Evolution of Aircraft Maintenance/Support Concepts with Particular Reference to Aircraft Availability – Czech Air Force Perspective

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ABSTRACT

This paper describes the Czech approach and experience gained during development of the Czech Subsonic Advanced Light Combat Aircraft L-159 (ALCA), from the point of view of maintenance concept and logistic support in general.

The L-159 is the first aircraft developed and produced in the Czech Republic after the year 1989 according to MIL-STDs. Prior to the L-159 aircraft, which was designed with respect to the requirements of "On-condition Maintenance", the Czech Air Force fleet inventory consisted Russian production combat type aircraft and Czech production training aircraft with maintenance concept based on Scheduled Maintenance and aircraft and engine Overhauls. This paper presents the differences between the two maintenance concepts and describes the results that have been observed in the field.

According to the operational plan to develop a light combat aircraft, which was initiated in the year 1992, the decisive requirements on combat usage were defined. The plan also described the main milestones of the project including the aircraft fielding demonstration, short project lead-time and issues related to logistic support.

This paper describes the aircraft design and its impact to the proposed and implemented logistic support. The entire logistic support has been prepared according to MIL-STD-1388-1A and the individual tasks are described, including the methods of fulfilment of selected subtasks, as well as the issued of preparation of logistic support analyses (LSA) according to MIL-STD-1388-2B under the conditions of international project while participation of the companies from USA, Italy, France, and UK.

The process of application of customer requirements from the Use Study prepared in the year 1996, until determination of optimum maintenance concept and implementation of changes of the organizational structure at the user (CzAF) side is described in the next part of the paper. The paper mentions the main stages of creation of the logistic support system and the set of technical publications for the Czech Air Forces. The paper further analyzes the impacts of the aircraft fleet reduction, decrease of the number of air bases and *decrease of the annual flight hours per aircraft unit to the entire logistic support system, and the LCC. From the point of difficulty and fulfilment of deadlines, the most critical element of the logistic support evaluated is the preparation, verification, and delivery of technical publications.*

The paper describes HW and SW means for monitoring of condition and service life of the aircraft and its systems and their influence to the maintenance concept, which was originally requested as the "on-condition" type. The paper also specifies the influence of the requested time schedule of completion of development and of the issues of the own maintenance system development process from the "On-Condition" to the "Combined Maintenance System". It means that for engine, avionics and airframe structure is on-condition maintenance applied and airframe systems have scheduled maintenance concept.

The paper discusses the methods of fulfilment of the individual parameters of reliability, availability, and maintainability in the process of realization of the project until the current operation of the modified fleet of the L-159 aircraft. Fulfilment of the required values of parameters is documented by evaluation of operational data from practical proof during operational usage of the aircraft during deployments and exercises of allied forces.

In the context of the necessity of further improvements, simplification and price reduction of the support concept, the paper analyzes the necessity to ensure the mutual exchange of operational data. Therefore, the paper describes in the end the system of data exchange between the user and the manufacturer, which includes the data from the aircraft operation, provided analyses and measures proposed to decrease LCC.

In the end, the paper contains the experience gained during the transition from one maintenance system (Scheduled Maintenance Period) to another (On-Condition) for the aircraft category of "Subsonic Light Combat Aircraft" – the CzAF L-159.

1.0 INTRODUCTION

With the retirement of the last Mig-21 aircraft units in the year 2005 the decades-long period of utilizing Soviet jet technology in the Czech Air Forces (CzAF) came to an end. The CzAF operated the following aircraft types during the 1980's and 1990's: Su-7, Su-22, Su-25, Mig-21, Mig-23, and Mig-29. These aircraft came to the CzAF inventory as established and operated types including full logistic support. They were purchased from the USSR, where these aircraft were developed, qualified and already in service for several years prior to delivery to the CzAF. Their implementation into service also meant to manage the corresponding system of operation and maintenance.

The Czechoslovak production jet aircraft L-29 and L-39 were used as trainers. They were delivered from the beginning of the 1960's or 1970's. These aircraft were designed according to NP CAGI standards (design standards for military aircraft of USSR).

The situation changed after 2005. Today, the CzAF operates two types of tactical aircraft the JAS-39 Gripen (12 a/c of C-version and 2 a/c of D-version) and L-159 (24 a/c). The JAS-39 Gripens are operated using a lease agreement between the Kingdom of Sweden and Czech Republic signed 2005. The Czech made L-159 aircraft has been in operation since 2000.

In this paper, we will focus on the L-159 aircraft as a representative of a complex military aircraft system, where NATO compatibility requirements were implemented for the first time in the Czech Republic as well as the requirements for an on-condition maintenance concept.

Since the time of L-39 trainer development, the L-159 was - after a certain period of time - the first domestic development of a light combat aircraft. This was major international project with participation of the Czech industry and foreign subcontractors. Based on the specific customer requirements, the development procedures were according to standards and specifications never before used in the Czech Republic (US Mil-specs and STANAGs). It was necessary to adopt these standards and determine the appropriate ways to work according to them.

2.0 L-159 PROJECT

The L-159 aircraft project was originated based on a detailed analysis of actual situations and needs of the CzAF at the beginning of the millennium. With respect to political orientation of the Czech Republic in the beginning of 1990's and based on military - technical and economical analyses, the decision was adopted to gradually re-equip the obsolete aircraft technology with the NATO compatible technology using production and development capacities of the Czech aircraft industry. After the analysis, both from time and economic aspects, the decision was made to select a light multi-role sub-sonic tactical combat aircraft called the L-159 (ALCA - Advanced Light Combat Aircraft). The concept of the aircraft was based on the utilization of advantages and heritage from the L-39/59 aircraft family, with the integration of a state-of-the-art propulsion power unit, avionics and armament systems for reasonable price compromise.

Approval of tactical – technical requirements (further referred to as TTP) for the L-159 system was accomplished at the end of 1993. The L-159 project development officially started in April 1994 with the signature of the development contract between the Ministry of Defence of the Czech Republic and the company AERO Vodochody a.s.

