# Integrated Logistics Framework for Indigenous Fighter Aircraft Development

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## Abstract

***When building and using a combat aircraft, logistical support is crucial. Paper-based systems were once the norm for managing logistical support tasks. The implementation of a computerized logistics support system facilitated the rapid examination of logistics records for supportability evaluation and alternative planning. Meanwhile, PLM systems evolved to offer a framework for sharing technical know-how through efficient configuration management, cutting down on development/induction times. PLM and logistics support systems worked together because of a shared desire to shorten the product development cycle, lower the product's overall cost, including maintenance and support, and improve the product's performance and dependability. With the expansion of PLM systems, the whole aircraft lifespan can now be managed via configuration. This includes the technical knowledge and the logistical support information. In the early phases of the program, the integrated approach, also known as Integrated Logistics Support (ILS), aided in defining the performance and reliability targets for the creation of a fighter aircraft that is easy to maintain. Innovations in the procurement of military aircraft resulted from the greater operational dependability. Performance-Based Logistics is an innovative approach to contracting that has emerged in recent years. (PBL).***

## Keywords:

***ILS; LSA; LSC; FRACAS; PBL; Reliability & Maintainability, Fighter Aircraft.***

## introduction

The introduction of PLM in the Aerospace & Defence (A&D) industry brought all stakeholders on a collaborative platform. It heralds an era of close coordination that had never been seen before and that yielded better design, reducing lead time and resources required. The PLM framework enabled the designers to leverage the state-of-theart technologies viz. Digital Mock Up (DMU), tolerance stack up analysis and build sequencing effectively. There have been concerted efforts to bring the logistics support under the ambit of PLM to establish digital thread across the lifecycle till the product phase out. The logistics support activities that had been previously managed through proprietary solutions were based on inputs from the product development teams, allowing analysis of the required logistics support, supportability assessment and plan for alternatives. The birth of ILS approach brought other stakeholders also for planning of the logistics requirements at the early stages of the product development. The following two major components of PLM framework were instrumental in bringing all business functions into a single change process that can effectively drive information both upstream and downstream to provide effective lifecycle management.

## Configuration Management (CM)

CM is a means through which integrity and continuity of the design, systems engineering and supportability are recorded, communicated and controlled. It results in complete audit traceability of decisions and design modifications, leading improvements in the change management by enabling change processes to include all affected organizations. CM includes the evaluation of all change requests, change proposals and their subsequent approval or disapproval, involving appropriate levels within the organisation of the customer and the developer for the project. It ensures that no change gets implemented without due consideration of its effect on the baselines, including logistics impact, costs, schedules, performance, or interface with any associate companies etc.

## Concurrent Engineering

PLM helped to improve the logistics support data creation by directly linking it with part and product data. PLM made available full product views across product engineering, logistics, manufacturing and sustainment, facilitating better impact planning and improving the customer responsiveness by linking the logistics support data to the latest engineering modifications. The single source of product and process knowledge, for all lifecycle disciplines, on a collaborative platform of PLM aided in improved productivity and logistics support data integrity.

| Nomenclature | |
|---|---|
| A&D | Aerospace & Defence |
| CAMMS | Computerized Aircraft Maintenance Management System |
| CM | Configuration Management |
| CMRS | Calibration Measurement Requirement Summary |
| CSDB | Common Source Data Base |
| DDPMAS | Design, Development and Production of Military Aircraft and Airborne Stores |
| DMU | Digital Mock Up |
| FMECA | Failure Mode Effect & Criticality Analysis |
| FRACAS | Failure Reporting Analysis and Corrective Action System |
| ILS | Integrated Logistics Support |
| LCC | Life Cycle Cost |

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|---|---|
| LOR | Level of Repair |
| LORA | Level of Repair Analysis |
| LSA | Logistics Support Analysis |
| LSAR | Logistics Support Analysis Record |
| LSC | Life Support Cost |
| OEM | Original Equipment Manufacturer |
| PBL | Performance Based Logistics |
| PHST | Packing, Handling, Storage and Transportation |
| PLCS | Product Life Cycle Support |
| PLM | Product Lifecycle Management |
| R&M | Reliability & Maintainability |
| RBOM | Reliability-Bill-of-Material |
| RCM | Reliability Centered Maintenance |
| SERD | Support Equipment Recommendation Data |
| SMA | Scheduled Maintenance Analysis |
| XML | Standard Generalized Markup Language |

