

Design, Development, Manufacture and Induction of Light Combat Aircraft

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Preface

This Performance Audit Report for the year ended March 2014, has been prepared for submission to the President of India under Article 151 of the Constitution of India.

The Report contains the results of examination by Audit of the issues relating to Design, Development, Manufacture and Induction of Light Combat Aircraft (Air Force). The Performance Audit (PA) covers the progress made in execution of LCA programme since the last Review, i.e., Para 28 of the Report No. 8 of 1999 of the C&AG of India, Union Government, Defence Services (Air Force & Navy) for the year ended 31 March 1998.

EXECUTIVE SUMMARY

Background

Indian Air Force (IAF) was operating MIG-21 series of aircraft manufactured during 1966 to 1987 and majority of these aircraft were expected to be phased out in the 1990s, thereby resulting in significant fall in combat level of IAF. Thus, IAF mooted the proposal (early 1980s) for a replacement aircraft for MIG-21 fleet. It was against this backdrop that the indigenous design and development of Light Combat Aircraft (LCA) was sanctioned (1983). Government of India constituted (June 1984) Aeronautical Development Agency (ADA), Bangalore, a society registered (June 1984) under the Societies Registration Act, 1860 under the Ministry of Defence, as a dedicated institution for the management of LCA project.

IAF had issued Air Staff Requirement (ASR) in Oct 1985 with a projected requirement of 220 Light Combat Aircraft (200 Fighters + 20 Trainers) to be inducted by 1994. As per the ASR, Light Combat Aircraft is required to be built as a light weight multi-mission fighter aircraft, having contemporary air combat and offensive air support capabilities with excellent maneuverability for close air combat at low and medium altitudes. The aircraft should be able to provide extended Air Defence cover over the forward bases and tactical battle area.

The LCA management structure consists of the General Body (chaired by the Defence Minister) responsible for taking decisions on the scientific and technical activities of ADA and the Governing Body (chaired by the Scientific Advisor to Raksha Mantri) for effective monitoring of its aims and objectives, apart from Technical committee (chaired by Director General, ADA) and LCA Programme Management Committee (chaired by Programme Director, ADA), which are responsible for the progress of the design and development of the LCA.

ADA executes the LCA development by utilising the capabilities of national agencies/institutions (referred as work centers) working in Aerospace technology. Hindustan Aeronautics Limited (HAL) is the principal contractor for detailed design, development, manufacture and flight testing of LCA.

Light Combat Aircraft Programme got delayed considerably and even after a lapse of thirty years, the Light Combat Aircraft has only achieved Initial Operational Clearance (December 2013) involving a delay of eight years and the Full Operational Clearance, which was scheduled to be completed by December 2008, is now scheduled to be achieved by December 2015 (as projected by ADA).

Audit Approach

The Performance Audit (PA) covers the progress made in execution of LCA programme since the last Review, i.e. Para 28 of the Report No. 8 of 1999 of the C&AG of India, Union Government, Defence Services (Air Force & Navy) for the year ended 31 March 1998. Our conclusions are based upon audit conducted at Aeronautical Development Agency, Hindustan Aeronautics Limited, Air Headquarters and DRDO Headquarters and its laboratories. The Report has five Chapters. Chapter I is introduction and Chapter II, III and IV contain audit findings. In Chapter V, the audit conclusions have been summarized.

Ministry of Defence (R&D)/ADA/Air HQ response

The PA report was issued to Ministry of Defence, ADA and Air HQ in December 2014. Our findings were finalized with reference to the replies furnished by ADA, HAL, Air HQ and DRDO Headquarters and its laboratories. Reply from Ministry of Defence is awaited (March 2015).

Key findings

LCA programme was initially sanctioned in 1983 with a development schedule of eight to ten years against IAF's requirement of induction by 1994. Our analysis revealed that the project schedules had slipped, mainly on account of design changes necessitated due to change in weapon requirements, non-availability of Kaveri¹ engine, delay in completion of work packages by the work centres, etc. LCA achieved IOC in December 2013 with 53 concessions/permanent waivers considerably reducing its operational employability, is yet to be inducted in IAF squadrons, as discussed below:

1. Execution of LCA Project, extent of meeting Air Staff Requirement including weaponisation

- ADA's decision to advance building of two prototypes from Full Scale Engineering Development (FSED) Phase-II to FSED Phase-I on the ground of accelerating the development process of LCA, failed to yield the desired results as the FSED Phase I was closed in March 2004 involving a delay of six years and without completing all the activities, which were carried forward to FSED Phase-II. More importantly, this decision of ADA rendered the prototypes deficient of critical onboard systems (Multi-Mode Radar, Self-Protection Jammer, Radar Warning Receiver) and led to ADA using the

¹ Gas Turbine Research Establishment, Bangalore could not develop the Kaveri engine, meant for LCA, as per the LCA schedule and specifications, necessitating ADA to go in for import of GE-F404-IN20 aero engine from M/s GE, USA to continue the development activities of LCA.

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Limited Series Production aircraft (meant for IAF use) towards flight testing/evaluation of these critical on board systems, in contravention to the commitment given to the GoI while obtaining sanction (November 2001) for building of these aircraft. **(Para 2.1)**

- LCA Mark-I, which achieved Initial Operational Clearance (December 2013) has significant shortfalls (53 permanent waivers/concessions) in meeting the ASR as a result of which, it will have reduced operational capabilities and reduced survivability, thereby limiting its operational employability when inducted into IAF squadrons. Shortcomings in LCA Mark-I (increased weight, reduced internal fuel capacity, non-compliance of fuel system protection, pilot protection from front, reduced speed) were expected to be overcome by development of LCA Mark-II, an aircraft with lower weight and a higher thrust engine which is expected to meet the ASR, had been taken up by ADA in November 2009 and is scheduled for completion by December 2018. **(Para 2.3)**
- IAF would be constrained to induct fighter LCA without availability of trainer LCA, adversely impacting pilot training. Production of trainer aircraft at HAL was delayed as the trainer LCA had not achieved IOC/FOC. As regards flight training simulator, IAF was using an upgraded Full Mission Simulator (FMS) at ADE for pilot training, pending supply of a FMS by HAL at LCA operating base. **(Para 2.3.1)**
- Addition of new weapons by Air HQ for operational edge of LCA (March 1997, December 2009) necessitating design changes on the aircraft, coupled with delayed specifying (December 2009) of integrating R-73E missile with Multi-Mode Radar/Helmet Mounted Display and Sight and delayed identification (December 2009) of Beyond Visual Range Missiles also contributed to the delays in achieving IOC/FOC by LCA. **(Para 2.3.2, 2.3.3)**
- LCA Mark-I is deficient in Electronic Warfare capabilities as specified by IAF, as the Self Protection Jammer could not be fitted on the aircraft due to space constraints and the Radar Warning Receiver/Counter Measure Dispensing System fitted on the aircraft are having performance issues, which are yet to be overcome (January 2015). **(Para 2.3.4)**
- LCA programme is being monitored by General Body, Governing Body, involving the representation of MoD, Ministry of Finance at the highest level,

various committees at ADA/HAL, Empowered Committee chaired by Chief of Air Staff. In spite of this, delays in completion of work packages which affected the LCA programme schedules, indicates that coordination of efforts at various levels and monitoring of the programme by all the agencies involved, has not been as envisaged. **(Para 2.4)**

- Need for a Liaison Group between Air HQ and ADA to ensure closer interaction between the design team and the user for better appreciation of mutual perception, had been recommended by the LCA PDP Review Committee² as early as in 1989. However, no such liaison group was formed and active user (Air HQ) participation in the LCA Programme started only after November 2006, which also impacted the LCA development. **(Para 2.5)**

2. Development of Indigenous capability through LCA Programme

- Government of India had emphasized (June 1993) on increasing the indigenous content of LCA while sanctioning FSED in phased manner, but ADA did not make any roadmap for indigenization during LCA development. As a result, indigenous content of LCA estimated by ADA as 70 *per cent* actually worked out to about 35 *per cent* (January 2015). **(Para 3.1)**
- LCA systems such as Kaveri engine, Multi-Mode Radar, Radome, Multi-Functional Display System and Flight Control System Actuators taken up for indigenous development could not be developed successfully, resulting in LCA's continued dependency on import of these systems. Development of Jet Fuel Starter, though achieved indigenously, had performance issues which are yet to be resolved (January 2015) **(Para 3.1.1).**

3. Creation of manufacturing facility at HAL for LCA and operational impact on IAF

- Prototype version (PV) and Limited Series Production (LSP) of LCA³ built by HAL had low serviceability due to delay in snags analysis, slow recovery of aircraft from rectification, shortage of critical LRUs at flight hangar, aircraft being used as test rigs, large number of unproductive sorties etc. which impacted availability of aircraft for flight testing and contributed to delays in development of LCA **(Para 4.2.2).**

² A committee chaired by Director, NAL, and consisting of members from ADA, HAL, ADA and Air HQ, constituted by SA to RM in May 1989 to review the comments of Air HQ on the LCA Project Definition Phase report prepared by ADA in September 1988.

³ Technology Demonstrators, Prototype Vehicles and Limited Series Production aircraft.

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- The manufacturing facilities created at HAL presently cater for production of only four aircraft *per annum* against the envisaged requirement of eight aircraft *per annum* due to delays in procuring plant and machinery, tools and jigs and also construction of production hangars, which would further impact production of LCA and induction into IAF squadrons. **(Para 4.3)**
- Repair and Overhaul (ROH) facility for LCA, as specified in the ASR has not been created fully at HAL. Out of the 344 Line Replaceable Units⁴ of LCA, 90 LRUs were considered non-repairable. Of the remaining 254 LRUs, while ROH facilities in respect of 185 LRUs were available, ROH facilities were yet to be established for 69 LRUs (January 2015). **(Para 4.4)**
- Design, development and productionisation of LCA through concurrent engineering did not compress the development time as envisaged in the FSED Phase-II sanction (November 2001) since LSP aircraft were built in a phased manner with specific capabilities for the purpose of flight testing/evaluation and even LSP-8 fell short of the ASR in terms of weight and speed, for which permanent waivers had to be granted by Air HQ when LCA achieved IOC (December 2013) **(Para 4.5.1)**.
- Awarding of the 20 IOC contract by MoD to HAL in 2006 when LCA design was nowhere near finalization, was premature, as only Technology Demonstrators/Prototypes were flying and LSPs were yet to be built. This led to delay in productionisation of LCA and formation of squadrons by IAF, as HAL is yet to supply any aircraft against the contract (January 2015). **(Para 4.6.1)**
- Awarding of contract (December 2010) for supply of 20 FOC configuration aircraft by MoD to HAL even before commencement of supply of IOC configuration aircraft, freezing of designs and achieving of FOC was premature. Further, HAL had advances of ₹1509.22 crore since 2010 without utilising it against the contract. (January 2015). **(Para 4.6.2)**
- Due to delay in manufacture and supply of LCA, IAF had to undertake alternate temporary measures such as upgradation of existing aircraft⁵ at a cost of ₹20,037 crore to overcome depleting squadrons with obsolete aircraft and

⁴ It is a modular component of an aircraft that is designed to be replaced quickly in case of failure, which reduces down time of the aircraft.

⁵ MiG BIS, Mirage, MiG-29 and Jaguar fleet.

IAF is looking forward for early induction of LCA to overcome the drawdown of squadrons. **(Para 4.7)**

4. Conclusion

While we appreciate the efforts made by ADA and its work centres in the indigenous development of LCA which is comparable to many contemporary aircraft in the world, considerable time taken in the development of LCA has delayed the productionisation and subsequent induction of the aircraft into IAF thereby impacting the operational preparedness of IAF with reduced squadron level. Moreover, the LCA Mark-I despite achieving the Initial Operational Clearance does not meet the ASR, which reduces its operational employability. Final Operational Clearance of LCA is yet to be achieved. This PA, therefore, points out the need for a more efficient management of planning and execution of aircraft development programmes, closer interaction and coordinated efforts among all the stake holders involved, ensuring effective indigenisation efforts, creation of adequate manufacturing facilities in a timely manner and supply of aircraft to IAF in line with their induction planning.

Recommendations

- Realistic timelines should be projected by MoD while seeking approval for such projects from the GoI and the same be adhered to during their execution with coordinated planning and effective in-built monitoring mechanism to produce desired results in time.
- In view of the complexity of the technology involved, while deviating from the approved plan of development, ADA should consult the user (Air HQ) and obtain prior approval of sanctioning authority/Ministry for such deviations, so as to minimize waivers and concessions at the time of acceptance by the user (IAF).
- The agencies *viz.* DRDO, ADA and HAL, should undertake the projects strictly in conformity with the specifications projected by the IAF, who should be involved right from the planning stage, so as to ensure timely achievement of their requirements.
- Indigenisation efforts should be made in coordination with all the agencies involved, with a well-defined indigenisation plan and a clear roadmap, so as to develop quality product as per the requirement, in order to avoid import substitution.
- MoD should award contract to production agency at an appropriate stage of development of a system/equipment in order to avoid the necessity of extending delivery schedule consequent to delay in development of the system, apart from the resultant blocking of funds/inventory and to overcome obsolescence of the components procured by the production agency.

CHAPTER I: INTRODUCTION

1.1 Introduction

Government of India (GoI) sanctioned (August 1983) design, development and manufacture of Light Combat Aircraft (LCA) over 8 to 10 years from 1983 at an estimated development cost of about ₹560 crore including six flying prototypes. Subsequently after the completion of the feasibility study and project definition, the Cabinet Committee on Political Affairs (CCPA) approved (February 1991) to execute the project in two phases of Full Scale Engineering Development (FSED). The project was assessed¹ to be completed by 2004. The project is still in progress (January 2015).

Delays in execution of LCA project with respect to project definition, deficiencies in planning and financial management were commented upon in Para 50 of Report No. 3 of 1989 of the C&AG of India, Union Government Defence Services (AF&Navy) for the year ended 31 March 1988. Delay in execution of Phase-I of LCA project which included development of Multi Mode Radar, Flight control system, Digital Electronic Engine Control, integration of Kaveri engine on LCA, etc and consequent up-gradation of MiG-Bis aircraft, import of Su-30 MKI aircraft to cover the shortfall in fighter aircraft, were highlighted in Para 28 of the Report No. 8 of 1999 of the C&AG of India, Union Government, Defence Services (Air Force & Navy) for the year ended 31 March 1998.

Ministry of Defence (MoD) in their Action Taken Note (ATN) had stated (July 2004) that regular review meetings of monitoring bodies were conducted and periodical Joint Review of LCA Programme by Scientific Advisor to Raksha Mantri (SA to RM) /Director General-ADA, Chairman HAL & Vice Chief of Air Staff of IAF to accelerate programme implementation had been introduced since 2002. Status of compliance to the ATN is discussed in Chapter II.

¹ As per joint recommendations (March 1990) of Chief of Air Staff and Secretary, Department of Defence R&D for Phased development of LCA.

However, the LCA development has slipped delaying manufacture of LCA at HAL and induction into IAF. Consequently, it has impacted the operational preparedness of IAF. Hence, the present review of the project was taken up to examine the project execution.

1.2 Organisational structure for implementation of LCA

GoI constituted (June 1984) Aeronautical Development Agency² (ADA) as a dedicated institution for the management of LCA project. MoD, besides sanctioning funds for LCA project, is involved in the decision making process through the General Body and Governing Body of ADA. The General Body of ADA presided by Raksha Mantri annually reviews the progress of LCA project, while the Governing Body chaired by the Secretary, Department of Defence R&D manages all affairs and funds of the society. Thus, Ministry had pivotal role to play in overall implementation of the LCA project. Hindustan Aeronautics Limited³ (HAL), a Defence Public Sector Undertaking is the principal contractor for the LCA project.

1.3 Roll out of the LCA project

The FSED Phase-II was taken up in February 2000 even before the closure of Phase-I and the FSED Phase-I was retrospectively closed (July 2005) with effect from 31 March 2004 within the sanctioned cost of ₹2,188 crore by carrying forward the pending activities to FSED Phase-II as discussed in Chapter-II.