2.1 L-159 Project Milestones

The main project milestones are listed below to illustrate time period for the L-159 development:

- 1992 Operational intent of light attack aircraft
- 6/1993 Feasibility Study
- 11/1994 Preliminary Project
- 4/1995 Development Contract
- 6/1996 L-159 Final Project approval
- 7/1997 Contract for delivery of 72 L-159 aircraft signed between Czech MOD and Aero Vodochody
- 9/1997 Logistic Guidance Conference
- 12/2000 first two aircraft delivered to Caslav AFB
- Deliveries: 2000 – 2 a/c, 2001 – 34 a/c, 2002 – 22 a/c, 2003 – 13 a/c, 2004 – 1 a/c
- 12/2001 Initial Operational Capability
- 7/2003 Type certificate

2.2 Tactical – Technical Requirements

Definition of the basic TTP for development of the L-159 aircraft system was a demanding process of iteration to fulfil the basic economical and scheduled constraints and to fulfil the requirements of the user to reach the minimum lifecycle costs (LCC) goals for the aircraft.

The documents "Prognosis of relative L-159 aircraft service spectra in the CzAF" and the "Use Study" formed the basis for completion of TTP during the development process and during verification of the product. In addition, integrated logistic support and its related elements were applied for the first time on an Aerospace project of this size in the Czech Republic.

In accordance with requirements of the CzAF, the L-159 aircraft was designed to be a light multi-role single-seat subsonic combat aircraft which can fulfil the following tasks under normal and adverse meteorological conditions during both the day and night:

- Tactical reconnaissance;
- Fights against air targets to short and medium distance within and behind the visual range;
- Destruction of ground targets with guided and unguided weapons; and
- Training and condition flying.

2.3 Principles Applied During L-159 Project

After detailed analysis, the decision was made that some instruments and aggregates developed and applied in the L-39/59 aircraft would be used without any changes, some would be modified, and some would require new development. Based on this principle, all the instruments and aggregates in the L-159 were divided into the following groups:

- Imported from foreign suppliers;
- Newly developed in the Czech Republic for the L-159;
- Modified for the L-159; and
- Adopted from the L-39/59 family.

Using this principle, the development schedule and acquisition costs were able to be significantly decreased.

The L-159 airframe structure is based on the L-39/59, where the load was defined in accordance with strength requirements of the USSR design standards – NP (Normy Procnosti) CAGI. It also fully utilizes all performed tests of the airframes of the L-39/59 aircraft family. These results were verified according to MIL-A-1530 and MIL-A-83444 standards.

Fatigue tests were performed using the Safe Life method. The results fully demonstrated that the airframe fulfilled the required 8,000 flight hours service life and that it has additional reserve. The service life can be increased upon application of fleet management system (FRAME159). Service life of the individual aircraft units, if their loads would differ from the design spectrum, can be determined by re-calculation. During a final part of the full-scale fatigue tests, the artificial cracks were evaluated, with following residual strength test. For a majority of the structure locations, the "limited damage tolerance" was proven using slow crack growth methods.

Aero-elasticity tests were performed in accordance with requirements of MIL-A-8870C. The airframe provides sufficient reserve to allow for available upgrades in the future.

Therefore, for operation monitoring and for efficient control of "life utilization" of the individual aircraft unit, a system of operational parameter collection from the Aircraft Monitoring System (AMOS) was developed. Evaluation of the airframe critical parameters (vertical load factor, pylon loads, maximum, take-off and landing weights, power unit temperature cycles, etc.) serves as the basis for decision making and effective fleet management.

The advantages and heritage of the L-39/59 aircraft family with the reliability and availability values applied to L-159 are shown in the following table.

Table 1: L-39 MTBF and Availability.

Year	Number of Flight Hours	Failures	Failures in Flight	MTBF	$MTBF_{FLIGHT}$	A_i
74	520	88	18	5,91	28,9	0,4324
75	2534	160	39	15,8	65	0,716
76						
77	3522	307	47	11,5	75	
78	3709	238	13	15,6	285	
79	759	32	5	23,7	152	
80	2087	108	6	19,3	348	
81	388	17	2	22,8	194	0,8211
82	1066	53	10	30,1	107	0,8535
83	6447	268	52	24,1	124	0,8376
84	6171	248	22	24,9	281	0,8953
85	8481	303	22	27,3	395	0,8621
86	6560	246	15	26,7	437	0,9124
87	5742	262	48	21,9	120	0,8859
88	5847	300	58	19,5	104	0,8738
89	7348	441	69	16,7	106	0,9048
90	6847	371	48	18,5	143	0,8482
91	3937	298	32	13,2	123	0,8301
92	3728	188	22	19,8	169	0,8945
93	2058	88	25	25,7	82	0,8684
94	1923	52	8	37	240	0,8715
95	1325	63	10	21	133	0,8511
96	901	38	7	23,7	129	0,8527
97	543	40	16	13,6	34	0,778
98	1492	67	30	22,3	54	0,8643