## Integrated Logistics Support (ILS)

ILS is an integrated and iterative process for developing material and support strategy, guiding the system engineering process to quantify and lower life cycle cost. By leveraging the existing resources, ILS optimises the functional support while decreasing the logistics footprint, making the system support friendly. ILS provides a

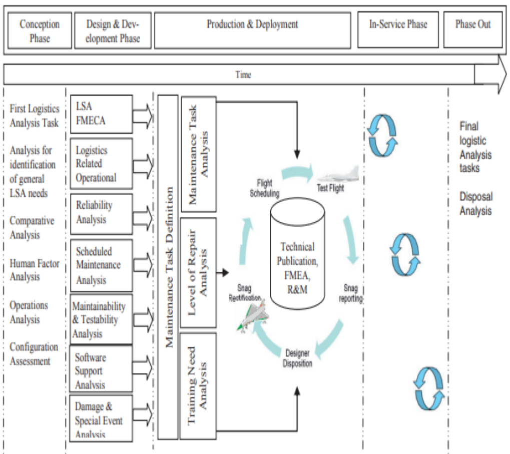


*Figure 1 Logistics Support Analysis Activities over the lifecycle of the aircraft [6]*

framework for the integrated evolution of technical manuals and required logistics for better product availability and sustenance. It ensures that the maintenance man hours per flight hour are within the acceptable limits. LSA is a subset of ILS that provides the framework for monitoring and controlling the systematic development and execution of the ILS program. LSA is a disciplined and live exercise that starts from the conceptual phase and evolves throughout the lifecycle of the aircraft. It is a comprehensive analytical process that integrates system design and support system requirements, maintaining the history of the supportability decisions for the product development. It helps in establishing a direct relationship between logistic-related design parameters such as reliability, maintainability and availability; and support resource requirements [4]. The use of LSA approach enforces the developer from the conception through disposal of the product to consider all elements of the product life cycle such as cost, schedule, performance, supportability, quality and user requirements. Combined with PLM, the LSA plays a deciding role in influencing the design so that both the product and the support can be provided at an affordable cost. Figure 1 describes various analyses that can be carried out over the lifecycle of the equipment for defining and maintaining the LSA record. In the early phase of a program, the logistic activities, as shown in figure 1, can be limited to the ones that only require a low level of information. Section 3 & 4 highlight the LSA activities that can be performed during “design and development” and “production and deployment” phase respectively. The standards that need to be complied with for implementing ILS are discussed in Section 5. Section 6 describes the PBL, which is a new trend in contracting and made possible by the ILS.

## ILS activities during Design & Development Phase

Any failure identified by analysis during design and development saves a huge cost by weaning out the possibility of a failure in the field trials or in-service. Thus, analysis plays a critical role as it helps to identify a failure in the early stages of the product development when the cost associated with the remedial action is minimal. As shown in figure 1, the following analysis/processes should be established during the design phase for implementing LSA.

### LSA FMEA and design-oriented FMECA

While the objective of a Failure Mode Effect & Criticality Analysis (FMECA) is to identify all modes of failure within a system design, its first purpose is the early identification of all catastrophic and failure possibilities so they can be eliminated or minimized through design correction at the earliest possible time. Although FMECA is an essential reliability task for design activities, it also provides data for maintainability, maintenance or safety analysis, availability analysis, logistics support analysis, failure detection and fault isolation. LSA FMEA is derived from FMECA and is used for Level of Repair Analysis (LORA), Reliability Cantered Maintenance (RCM) and Scheduled Maintenance Analysis (SMA). Because the maintenance activities may not focus on the individual components but on replaceable or repairable units, which may be located at a higher level of breakdown than that of individual components, LSA FMEA is generally coincident with, but not identical to, design oriented FMECA.

### Logistics related Operational analysis

The identification of logistics relevant operations, including the requirements concerning personnel, support equipment, consumables, spare parts, facilities and required training, is an important area of logistics analysis tasks. The logistics related operational analysis helps to identify the tasks related to servicing, Packing, Handling, Storage and Transportation (PHST); mooring, shoring, disposal and recycling, and other logistics related operations.