It is seen from the minutes of the Empowered Committee meeting (October 2007) that LCA powered by the imported engine would have performance shortfalls towards meeting the ASR and further observed that LCA weight had exceeded the specification by one tonne, and accordingly it was felt that a higher capacity and bigger aero engine was the only possible solution to achieve LCA performance as laid out in the ASR. The Committee, therefore, recommended (October 2007) redesigning of airframe in order to

² A society set up under Societies Registration Act, 1860 under MoD.

³ Engaged in design, development and manufacture, upgrade, repair and overhaul of aircraft, helicopters, aero engines, avionics and navigation system equipment and marine and industrial gas turbine engines for both military and civil applications.

accommodate a larger diameter engine and suggested that LCA Mark-II⁴ with redesigned airframe must be ready by the time existing LCA Mark-I with IOC and FOC configuration would be produced by HAL, with an aim to productionise LCA Mark-II by 2016.

Accordingly, MoD sought (August 2009) sanction from GoI for an additional FSED Phase, termed as FSED Phase III, at a cost of ₹2431.55 crore (FE ₹818.60 crore), with the stated benefits of an aircraft with alternate engine and lower weight having better performance to meet the requirements of IAF.

Government of India, accordingly, sanctioned (November 2009) FSED Phase-III at a cost of ₹2431.55 crore (FE ₹818.60 crore) for design and development of two prototypes of LCA Mk-II with an imported alternate engine⁵ with a delivery schedule of 31 December 2018. Thus, LCA development can be termed as completed only when the LCA Mk-II is developed (December 2018) under FSED Phase-III, productionised and inducted into IAF squadrons thereafter, as LCA Mk-II is expected to meet the ASR.

Development of LCA Mk-II under Phase-III is also simultaneously in progress (January 2015) along with FSED Phase II and an expenditure of ₹804.15 crore had been incurred (January 2015).

1.4 Expenditure on LCA programme

A total amount of ₹10397.11 crore (FE ₹3800.01 crore) was sanctioned for the three FSED phases of LCA programme, against which, ADA had incurred (October 2014) a cumulative expenditure of ₹8294.39 crore (FE ₹2768.18 crore) as detailed in the **Annexure-I**. This sanction and expenditure are exclusive of cost of Kaveri engine (₹2,839 crore) and Electronic Warfare Suite (EWS) (Mayavi) (₹154.74 crore) developed for LCA as development of Engine and EWS were sanctioned (1989, 2005) as separate projects by DRDO. These two cases are discussed in Chapter II and III.

⁴ LCA Mark I and Mark II distinguished only in October 2007, as the aircraft planned with improved aero engine was designated as LCA Mark II, and the present version as LCA Mark-I.

⁵ GE-F414-INS6.

1.5 Audit objectives

The execution of the LCA programme was examined to assess the extent of

- i. Achievement of Air Staff Requirement (ASR) and Weaponisation of LCA;
- ii. Indigenous capability developed through LCA programme;
- iii. Development and manufacturing of LCA (AF) including setting up of manufacturing facilities at HAL;
- iv. The preparedness of IAF to induct LCA into Service and consequent operational impact.

1.6 Sources of Audit Criteria

The sources of Audit Criteria were:

- The Air Staff Requirement of 1985;
- Ministry of Defence's (MoD) sanction letters and approvals of Cabinet Committee on Security (CCS) including papers leading thereto;
- Procedure for Design, Development and Production of Military Aircraft and Airborne Stores (DDPMAS) – 2002;
- Minutes of meetings of General body, Governing Body of ADA, Empowered Committee, Programme Management Team of IAF, HAL Board of Directors etc.;
- Memorandums of Understanding, Consultancy contracts, supply orders entered into by ADA and HAL and MoD contracts with HAL for supply of LCA;
- Papers relating to the Work services and IAF preparedness for induction into IAF and operation of LCA;
- LCA trial reports, reports of various committees and certifying agencies;

1.7 Scope and methodology of Audit

The Performance Audit (PA) covers the progress made in execution of LCA programme since the last Review i.e. Para 28 of the Report No. 8 of 1999 of the C&AG of India, Union Government, Defence Services (Air Force & Navy) for the year ended 31 March 1998. The records of ADA, Air HQ, HAL and DRDO Headquarters and its laboratories⁶ affiliated to design and development of LCA were seen for conducting the review. As MoD had requested (October 2013) to take up the audit after completion of Initial Operation Clearance of LCA, an Entry Conference for the performance Audit could be held on 24 March 2014 at DRDO Bhavan, New Delhi. The field audit was conducted during the period from April 2014 to mid October 2014. Preliminary Audit observations and questionnaires were issued to ADA, Air HQ, DRDO and HAL for eliciting their replies and obtaining requisite information, evidences and clarifications, wherever required. A draft PA report was issued (December 2014) to the Ministry of Defence, for which reply is awaited. MoD was requested (December 2014) for an Exit Conference which is still (March 2015) to be held.

1.8 Acknowledgement

We acknowledge the support extended by MoD, Air HQ, ADA, DRDO & its laboratories and HAL in the furnishing of documents, information, and replies to the audit queries raised during the course of the PA.

⁶ Defence Avionics & Research Establishment (DARE), Bangalore, Aeronautical Development Establishment (ADE), Bangalore and Centre for Air Borne Systems (CABS), Bangalore.

CHAPTER II : PROJECT PROGRESS

Objective: To examine the execution of the LCA project to assess the achievement of Air Staff Requirement and Weaponisation for LCA.

2.1 FSED Phase-I

Cabinet Committee on Political Affairs approved (Feb 1991) in principle, execution of the LCA project in two Full Scale Engineering Development (FSED) phases as detailed below:

FSED Phase-I closed without achievement of milestones

FSED Phase-I: Building and limited flight testing of two LCA Technology Demonstrator (TD1 and TD2) aircraft to demonstrate confidence levels in critical technologies¹ through 210 hours of test flying and parallel development of other technologies² and proving them on ground rigs/ flying test beds.

FSED Phase-II: Building further five prototypes and integration of other technologies developed in parallel in Phase I, Integration of Kaveri engine, Flight-testing and weapon integration to achieve IOC and FOC.

Accordingly, FSED Phase-I was sanctioned (June 1993) by GoI at a cost of ₹2188 crore³ [including Foreign Exchange (FE) ₹873 crore] for development and limited flight testing of two LCA Technology Demonstrators (TD1 & TD2) and parallel development of other technologies by June 1998.

It was however seen in audit from the approval (November 1995) of the General Body, ADA, that during the course of FSED Phase-I, ADA had, on the ground of accelerating the development process of LCA, advanced the manufacture of two prototypes (PV1 and PV2) from FSED Phase II to FSED

¹ Fly-by-wire control system, Composite technology, computer controlled Electro Mechanical System & Glass Cockpit.

² Multi-Mode Radar (MMR), Internal Self-Protection Jammer (SPJ)/Radar Warning Receiver (RWR).

³ This amount was inclusive of ₹560 crore sanctioned in August 1983.

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Phase-I so as to utilise the savings in FSED Phase-I occurred due to shifting of certain systems⁴ from import list to indigenous development list. ADA's decision was in contravention of the Cabinet approval for Phased development, wherein the building of PVs was to be taken up in FSED Phase-II only after TDs had been built and flight tested for 210 hours to demonstrate confidence levels in critical technologies.

As a result of ADA's decision, the two PVs (viz. PV1 and PV2), building of which was taken up even before the first flight of TDs⁵ and development of other technologies, could not be integrated with systems such as Multi-Mode Radar⁶ (MMR), Internal Self Protection Jammer⁷ (SPJ)/Radar Warning Receiver⁸ (RWR) (other technologies) which had not been developed by then (1995-2006). These systems were required to be developed and proved on ground rigs/flying test beds in FSED Phase-I and integrated on the PVs in FSED Phase-II as per the phased development sanctioned in June 1993.

Subsequently, as per the sanction (November 2001) for FSED Phase-II, remaining three PVs and eight Limited Series Production (LSP) aircraft were to be manufactured and the LSPs were required to be delivered (May 2006-May 2008) to IAF. Besides, the PVs were also required to be integrated with the other technologies (MMR, SPJ, RWR).

However, we observed that decision of ADA to advance the development of PV1 and PV2 had a cascading effect on the remaining PVs (PV3, PV4 (converted as PV6⁹) and PV5), which were also rendered deficient of these systems (MMR, SPJ, RWR). As a consequence of this, ADA had to resort to utilisation of even the LSP aircraft (which were to be handed over to IAF) towards flight testing/evaluation as discussed under Para 2.2. The decision to advance building of two PVs was got ratified by ADA from GoI (January 1998).

⁴ Carbon Fibre Composite Wing, Jet fuel Starter and Aircraft Mounted Accessory Gear Box.

⁵ First flight was made on January 2001.

⁶ Used for tracking targets from Air to Air, Air to Surface including sea. It facilitates all weather launching of weapons.

⁷ Internally mounted electronic warfare system that detects and interprets radar signals and automatically selects the proper countermeasure to jam or deceive them.

⁸ Alerts pilots of the various types of hostile emitters employed by other countries and enables pilots to initiate suitable action to minimize attrition.

⁹ Discussed at Para 2.3.1.

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The development of other technologies (MMR, SPJ, RWR) and development of Kaveri engine was also delayed as discussed in sub Para 2.3.4 and Chapter III.

Various milestones under FSED Phase-I and their actual achievements are indicated in Table I below:

Table I

Sl No	Milestone	Scheduled date of completion	Actually date of completion
1	Roll out of first aircraft (TD1)	June 1995	November 1995
2	First flight of first aircraft (TD1)	December 1996	January 2001
3	First flight of second aircraft (TD2)	September 1997	June 2002
4	First flight of PV1 ¹⁰	December 1999	November 2003
5	First flight of PV2 ¹¹	June 2000	Shifted to FSED Phase II
6	Completion of 210 hours of flying (TD1 and TD2)	June 1998	124 hours completed by 31 March 2004 and balance shifted to FSED Phase II

Department of Defence R&D, MoD had requested (April 2005) approval of Cabinet Committee on Security for post-facto closure of FSED Phase-I with effect from 31 March 2004 and within the sanctioned cost of ₹2,188 crore while the remaining flight testing of TDs, flight testing of PV2 and completion of development of Multi-Mode Radar (MMR) would be carried out as part of LCA FSED Phase-II. Based on CCS approval, GoI accorded post-facto sanction (July 2005) for the closure of FSED Phase-I with effect from 31 March 2004. ADA also carried forward (August 2005) balance work of 42 ongoing work packages valuing ₹65.16 crore as on 31 March 2004 to FSED Phase-II. These 42 work packages pertained to development of MMR, Flight control System actuators, Digital Flight Control Computer, Jet Fuel Starter, Drop Tanks, etc (delay in development of these systems has been discussed in sub-para 2.3.4, 2.4.2 and Chapter III).

¹⁰ As per GoI ratification of January 1998.

¹¹ As per GoI ratification of January 1998.

Thus, in spite of the fact that FSED Phase-I was delayed by six years and treated as completed in March 2004 as against the scheduled completion of June 1998, the intended objectives of the phased development were not met completely. ADA's decision (1995) to advance two PVs from FSED Phase-II to FSED Phase-I in order to accelerate the LCA programme failed to yield the desired results, as other technologies (MMR, SPJ, RWR) to be integrated on PVs were yet to be developed and proved.

2.2 FSED Phase-II

FSED Phase-II ongoing with delayed completion of mile-stones

While FSED Phase-I was in progress, MoD, Department of Defence R&D submitted (November 1999) a Note to CCS seeking an interim sanction of FSED Phase-II towards developing remaining three prototypes including one trainer variant (PV-3, PV-4 and PV-5) at a cost of ₹666.34 crore, on the ground that some of the work centres had already completed the activities assigned to them under FSED Phase-I and it was necessary that the remaining tasks were also assigned to them to avoid idling of facilities. Accordingly, GoI accorded sanction (February 2000) for Interim FSED Phase-II, specifying that this sanction would merge with the final FSED Phase-II sanction.

Later, Department of Defence R&D, MoD submitted (October 2001) a Note to CCS for sanction of FSED Phase-II which included apart from the three prototypes sanctioned under Interim FSED Phase-II, completion of Initial Operational Clearance (IOC) and Final Operational Clearance (FOC) using all the LCA prototypes by December 2008. The Note also sought (October 2001) creation of production facilities at HAL at the rate of eight aircraft *per annum* and concurrent production of eight Limited Series Production (LSP) aircraft (for IAF use), in order to address technology transfer issues involved in the transition from development to production and also to reduce production lead time. GoI sanctioned (November 2001) the proposal of DRDO for FSED Phase II at a total cost of ₹3301.78¹² crore (FE ₹1526.49 crore) with a probable date of completion (PDC) by end December 2008.

Various milestones under FSED Phase-II and their actual achievements are indicated in **Table II** below:

¹² Including interim sanction of ₹666.34 crore.

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Table II

Sl No	Milestone	Original date of completion (November 2001)	Revised date of completion (November 2009)	Actually achieved date
1	PV2- first flight (Carried forward from Phase-I)	December 2002	-	December 2005
2	PV3-first flight	July 2003	-	December 2006
3	PV4 ¹³ -first flight	December 2003	Jan-Feb 2010	November 2014
4	PV5-first flight (Trainer)	October 2004	August 2009	November 2009
5	Achievement of IOC	December 2005	December 2010	December 2013
6	Creation of facilities for achieving LSP of 8 aircraft per annum at HAL	May 2006	May 2006	Facilities created at HAL only for manufacture of four aircraft
7	Manufacture of eight LSP standard LCA by HAL and delivery to IAF	May 2006 - May 2008	May 2006 - May 2008	HAL manufactured seven LSP aircraft ¹⁴ during April 2007 to March 2013
8	Achievement of FOC	December 2008	December 2012	Not achieved

It is evident from the above Table that building of PVs was completed three to eleven years beyond the scheduled date. This further contributed to delay in achieving of IOC, which was achieved in Dec 2013, against the sanctioned date of December 2005.

Audit observed that delays pertaining to achievement of milestones of FSED Phase II were mainly on account of continued design modifications on LCA (discussed at Chapter IV Para 4.5.1) and low availability of aircraft (discussed at Chapter IV Para 4.2.3).

As per the MoU (June 2002) entered into between HAL and ADA, HAL was to manufacture and supply eight LSP aircraft between 2006 and 2008. Against this, HAL supplied seven LSP aircraft during April 2007-March 2013 with a delay ranging from 4 to 51 months, mainly due to design changes by ADA, which resulted in equipping each of the LSPs with different configuration (as discussed in Chapter IV Para 4.5.1). We also observed that ADA had utilised these LSP aircraft towards flight testing/evaluation for achieving IOC/FOC,

LSPs built for IAF use were utilised by ADA towards flight testing /evaluation purposes

¹³ PV4, which was a fighter version was re-designated as a Trainer Version, PV6 in December 2005, thus rendering one fighter prototype deficient for flight testing/evaluation against the initially planned four fighter prototypes (PV1 to PV4).

¹⁴ LSP-6 was planned for 2015-16.

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instead of handing over these aircraft to IAF, in contravention to the commitment given (October 2001) while obtaining GoI sanction for building these LSPs under FSED Phase II.

When reasons for using the LSPs for flight testing/evaluation instead of handing them over to IAF were enquired (July 2014) in audit, ADA stated (October 2014) that due to shortcomings on TD/PV aircraft (discussed in Para 2.1), LSP aircraft were built in a phased manner with specific capabilities. As such the transfer of technology to the production agency (HAL) was executed in batches by identifying the LSP-1 to LSP-8 to resolve design issues and conduct the flight test towards finalization of standard of preparation (SOP) for production.

Reply of ADA confirms the audit view that building of PVs before development of other technologies resulted in these aircraft having shortcomings, compelling ADA to utilise even the LSPs towards flight testing of LCA.

