aerospace Jaguar International combat aircraft. The first UK built airframe components for final assembly in India were delivered to HAL in 1981 and the first Indian assembled Jaguar flew on 31 March 1982, and the second in June. A trainer version was completed at the end of the year and the initial program for the assembly of 45 aircraft is expected to be completed by 1986.