## ILS activities During Production & Deployment Phase

The data captured during the field trials, in accordance to MIL-STD-1533B, is of immense value to both designers and shop technicians. It is rich in information related to fault observed, their diagnosis, corrective action taken, provisioning of spares and logistics. The data can be utilized to validate the analysis done for the LSA activities or enhance upon it. Also, the data can be utilized to do the sensitivity analysis on the baseline processes established for LSA in the design phase. As shown in figure 3, the failure report and the corrective action data as recorded in the FRACAS framework during field trials is utilized to update the performance/R&M data as calculated during the

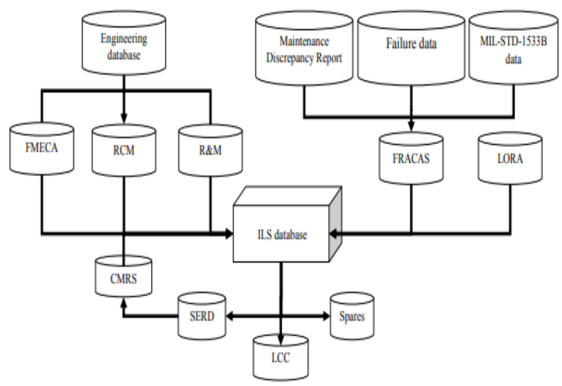


*Figure 2Logistics Support Analysis [10]*

design phase. The data is useful for carrying out LORA, establishing Support Equipment Recommendation Data (SERD), creating Calibration Measurement Requirement Summary (CMRS) and Life Cycle Cost (LCC). The vast repository of data builds up in the ILS program is used to produce the training, provisioning and technical publications required to support the system or equipment. The initial spares, replenishment spares and cost required for sustaining the product for a given operating scenario and period of performance can be calculated by the Life Cycle Costing procedures, which derive their data from ILS database. This further can be used to conduct sensitivity analysis to reduce the total support cost by optimising spares mix and highlight the items where reliability improvement would produce the greatest cost savings. The section below discusses various LSA activities that can be carried out based on the field data.

### Maintenance task analysis

Maintenance Task Analysis is one of the central analysis activities within the LSA process. Here, the identified maintenance tasks (both scheduled and unscheduled) are detailed with all required information viz. I) Documentation of general task information such as preconditions for task performance, training requirements or criticality information, ii) Assignment of maintenance tasks to the identified events, iii) Rough task description (sequence of subtask), iv) Identification of related logistics resource requirements (e.g. personnel, support equipment, spares, facilities, software), v) Time estimations, vi) Calculation of task frequencies, vii) Consideration of required pre- and post- tasks (e.g. test, fault location, gaining access)

### Training Need Analysis

The identification of training requirements concerning maintenance activities can be derived from the maintenance tasks documented in the LSA database. Within this analysis, it must be decided whether a task requires special training or not. If training is required, it must be determined how the training can be applied most effectively. This process can be supported with the help of the content of the LSA database concerning the identified tasks.

### Level of Repair Analysis

For a complex engineering system containing thousands of assemblies, sub-assemblies, components, organized into several levels of indenture and with a number of possible repair decisions, the Level of Repair (LOR) studies help to determine an optimal provision of repair and maintenance facilities to minimize overall system. Based on personnel expertise, the initial LOR can be established. The improvement on the baseline LOR decisions can be taken up as the feedback is accrued over the lifecycle of the product. Though the process is generally useful in establishing the LOR it results in less collaboration from the engineering teams and thus escalation of the costs. LORA, as defined in MIL STD 1390C [3], is an analytical methodology used to determine when an item will be replaced, repaired, or discarded based on cost considerations and operational readiness requirements. It determines where each required maintenance action will be performed, the physical resources that must be available to support performance of maintenance, and the support infrastructure required to sustain the system throughout its operational life. The LORA can be applied on the baseline indenture levels or on initial LSA components. A sensitivity analysis can be performed on various cost significant parameters. The results of the various sensitivity runs will indicate whether the maintenance solution from the baseline run is stable or not. The output of the sensitivity analyses can be used as a baseline to establish a preliminary maintenance solution and the indenture level for the LSA components. An example of a maintenance strategy is given below, based on three levels of maintenance, which indicates the capability of personnel, availability of special facilities, time limits and the environmental conditions to be assumed in determining the functions to be accomplished at each maintenance level.

## Organizational maintenance / Operational Level

Organizational or O-level maintenance is done at the organizational unit level, for example by a single maintenance squadron, and is typically optimised for quick turn-around, to enhance operational availability. Maintenance at this level typically consists of preventive maintenance, corrective maintenance i.e., removal and replacement of the unserviceable LRUs, simple modifications, usage preparation and role changes, pre-and post-flight inspections, functional checks, trouble shooting, loading of software and data retrieval.