Thus, the purpose of manufacturing of LSPs for the usage by IAF has not yet been met (January 2015) and these aircraft have been used by ADA as additional prototypes for evaluation purposes, in contravention to the commitment given (October 2001) while obtaining sanction for building these LSPs.

In November 2009, GoI extended the milestones of LCA project up to end of December 2012 (IOC-December 2010 and FOC-December 2012) and additional amount of ₹2475.78 crore (FE ₹581.92 crore) was sanctioned to cover extended programme cost, expenditure towards Programme Management, maintenance and operational cost of 15 aircraft (2 TDs, 5 PVs and 8 LSPs), foreign flight test consultancy for optimizing the flight testing, spares for LSP aircraft, etc. Out of this, the major portion of the cost towards maintenance of 15 aircraft (₹187.78 crore) during this extended period was due to ADA utilising the LSP aircraft along with TDs/PVs towards flight testing/evaluation.

However, even these extended timelines could not be adhered to by ADA as LCA achieved IOC only in December 2013 and FOC is yet to be achieved (January 2015). In response to an audit observation (December 2014) regarding non-accomplishment of FOC, ADA stated (January 2015) that FOC of LCA had been rescheduled to December 2015.

Thus, LCA programme sanctioned in 1983 and taken up (1993) as phased development for completion by 2004, is yet to be completed (January 2015). This had impacted the manufacture of 20 IOC standard LCA and 20 FOC standard LCA, for which contracts had been awarded by the Ministry to HAL in 2006 and 2010 (as discussed in Chapter IV Para 4.6.1 and Para 4.6.2) and induction into IAF to tide over the depletion of combat squadrons (as discussed in Chapter IV Para 4.7 and 4.9).

2.2.1 Inadequate expertise in flight testing and consequent flight test consultancy with a foreign firm

An Empowered Committee (EC) was constituted (November 2006) with Chief of Air Staff as its chairman to monitor the flight development activity and all issues for smooth induction of LCA on a quarterly basis. It is seen in Audit from the minutes of the very first meeting of the EC (December 2006) that there was inadequate expertise in flight testing within the Indian design community; and therefore EC felt that consultancy with reputed design centres in advance nations would be needed for flight testing to meet the IOC and FOC schedules.

Accordingly, ADA concluded (March 2009) a consultancy contract with M/s EADS, Germany at a cost of 18.5 Million Euros (₹127.65 crore) which comprised two Phases:

- Phase I of the consultancy contract was to be completed by July 2011 along with the achievement of IOC of LCA and
- Phase II of the consultancy contract was to be completed by January 2013 along with the achievement of FOC.

ADA could not implement all the recommendations of the consultancy contract pertaining to both Phase-I and II during its currency by January 2013 as detailed below:

- Pertaining to IOC Release Sequence of carrier Bomb, Light Stores
- Pertaining to FOC
 - i. System test philosophy, test process, rig test environment,
 - ii. BVR Missile and usage of Air-to-Air Identification of Friend or Foe,
 - iii. ADA Rig improvements using the Test Support System

ADA could not complete flight testing activities for FOC during the currency of the consultancy contract and had to go in for a second consultancy contract for completing these activities

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However, ADA signed (March 2013) the Closure Report of the consultancy contract treating the contract closed with retrospective effect from January 2013, as PDC of consultancy contract had since expired in January 2013.

In response to an audit observation seeking (October 2014) the reasons for not implementing the recommendations of the consultant and acceptance of the closure of the contract, ADA clarified (October 2014) that it could not implement the consultant recommendations during the period of the contract as IOC schedules were shifted because of major safety related snags, ejection related issues, etc. ADA further stated (January 2015) that task wise recommendations of consultant were since implemented for achieving IOC and in respect of Phase II of the contract (FOC), it was stated that these were understood and work was in progress.

Audit further observed (October 2014) that ADA concluded (August 2014) another contract with the same firm viz. EADS, Germany for consultancy in flight testing for achieving FOC and Post-FOC activity for a period of 16 months with consultation charges of 3.7 Million Euros (₹30.34 crore). The scope of work included consultancy for (i) Flight test envelope expansion and carefree maneuvering and (ii) separation of weapons and stores from LCA and (iii) design improvement of the Crew Escape System. Out of the three tasks, two tasks at (i) and (ii) were already included as part of the scope of the first consultancy contract (March 2009).

Audit enquired (October 2014) reasons for conclusion (August 2014) of another contract with the same firm for two tasks which should have been completed under the first contract. In response, ADA while admitting the fact of re-inclusion of the two tasks in the scope of work, clarified (October 2014) that the Phase III included not only FOC related tasks, which would be completed within six months, but also post-FOC activity related to design improvements of Crew Escape System.

The fact remains that all the recommendations of consultant under the first contract (March 2009) were not implemented. The financial impact on account of re-inclusion of the two tasks of the first contract again in the second contract could not be quantified in Audit as there was no task wise price in the above contracts. Also, the very purpose of going in for flight consultancy for timely meeting of the IOC/FOC schedule was also not met.

2.3 Shortfall in accomplishment of Air Staff Requirement (ASR)

Air Staff Requirement (1985) prescribes the physical parameters of LCA such as aircraft weight, fuel capacity, load carrying capacity of weapons, missiles, survivability, navigation, etc and features like single point defueling, pilot protection system, all weather operations, fuel system protection etc. to make the aircraft capable of performing its role of multi mission fighter aircraft and have increased survivability against battle damage. The ASR also envisages timeline for induction of LCA, quantity of LCA fighter and trainer required. There were no revisions to the ASR by IAF, except in respect of weapon requirements, as discussed in Para 2.3.2.

The Project Definition Phase (PDP) document of LCA prepared by ADA (December 1988) had been reviewed by Air HQ (March 1989) who found it deficient in the crucial parameters of aerodynamic configuration, volume and weight as set in ASR, particularly with reference to significant increase in weight of LCA, which could adversely affect performance. To resolve the deadlock, it had been decided (March 1990) that the development may be executed as Full Scale Engineering Development (FSED) in a phased manner.

We however observed during the course of audit that LCA which had achieved (December 2013) IOC did not meet the ASR in terms of increased weight, reduced internal fuel capacity, non-compliance of all-weather operations, non-achievement of single point defueling, fuel system protection, pilot protection, etc., for which, ADA obtained (December 2013) from Air HQ altogether 53 temporary concessions/permanent waivers.

To an audit observation (June 2014) regarding operational impact of the concessions/ waivers, IAF replied (December 2014/February 2015) that the concessions/permanent waivers would adversely impact the operational performance.

The 20 permanent waivers were granted for ASR parameters which the current configuration of LCA Mk-I with GE-F-404-IN20 engine cannot achieve. Also, the performance shortfalls applicable to 20 IOC aircraft under production at HAL will also be applicable 20 FOC aircraft as these waivers were granted for LCA Mk-I in its current configuration. The 33 temporary time bound concessions were granted for ASR parameters which are still under design/development and testing and would adversely affect LCA's combat potential.

LCA Mark-I achieved IOC in December 2013 with 53 waivers/ concessions due to shortfalls in meeting the ASR, impacting its operational utilisation by IAF

Thus, the views expressed by Air HQ as early as in March 1989 that the aircraft planned to be developed by ADA would be deficient in crucial parameters of aerodynamic configuration, volume and weight adversely affecting its performance have not been overcome in LCA Mk-I developed by ADA as it does not meet the requirements of IAF fully in terms of combat potential and survivability.

It was precisely with this forethought that the Empowered Committee headed by Chief of Air Staff had recommended in October 2007 for the building of LCA Mk II under FSED Phase III in order to meet the ASR parameters. Consequently, till the LCA Mk II is developed, manufactured and inducted into squadrons, the IAF would be constrained to use the LCA Mk-I (40 aircraft) with reduced operational capabilities.

2.3.1 Delay in development and supply of trainer aircraft and simulator

In order to impart effective operational training in air combat and ground attack to IAF pilots, the ASR also specified delivery of a trainer variant of LCA and a full mission flight simulator, which are discussed below:

A. Trainer aircraft

LCA trainer aircraft is yet to achieve IOC/FOC, thus trainer aircraft cannot be produced by HAL and supplied to IAF, impacting the training requirements

The ASR envisaged a total requirement of 200 fighters and 20 trainer aircraft of LCA. The trainer variant of the LCA was to retain all attributes of the fighter variant except for the changes necessary to accommodate a second seat for imparting training to IAF pilots. The ASR had envisaged that the fighter and trainer aircraft should enter the IAF service by 1994.

Out of the five prototypes to be built under FSED Phase-II, PV5 was to be the trainer prototype. However, based on the requirement projected (December 2005) by IAF for an additional trainer prototype, ADA decided (March 2006) to convert PV4, a fighter variant prototype, to a trainer variant (as PV6). These trainer prototypes (PV5 and PV6) were also to be built and flight tested along with the fighter prototypes (PV1, PV2 and PV3) towards achieving IOC/FOC and consequent production of trainer aircraft against 20 IOC and 20 FOC contracts (2006, 2010) at HAL (each of these contracts included 4 trainers along with 16 fighters). However, first test flight of PV5 was achieved only in November 2009 and PV6 achieved its first flight only in November 2014. Consequently, trainer LCA is yet to achieve IOC/FOC

(January 2015). Air HQ had expressed in Empowered Committee meeting held in April 2013 that availability of operational trainer aircraft was essential for pilot training.

When Audit pointed out (May 2014) delays in attaining IOC/FOC of trainer prototypes and their consequent non-availability to IAF, Air HQ stated (December 2014) that non-availability of trainer aircraft would have adverse impact on pilot training. In response to an audit query (December 2014) regarding non availability of trainer LCA, ADA stated (January 2015) that PV-6 would be handed over to IAF for pilot training.

ADA's reply is not tenable as a prototype trainer is not a substitute for a production standard trainer which had undergone flight testing/certification towards meeting the operational standards.

Thus, HAL would not be able to produce production standard trainer aircraft (against IOC/FOC contracts) for IAF till the achievement of IOC/FOC of trainer aircraft and its finalization of Standard of Preparation (SOP). Thus, trainer variant as specified in ASR was yet to be handed over to IAF (January 2015), and resultantly, IAF would be constrained to induct fighter LCA without availability of trainer aircraft which would have adverse impact on pilot training.

B. Full Mission Simulator

A flight simulator artificially re-creates aircraft flight and the environment in which it flies, for pilot training. It includes replicating how aircraft fly, how they react to applications of flight controls, the effects of other aircraft systems, and how the aircraft reacts to external factors such as air density, turbulence, wind shear, cloud, precipitation, etc.

ASR specifies that a full mission flight simulator of the LCA single seater variant was to be developed and delivered in advance of production aircraft (1994) as part of training requirement.

As a full mission simulator (FMS) required for training of IAF pilots is yet to be built by HAL and supplied to IAF at the LCA operating base, IAF pilots have to utilise the up-graded FMS at ADE, Bangalore

It was observed in audit that HAL forwarded (November 2006) a proposal for manufacture and supply of Full Mission Simulator (FMS) in respect of LCA to Air HQ. While the proposal was pending for clearance by MoD, ADA sanctioned (July 2010) a project to Aeronautical Development Establishment (ADE), Bangalore to upgrade the existing Real Time Simulator¹⁵ (RTS) at their end to the standard of FMS at a cost of ₹4.50 crore in order to meet the training requirements of the IAF pilots.

In response to an audit observation (September 2014) regarding the status of FMS, ADE stated (October 2014) that the existing RTS had been upgraded to FMS and was being used by NFTC¹⁶/HAL test pilots for evaluation and training.

When present position of HAL's proposal for supply of FMS submitted (November 2006) to Air HQ was enquired (February 2015) in audit, Air HQ stated (February 2015) that though technical evaluation of HAL's proposal had been accepted by MoD, a case for procurement of FMS from ADE is being processed as per the decision taken (July 2014) in the Empowered Committee.

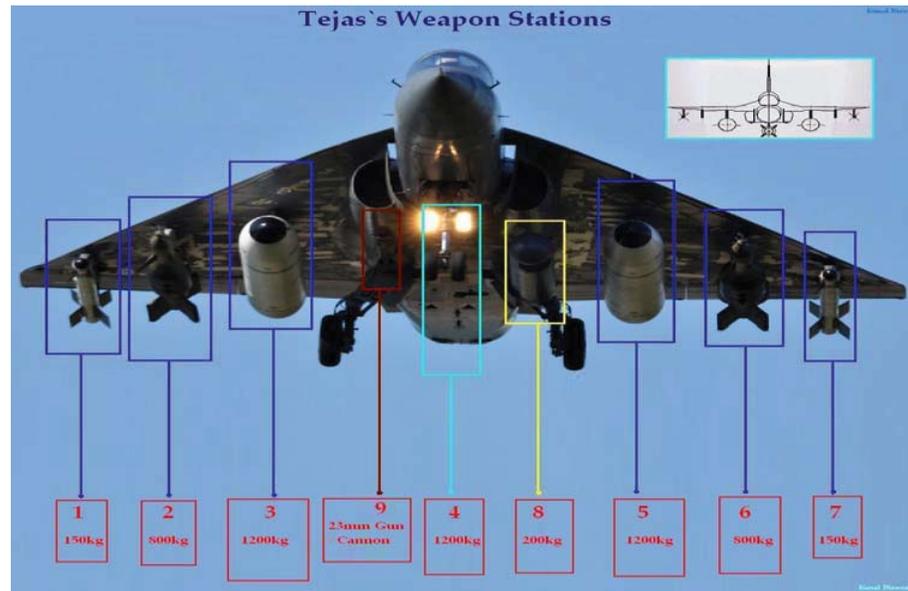
Thus, IAF would be using the RTS upgraded as FMS at ADE, till a full fledged FMS is manufactured by HAL and supplied for the usage at LCA operating base.

2.3.2 Meeting of weapon requirement on LCA as per ASR

As per the ASR, LCA is required to be provided with seven under-wing/fuselage hard points for the carriage of bombs, rockets, missiles, Recce/laser designator pods and fuel tanks. The outboard stations were exclusively for the carriage of close combat missiles (CCMs). The aircraft should be able to carry a weapon load of at least 3000 kg.

¹⁵ RTS built under a work package sanctioned (March 2008) by ADA at a cost of ₹98 lakh, for evaluation of control law of LCA.

¹⁶ National Flight Test Centre, Bangalore.



Weapon stations load carrying capacity- Source: <http://defenceforumindia>

Revising the requirement of weapons on LCA by IAF periodically contributed to the delays in LCA programme

Audit observed (May 2014) that IAF had revised¹⁷ the weapons requirement from time to time such as replacing R-60 missile with R-73E missile¹⁸, adding M-62 Russian Bombs, Counter Measures Dispensing System¹⁹, etc for integration on LCA. When impact of these changes on the LCA programme were enquired in audit, ADA stated (June 2014) that these changes had delayed the programme schedules as follows:

- Change of Close Combat Missile from R-60 to R-73E had resulted in redesign of integral wing and associated manufacturing and testing efforts involving delay of 14 months.
- Addition of Russian 500 Kg (M-62) bombs necessitated design and fabrication of adopter and software development which delayed the programme by 16 months.
- Addition of CMDS led to design modifications and software development with an additional time of 18 months.

When the above delays caused due to changes in the weapons by IAF as reported by ADA was pointed out (September 2014) in audit, Air HQ stated (December 2014) that the extended schedule of design and development of

¹⁷ March 1997 and December 2009.

¹⁸ An infrared-guided (heat-seeking) missile.

¹⁹ A mission critical system to protect the aircraft against radar and heat-seeking missiles and Radar Guided Anti-Aircraft Missiles.

LCA had resulted in several weapons and systems becoming obsolete/out of stock/operationally irrelevant and to retain operational edge, newer weapons had to be included. It was also stated that ADA being the programme manager could have inducted additional resources to realize the integration of the changed weapons in time.

Thus, due to design and development of LCA programme getting extended from time to time, IAF had to opt for newer weapons to retain operational edge of LCA. This consequently had a further impact on the timelines of the LCA programme.