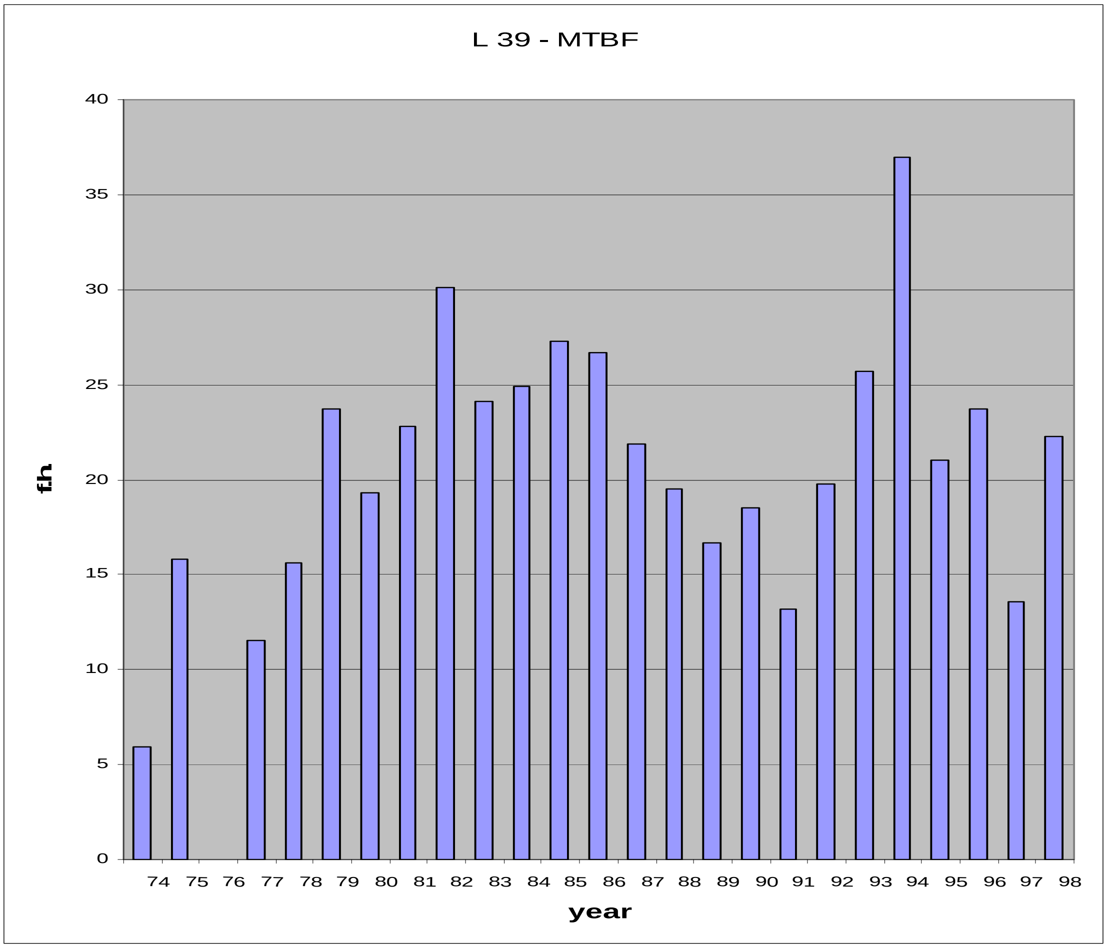

Figure 1: L-39 MTBF.

2.4 Standards Applied

Early on, it was agreed that the Czech standards (CSN, CSVN and CSN ISO), the USSR standards (ENLGS, NP CAGI), the US Mil-specs and RTCA standards would be applied to the process of development, design and testing of the L-159. Important standards with respect to the logistic support are listed below:

- Airframe structure according to NP CAGI (USSR standard).
- Aircraft structural integrity program according to MIL-STD-1530A.
- Reliability program according to MIL-STD-785B.
- Reliability predictions of electronic equipment according to MIL-STD-217E.
- Reliability design qualification and production acceptance tests according to MIL-HDBK-781A.
- Safety program according to MIL-STD-882B.
- FMEA/FMECA analysis performed according to MIL-STD-1629A.
- LSA according to MIL-STD-1388-1A.

- LSAR according to MIL-STD-1388-2B.
- Technical manuals according to MIL-M-38784B.

2.5 L-159 Introductions

The L-159 is a single-seat light multi-role combat aircraft designed for a variety of Air-to-Air, Air-to-Ground and Reconnaissance missions. The aircraft is equipped with state-of-the-art multi-mode radar for all-weather, day and night operations and it can carry a wide range of NATO standard stores including air-to-air (AIM-9) and air-to-ground (AGM-65) missiles and laser guided bombs.

2.5.1 L-159 Main Features

Despite the L-159 and L-39 have an external shape similarity at the first glance, it must be highlighted that the L-159 is an aircraft of new generation. Therefore, the L-159 main features are introduced below:

- Multi-Mode Pulse Doppler Radar.
- Advanced Human/Machine Interface wit Head-Up Display (HUD), Multi-Function Color Display (MFCD) and Hands-On-Throttle-And-Stick (HOTAS) controls.
- Avionics Integration based on MIL-STD-1553 databus.
- Accurate and autonomous navigation system with laser gyro based Inertial Navigation System (INS) and Global Positioning System (GPS).
- Extensive in-flight recording and debriefing capability for video, audio, self-protection system, engine and aircraft parameters (AMOS).
- On-condition maintenance and fatigue monitoring system for low operational cost and optimum use of aircraft service life (FRAME159).
- On-Board Oxygen Generating System (OBOGS), On-Board Inert Gas Generating System (OBIGGS) and Auxiliary Power Unit (APU) for self-contained operation with minimum support.
- Seven pylons for various stores.
- Ability to operate from semi-prepared airfields.
- Two-shaft, non-afterburning turbofan engine, controlled by dual FADEC with Engine Monitoring System (EMS).
- Self-protection system installation and use of redundant systems for high level of survivability and flight safety.
- Zero height and zero speed ejection seat.

2.5.2 L-159 Basic Data

• Wing span	9.54 m	31 ft 3 in
• Overall length	12.73 m	41 ft 9 in
• Overall height	4.8 m	15.8 ft
• Basic weight	4,300 kg	9,500 pounds
• Maximum ramp weight	8,000 kg	17,640 pounds

- Airspeed limitations 0.82 Mach 520 KIAS
- Maximum level speed at SL 963 km/h 505 KTAS
- Max structural limit +8g -4g