## Intermediate maintenance

Intermediate or I-level maintenance is done in specialized facilities, typically allocated to multiple operating units residing at a common operating location, that are capable of accommodating the maintenance tasks that could include special equipment or specialized workshops and will be performed by appropriately trained and specialized personnel. I-level maintenance is of more specialized nature and allows for thorough and time-consuming diagnostic testing and repair procedures, usually in support of failed items removed at the O-level of repair. Test equipment is more common at this level of repair, and is used to automate many test procedures. The activities at I-level include repairs down to module and subassembly level, moderate structural repairs, major scheduled inspections, moderate modifications, technical assistance to the O-level organisation, software servicing concerning engineering data, preservation of complete product, corrective and preventive maintenance and specific maintenance activities that will be performed both on product, and off product

## Different Standards required to implement the ILS

The lifecycle of military aircraft can be over 50 years, much higher than any other commercial product lifecycle. The operating and support costs of the military equipment's make up about 60-70 percent of a weapon system's total lifecycle costs. An extended lifecycle implies that the system will go through constant change to adapt to the warfighting environment. The challenge is to support the equipment's after production while reducing sustainability costs [9]. In compliance with the standards and protocols that allow legacy systems as well as future technological innovations to interoperate seamlessly, an ILS can achieve the objective as stated above. Figure 4 shows the different specifications, described below in brief, that needs to be followed while establishing the PLM enabled logistics support system.

**S1000D:** It is an international specification for technical publications. It uses international standards such as the Standard Generalized Markup Language (XML) and Computer Graphics Metafile for the production and use of electronic documentation. S1000D is organized in a modular approach based on the Common Source Data Base (CSDB) principle for data creation and storage.

**S2000M:** International publication for material management. This is a standard for spares and provisioning. S2000M defines the process and provides the mechanism for communicating and exchanging provisioning data between contractors, partners and government agencies. This information is a key component of the required ILS data set.

**S4000M:** International procedure handbook for the development of scheduled maintenance programs for military aircraft.

**S3000L:** It is a logistics handbook for performing LSA based on Product Life Cycle Support (PLCS) and specifically tailored for A&D.

**S5000F:** It is the specification for operational and maintenance data feedback. The data feed from in-service operations and maintenance forms the basis for the empirical validation, update and correction of the theoretical, calculated and predicted values that have been established within the LSA activities. The different standards in an ILS program intercommunicate among each other in compliance with DEX1A&D and DEX3A&D, the standard for exchange of product breakdown and task specification.

## Operational & Maintenance Data Feedback – Functional Coverage by S5000F

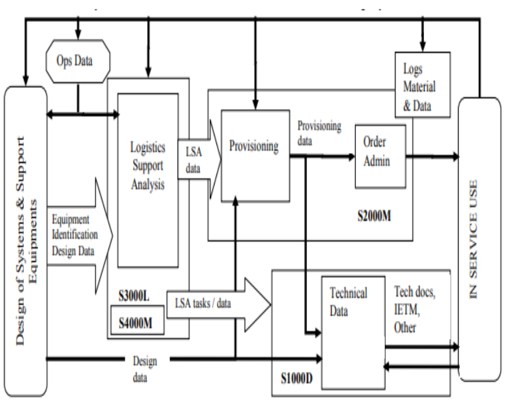


*Figure 3 Different standards for the implementation of ILS [5*

## Conclusion

There is a lot of competition in the aerospace and defines (A&D) sector, but using ILS technologies and procedures may help you stand out from the crowd by reducing your product's ongoing maintenance costs and boosting its overall performance. PBL is a relatively new development in the military aircraft purchasing process made possible by ILS. The duty to maintain the fighter aircraft in a state of combat readiness falls on the manufacturer under a PBL based contract, and the mission capability rates are set during the design process itself. It's a way to ensure your systems are always ready to go by purchasing support as a bundled, cost-effective performance bundle. While decreasing both expenses and the size of any necessary deployments, PBL increases the effectiveness of operations. To improve fighter aircraft capabilities across the life of a system or product, PBL seeks to forge an early and lasting relationship between industry and the government. For PBL to work, an OEM would have to sign a long-term, fixed-price contract to manufacture and maintain the fighter aircraft during its service life. Over many decades, ILS has become standard procedure in the developed countries. When it comes to military aircraft, India is now a serious contender.

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