2.3.3 Status of integration of weapons on LCA

Audit observed that delayed identification/procurement of weapons/integration also contributed to delays in LCA programme as discussed below:

i. Integration of R-73E Missiles

R-73E is an infrared-guided (heat-seeking) missile capable of being targeted by a helmet-mounted sight allowing pilots to designate targets by looking at them. The R-73E is a highly maneuverable missile capable of making a significant difference in combat.

As per the ASR, R-60 a close combat missile was to be fitted on LCA. IAF revised (March 1997) the requirement to fitment of R-73E missile in place of R-60 missile. ADA concluded (August 2004) a contract with M/s Elbit, Israel, for integration of R-73E missile on LCA including consultancy thereon at a total cost of 3.69 Million USD (₹17 crore) to be completed within 24 months (August 2006). There were delays in integration of R-73E missile on LCA due to redesign of integral wing and associated manufacturing and testing efforts (necessitated due to change from R-60 to R-73 missile). In the meanwhile, Air HQ while revising (December 2009) the weapon requirements, further specified that R-73E should be integrated with Multi-Mode Radar²⁰ (MMR) and Helmet Mounted Display & Sight²¹ (HMDS) as an IOC requirement. The delivery schedule was amended several times (eight times involving a total of

Delayed specifying of integrating the R-73E missile with MMR/HMDS contributed to the delays in achievement of IOC

²⁰ Used for tracking targets from Air to Air, Air to Surface including sea and facilitates all weather launching of weapons. Delay in development of MMR is discussed in Chapter III.

²¹ HMDS is used for launching of weapons accurately. HMDS was procured from M/s Elbit Israel by ADA (Purchase Order dated August 2004 valuing 6.85 MUSD, items received in November/December 2011).

delay of 88 month) due to integration of R-73E missile with HMDS/MMR and related flight tests. The integration of R-73E missile with LCA was completed (December 2013) by ADA, after integration and release of R-73E using HMDS and MMR, and LCA achieved IOC (December 2013).

In response to audit observation (October 2014) regarding impact of delay in integration of R-73E missile on LCA on IOC schedule, ADA admitted (October 2014) that delay in integration of R-73E missile with HMDS and MMR had impacted the IOC schedule. ADA further stated (January 2015) that the avionics integration of R-73E missile with MMR and HMDS sensor was delayed due to delay in development and flight testing of MMR/HMDS.

Thus, IAF specifying additional requirement of firing the R-73E missile using HMDS/MMR sensors in December 2009, which was not specified earlier in the ASR (1985), contributed to slippage of IOC schedule beyond the planned date of December 2010, which was achieved only in December 2013.

ii. Integration of Derby & Python-5 Missile

Derby missile is a Beyond Visual Range²² (BVR), medium-range (50 km) active-radar seeker, air-to-air missile built by the Israeli weapons manufacturer M/s Rafael Advanced Defense Systems. Python-5 is also a missile built by M/s Rafael with a range of 20 kms with an advanced electro optical imaging and infrared seeker.

ASR of 1985 broadly indicated the requirement of BVR configuration missiles on LCA without specifying any particular BVR missile. It was only in December 2009 the Air HQ communicated the requirement of specific BVR missiles viz. Derby and Python-5 Missiles on LCA as part of the FOC.

ADA placed (December 2011) a Purchase Order on M/s Rafael Advanced and Defence Systems Ltd, Israel for supply and Integration of Derby & Python Missile on LCA-Air Force / Navy at a total cost of 21.2 Million US dollars (equivalent to ₹99.64 crore) with a delivery schedule of 20 months which was revised (June 2013) to 34 months (i.e. up to October 2014). Audit also observed from the ADA records that ADA had attributed (October 2013) delayed identification of specific BVR missiles viz., Derby and Python-5 by IAF had resulted in revision of the FOC schedule beyond December 2008.

²² BVR missile is an air-to-air missile which engages enemy target at 37 kms or above.

Delayed identification of BVR missiles by IAF impacted the FOC schedule of LCA

To an audit query (October 2014) with regard to present position of receipt of the missiles and integration on LCA, ADA stated (October 2014) that the missiles had been received in October 2014 and integration on LCA was in progress.

Audit sought (November 2014) the reasons for belated decision of IAF in identifying specific BVR missiles. In reply, Air HQ stated (December 2014) that correct choice of weapons on any platform was a critical decision and effectiveness of the platform was directly proportional to the weapons that it could employ. Thus, weapons were to be introduced when the aircraft was close to maturity to maintain an operational edge over the adversary. Air HQ also did not accept the contention of ADA that delay in identification of BVR missile by IAF resulted in extension of FOC schedule as even core issues such as design of avionics, all weather clearance, MMR evaluation, etc were required to be resolved.

ADA further replied (January 2015) that all weather clearance of the aircraft had no impact on BVR integration and avionics design did not have any issues. It was further stated that BVR integration activities were undertaken by them only after concluding contract in December 2011, after Air HQ had given (July 2011) go-ahead for integration of Derby and Python missiles.

The fact remains that delayed development of LCA by ADA, coupled with delayed identification/go-ahead of specific BVR missile by IAF had impacted the FOC schedule of LCA, which is now expected to be achieved by December 2015.

iii. Manufacture of Drop tanks and pylons

Drop tanks are auxiliary externally mounted fuel tanks and Aircraft pylon is a vertical structure used to mount external equipment such as drop tanks and weapons (stores) on an aircraft. The MoU (June 2002) between ADA and HAL stipulated supply of eight aircraft sets of role equipment consisting of drop tanks²³ and pylons.

Delay in manufacture and supply of 725 litre drop tanks by HAL resulted in non-compliance of IOC requirement and concession had to be obtained by ADA

²³ 1200 litres-16 Nos, 800 litres-16 Nos and 725 litres-8 Nos.

It was observed in audit (October 2014) that as against 64 pylons and 40 drop tanks to be supplied by 2008, HAL manufactured and supplied 49 pylons and 13 drop tanks between April 2007 and August 2014 thereby completing only 60 percent of the deliverables.

In response to Audit enquiry (October 2014) regarding delay in manufacture and supply of drop tanks and pylons, HAL stated (November 2014) that delay in manufacture of drop tanks and pylons were due to changes in design of components, process of manufacturing, non-availability of anodizing²⁴ plant facility in Composite Manufacturing Division (CMD), and delay in getting type approval for drop tanks and pylons.

HAL further stated (November 2014) that it had planned for completing the manufacture and supply of the balance drop tanks and pylons by 2015-16.

Thus, due to changes in design and delay in establishment of manufacturing facilities, HAL could not adhere to the committed delivery schedule. As a result, 725 litre drop tank was not integrated on LCA (IOC requirement) and ADA had to obtain concession towards this while achieving IOC (December 2013) (discussed at Para 2.3).

2.3.4 Electronic Warfare capabilities for LCA

LCA Mark-I will be deficient in EW capabilities as the SPJ developed by DARE cannot be fitted on it due to space constraints and RWR/CMDS are having unresolved performance issues, impacting operational utilisation of LCA

Combat aircraft are equipped with Electronic Warfare (EW) capabilities to degrade the effectiveness of enemy radar and radio systems. ASR specified that LCA should be capable of carrying an Electronic Counter Measures (ECM) Pod. In addition, provision was to be made for an internally mounted Self Protection Jammer (SPJ) in the LCA with provision for future updates. Air HQ revised (March 1997) the EW capability on LCA to include SPJ, Radar Warning Receiver (RWR) and Counter Measures Dispensing System (CMDS).

²⁴ An electrochemical process that gives the metal surface a durable, corrosion-resistant finish.

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Details of development of these EW systems for LCA Mk-I by Defence Avionics Research Establishment (DARE), Bangalore – SPJ and RWR – and Bharat Dynamics Limited (BDL), Hyderabad – CMDS – are indicated in the Table below:

(₹ in crore)

Sl No.	Item Description	Role on the aircraft	Sanction No and date	Sanctioned cost/ Revised cost	Original PDC/ Revised PDC	Present position	Impact on LCA
1	Self-Protection Jammer	It radiates interfering signals toward an enemy's radar, blocking the receiver with highly concentrated energy signals.	No DARO/04/1216/M/01/91/ S/D(R&D) dated 29 September 2005	116.02/154.74	March 2011/ December 2014	System developed by DARE will not be fitted on LCA Mk-I due to space constraints	LCA Mk-I is deficient in a self - protection jammer
2	Radar Warning Receiver	It alerts pilots of the various types of hostile emitters employed by other countries and enables pilots to initiate suitable action, which is crucial for the success of missions and survival of aircraft deployed for such missions.	ADA letter No ADA/PD (S)/TARANG-1B/2010 dated 15 May 2010	7.12	December 2010	RWR fitted on LCA Mk-I is having issues such as degradation of direction finding accuracy, reset in air, etc and DARE is in the process of resolving these issues.	LCA Mk-I is deficient of a fully functional RWR
3	Counter Measure Dispensing System	It is a mission critical system to protect the aircraft against radar and heat seeking missiles and Radar Guided Anti-Aircraft Missiles	ADA letter No ADA/PD(S)/CMDS /08/06 dated 27 October 2006	1.58	April 2008/ May 2010	CMDS fitted on LCA Mk-I exhibited deficiency in misguiding enemy missiles and ADA/BDL are in the process of modifying the design to overcome the flaw.	LCA Mk-I is deficient of a fully functional CMDS

It can be seen from the above Table that development of SPJ by DARE was not successful, and as a result, the LCA Mk-I will be deficient of this system. As regards the other two EW components - RWR and CMDS - till the performance issues are resolved, these two systems will also have performance shortfalls as indicated in the above Table. Consequently, LCA Mk-I remains deficient in full EW capabilities as specified in the ASR.

2.3.5 Shortfall in creation of Manufacture and repair facilities

ASR also envisaged establishment of manufacture and repair facilities at HAL. However, there were shortfalls in creation of manufacture and repair facilities at HAL as discussed in Chapter-IV.

2.4 Work-packages for LCA programme

As per the Memorandum of Association (1984), ADA was to execute the LCA development by utilising the capabilities of national agencies/ institutions (referred as work centers) working in Aerospace technology. There were/are 152 work centres in all, viz. DRDO labs (38), Public Sector Undertakings (PSUs) (22), Government organizations (36), educational institutes (14) and other private agencies (42). Audit examination of the work packages awarded to work centres by ADA and results thereof are discussed below:

2.4.1 Non-maintenance of complete data in respect of Work-packages for FSED Phase-I

ADA had not maintained the work package-wise complete details of FSED Phase I as confirmed by it (January 2015) in its reply to draft Audit report (December 2014). Thus, analysis of the work packages (WPs) undertaken by ADA under FSED Phase-I could not be carried out in the present Audit.

2.4.2 Work-packages for FSED Phase-II

The details of the WPs awarded by ADA for FSED Phase II and its completion are indicated in the **Table** below:

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Type	Number of work packages	Value (₹ in crore)	Work packages completed				Ongoing Work Packages
			Within schedule	With delay ranging			
				< one year	1-3 years	> 3 years	
Critical	110	630.21	14	32	16	29	19
Non-Critical	393	482.18	119	89	46	96	43
Total	503	1112.39	133	121	62	125	62
Percentage to total packages			27	24	12	25	12

Delay in completion of work packages by work centres contributed to the overall delays of the LCA programme

As per the Table, ADA had awarded 503 WPs amounting to ₹1,112.39 crore for FSED Phase-II. Out of 503 WPs, ADA had identified 110 WPs valuing ₹630.21 crore as critical based on the basic functionality requirement for the safe flight of the aircraft. ADA entrusted all the work packages (from 2002 to 2013) to 152 work centres and out of which, only 27 per cent of the WPs were completed within the schedule and remaining 73 per cent of the WPs were delayed. Among the critical WPs, only 13 per cent were completed within schedule. Even the on-going 62 WPs (related to FOC activities) were also behind schedule with delays ranging from 2 months to 11 years.

Audit on a sample review of execution of 194 WPs (51 critical, 143 non-critical) valuing ₹632.23 crore (₹338.37 crore - critical, ₹293.86 crore - non-critical) noticed instances of delayed completion of work packages, which are shown in the Table below:

(₹ in crore)

Sl. No.	Item description	Name of the work centre	Sanction No. and date	Sanctioned cost/ revised cost (₹)	Original PDC/ revised PDC	Actual date of completion	Delay in month
1	Digital Flight Control Computer	Aeronautical Development Establishment, Bangalore	ADA sanction letter No ADA/LCA/IFCS/DFCC/PM/99 dated 27 May 1999	8.30/12.84	May 2001/ September 2009	September 2009	100
2	Multi-Mode Radar	Electronic & Radar Development Establishment (LRDE),	ADA letter No ADA/PD(S)/192/91/631 dated 17 June 1991	62.27	December 1997/ December 1999	MMR developed by LRDE/HAL found short of expectations and joint development of MMR with a	

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		Bangalore & HAL, Hyderabad Division				foreign firm discussed in Chapter III	
3	Hydraulic System LRUs	HAL, Lucknow Division	ADA sanction letter No ADA:GS:9438:S09 dated 07 October 2000	3.69	March 2002/ December 2009	December 2009	93
4	LRUs for fuel system sensors, Hydraulic systems, etc	HAL, Lucknow Division	ADA Sanction No ADA:GS:16712:080/S103(A) dated 28 January 2006	3.40	June 2007/ April 2012	April 2012	58

Audit enquired (September 2014) about delays in completing the WPs by the entrusted work centres and basis for selection of work centres. In reply, ADA stated (September 2014) that it had no authority/control on the working of work centres. ADA also admitted (October 2014) that the delay in development of WPs had affected the LCA programme schedule. ADA also stated (January 2015) that work packages/ project sanctions were continuously reviewed and monitored by ADA through participation in Project Review Committee (PRC) meetings. However, the priority accorded by these work centres was depending upon the production targets set by their management on which ADA had no authority. As regards the basis for selection of work centres, ADA stated (October 2014) that during 1990s selection of vendor for development of strategic aviation equipment was very limited in the country, hence it had no choice but to go with the vendors who had past experience in the related field.

ADA's contention that they had no authority/control on the working of the work centres is not tenable in audit as the LCA programme was being monitored by MoD and ADA had representation at all levels in the decision making of the Government. The work centres, majority of which were DRDO labs, PSUs and Government organizations, should have accorded due importance to the LCA development programme due to its national importance. As such, delays in completion of work packages which affected the LCA programme schedules indicates that coordination of efforts at various levels and monitoring of the programme by all the agencies involved, has not been as envisaged.

2.5 Lack of user involvement

Involvement of user (Air HQ) commenced only after 2006 even though LCA programme commenced in 1983 and need for a liaison group between Air HQ and ADA had been expressed by the LCA PDP Review Committee as early as in 1989

Audit observed (September 2014) from the LCA PDP Review Committee, which examined the work done at Project Definition Phase, had strongly recommended (September 1989) early establishment of a standing Liaison Group between Air HQ and ADA to ensure closer interaction between the design team and the user for better appreciation of mutual perception, including appropriate trade-offs in performance, weight, time frame, cost, technological complexity and operational considerations of LCA.

However, audit observed (September 2014) that no such liaison group was formed. As a result, IAF played limited role as a member in Governing Body and General Body meetings. The active user participation in the LCA Programme was started only after the formation of an Empowered Committee (November 2006), LCA Review Committee consisting of ADA, HAL and IAF (November 2006) and LCA Project Management Team (LCA-PMT) at ADA (August 2007). The Empowered Committee chaired by Chief of Air Staff and co-chaired by Secretary (DP) and SA to RM/DG ADA met Quarterly to review the complete programme with the sole objective to monitor the flight development activities. The LCA Review Committee headed by Deputy Chief of Air Staff met every month to review all the issues concerning the programme. LCA Project Management Team (LCA-PMT) headed by Air Vice Marshal to function as a single point interface between the IAF and ADA/NFTC/HAL for co-ordination of flight test activities, positioning of weapons stores for LCA, etc.