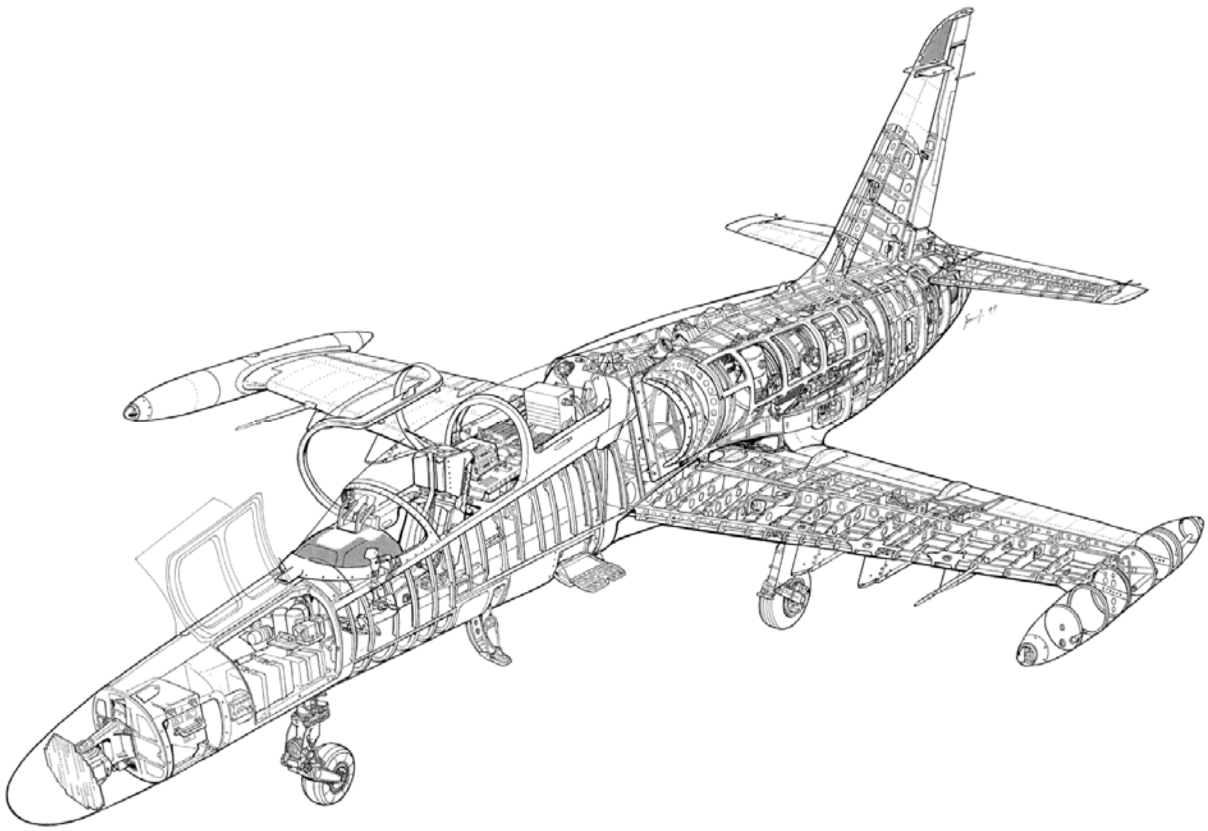

Figure 2: L-159 general arrangement.

Figure 3: The CzAF L-159.

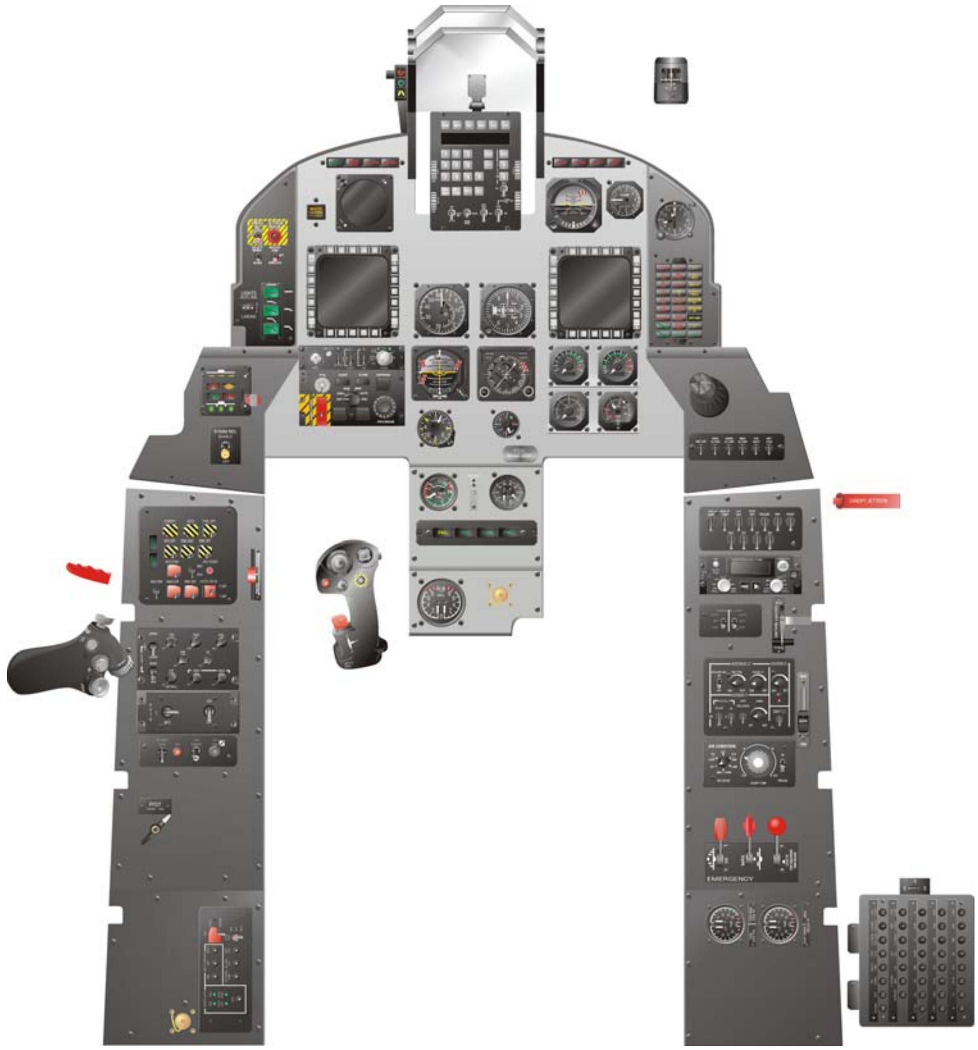

Figure 4: L-159 cockpit layout.

2.6 Use Study

The CzAF and MOD prepared the Use Study to identify and define the intended use, supportability factors, operational assumptions and the CzAF operating environment and mission. This document was beneficial to the aircraft producer and the various subcontractors and allowed the team to meet the requirements of the L-159 Technical Specification, including the logistic support requirements. The structure and content of the Use Study was developed according to MIL-STD-1388-1A, Task 201.2.4.

2.6.1 Use Study Logistics Requirements

Requirements related to the logistic support and maintenance are listed:

- On-condition maintenance with three level maintenance concept ("Aircraft operation and maintenance shall enable – both from technical and legislation aspect – the maintenance according to actual condition – on-condition maintenance").

- Monitoring systems:
  - Aircraft and systems – Aircraft Monitoring System (AMOS).
  - Engine – Engine Monitoring System (EMS).
  - Airframe structure – FRAME159.
- Low LCC (value unspecified).
- Total MTBF = 10 ($MTBF_F$ = 40 – in flight), assumed AOR = 250 flight hours/aircraft/year.
- Simple Pre-flight, Thru-flight and Post-flight maintenance. (Thru-flight inspection for repeated combat take-off shall not take more than 20 minutes (Air-to-Air mission).
- Total service life of the aircraft shall not be less than 8,000 flight hours during the period of 25 years for the defined operational spectrum.
- The aircraft shall be equipped with a pressurized system of refuelling.
- The project shall contain the analysis of parameters of operational reliability and safety, including economical analysis; analysis of operational costs, according to the MOD approved methods.
- At the same time with aircraft delivery, the user must obtain technical publications, including multimedia-training aids.
- System ensuring safe movement, take-off and landing of the aircraft within the range of the aircraft operational envelope on paved and unpaved RWYs.