Audit sought (September 2014) the reasons for non-formation of standing Liaison Group between Air HQ and ADA to ensure closer interaction between the design team and the user as recommended (September 1989) by the LCA PDP Review Committee. In reply, Air HQ stated (December 2014) that expertise of IAF personnel was not in the area of design of aircraft, but in capability to guide the programme in terms of user requirement of operations and maintainability. Hence formation of standing Liaison Group earlier than 2007 may not have been fruitful. It was also stated that IAF test pilots and test engineers were involved in the project as part of National Flight Test Centre (NFTC), Bangalore since 2001.

However, Air HQ reply is not tenable as user involvement would be essential right from inception for effective and efficient completion of any project. This is evident from the fact that as soon as Empowered Committee was formed (November 2006), in its very first meeting (December 2006), need for foreign consultancy in flight testing was emphasized (as discussed at Chapter II Para 2.2.1) and in its fourth meeting (October 2007), need for going in for LCA Mk-II was highlighted (as discussed at Chapter I Para 1.3) based on which FSED Phase III was sanctioned (November 2009).

Thus, non-formation of a standing Liaison Group between Air HQ and ADA to ensure closer interaction between the design team and the user for better appreciation of mutual perception, including appropriate trade-offs in performance, weight, time frame, cost, technological complexity and operational considerations of LCA also impacted the LCA development timelines.

**CHAPTER III : DEVELOPMENT OF
INDIGENOUS CAPABILITY**

Objective: To assess whether Indigenous capability was developed through LCA programme

3.1 Absence of Indigenisation Plan

The GoI sanction of LCA project (August 1983) envisaged use of as many sub-systems as were readily available in the world market. However, GoI sanction (June 1993) for FSED Phase-I required to shift the focus on maximising the indigenous development, even if it meant increase in cost and time, partly because of severe foreign exchange crunch faced by the country in early 1990s and partly for attaining self-reliance in critical areas. Accordingly, ADA had proposed (June 1993) to undertake indigenous development of items such as Jet Fuel Starter, Gear Box, avionics software development and mechanical systems of LCA. In addition, import content was planned to be reduced in design and development of Carbon Fibre Composite (CFC) Wing, Multi-Mode Radar, General systems, import of components instead of systems, apart from increase of import content in infrastructure and aircraft manufacturing activities.

In response to audit observation (July 2014) regarding indigenisation plan for LCA, ADA stated (August 2014/January 2015) that no indigenization plan/roadmap for LCA was made because the scope of the Project was to develop advanced technologies/components along with LCA development. ADA, however, further stated (January 2015) that sufficient emphasis had been given towards indigenous design and development of various critical systems right from the beginning of the programme.

Various systems/equipment/items of LCA that were taken up for indigenous development are indicated in **Annexure II**. In response to an Audit query (July 2014) regarding the extent of indigenisation in LCA, ADA claimed (August 2014) that indigenous capability developed worked out to *70 per cent* of the LCA content in terms of value.

Audit observed (August 2014) from the CCS Note submitted (August 2009) for extension of FSED Phase-II that indigenous Line Replaceable Units¹ (LRUs) had been developed with the imported electronic components and accessories.

In response to audit query (August 2014) on the extent of indigenous content, ADA clarified (October 2014) that the LRUs were built in-house using imported components with indigenous design qualifications and certification efforts and hence indigenous content had been worked out at LRU level. ADA, however, further stated that the indigenous content of LCA worked out to about 35 *per cent* considering the use of imported components and accessories in LRUs. ADA also confirmed (October 2014) the continued dependency on imported electronic components, accessories etc. for LCA.

In the absence of a roadmap for indigenous development, the efficiency and effectiveness of the indigenous development achieved in the LCA programme could not be assessed in Audit. We also observed (December 2014) that ADA had further initiated (February 2014) a proposal for indigenous development of 109 LRUs at an estimated cost of ₹479 crore.

3.1.1 Indigenisation efforts

While ADA successfully developed systems such as CFC Wing, Gear Box, efforts made by ADA and its work centres for indigenous development of major items like Kaveri engine, Radome, Multi-Mode Radar, Jet Fuel Starter, etc, were not completely successful as discussed below:

i. Development of Engine for LCA

Government of India sanctioned (March 1989) a project for the design and development by Gas Turbine Research Establishment (GTRE) of an engine (named 'Kaveri') for LCA at a cost of ₹382.81 crore (FE ₹155.39 crore) with a PDC upto December 1996. The prototype version of LCA would be developed with a proven imported engine, while the production version of LCA was to use indigenous engine.

GTRE's failure to develop Kaveri engine as per the requirements has made the LCA perennially dependant on imported aero engines throughout its service life

¹ It is a modular component of an aircraft that is designed to be replaced quickly in case of failure, which reduces down time of the aircraft.

GTRE, however, could not develop the Kaveri engine as per the LCA schedule and specifications; particularly the engine weight exceeded by 135 Kgs (1235 Kgs as against 1100 Kgs) and also engine thrust achieved was 70 kilo Newton (kN) against the requirement of 81 kN despite extensions of the project schedule till December 2009 and enhancement of the sanctioned cost to ₹2,839 crore (FE ₹1,730 crore). Inordinate delay in fructification of Kaveri engine and cost overrun of the programme was commented upon in Paragraph 5.1 of the Report No 16 of 2010-11 of the C&AG of India, Union Government, Defence Services (Air Force and Navy) for the year ended March 2009.

The Ministry in their Action Taken Note (ATN) had stated (August 2011) that indigenous development of Kaveri engine for technology demonstration would continue.

In response to the present position of the Kaveri Project sought for (December 2014) in Audit, GTRE stated (December 2014) that a revised proposal was under preparation to develop the Kaveri engine for another aircraft² at an estimated cost of ₹2652 crore and time frame of 7 years.

Thus, even after incurring (January 2015) a development expenditure of ₹2020 crore by GTRE, indigenous development capability for LCA propulsion was not successful and ADA would continue to depend on GE imported engine for LCA.

ii. Development of Radome

Radome developed by ASL and manufactured by HAL was not found suitable for LCA and imported Radome is yet to be tested along with MMR for assessing its performance

The Radome is a primary structure on an aircraft, which houses the antenna. It needed to possess electro-magnetic (EM) transparency to get the best performance of the Antenna as well as structural integrity. The Radome designed and developed by the Advance Systems Laboratory (ASL), Hyderabad was selected (December 1989) for the LCA prototypes.



² Unmanned Combat Air Vehicle (UCAV), being proposed for development by ADA.

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Manufacturing of Radomes was started (June 2008) in HAL and the Regional Centre for Military Airworthiness (Aircraft), Bangalore accorded structural clearance (October 2009) to Radome manufactured by HAL. The first Electromagnetic test result of production Radome, supplied (December 2011) by HAL showed (June 2012) high loss of signal power resulting in significant reduction in radar range thereby affecting its performance. The Empowered Committee (June 2013) noticed that the losses of signal power were due to design deficiency and choice of Kevlar³ material. Subsequently, due to this deficiency, ADA had to conclude (September 2013) a contract with M/s Cobham, England for development and supply of six Radomes⁴ with quartz material at a cost of GBP 2.5 million (₹22.75 crore) by January 2015 for testing on LCA.

Thus, ADA has to depend on imported source for meeting the requirement of Radome as the one developed indigenously by ASL, Hyderabad and manufactured by HAL was not found suitable for LCA. This had impacted testing of MMR with cascading effect on accomplishment of FOC.

iii. Development of Multi-Mode Radar (MMR)

MMR developed jointly by LRDE/HAL had performance shortfalls and ADA had to go in for co-development of MMR with foreign firm, performance of which is yet to be tested with imported Radome

Multi-Mode Radar (MMR) is used in LCA for tracking targets from Air to Air, Air to Surface including sea. It facilitates all weather launching of weapons. It should operate under different modes viz., single target tracking (STT)⁵ mode, close combat mode and air-to-ground ranging modes.

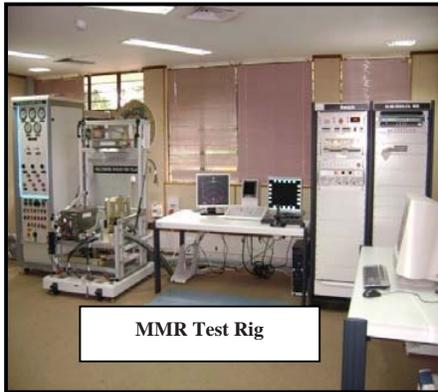


³ Kevlar is a super-strong plastic.

⁴ One for qualification testing and the others for testing on different aircraft for consistency in results.

⁵ This mode is used to provide the most accurate information to the fire control computer so that accurate missile or gun firing can be accomplished.

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The joint indigenous development of MMR for LCA was entrusted (June 1991) to M/s HAL,⁶ Hyderabad Division and LRDE⁷, Bangalore at a cost of ₹62.27 crore (FE ₹35.374 crore), to be completed by December 1997.

The delay in development of MMR despite consultancy from Ericsson and consequent import of three antenna were commented in Paragraph No 28 of Report of C&AG of India for the year ended March 1998 (No 8 of 1999).

However, Ministry's reply was silent on this aspect while furnishing (July 2004) the ATN.

The MMR developed by HAL/LRDE was found (2006) short of expectations. Subsequently ADA concluded (October 2006) a contract with M/s Elta Israel for co- development/ consultancy, supply & integration of MMR on LCA at a cost of 26.5 Million USD (₹119.25 crore) by June 2009. Though the MMR was ready by 2009 for integration on LCA, the LCA (LSP3) required structural changes in front fuselage for installation of MMR LRUs. After the LSP3 was ready in 2010, the MMR was put to functionality and performance testing. While the functionality testing of MMR was completed in December 2013, it could not be cleared in performance testing.

To an audit observation (October 2014) seeking reasons for delay in testing of MMR and resultant impact on IOC/FOC schedule of LCA, ADA stated (October 2014) that the MMR required several software updates during its development, which contributed to delay apart from non-availability of aircraft for testing. As regards availability of MMR for IOC achieved in December 2013, ADA stated (October 2014) that though MMR was integrated on LCA at the time of IOC, certain performance requirements such as range performance was falling short due to Radio Frequency (RF) losses of Radome and these limitations were recorded as part of Release to Service Document (RSD) of IOC of LCA. This had resulted in ADA concluding a fresh contract with M/s Cobham for an improved Radome with quartz material as has been discussed in sub-para 3.1 (ii).

⁶ Hindustan Aeronautics Limited.

⁷ Electronics and Radar development establishment.

As MMR performance could not be proven due to change in Radome, ADA had to obtain (December 2013) concession from Air HQ while obtaining IOC for LCA. As discussed in Para 2.3, Air HQ while commenting (December 2014) on impact of concessions on the combat potential of LCA, had stated with regard to non-evaluation of MMR that 'Delay in addressing the issue would have an adverse impact on combat employability of LCA'.

Thus, indigenous development of MMR for LCA could not be accomplished even after 22 years. Further, pending testing of MMR with the newly developed Radome, the performance testing and integration of MMR would remain incomplete, which would impact the combat employability of LCA.

iv. Multi-Functional Display System (MFDS)

Multi-Functional Display System (MFDS) facilitates display of information to the pilot relating to various functions of the aircraft. MFDS was identified in MoU (June 2002) for productionisation in Korwa Division with Transfer of Technology (TOT) from M/s Thales, France. However, the TOT did not include the core element, i.e., Optical Display Device - Active Matrix Color Liquid Crystal Display (AMLCD). As such, HAL approved (March 2006) formation of a Joint Venture Company (JVC) with M/s Samtel HAL Display Systems Limited (SHDS), New Delhi with the main objective to design, develop and manufacture various types of display systems. However, since the development of MFDs was getting delayed, HAL imported (from September 2010 to December 2012) MFDS at a total cost of ₹9.69 crore for the 20 SP (IOC) aircraft from M/s Elbit, Israel.

Due to delay in development of MFDS by SHDS, LCA will be fitted with imported MFDS till the indigenous MFDS are realised.

In response to an audit observation (October 2014) regarding delay in development of MFDS for LCA, HAL stated (November 2014) that the HAL Board had approved (January 2008) placement of an order on SHDS for development and supply of MFD prototypes for LCA and Intermediate Jet Trainer (IJT) on successful development and certification of MFDs for Su-30 MKI.

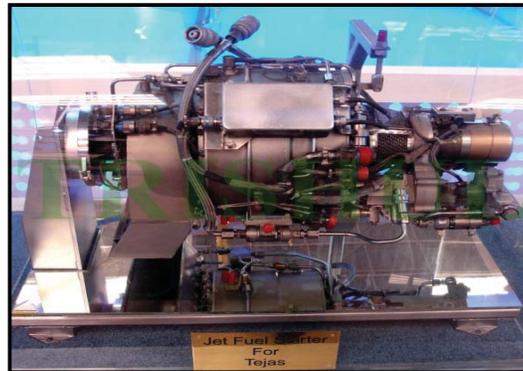
Fact remains that HAL was unable to manufacture MFDs either in-house or through the JV Company formed for the specific purpose of developing MFDs and had to resort to procurement from foreign source.

v. **Jet Fuel Starter (JFS)**

JFS is used to start the engine. Its performance becomes very critical particularly while operating in the Himalayan Terrain, where the temperature goes below (-) 16 degrees centigrade. As per the ASR, the LCA power plant and intake should permit at least two consecutive starts.

JFS developed by HAL for LCA is having performance issues and the modified JFS is yet to be developed and flight tested

ADA approached (November 1984) M/s HAL Engine Design Bureau (HAL-EDB), Bangalore for development of JFS (Model GTSU 110) for LCA. HAL-EDB developed and delivered to ADA⁸ the first unit of JFS in February 1994 and 12 units from August 2002 onwards for PV series aircraft at a total cost of ₹25.81 crore. JFS (GTSU-110) developed by HAL-EDB had two consecutive starts capability.



We observed from the records of ADA that IAF expressed⁹ the need for three consecutive starts capability of JFS against its own approved ASR. This was necessitated to cater for two main engine starts and dry rollover in-between. Accordingly, ADA sanctioned (September 2011) modification of JFS by HAL ETBRDC¹⁰ at a cost of ₹1.99 crore. Modified JFS (GTSU 110 M1) could not be proved for the mandatory three consecutive starts in the high altitude trials and in cold weather trials held in January 2013 and January 2014 respectively at Leh. During the trials held (January 2014) at Bangalore, excessive oil consumption by JFS beyond permitted levels was noticed.

When rectification of the snag of excess oil consumption of JFS was enquired in audit (May 2014), ADA stated (June 2014) that another proposal for modification to JFS (GTSU 110 M2) had been mooted (2014) to overcome the issue of excessive oil consumption. It also stated that the first two Series Production (SP) aircraft would, however, be delivered only with the original JFS (GTSU 110) and the modification kits would be retrofitted during March/April 2015.

⁸ For testing at engine test bed.

⁹ Copy of IAF letter and details as to when IAF expressed are not furnished to Audit by ADA.

¹⁰ Engine Test Bed Research and Development Centre – HAL EDB was later renamed as HAL ETBRDC.

Thus, development of JFS as required by IAF with three consecutive starts was still pending (January 2015) and even after the induction of LCA into IAF, the aircraft would continue to operate under concessions in respect of the JFS until it is retrofitted with modified JFS.

vi. **Flight Control System Actuators**

LCA is equipped with quadruplex digital Fly-By-Wire Flight Control System¹¹. The maneuverability of the LCA is controlled by 13 Flight Control System Actuators¹². ADA, in order to combat the US sanctions, had taken up (May 1998) the task of indigenizing the flight control system actuators for LCA. A committee was set up (May 1998) with participation of Control system experts from DRDO, ISRO, HAL and ADA.

Due to delay in development of flight control system actuators by VSSC, LCA will be dependent on imported actuators till the indigenous actuators are realised

Vikram Sarabai Space Research Centre (VSSC), Thiruvananthapuram was assigned (September 1998) the task of developing some of the flight critical components of the actuators viz., Elevon and Rudder actuators under the name 'Development and Advanced Linear Actuators (DALIA)'. VSSC was to pass on the Intellectual Property Rights (IPR) to the Nodal Agency, HAL for productionisation. A consortium consisting of HAL, MTAR Hyderabad, Godrej Mumbai was formed (May 2006) for productionisation of the actuators at HAL. Subsequently, HAL Board approved (November 2007) establishment of assembly and test facilities at HAL Accessories division, Lucknow for manufacture of the Actuators.

DALIA was to transfer the IPR to consortium in three phases for manufacture of 13 sets of actuators. Accordingly, HAL placed a Purchase Order (August 2009) on the consortium for manufacture, assembly and testing of the actuators at a cost of ₹14 crore after a delay of 21 months. The activities, timeframe and achievement against the delivery schedule as per the purchase order are tabulated below:

¹¹ Fly-by-wire control systems allow aircraft computers to perform tasks without pilot input. Gyroscopes fitted with sensors are mounted in an aircraft to sense movement changes and send signals to the computer, which automatically moves control actuators to stabilize the aircraft.

¹² (4 Elevon actuators, 1 Rudder actuator, 6 Leading edge slat Actuators & 2 air-brake Actuators).

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Phase	Activity	Time frame (To = August 2009)	Revised Time frame	Actual
I (2.5 sets)	DALIA to take up assembly and testing activity. The consortium members along with HAL, Lucknow will participate in assembly and testing activity and absorb the technology.	To+21 months i.e. May 2011	To + 10 months i.e. June 2010	Expected to be supplied by December 2014.
II (2.5 sets)	Fabrication assembly and testing to be carried out under the guidance of DALIA team with the participation of HAL, Lucknow.	To+30 months i.e. Feb 2012	To + 16 months i.e. December 2010	Not completed
III (8 sets)	The entire activity from procurement of material to supply of flight worthy actuators to ADA was to be carried out. As a parallel activity, HAL, Lucknow was to establish minimum test facility at their factory which would help in conducting the sub-assembly and testing activity to support the future LCA squadron requirement.	To+36 months i.e. Aug 2012	To + 20 months i.e. April 2011	Not completed

Audit observed (September 2014) from the records of HAL that it continued to procure the Actuators from foreign source¹³ due to the delay in indigenous development of the actuators. HAL replied (September 2014) that the development work and the qualification tests were completed in January 2014 and the first stage of supply of actuators would be completed by December 2014.

Thus, till the indigenously developed flight worthy actuators are delivered to HAL by DALIA, LCA will depend on imported source for these items.

To sum up, even though GoI had emphasized (June 1993) on increasing the indigenous content of LCA while sanctioning FSED in phased manner, there was no roadmap for indigenization during LCA development. ADA could not achieve indigenisation as planned in June 1993. As a result, indigenous content of LCA estimated by ADA as 70 *per cent* actually amounted to about 35 *per cent* (January 2015), with the aircraft dependent on foreign sources for important components such as aero engine, Multi-Mode Radar, Radome, Flight control System Actuators and Multi-Functional Display System.

¹³ M/s BAe Systems, USA.

CHAPTER IV : MANUFACTURE AND INDUCTION OF LCA

Objective: To examine and assess whether manufacturing of LCA (AF) including setting up of manufacturing facilities at HAL was completed efficiently and the level of preparedness of IAF to induct LCA into Service and consequent operational impact

4.1 Introduction

In line with the approval of CCPA (February 1991) for development of LCA in two FSED phases as discussed in chapter-II, ADA signed three Memorandums of Understanding (MoUs) with HAL as detailed below:

Sl. No.	FSED Phase	Date of signing MoU	Sanction (₹in crore)	Scope of work	Scheduled date of completion
1	I	January 1992	661.80 (Overall sanction ₹2188 crore)	Detailed Design, Development, Manufacture, Flight Clearance and Testing of Technology Demonstrators (TDs) TD1 and TD2 – Building of PV1 and PV2 was included in 1995 ¹	June 1998
2	II	(a) June 2002 (manufacture and creation of facility-LCA), and Amendment-I January 2011	795.23 (Overall sanction ₹3301.78 crore) 1471.52 (Overall sanction ₹5777.56 crore)	Creation of facilities at various divisions of HAL for manufacturing eight LCA <i>per annum</i> and eight LSP standard aircraft (LSP1 to LSP 8)	May 2006 to May 2008 Revised to 2007-08 to 2011-12 for manufacture and delivery of aircraft
3		(b) December 2006 (Development-ARDC) Amendment-1 (November 2010)	650.58 (Overall sanction ₹3301.78 crore) ₹732.12 (Overall sanction ₹5777.56 crore)	Design, development, manufacture of three PVs (PV3, PV4 & PV5) and testing of the PVs and TDs to achieve Initial Operation Clearance (IOC) and Final Operation Clearance (FOC)	December 2005 to December 2008 Revised to December 2010 to December 2012

¹ Shifting of PV1 and PV2 from FSED Phase II to FSED Phase I in 1995 and consequent impact on LCA Programme is discussed in Chapter II Para.

Delays in execution of Phase-I activities of LCA programme (covered under the MoU of 1992 at SI No. 1 of the above table) were highlighted in Para 28 of the Report No. 8 of 1999 of the C&AG of India, Union Government, Defence Services (Air Force & Navy) for the year ended 31 March 1998. In the present Report, MoUs at SL No 2 and 3 of the above Table covering activities under FSED Phase II sanctioned in November 2001 are discussed below in order of their activity i.e. design & development of PVs (MoU 2006) and manufacture of LSPs (MoU 2002).

Premature conclusion (2006, 2010) of two contracts by MoD with HAL for 20 IOC configuration and 20 FOC configuration LCA even before the design of LCA was frozen by ADA, resulted in delays in supply of aircraft against these contracts by HAL due to delay in freezing of design of LCA, which impacted the handing over of Series Production (SP) aircraft to IAF for formation of squadrons, besides blocking up of funds/inventory at HAL as discussed in this chapter.

4.2 Design and development activity

Absence of FTS, low availability of aircraft for flight tests and deficiencies in LSP aircraft affected the Design and development activity

As discussed in Para 2.2 of Chapter II, though sanction for development (FESD phase II) was accorded in November 2001, the MoU for design and development of LCA was signed between ADA and HAL only in December 2006. MOU of December 2006 with HAL envisaged continuance of the development activities of FSED Phase-I along with that of FSED Phase-II. As per MOU 2006 scope of work of HAL broadly included:

- Design, development, fabrication and testing of LCA (PV5) (discussed in Chapter II);
- Fabrication and testing of LCA (PV3 & PV4) (discussed in Chapter II);
- Fatigue Test Specimen (FTS);
- Delivery of LCA (PV3, PV4 & PV5) as per the prescribed timeframe;
- Participation in flight testing of LCA (TD's & PVs) to achieve IOC and FOC; and
- Co-ordination/control of all technical/development activities as envisaged in HAL(AR&DC) projections;

ADA allocated (November 2001) ₹650.58 crore against the MoU activities, which was enhanced (November 2009) to ₹1382.70 crore, out of which, HAL received ₹1006.57 crore and spent ₹1046.43 crore (March 2014).

Audit Scrutiny of the records relating to the above scope of work brought out the following findings:

4.2.1 Absence of Fatigue Test Specimen (FTS)

A Fatigue Test Specimen (FTS) was required to be built for testing the endurance of LCA for determining the total technical life. Audit observed that (February 2014) building of FTS was not taken up by HAL.

When reasons for not building the FTS was enquired (February 2014) in audit, HAL stated (July 2014) that production standard fuselage was required for carrying out the FTS and the same was yet to be manufactured.

Reply of HAL is not tenable in audit as the FTS was to be built under the MoU of 2006 covering developmental activities and not after building production standard aircraft as stated by HAL now.

Thus, in the absence of FTS, technical life of LCA could not be determined and ADA/HAL had to obtain concession at the time of IOC (December 2013) from Air HQ which limited the life of airframe to 1000 hours as against the ASR specification of more than 3000 hours.

4.2.2 Low availability of LCA for flight testing towards achieving IOC/FOC

HAL was to provide TDs and PVs for flight testing to achieve IOC and FOC as per the MoU (December 2006). However, due to deficiencies in the PVs as discussed in Chapter II Para 2.1, LSPs were included for flight testing activities by an amendment in November 2010.

Audit observed from minutes of EC meetings (December 2006 to July 2014) that low availability of LCA for flight testing was a critical issue delaying the achievement of IOC. The reasons pointed out in the EC meetings were mainly delay in snags analysis, slow recovery of aircraft from rectification, shortage of critical LRUs at flight hangar, aircraft being used as test rigs, large number

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of unproductive sorties², production quality issues affecting flight safety, non-availability of aircraft in the correct SOP. Serviceability of LSP 7 and 8 aircraft had remained low even though both of them were the representative aircraft closest to production series. However, it was observed that no solutions/timelines were advised for analysis and rectification of snags even though the EC had representation from MoD, Air Force and HAL.

Audit examination from HAL records brought out that the number of flights undertaken with each aircraft, average number of flights achieved per month and the number of days for which the aircraft were not available for conducting flight tests as per details indicated in **Annexure-III**.

It could be seen from the annexure that the average number of sorties per month ranged between one and five sorties and were well short of the minimum of 22 sorties per month desired by ADA. The LCA was not made available for flight trials at several occasions resulting in low availability of aircraft for flight testing for 18891 days. Out of 12 aircraft (except PV5 trainer aircraft) utilised for conducting tests, five had performed their last flights for 20 to 72 months prior to the date of IOC.

To an audit query (October 2014) seeking reasons for low availability of LCA for flight testing, HAL stated (November 2014) that TD 1 and TD 2 were taken off from the development test flight phase by ADA as their SOP was not upgradable to sustain the level of requirement for current flight testing. HAL further stated that the shortfalls in sorties per month were attributable to the delay in the developmental programme in implementing the improvements to clear the test points envisaged as an evolution process.

HAL's Reply is not acceptable as the reasons stated by HAL now are different from those observed by the EC in its various meetings where HAL was also represented.

Thus, low availability of LCA for flight testing impacted the timely achievement of IOC/FOC.

² Sorties used for display and fly pasts.

4.2.3 Deficiencies in the HAL manufactured LSP aircraft

Audit observed (October 2014) from the Empowered Committee (EC) meetings (September 2012 to July 2014) that the LSP aircraft manufactured by HAL had the following deficiencies:

- (a) Design deficiencies in fuel system, brake management system, brake parachute, undercarriage system;
- (b) Quality problems (September 2012) on the MMR with HAL manufactured Radome (also discussed in Chapter III Para 3.1);
- (c) Water seepage observed during the flight testing to prove all weather clearance, in critical areas of aircraft including cockpit, radar, DFCC, avionics bay, etc. which required design solutions;
- (d) Structural problems like fuel leak, cracking of turkey feathers, de-lamination, and contour deviation;
- (e) The performance of aircraft was affected by low reliability of critical LRUs like Jet Fuel Starter (JFS), Cockpit Pressure Transducer³ (CPTCV) on the aircraft.

In reply to audit query, HAL informed (November 2014) that the deficiencies noticed in fuel system, brake management system etc were part of developmental issues and resolved subsequently. While Radomes manufactured by HAL were as per the technology provided by ADA, shortfall in performance was due to material selection and not due to production process and CPTCV and JFS were new units which were under certification.

HAL's contention to have resolved the deficiencies in fuel system and brake management system is not tenable as permanent waiver for deficiencies in fuel system and concession for deficiencies in the brake parachute system were obtained from Air HQ at the time of achieving IOC of LCA (December 2013).

Thus, all the LCA Mk-I would have deficiencies in Fuel System, being a permanent waiver. As regards deficiencies in Brake Parachute System (under concession), LCA Mk-I will fly with this deficiency till the issue is resolved.

³ Used for providing position feedback information of flight control surfaces to the cockpit.

4.3 Creation of production facilities and manufacture of LSPs

Creation of facilities for manufacturing eight aircraft per annum was not achieved.

MoU of June 2002 between ADA and HAL envisaged creation of manufacturing facilities under FSED Phase II at the rate of eight aircraft per annum by May 2006 and production of eight LSP aircraft during May 2006 to May 2008. (As discussed in Chapter II Para 2.2)

Audit scrutiny of the records relating to MoU implementation brought out delay in completion of manufacturing facilities as discussed in the following paragraphs:

4.3.1 Delay in creation of production facilities:

Audit observed that HAL had been utilizing the existing facilities available with it for manufacture of LCA. Even though HAL initiated action in April 2006 to form a dedicated LCA facility, LCA Project Group was established as a full-fledged Division only in March 2014 as seen from HAL's 371st Board Meeting papers.

MoU of 2002 sanctioned ₹391.18 crore towards creation of facility i.e. Capital⁴ expenditure Rs. 188.71 crore and DRE⁵ ₹202.47 crore. Audit noticed that as of March 2014, HAL had incurred an amount of ₹118.99 crore (63 *per cent*) towards capital expenditure and ₹139.12 crore (69 *per cent*) towards DRE.

When reasons for delay in creation of manufacturing facility was enquired (October 2014) in audit, HAL stated (November 2014) that extensive changes in the design and development post 2006 had resulted in reviewing the facility requirement and a capacity augmentation plan was being put up for meeting the objectives. It was also stated that non-finalisation of configuration of LCA had led to the postponement of establishment of production facilities.

Reply is not acceptable as the GoI sanction of November 2001 stipulated that the facilities for manufacture of eight LCA were to be created and the first LCA was to be delivered within 4 ½ years from the date of sanction i.e. by May 2006. Further, the delay in creation of manufacturing facility of eight

⁴ Capital expenditure consists of expenditure towards Plant & machinery and civil works.

⁵ Deferred Revenue Expenditure (DRE) consists of expenditure towards tooling, test equipments, technical assistance, training, project management, publications and long and series tests.

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aircraft per annum impacted the production of LSPs, as discussed in Para 4.3.4 as well as the Series Production Aircraft.

4.3.2 Delay in procurement of plant and machinery

As against the target date of May 2006 for creation of facilities for manufacture of eight aircraft per annum, HAL placed 308 purchase orders valued ₹73.85 crore during the years 2006-07 to 2013-14. Of these, 203 purchase orders valuing ₹70.84 crore were placed only between 2011-12 and 2013-14. Further, the sanctioned cost of the project was revised (January 2011) to include procurement of five machines for ₹54.50 crore to enhance quality and productivity. The details of purchase orders placed and progress made (December 2014) in respect of these five machines are as given below:

Sl No	Purchase Order date and Machine name	Value ₹in crore	Scheduled delivery	Date of receipt	Date of Installation/ commissioning	Delay (in months)
1	6.11.2012-Laser tracker	1.93	January 2013	January 2013	commissioned in January 2013	-
2	14.6.2011- Automatic wing drilling LOXIN Machine	14.95	June 2012	December 2012	Installed in May 2013 but not commissioned.	5
3	18.2.2013- 5 Axis skin Router	12.32	March 2014	June 2014	Installed in May 2013 but not commissioned	18
4	HSM Profiler	7.00	Purchase Order yet to be placed			24
5	30.1.2014 - CNC Profiler	5.41	January 2015	Yet to be received	-	24

Source: compiled from HAL records.

It could be seen from the above table, that against the order of four machines between June 2011 and January 2014, three machines valued ₹29.20 crore were received between December 2012 and June 2014. However, only one machine has been commissioned so far (November 2014) while two machines even though installed in May 2013 could not be commissioned as the supplier had to prove wing drilling on one aircraft. The fourth machine valued ₹5.41 crore was expected to be received in January 2015. Action to procure one machine i.e. HSM profiler was yet to be initiated (November 2014).

In response to audit observation (October 2014) regarding delay in creation of manufacturing facilities for LCA, HAL while admitting the fact stated

(November 2014) that the establishment of facilities was accelerated after 2011.