During processing, some differences in interpretation of NATO standard requirements and the CzAF regulations of terms occurred, which influenced logistics and reliability. The two following examples are shown for illustration.

2.6.2.1 Flight Time Definition

The first case is the definition of time of flight. It is defined as a time from the moment the aircraft first moves under its own power for the purpose of flight until the moment it comes to rest at the next point of landing. (“Block-to-block” time). Unlike this definition, the CzAF understands flight time as the time elapsed between take-off and landing.

This had a big impact on evaluation of reliability parameters and technical service life as well as records to log book.

2.6.2.2 Initial Operational Capability

The second example is Initial Operational Capability (IOC). The IOC was defined as fielded aircraft meeting the following conditions:

- Delivery and take-over of the first squadron of aircraft (18 aircraft) to a determined place, on agreed date.
- Initial training of 36 pilots accomplished.
- O-level ground support equipment and test equipment delivered and ready for use.
- Technical publications delivered.
- Provisioning system determined.

- Training of the CzAF ground personnel for O-level accomplished.
- POL delivered in agreed quantity.

Deadline for complying with these requirements was determined but it was difficult to find an equivalent of this status in the CzAF regulations.

3.0 LOGISTIC SUPPORT

Based on the requirements of the CzAF Specification and US Military Standards (MIL-STD), the complete scope of the L-159 logistic support tasks was accomplished as an integrated system (Integrated Logistic Support – ILS). The integrated approach aims to comply with the required level of availability, safety, reliability and maintainability, while achieving the optimum Life Cycle Cost (LCC).

Each ILS element was analyzed during the stages of development, design, manufacture and fielding of the aircraft, according to MIL-STD-1388-1A and -2B. Separate analysis plans were prepared for each ILS area (LSA Plan, Technical Publication Plan, Training Plan etc.). The plans became an important tool in managing and controlling all ILS activities.

3.1 Logistic Management

A team of experienced and dedicated personnel were established to support the L-159 project. The joint L-159 ILS Team was established by the aircraft, engine and avionics manufacturers and the CzAF representatives:

- Aero Vodochody — Manufacturer of the L-159 aircraft
- ITEC/Honeywell — Manufacturer of the F124-GA-100 turbofan engine
- Boeing — Designer and integrator of the L-159 avionics system
- CzAF — MOD, Military Technical Institute and AFBs representatives

The joint ILS Team had combined design experience, international product support experience and operational expertise across a variety of geographic sites. Integrated Logistic Support Plan (ILSP) and Logistic Support Analysis Plan (LSAP) were jointly developed between Aero Vodochody, Boeing and ITEC/Honeywell. These documents were maintained at Aero Vodochody and kept links with the L-159 master programme schedule, thus ensuring that the Logistic programme was synchronized with programme requirements.

3.2 Logistic Support Analysis

The Logistic Support Analysis (LSA) served as the fundamental source for determining the logistic support scope, location and level. The LSA objective was to create an effective aircraft maintenance concept and optimize the aircraft logistic support elements. Required LSA tasks and activities were identified in the LSA Plan. The LSA Plan was supplemented with a list of input data to be collected and stored for each of the LSA candidate items. When selecting LSA candidates, the following aspects were considered: item price, reliability, service life, required maintenance (scheduled/unscheduled) and safety.

Out of the selected items, the LSA Candidate List was prepared. The LSA Candidate List was approved by the CzAF. Each candidate was provided with an LCN number and inserted in the LSA Record (LSAR) database. The DD-Form 1949-3 of the MIL-STD-1388-2B contained a survey of the data stored in the LSAR database.

The LSA Plan also contained the list of output reports essential for determination in all selected ILS areas. The output reports include: maintenance concept, training, supply support, reliability, ground support equipment, test equipment and technical publications, etc.

3.3 LSA Software

For the logistic analyses, the L-BASE software system was used. This system met the requirements of the MIL-STD-1388-2B and was an effective tool for collecting, classifying and processing the required logistic data. The appropriate LSAR was prepared also by Boeing and ITEC/Honeywell and the data was loaded into the common database. The LSAR was validated and approved by the CzAF during regular logistic meetings.

3.4 LSA Tasks Required

Following MIL-STD-1388-1A tasks were performed to support the LSAR database.

102 Logistic support analysis plan

- 102.2.1 LSA plan
- 102.2.2 Updates

103 Program and design reviews

- 103.2.3 Program reviews
- 103.2.4 LSA reviews
- 103.2.5 LSA guidance conference

201 Use study

- 201.2.3 Field visits
- 201.2.4 Use study report and updates

301 Functional requirements

- 301.2.4 Operations and maintenance tasks
- 301.2.5 Design alternatives

303 Evaluation of alternatives and trade-off analysis

- 303.2.7 Level of repair analysis

401 Task analysis

- 401.2.1 Task analysis
- 401.2.2 Analysis documentation
- 401.2.3 New/Critical Support Resources
- 401.2.4 Training requirements and recommendations
- 401.2.5 Design improvements

- 401.2.7 Transportability Analysis
- 401.2.8 Provisioning requirements
- 401.2.9 Validation of LSAR
- 401.2.10 ILS output products
- 401.2.11 LSAR updates
- 401.2.12 Provisioning screening

501 Supportability test, evaluation and verification

3.5 LSA Application to ILS Elements

Various ILS documents such as provisioning parts lists, training curricula, and operation and maintenance manuals were required. The LSA output reports selected for the L-159 Project are listed in the following table.

Table 2: LSA output reports.

LSA Output Reports		
	Number	Name
1.	LSA-003	Maintenance Summary
2.	LSA-004	Maintenance Allocation Summary
3.	LSA-014	Training Task List
4.	LSA-016	Preliminary Maintenance Allocation Chart
5.	LSA-019	Maintenance Task Analysis Summary
6.	LSA-023	Maintenance Plan Summary
7.	LSA-024	Maintenance Plan
8.	LSA-030	Indentured Parts Listings
9.	LSA-037	Spares and Support Equipment Identification List
10.	LSA-056	Failure Modes, Effects and Criticality Analysis (FMECA)
11.	LSA-070	Support Equipment Recommendation Data (SERD)
12.	LSA-074	Support Equipment Tool List
13.	LSA-076	Calibration Measurement Requirements Summary
14.	LSA-126	LCN/PCCN Indenture Structure Tree
15.	LSA-151	Provisioning Parts List Index (PPLI)
16.	LSA-155	Recommended Spare Parts List for Spares Acquisition Integrated

3.6 LCC

Life cycle cost modelling was performed to determine the most cost effective logistic support method. It took into consideration the operational support scenario and operational environment as defined by the CzAF and looked at the available support from various sources including the military, contractors and vendors. Input data were gained from the LSA.

Life Cycle Cost analyses were performed in three levels:

- Entire Life Cycle Cost analysis for the whole L-159 aircraft. This analysis was the first stage of LCC analyses and was centred on preliminary calculation of operational LCC for the whole aircraft (acquisition price, fuel cost, scheduled maintenance unscheduled maintenance, labour cost).
- More accurate Life Cycle Cost analyses centred on maintenance costs of aircraft systems. This analysis was the second stage of LCC analyses and utilized operational cost for all aircraft systems.
- This analysis was the third stage of LCC analyses put on software product EDCAS. For this analysis Aero Vodochody created database of EDCAS parameters for all aircraft systems. Than Level of Repair Analysis (LORA) were performed for these systems to optimize the maintenance.

3.7 Reliability and Safety

A Reliability and Safety programme was implemented for the L-159. This programme was documented in a System Safety Programme Plan (SSPP) and Reliability Programme Plan (RPP). The purpose of the SSPP and RPP was to identify and co-ordinate tasks necessary for the management of an effective reliability and safety programme for the L-159. Both documents detailed the approach to the evaluation and execution of reliability and safety activities and included procedures for monitoring and controlling progress measured against milestones within the programme.

The FMEA/FMECA analyses were accomplished according to the MIL-STD-1629A. All L-159 consequential, new and redesigned systems were analysed. The FMEA/FMECA output data were provided in the MIL-STD-1388-2B database format.

A majority of the tasks regarding MIL-STD-882C, inclusive of Hazard analyses of aircraft systems have been applied within the framework of the aircraft development.

3.8 L-159 Logistic Support Milestones

The main logistic milestones for the L-159 project are listed below:

- 1995 and 1996 Site Surveys at Caslav and Namest AFBs.
- 9/1997 Logistic Guidance Conference:
  - ➢ Decision to apply MIL-STD-1388-1A/2B standard (Use Study, ILS Plan, LSA Plan, Technical publication Plan).
- 11/1997 – 3/2001 Logistic Conferences (quarterly).
- 3/1999 Provisioning Meeting.
- Since 5/2001 to 11/2005 Logistic Reviews (61 totally).

4.0 TECHNICAL PUBLICATIONS

The L-159 technical publications programme originally required delivery of the O and I maintenance level technical publications to coincide with the first aircraft delivery to the CzAF to assure safe operation and allow for immediate maintenance of the aircraft by the CzAF maintenance personnel. Since the domestic acquisition procedures for the technical publications of military flying equipment were out-of-date and not useable, the L-159 project adopted the USAF TO (Technical Order) system, in terms of both acquisition procedures and publications structure and data provided (i.e. TO 00-5-1 and 00-5-3, and US Mil-specs).

In the early phase of the project, the organizational tree, programme schedule and responsibility structure required by the TO system (TO 00-5-3) were not established, thus causing technical and even terminology misinterpretations between contractor and the acquisition office. The acquisition procedures and time schedules were modified several times during the project, deviating from the TO systems and tailored to the CzAF environment. This underestimated project management result in schedule slippage and increased programme costs. The acquisition process was concluded with one-year lasted TOs verification, provided by the CzAF operational personnel, and formalization made by the Military Aircraft Authority of the Czech MoD. The TO Verification resulted in nearly two thousand TO Improvement Reports.

Another issue that had an adverse effect on the smoothness of the TOs process was logistic planning (e.g. not properly adjusted line between O, I and D level maintenance, continuous modifications of maintenance concept, etc.).

In summary, the formalization of printed technical manuals and handbooks was delayed by three years after the first aircraft was delivered to operational base. Because the initial goal of delivering the final and formal TOs at the moment of the first aircraft delivery was not achieved, the safety operation and maintenance concept establishment was re-prioritized, being followed by delivery of all other data (e.g., non essential removal/installation procedures, troubleshooting, IPB, off-equipment manuals, GSE and Test Equipment Manuals, etc.). Current activities in the field of the L-159 technical publications are focused on proper publication configuration and change management, and delivery of (Interactive) Electronic Technical Manuals concurrently to the hardcopies.

5.0 SERVICE LIFE

Initial service life of the aircraft is designed at eight thousand (8,000) flight hours within twenty-five (25) years. The aircraft operational scenario specified in the Use Study was based on AOR of two hundred fifty (250) flight hours per aircraft per year. This value of AOR was considered when the maintenance concept was established.

We emphasize the initial service life, because it could be changed according to actual consumed fatigue life monitored by Fleet Management System FRAME159.

6.0 AIRCRAFT MAINTENANCE

6.1 Maintenance Levels

A traditional three-level maintenance concept, consisting of Organisational level (OLM), Intermediate level (ILM) and Depot level (DLM) maintenance was adopted for the L-159.

6.1.1 Organisational Level

The OLM is performed by operational squadron and consists of the preparation of aircraft for flight and elementary aircraft servicing, including these activities:

- Pre-flight inspection, Thru-flight inspection, Post-flight inspection.
- Aircraft Servicing and Operation.
- Aircraft Ground Handling.
- Ammunition loading.
- Diagnostic system data evaluation.
- Remove/Replace of failed LRUs.

6.1.1.1 Thru-Flight Inspection

The Technical Specification and Use Study require that an aircraft in configuration air-to-air is able to take off within 20 minutes after landing.

The following procedures were identified as the most significant for the determination of the length of aircraft preparation for a repeated flight:

- Inspection of the Central Maintenance Panel.
- Download of flight data via GSU or PMU after the flight.
- Insertion of data for the next flight.
- Servicing.
- Ammunition loading.
- Aircraft launch.

Time required for data loading does not exceed two minutes. Airframe systems can be serviced utilising pressurised replenishment connections to shorten the required time. Ammunition loading ground support equipment and tools were designed to satisfy the determined time limit. Fulfilment of the requirement was verified during the CzAF military tests.

6.1.2 Intermediate Level

The ILM is performed by maintenance squadron and consists of work on the aircraft as well as on individual disassembled components is accomplished. During the ILM, activities defined within both the scheduled and unscheduled maintenance are carried out.