Thus, on account of delayed creation of manufacturing facilities, and that too limited to four aircraft per annum as against required eight aircraft per annum the production of 20 IOC LCA has been delayed although IOC was achieved in December 2013. HAL had not supplied any aircraft (IOC standard) to Air Force so far (January 2015).

4.3.3 Delay in completion of LCA hangars

While according (July 2003) approval for completion of hangars for LCA production by HAL Board, one of the benefits expected to be realised was contiguous location of assembly shops with related departments to reduce movements, handling and reduce the cycle time, etc. Audit observed that the hangars were completed in April 2009 against the scheduled date of completion by September 2007. Due to delay in completion of LCA hangars, certain machines⁶ (costing ₹30.56 crore) procured during 2004 to 2006 out of LCA funds and installed in the Aircraft Division (Jaguar Machine Shop) continued to remain in the Aircraft Division even after construction of new hangars for LCA production. Hence, the intended benefit from construction of the new building was not realised by HAL completely.

In reply to an audit observation (October 2014), HAL stated (November 2014) that the new hangars built was planned for structural assembly and final assembly and hence, the machines could not be shifted from Aircraft Division to new LCA division.

Reply is not acceptable as the envisaged benefits of having a dedicated hangar facility for LCA to have contiguous location of assembly shops with related departments to reduce movements and handling and thereby to reduce the cycle time had not been achieved.

⁶ 5-axis Profiler, 3-axis Profiler, 5-axis machining centre, 2.5m x 6m CM machine, CNC jig-borer, controlled heating/quenching furnace and chrome-plating facility etc.

4.3.4 Delay in procurement of tools and jigs

The rate of manufacture of LCA depended on availability of the main assembly jigs. The time chart prepared by the division showed that 66 weeks were required for completion of the main assembly activity subject to availability of the required jigs and man power. The Methods Engineering Group of LCA division, reassessed (October 2012) the total jig requirement as 57 for manufacturing of eight LCA per annum out of which it already had 32 jigs and balance 25 were to be procured. However, the production plan of the Division for the year 2014-15 stipulated manufacture of only four LCA.

LCA Division had placed a total of 932 purchase orders (value: ₹43.40 crore) for tools and jigs required for assembly of LCA from May 2006 (scheduled date for delivery of first LSP) to as late as March 2014. 43 purchase orders for a total value of ₹2 crore were yet to be placed (December 2014). As per GoI sanction (November 2001), the creation of facilities for eight LSP aircraft per annum and delivery of the first LSP standard LCA was 4 ½ years from the date of sanction i.e. by May 2006.

Audit scrutiny (October 2014) of purchase orders revealed that the purchase order for procurement of 25 jigs were placed between February 2008 to January 2014. Out of this, 10 have been received and commissioned (one in March 2014 and nine in November 2014). Commissioning of eight jigs received (December 2010 to January 2013) were under progress. The balance seven jigs were under fabrication at vendor's premises (November 2014).

HAL in response to audit observation (October 2014) while concurring with (November 2014) the fact regarding lack of facility to produce eight aircraft per annum stated that even the current structural assembly operations on the jigs were not continuous due to breakage in supply of parts due to changes in the acceptance standards by certification agency vis-à-vis the procedure adopted in the LSP program.

The fact remains that HAL had estimated that 66 weeks were required for completion of main assembly activity of LCA aircraft and considering the lead time of one year for procurement of jigs, the purchase orders should have been placed at least by January 2004. Further, HAL's reply is silent on the issue of delayed placement of orders for jigs.

Thus, due to delay in placement of purchase orders in time, HAL could not ensure timely creation of facility to adhere to the committed delivery schedule.

4.4 Delay in creation of facilities for Repair and Overhaul (ROH)

ASR stipulated that manufacturer would be responsible for defect investigation, repair and overhaul of the aircraft, engine and components. Repair and overhaul of certain equipment may be undertaken by IAF. However, during the interim period, before IAF facilities are established, repair and servicing of all rotables will be manufacturer's responsibility. Development/manufacturing agency should be prepared to maintain the repair facility for selected equipment and sub assemblies for the proposed lifespan of the aircraft or as required by IAF.

LCA comprises 344 Line Replaceable Units (LRUs). Of these, 90 LRUs were considered non-repairable. While Repair and Overhaul (ROH) facility in respect of 185 was available with HAL. For the remaining 69 LRUs, ROH facilities were required to be established in HAL. Audit observed (October 2014) that proposals received (between May 2008 and May 2009) from Original Equipment Manufacturers (OEM) for creating ROH facilities in respect of 40 LRUs were under evaluation (October 2014) and proposals for ROH facilities for the remaining 29 LRUs were awaited (October 2014).

HAL, while concurring with the audit observation (October 2014) replied (November 2014) that for the remaining 69 repairable LRUs, Long Term Repair Agreement (LTRA) was planned for 29 LRUs, ROH establishment was planned for 39 LRUs and one LRU had been deleted from ESOP⁷. Respective Divisions were taking up the matter with the OEMs and the establishment of the ROH facilities would be completed by December 2016.

The fact remains that HAL delayed finalising the proposals received in May 2009 from vendors. As a result, establishment of the ROH facilities for the repairable LRU's was yet to be fully accomplished⁸ by HAL (January 2015).

⁷ Equipment Standard of Preparation (ESOP) envisages the standard specification of the aircraft.

⁸ HAL Bangalore letter No.HAL/CM/LCA-LMG/97/2015 dated 05.02.2015.

4.5 Delay in manufacture and supply of LSP aircraft

HAL did not supply the LSP aircraft according to the delivery schedule and as per the weight and speed envisaged in the ASR

MoU of June 2002 stipulated manufacture and supply of eight LCA (LSP) between 2006 and 2008, which was revised (January 2011) to 2007-08 to 2011-12. HAL manufactured and supplied seven LSP between 2007 and 2013. Audit reviewed (October 2014) the planning, actual manufacture and supply of LCA and cost of manufacture as discussed below:

4.5.1 Frequent changes in design after release of standard of preparation

Audit observed (October 2014) that frequent changes to SOP were made from time to time by ADA which required changes to design of the aircraft resulting in changes in Drawing Applicability Lists⁹ (DAL).

Details of the number of design changes effected in each of the seven LSP standards LCA are tabulated below:

Aircraft	Date of release of ESOP	Configuration/ modifications added further in comparison to respective previous aircraft	Number of design changes after ESOP
LSP-1	29.12.2005	Basic	2337
LSP-2	24.05.2007	Open Architecture Computers	891
LSP-3	16.07.2007	Major changes in Avionics Sensors	646
LSP-4	31.10.2008	CMDS	2954
LSP-5	12.02.2010	Night Vision LRUs	1046
LSP-6	Aircraft not manufactured		
LSP-7	23.09.2011	Major changes in fuel system and all weather clearance LRUs was added	150
LSP-8	31.08.2012	Fully configured	874

Source: compiled from HAL records

Due to frequent and continuous changes in design, each of the aircraft differed in its configuration and as a result even LSP-8 fell short of the standard required for achievement of IOC. These design changes resulted in addition of 3041 new drawings, 3965 changed drawings and cancellation of 245 drawings with additional cost implications besides time overrun impacting the delivery schedules.

⁹ List containing systems wise detailed drawings of an aircraft.

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In reply, HAL stated (November 2014) that the changes in the SOP of the LSP aircraft vis-à-vis TD and PV aircraft were introduced by the program manager ADA. ADA, had released the SOP for LSP 6 as IOC standard in January 2014. The design and development of aircraft of the class of LCA without the availability of a similar class indigenous aircraft was an ambitious program. Concurrent development and production would be successful only if the user accepted the aircraft in smaller batches (say 4 to 5 aircraft) as per the SOP frozen at regular intervals of development cycle. It further stated IOC is precursor for production agency to deliver the aircraft and due to the delay in IOC, the concurrent development and production approach was not fully met in the program.

Thus, fact remains that the design, development and productionisation of LCA through concurrent engineering did not compress the development time as was envisaged in the FSED-II sanction of November 2011 and even LSP-8 fell short of the standard required for achievement of IOC. It also resulted in time overrun and substantial delay in achieving IOC apart from having a cascading effect on the supply of Series Production LCA to IAF.

4.5.2 Delay in supply of aircraft to ADA

The following Table shows the dates of stipulated and the actual delivery of aircraft:

Sl. No. of the LSP aircraft	Stipulated date of delivery (MoU June 2002)	Revised Delivery (Amendment (January 2011))	Actual date of delivery	Delay in delivery from stipulated dates (months)	Delay in delivery from amended dates (months)
1	2006	2007-08	25.04.2007	4	-
2	2007	2008-09	16.06.2008	6	-
3	2007	2010-11	23.04.2010	28	-
4	2008	2010-11	02.06.2010	17	-
5	2008	2010-11	19.11.2010	23	-
6	2008	2011-12	Aircraft not manufactured		
7	2008	2010-11	09.03.2012	38	12
8	2008	2011-12	31.03.2013	51	12

Source: compiled from HAL records

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It can be seen that none of the aircraft was delivered within the stipulated date and the delay ranged from 4 to 51 months.

In reply to audit observation (October 2014), HAL stated (November 2014) that production of LSP-1 to LSP-8 (except LSP-6) had to be progressed at HAL for different SOP standards. Even as on date, final ESOP for full IOC configuration was yet to be frozen which is evident from the concessions given by IAF at the time of achieving (December 2013) IOC.

Fact remains that there had been delay of 12 months in adhering to even the extended delivery schedule. Thus, reduction in production lead time envisaged in adopting concurrent engineering was not accomplished.

4.5.3 Stipulated weight not achieved

ASR specified that basic weight of LCA should not exceed 5500 kg. The MoU (June 2002) stipulated the basic weight of the aircraft (with fuel) to be 8485 kg and the empty weight (without fuel) to be 5365 kg. The basic and empty weights achieved in respect of each of the LSP aircraft are tabulated below:

(weight in kg)

Aircraft No.	Empty weight			Basic weight		
	Stipulated	Actual	Excess	Stipulated	Actual	Excess
LSP 1	5365	6707	1342	8485	9799	1314
LSP 2	5365	6696	1331	8485	9855	1370
LSP 3	5365	6802	1437	8485	9949	1464
LSP 4	5365	6755	1390	8485	9911	1426
LSP 5	5365	6683	1318	8485	9861	1376
LSP 7	5365	6682	1317	8485	9852	1367
LSP 8	5365	6735	1370	8485	9851	1366

Source: compiled with HAL records

It can be seen that the parameters of both empty weight and basic weight were not achieved in any of the LSP aircraft.

Audit observed (October 2014) that the low weight envisioned to maximise the combat capabilities of this aircraft had not been achieved. In reply, HAL stated (November 2014) that the aircraft were produced as per the SOP released by ADA.

Fact remains that the LSP aircraft did not meet the prescribed parameters of weight as envisaged in the MoU (June 2002). Consequently, ADA/HAL had to obtain permanent waiver towards this from Air HQ at the time of achieving IOC (December 2013). It is also pertinent to mention that increased weight of LCA had necessitated ADA going in for LCA Mk-II development with a higher capacity engine, as discussed in Chapter II.

4.5.4 Envisaged speed not achieved

ASR specified that the LCA should have maximum speed in excess of 1300 kmph and minimum touch down speed of 240 kmph. The MoU (June 2002) specified the maximum speed at sea level as 1325 kmph and touchdown speed of 240 kmph. However, the maximum speed achieved was 1204 kmph and touchdown speed of 308 kmph (December 2013). Thus, there was shortfall in achievement of maximum speed as well as in touchdown speed with reference to MoU specifications.

In reply to audit observation (October 2014), HAL stated (November 2014) that LSP aircraft were produced as per the Standard of Preparation (SOP) issued by ADA. The parts have been realized as per the drawings and in case of deviations, necessary design concurrences had been obtained as part of the production process.

Fact remains that the aircraft could not achieve the speed range specified in the MoU. Consequently, ADA had to obtain permanent waiver from Air HQ at the time of achieving IOC (December 2013) towards the limitation of LCA.

4.6 Premature conclusion of contracts for LCA (IOC and FOC) before freezing of design

Premature conclusion of IOC and FOC contracts before freezing of designs affected the formation of squadrons

The Equipment Standard of Preparation (ESOP) for IOC¹⁰ aircraft was jointly released (September 2005) by ADA and HAL. Based on the ESOP, MoD concluded a contract (March 2006) with HAL for manufacture and supply of 20 LCA of IOC standard to IAF. Notwithstanding the delay in implementation of this contract, MoD concluded (December 2010) another contract for 20 LCA of FOC standard. However, ADA could freeze the design for IOC standard LCA only in December 2013 and freezing of design for FOC standard aircraft was still pending (January 2015).

¹⁰ Design specification for LCA with IOC standard.

Therefore, conclusion (March 2006, December 2010) of two contracts by MoD pending freezing of design for IOC and FOC was premature. This had resulted in HAL's inability to effect deliveries against the two contracts for 40 LCA and their consequent induction into IAF as discussed below:

4.6.1 Manufacture and supply of LCA(IOC standard) under Series Production

MoD concluded (March 2006) a contract with HAL for supply of 20 LCA built to IOC standard (16 fighter and 4 trainer) along with role equipment and support equipment consisting of spares and Tools, Testers and Ground Equipment (TTGE) items, training devices and maintenance simulators, four reserve engines, engine support package and engine test bed at a total cost of ₹2701.70 crore. The above deliverables were to be supplied between April 2009 and December 2011. The contract was amended in May 2008 to ₹2812.91 crore to include escalation in price of engines. Up to March 2014, HAL had claimed¹¹ and received ₹2104.11 crore after achievement of milestones against which HAL had spent ₹2039.13 crore and committed further expenditure of ₹709.26 crore.

Audit observed that conclusion (March 2006) of contract for supply of 20 IOC aircraft by MoD even before freezing of design of LCA, had a cascading effect on manufacture and supply of IOC configuration aircraft to IAF (which affected operational preparedness of the Air Force, discussed at sub-para 4.7 and 4.9) besides extra cost due to cost overrun and holding of inventory as brought out below:

- HAL has not supplied (January 2015) aircraft of the IOC configuration but supplied reserve engines valuing ₹87.21 crore.
- HAL completed (December 2011) the construction of Engine Test Bed¹² at Sullur at a cost of ₹46 crore even though LCA squadrons were yet to be set up (as discussed in sub-para 4.7).
- HAL held warranty expired inventory¹³ valuing ₹521.14 crore at its divisions which were procured prior to 2012.

¹¹ For 20 aircraft on start of manufacturing activity, for 16 aircraft on start of structural assembly and for 8 aircraft on commencement of equipping.

¹² Engine Test Bed are used for testing the engines for conducting tests before fitment on the aircraft.

¹³ Engine Division ₹443.16 crore, LCA Division ₹65.70 crore and Hyderabad Division ₹12.28 crore.

- Retro modification of LRUs were to be carried out by OEM's on LRUs (20 types) to enable them to be integrated along with other LRUs in the aircraft. Out of 20 types of LRUs, HAL incurred an expenditure of ₹10.63 crore on 5 types of LRU's and the cost of retro modification would further increase as the balance 15 types of LRUs are yet to be taken up.
- HAL supplied spares valuing ₹97.36 crore (up to March 2014) where as the aircraft was yet to be delivered, and these spares will remain unutilized till LCA get inducted into IAF squadron.
- Against the above supplies, IAF deducted (July 2013) liquidated damages (LD) of ₹9.83 crore towards delayed supplies as per the terms of the contract and the LD amount would further increase on supply of aircraft, even though this situation has arisen due to premature conclusion of contract by MoD.
- HAL sought (October 2011) additional funds of ₹1381.98 crore towards meeting the extra costs of manufacture¹⁴.

HAL replied (November 2014) that the delayed finalisation of SOP due to delay in achievement of IOC (December 2013) contributed to delayed procurement of materials and postponement of production activities. Regarding the cost overrun of the IOC contract, HAL further stated that the detailed cost revision proposal covering all the design changes effected from 2006 in the basic build of the aircraft, LRUs, GHE/GSE, testers had been submitted to ADA for vetting which was still under progress (December 2014).