6.1.2.1 Scheduled Maintenance

Periodic and phase inspections are activities carried out on mechanical systems such as:

- Airframe systems servicing.
- Clearance check and adjustment.
- Cleaning or replacement of the filter elements.
- Lubricating according to lubrication plan.

The other systems (engine, avionics etc.) are maintained depending of their actual condition. The aircraft actual condition monitoring is provided by the Aircraft Monitoring System (AMOS). The AMOS identifies systems failure or condition and informs both to the Central Maintenance Panel and the Multi-Function Display in the cockpit. The technical publications then provide a guide how to deal with identified troubles. The questionnaire YES/NO trouble shooting system is provided.

6.1.2.2 Unscheduled Maintenance

In the course of aircraft operation, unscheduled maintenance activities occur, too. These are especially:

- Special inspection after a specific occurrence.
- Upgrades or maintenance activities performed on aircraft systems in compliance with bulletins/ TCTOs.
- Remove/Replace of systems components due to failure.
- Troubleshooting and isolation

At the ILM, selected O level LRUs and SRUs are tested and inspected in order to identify and repair the failure. Repairs are carried out on those LRUs and SRUs, for which repairs are prescribed at the I level. If the failure cannot be identified or repaired, the unit/component is delivered to a repair facility or the manufacturer (Depot level).

The OLM and ILM are performed by the CzAF operational (OLM) and maintenance (ILM) squadrons at one AFB.

6.1.3 Depot Level

The LRUs and SRUs requiring maintenance at the Depot Level are repaired by the aircraft manufacturer or by the unit/component supplier/manufacturer.

Detailed specification of the Depot level maintenance performed on each system, aggregate and module are based on the Logistic Support Analysis. The period of D level scheduled maintenance performance is designed to be set to 2,000 and 4,000 flight hours. During the 2,000 flight hour intermediate repair, those components of shorter service life are disassembled and repaired or replaced.

The unit/components which are not maintained according to their condition and whose service life is limited by flight hours, number of cycles or calendar period, are listed in the Aircraft Log Book and T.O. 1F/A-L159-6 Inspection Requirements.

After 4,000 flight hours (which is half of the aircraft service life), the intermediate repair broadened by the Mid Life Upgrade (MLU) is carried out. The work includes visual inspections of the main airframe structure elements and check of the engine air ducts and main suspension points with eddy currents, with consequent disassembly.

The feasibility study for the DLM is prepared now under the MOD requirements.

6.2 Maintenance Concept

If we speak about inheritance from L-39/59, first we also have to briefly introduce the L-39/59 maintenance concept.

6.2.1 L-39/59 Maintenance Concept

The L-39/59 aircraft had the maintenance concept based on phase inspections according to the number of flight hours. The interval of these inspections was 100 and 200 flight hours. Because of planning purposes, these phase inspections contained also periodic maintenance tasks, which would be otherwise performed according to calendar time, number of starts, number of landings, etc.

Except of general kinds of inspections such as Pre-flight inspection, Thru-flight inspection, Post-flight inspection the CzAF implemented also the Preliminary inspection on the O level of maintenance, which after being performed had the validity for 6 flight days during 12 calendar days. The Preliminary inspection contained mainly some checks of systems, thus it was possible to simplify the Pre-flight inspection. This method was advantageous from the point of planning of maintenance, and it was suitable in cases when the aircraft units fly regular and high annual number of flight hours. Some work operations, however, were performed early.

The CzAF achieved high readiness. The defects revealed during a flight day were eliminated until resolved. The main type of inspection at Organizational level of maintenance during a flight day was the Pre-flight inspection.

The TBO of the L-39/59 aggregates was 1,500 flight hours and it was increased for L-159 to 2,000 flight hours after analysis and/or tests.

6.2.2 L-159 Maintenance Concept

There were two main requirements in design of the L-159 aircraft maintenance concept:

- To adopt the existing individual LRUs / systems of the L-39/59 aircraft, for which the scheduled maintenance were defined.
- To implement modern systems of engine, avionics and weapon systems with on-condition maintenance.

The result of LSA and verification in tests is the combined system of maintenance of the L-159. Maintenance concept is combination of on-condition and scheduled maintenance. The combined system comprises the following:

- On-condition maintenance – engine, avionics and airframe structure:
  - Engine: ECU (Electronic Control Unit) calculates number of cycles (TACs).
  - Avionics: BIT assists in fault detection and isolation.
  - Actual condition of a/c systems: Aircraft Monitoring System (AMOS).
  - Airframe fatigue life: FRAME159.
- Scheduled maintenance – airframe, mostly mechanical systems:
  - Phase inspections: 125, 250, 500 flight hours.
  - Periodic inspections: based on calendar time, cycles, starts, landings.

The first type of **phase inspection** is performed after one hundred twenty-five (125) flight hours. The second type of phase inspection is performed after two hundred fifty (250) flight hours. Besides the phase inspection concept there is a system of **periodic inspections** based on calendar time, cycles, starts, landings or on other figures than phase inspections.

In development stage of the project the most of maintenance tasks of periodic inspections were incorporated into phase inspections due to planning purposes. With respect to decreased AOR these maintenance tasks have been transferred to periodic inspections and it was necessary to change the original maintenance concept.

Additional scheduled maintenance is planned at two thousand (2,000) flight hours for airframe and systems not currently recommended for on-condition maintenance. Time Between Overhauls (TBO) of some airframe LRUs is two thousand (2,000) flight hours. A mid life upgrade for the aircraft is scheduled at four thousand (4,000) flight hours consisted of removal of all systems, inspection and repair of the airframe.

6.2.2.1 Airframe and Systems

The L-159 airframe is designed as a standard riveted semi-monocoque structure manufactured from aluminium alloys and is similar to the proven and reliable design of the L-39/59 aircraft family. Advanced technologies and materials are used only in limited numbers.

The aircraft is operated practically without any care about the airframe structure. Scheduled maintenance consists from visual inspections only. On-condition maintenance of overall protective paint coating and sealings (depending on operational environment) is required.

The L-159 fatigue design philosophy is “safe life” but important structure parts as main wing spar and fuselage dorsal longerons are evaluated as “damage tolerance” parts.

6.2.2.2 Engine and Engine Modules

The F124 is a modular engine with complete interchange of all modules, minimum maintenance times, and ease of maintenance operations, reduced parts counts, elimination of safety wire, reduced support equipment needs and enhanced troubleshooting capabilities. The operational environment and support concept was evaluated to optimise life cycle cost savings. The F124 engine provides an opportunity to significantly reduce life-cycle costs for the aircraft system.