Thus, awarding of the contract for delivery of 20 IOC configuration aircraft by MoD to HAL in March 2006, when only two TD's and PV's (development stages as discussed in Chapter II) were flying and LCA design was nowhere near maturity, was premature. Further, HAL is yet to supply (January 2015) the IOC configured aircraft. Delay in productionisation of LCA impacted the induction of LCA and formation of IAF squadrons, besides cost overrun of the contract as discussed above.

14 Towards changes in drawings (₹564.64 crore), escalation in procurement and increase in labour cost (₹516.85 crore), Statutory levies on indigenous procurement ₹43.89 crore), additional scope towards supply of floats of LRU's ₹90.70 crore) and technical publications ₹65.90 crore.

4.6.2 Supply of LCA (FOC standard) under Series Production

MoD concluded (December 2010) a contract with HAL for supply of 20 LCA FOC standard (16 fighter and 4 trainer) along with role equipment, engineering support package consisting of spares/TTGE/GHE/GSE, training aggregates, four reserve engines, engine support package, operational support equipment, etc. at a total price of ₹5989.39 crore. The delivery of 20 FOC aircraft was to commence within 42 months from the date of signing the contract i.e., by June 2014 and to be completed gradually by 72 months i.e., by December 2016.

Audit observed (October 2014) that in accordance with the terms of payment, HAL claimed and received ₹1810.59 crore against the stipulated milestones. Out of ₹1810.59 crore received since 2010, HAL had (March 2014) spent only ₹287.59 crore and committed ₹1099.51 crore. However, HAL has not supplied any aircraft (January 2015)

HAL stated (November 2014) that it had drawn the advance as per the activity based milestones stipulated in the contract. Further, commitment aggregating about ₹1200 crore had been made towards start of the manufacturing activity of FOC Aircraft. Further HAL stated that the FOC was yet to be accorded and delivery of 20 FOC aircraft could commence only after achieving FOC. A change order to the FOC contract would be put up after the FOC certification was accorded by ADA.

Thus, awarding of contract by MoD for supply of 20 FOC configuration aircraft even before supply of IOC configuration aircraft, freezing of designs and achieving of FOC was premature. Further, HAL had not utilised advances to the tune of ₹1509.22 crore drawn since 2010 against the contract. (January 2015).

4.7 LCA induction Plan

The Air Staff Requirement (ASR) (October 1985) envisaged that LCA was required to be inducted in IAF squadrons by 1994 as a replacement of Mig-21. The requirement projected by Air HQ was for 200 fighters and 20 trainers, with a view to form 11 squadrons of LCA in order to overcome depletion of squadrons due to phasing out of ageing fleet. However, inordinate delay in

development of LCA (as discussed in Chapter II) has delayed the induction of LCA into service and impacted formation of the squadron as discussed below:

I) IAF had to resort to alternate measures to maintain the force level

Audit enquired (June 2014) regarding steps taken by Air HQ to overcome the depletion of squadron level in view of delay in induction of LCA. In reply, Air HQ stated (February 2015) that the following measures had been taken by them, apart from revising the phasing out of MiG-21 squadrons:

- a. Up-gradation (November 1995) of 125 MiG BIS aircraft at a cost of 626 million USD (equivalent to ₹2135 crore)
- b. Up-gradation (March 2008) of 62 MiG-29 aircraft into multi role MiG-29UPG standard aircraft at a cost of 964 million USD (₹3841.87 crore). Upgradation was in progress (February 2015)
- c. Up-gradation (December 2009) of 61 Jaguar Aircraft at a cost of ₹3113.02 crore. Upgradation was in progress (February 2015)
- d. Up-gradation (2011) of Mirage 2000 aircraft through OEM and HAL at a total cost of ₹10947 crore. Upgradation was in progress (February 2015)

Thus, due to delay in development and induction of LCA, IAF had to up-grade other aircraft at a cost of ₹20,037 crore. Besides, phasing out of MiG-21 was also revised (January 2013) to utilise the ageing fleet for extended period.

II) Delay in formation of LCA squadron

Air HQ had planned to have two squadrons of LCA and placed two contracts (March 2006, December 2010) for supply of 40 aircraft (20 IOC and 20 FOC aircraft). However, forming of LCA squadrons could not materialize (January 2015) due to delay in LCA programme (as discussed in Chapter II) as delivery of aircraft was pending (January 2015).

Audit observed from the ADA documents that IAF had planned (September 2010) to initially operate the first squadron of LCA (No 45 Squadron) from Bangalore for a period of two years to complete first 50 sorties per aircraft, for timely product and maintenance support in order to resolve teething problems,

before relocating the Squadron at Sulur. However, operation of No.45 Squadron from Bangalore was still pending (January 2015).

In the meanwhile, based on a proposal submitted (October 2013) by Air HQ, MoD sanctioned (December 2013) the necessary work services for construction of new infrastructure for induction of two LCA squadrons at Air Force Station, Sulur at an estimated cost of ₹524.05 crore. The tendering action for the work services was in progress (December 2014).

Thus, formation of the first squadron at Bangalore, its consequent operation for two years before relocating to Sulur and synchronization with the infrastructure being created at Air Force Station Sulur remains to be seen.

4.8 Shortfall in creation of production facilities impacted Induction of LCA

Audit observed that due to delays in development and achieving IOC (December 2013) of LCA, HAL had indicated (July 2014) supply of 20 IOC aircraft during 2014-15 to 2016-17. Consequently, HAL production lines would be engaged in manufacturing of 20 IOC aircraft up to 2016-17. In case FOC of LCA Mark-I is achieved by December 2015 (as projected by ADA) the production of FOC aircraft cannot commence before 2016-17.

On the similar lines, even if LCA Mark-II would be developed by 2018 (as per the delivery schedule of FSED Phase III), the production of LCA Mark-II could commence only in 2020-21, as production line of HAL would be occupied with the production of LCA Mark-I FOC aircraft from 2017-18 to 2019-20.

In response to an audit observation (September 2014), HAL stated (October 2014) that in-principle approval was obtained (2012) from the GoI for capacity augmentation of LCA production line and CCS approval envisaging a total outlay of ₹1259.80 crore was under process (October 2014). Thus, with the anticipated capacity augmentation, HAL planned to increase progressively the rate of production to 16 aircraft per annum in three years to take up manufacture and delivery of aircraft in FOC configuration from 2016-17.

Reply of HAL is not acceptable due to the fact that in spite of obtaining in principle approval (2012) from the GoI, HAL was yet (October 2014) to get CCS approval for the proposed augmentation of LCA production line. In view

of this, HAL would continue to encounter production capacity constraints which would further delay the induction of LCA into IAF.

4.9 Operational Impact

Audit enquired (June 2014) regarding the operational impact of delay in development and productionisation of LCA on the formation of squadrons of IAF. In reply, operational impact brought out by Air HQ (July - October 2014) was as under:

- i. IAF is operating with 35 squadrons as against 42 squadrons sanctioned. Against this, squadrons for MiG 21 aircraft and MiG 27 aircraft would retire over the next ten years. Therefore, it was crucial for an early induction of LCA for maintaining the operational preparedness of IAF. The formation of the first Squadron was being continuously postponed due to delay in LCA development.
- ii. Air HQ further added that the measures taken to import/upgrade other aircraft were of temporary nature to prevent the decline of squadron strength of IAF. Therefore LCA's induction into IAF was necessary to overcome the drawdown of the squadrons permanently.

Thus, in view of depleting squadrons, delay in development of LCA and its consequent delay in induction into IAF was a cause of concern to IAF. The first two squadrons, even if inducted with LCA Mark-I, would not be provided with complete EW capabilities¹⁵. Besides, 20 LCA of IOC configuration (forming the first squadron of LCA), would not have BVR missiles till the aircraft were upgraded to FOC configuration at a later date. Also, IAF would be constrained to use LCA Mk-I having reduced survivability, lower performance, lower range and endurance, reduced pilot protection, reduced operational capability and reduced weapon accuracy as discussed in Chapter II.

¹⁵ Only RWR and CMDS would be provided without SPJ.

CHAPTER V: CONCLUSION

Indian Air Force (IAF) was operating MIG-21 series of aircraft manufactured during 1966 to 1987. Majority of these aircraft were to complete their total technical life and were expected to be phased out in the 1990s, thereby resulting in significant fall in combat level of Air Force. Thus, IAF mooted the proposal (early 1980s) for a replacement aircraft for MIG-21 fleet. It was against this backdrop that the indigenous design & development of Light Combat Aircraft (LCA) was sanctioned (1983) and Aeronautical Development Agency, Bangalore was formed (1984) to execute the programme.

As specified in the ASR (1985), LCA was required to be inducted into IAF by 1994. However, the LCA programme was riddled with delays right from the sanction of 1983 and even after three decades since, LCA is yet to be inducted into IAF squadrons.

During the course of phased development, ADA's decision to advance building of two prototypes from FSED Phase II to FSED Phase I rendered these prototypes deficient of critical on board systems, which had a cascading effect on the remaining three prototypes, and led to ADA using even the Limited Series Production aircraft meant for IAF use towards flight testing/evaluation, in contravention to the commitment given to the GoI at the time of obtaining sanction for building of these aircraft.

Further, IOC for LCA Mark-I was achieved (December 2013) with 53 concessions/permanent waivers, which limits the operational efficiency and survivability of the aircraft. Consequently, LCA Mark-I currently under development (both IOC/FOC aircraft) has shortfalls in meeting the engine thrust and other parameters such as weight of the aircraft, fuel capacity, pilot protection from front against 7.62 mm bullets etc. The self-protection jammer which was originally to be fitted on LCA Mark-I is now planned to be fitted on LCA Mark-II, thus the 40 LCA Mark-I would be provided only with RWR Tarang-1B and deficient of self-protection jammer, thus limiting its electronic warfare capabilities. Thus, IAF would be constrained to use 40 LCA Mk-I

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aircraft with limited operational capabilities, and LCA Mark-II being developed by ADA presently is expected to meet the ASR.

Delays in identification/replacement/ addition of weapons by IAF and their integration as per IAF requirement to make the LCA contemporary also added to the delays. In addition, there have been delays in completion of work packages by various work centres, which indicated ineffective monitoring of the project by MoD.

User involvement right from inception would be essential for effective and efficient completion of any project. However, active user (Air HQ) participation in the LCA Programme started only after November 2006, even though the need for a Liaison Group between Air HQ and ADA to ensure closer interaction between the design team and the user for better appreciation of mutual perception, had been recommended by the LCA PDP Review Committee as early as in 1989.

Though ADA claimed achievement of 70 *per cent* indigenisation, half of these sub-systems are developed with imported electronic components and accessories etc. The LCA programme suffered major setbacks in the indigenous development of Kaveri engine, Multi-Mode Radar, self-protection jammer, etc. The proposal for indigenous development of 109 LRUs was pending approval since February 2014.

The setting up of a production capacity of eight LCA *per annum* was delayed by HAL, which coupled with delay in production capacity augmentation, had impacted the formation of LCA Squadrons. Further, there has been delay in the manufacture and supply of series production aircraft due to delayed LCA development.

As a consequence of delay in development and induction of LCA, IAF had to up-grade MiG Bis, MiG-29, Mirage-2000 and Jaguar aircraft at a cost of ₹20,037 crore and revise phasing out of MiG-21 to ensure credible combat potential.

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Considering that measures taken by IAF to upgrade other aircraft were of temporary nature and induction of LCA was crucial for maintaining the operational preparedness of IAF in order to overcome the drawdown of squadron strength permanently, the LCA programme needs to be expeditiously completed to cater to the needs of the Defence Forces so as to avoid import of the fighter aircraft of this class and to ensure self-reliance in the long run.



(RAJIV KUMAR PANDEY)
Principal Director of Audit
Air Force

New Delhi
Dated:21 April 2015

Countersigned



New Delhi
Dated:21 April 2015 **(SHASHI KANT SHARMA)**
Comptroller and Auditor General of India

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ANNEXURE-I
(Refer Para 1.4)

Financial progress of the LCA programme

(₹ in crore)

Period	Brief Description of the Activity	Date of sanction	Sanctioned cost - FE within bracket			Actual expenditure (Jan 2015) ₹
			Original ₹	Revised ₹	Total ₹	
1983 – 1994	Sanction for LCA Programme	August 1983	560.00	-	2188.00 (873.00)	2188.00 (815.00)
1993-2004	Full Scale Engineering Development (FSED) –I	June 1993	2188.00 (873.00) (Including 560.00 crore sanctioned in August 1983)			
2000-in progress	Interim FSED Phase-II	February 2000	666.34 (349.71)		5777.56 (2108.41)	5302.24 (1468.54)
	FSED Phase-II	November 2001	3301.78 (1526.49) (Including 666.34 crore sanctioned in February 2000)			
		November 2009				
2009-2018	FSED Phase-III	November 2009	2431.55 (818.60)	-	2431.55 (818.60)	804.15 (484.64)
	Total		7921.33 (3218.09)	2475.78 (581.92)	10397.11 (3800.01)	8294.39 (2768.18)

ANNEXURE-II
(Refer Para 3.1)

Details of development of indigenous capability

SI No	Description	Indigenisation level projected
1	Aerodynamic design	Complete
2	System Architecture	Complete
3	Structural Design	Complete
4	Manufacture of structure	95 <i>per cent</i> indigenous
5	General Systems	85 <i>per cent</i> indigenous Import–heat exchangers, pumps, sensors
6	Metallic materials	80 <i>per cent</i> indigenous
7	Engines	Import – as interim solution
8	Avionics equipment	80 <i>per cent</i> indigenous Import – Multi Functional Displays, Electrical Generators, RLG, Electronic components
9	Software	Complete
10	Flight Control System	40 <i>per cent</i> indigenous Import – Actuators, sensors
11	Radar	Indigenous Import – Electronic components
12	Aircraft integration	Complete
13	Ground test rigs	Complete
14	Flight testing	Complete
Total Indigenous content		61 percent
Total Import content		39 <i>per cent</i>

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**ANNEXURE-III
(Refer Para 4.2.2)**

Statement showing aircraft details of flights undertaken, average number of flights achieved and number of days for which the aircraft were not flown for conducting flight tests

Sl. No.	LCA reference	Date of first flight	Date of last flight	Number of Sorties	Average Sortie Per month	Cumulative hours flown (in hours)	Flight duration (in minutes)			From first flight to IOC	Aircraft not flown	Aircraft flown for tests
							Mini mum	Maxi mum	Average per sortie			
1	TD 1	04.01.2001	11.12.2007	233	3	133.58	6	78	34	2532	2305	227
2	TD 2	06.06.2002	14.05.2009	305	4	152.24	6	68	30	2533	2242	291
3	PV 1	25.11.2003	18.01.2010	242	3	161.33	8	112	40	2245	2015	230
4	PV 2	01.12.2005	26.04.2012	222	3	123.23	6	102	33	2338	2132	206
5	PV 3	01.12.2006	19.12.2013	381	5	226.01	6	105	36	2575	2231	344
6	PV 5 (Trainer)	26.11.2009	20.04.2011	36	2	21.42	12	50	36	510	475	35
	Total			1419		817.81				12733	11400	1333
7	LSP 1	25.4.2007	21.4.2012	74	1	40.10	6	103	33	1823	1750	73
8	LSP 2	16.6.2008	7.12.2013	289	3	185.43	5	108	39	2000	1730	270
9	LSP 3	23.4.2010	20.12.2013	183	2	142.06	12	102	47	1337	1166	171
10	LSP 4	2.6.2010	23.11.2013	95	1	77.22	8	91	48	1270	1178	92
11	LSP 5	19.11.2010	20.12.2013	242	3	186.31	8	102	46	1127	907	220
12	LSP 7	9.3.2012	15.12.2013	77	1	59.54	16	102	47	646	576	70
13	LSP 8	31.3.2013	20.11.2013	62	1	52.33	14	100	51	234	184	50
	Total			1022		742.99				8437	7491	946
	Grand Total			2441		1560.80				21170	18891	2279