The F124 engine incorporates an on-condition maintenance concept. The maintenance and life limits are based on number of engine TACs. The TAC means Total Accumulated Cycle. The TACs are calculated during engine operation automatically by ECU (engine Electronic Control Unit).

Engine lifetime and maintenance (inspection) intervals are significantly affected by the aircraft/engine operational scenario. In a very aggressive type of flying, with high number of power changes between idle and maximum, the number of TAC’s per engine operating hour are higher and it causes decrease of the engine lifetime.

Each engine module has its own maintenance plan. The minimum engine/module inspection interval is 897 TAC’s for borescope inspections (engine disassembly is not needed) and 1,794 TAC’s for detailed inspection (needs engine/modules disassembly). The service life of HPT blades is 5,381 TAC’s and of LPT blades is 8,969 TAC’s. The service life of all modules is 10,763 TAC’s.

With comparison of the L-39/59 maintenance concept the new engine test cell is required for F124 engine I level maintenance and run up tests.

6.2.2.3 Avionics

The resulting system combines both proven existing avionics equipment and modified off the shelf avionics equipment consisting of commercial and military standard equipment. This combination results in the advantage of a modern design and highly reliable, state-of-the art equipment selected to ensure maximum supportability.

System level BIT for the avionics is mechanised to assist in fault detection and fault isolation of failed avionics suite LRUs. These LRUs are installed in locations on the aircraft, which facilitate easy access for removal and replacement. To further ensure ease of removal and replacement, each LRU is attached via quick release connectors to power sources and MIL-STD-1553 interconnect to the other avionics units of the system.

The avionics maintenance on the aircraft is planned as on-condition and consists of fault detection and isolation, replacement and checkout of the replacement unit. Periodic maintenance items, if identified for avionics items, are performed in conjunction with established aircraft periodic maintenance checks.

The avionics Intermediate level maintenance is primarily-failure related only, barring identification of periodic maintenance requirements. Avionics maintenance consists of fault verification and isolation, replacement of Shop Replaceable Unit (SRU) and checkout of the repaired unit.

7.0 AIRCRAFT MONITORING SYSTEM

The L159 aircraft is equipped with Aircraft Monitoring System (AMOS). The AMOS consists of on-board and ground evaluating equipment. The AMOS collects, processes and records aircraft systems information during the entire operational environment.

- Facilitates integrated troubleshooting.
- Allows automated data transfer to the aircraft maintenance management system.
- Provides data for pilot mission debriefing.
- Monitors and collects airframe fatigue life data (Fatigue Monitoring System – FRAME159).
- Preserves data for accident investigation (crash recorder).

The AMOS monitors 250 parameters, 400 events, 12 hours of record. Recorded parameters are as follows:

- Aircraft system status.
- Airframe loads and stress.
- Flight parameters.
- Pilot actions.
- Weapon release.

The AMOS is designed to monitor the actual condition of aircraft systems. The AMOS makes it possible to quickly inspect selected aircraft systems before and after a flight within the scheduled O level inspections, and to evaluate the technical status of the aircraft at I level. The Ground Support Unit (GSU) is used for data evaluation and downloads while the Portable Memory Unit (PMU) is used for data transfer into Ground Evaluating Equipment (GEE).

The AMOS monitors status of the aircraft systems as follows:

Table 3: Means of checking individual aircraft systems.

Means of Checking Individual Aircraft Systems		
System	Built-In Test/Built-In Test Equipment (BIT/BITE)	Aircraft Monitoring System(AMOS)
Aircraft Control System	No	Yes
Nose Wheel Control System	Yes	Yes
Antiskid System	Yes	Yes
Avionics System	Yes	Yes
Autopilot	Yes	Yes
Storage Management System	Yes	Yes
Main Electrical Power Source	Yes	Yes
Emergency Electrical Power Source	Yes	Yes
Battery	Yes	Yes
Power Plant	**Yes**	**Yes + EMS**
Gearbox	No	Yes
Fuel System	No	Yes
APU	Yes	Yes
Air-conditioning System	No	Yes
De-icing System	No	Yes
Escape System	No	Yes
Fire Extinguishing System	Yes	Yes
Hydraulic System	No	Yes
Landing Gear	No	Yes
Airframe	**No**	**Yes + FRAME159**
Lighting System	Yes	Yes
OBIGGS	Yes	Yes
OBOGS	Yes	Yes

The F124 engine monitoring is performed by the Engine Control Unit. The AMOS system receives information about engine status and values of main engine operation parameters via the RS422 serial data link.

The AMOS collects data about status of systems mentioned above and processes them in real time on the aircraft board. The results of data processing are displayed as short text messages on the multifunction displays (MFD) of the avionics system. The list of all evaluated events in the table form can be displayed too. The final result of data processing is indicated through lighting the colour bulbs placed on the Central Maintenance Panel (CMP) of the aircraft. The CMP is placed on the left side of the L159 under a quick-access cover.

- The green bulb means: the AMOS did not evaluate any event that limited aircraft operation.
- The yellow bulb means: the AMOS evaluated an event that required the maintenance action after the flight shift (day).
- The red bulb means: the AMOS evaluated an event or events that required the maintenance action immediately after the flight.

Many of the parameters provided by AMOS (number of flight hours, number of engine and APU starts, engine run ratings, number of landings etc.) are used for the purpose of maintenance scheduling and spare parts and POL consumption planning.

The AMOS output data contributes to the process of making the L159 aircraft operation and maintenance as effective as possible. The technical publications then provide a guide how to deal with identified troubles.

A maintenance checklist displayed on MFD is a part of the AMOS and helps pilot or maintenance personnel to perform the Pre-flight inspection.

7.1 AMOS Software – PANDA

AMOS Ground Evaluation Equipment (GEE) is a complete hardware and software package for flight data downloading from the aircraft to a PC. PANDA Software is provided as a Universal Evaluation System that helps the ground maintenance crew perform comprehensive analysis, replay, and processing of flight data from various recorder types.

PANDA’s Basic Configuration:

- MANAGER – ensures that other program modules included in the package operate properly.
- VIEW – graphic and table representation of analog and digital parameters, zoom, print, time and physical scale adjustment, user-defined analysis results visualization.
- LOAD – data transfer from board module.
- EDIT – definition and editing of the recorded frame structure.
- CALB – sensors calibration and conversion into physical values.

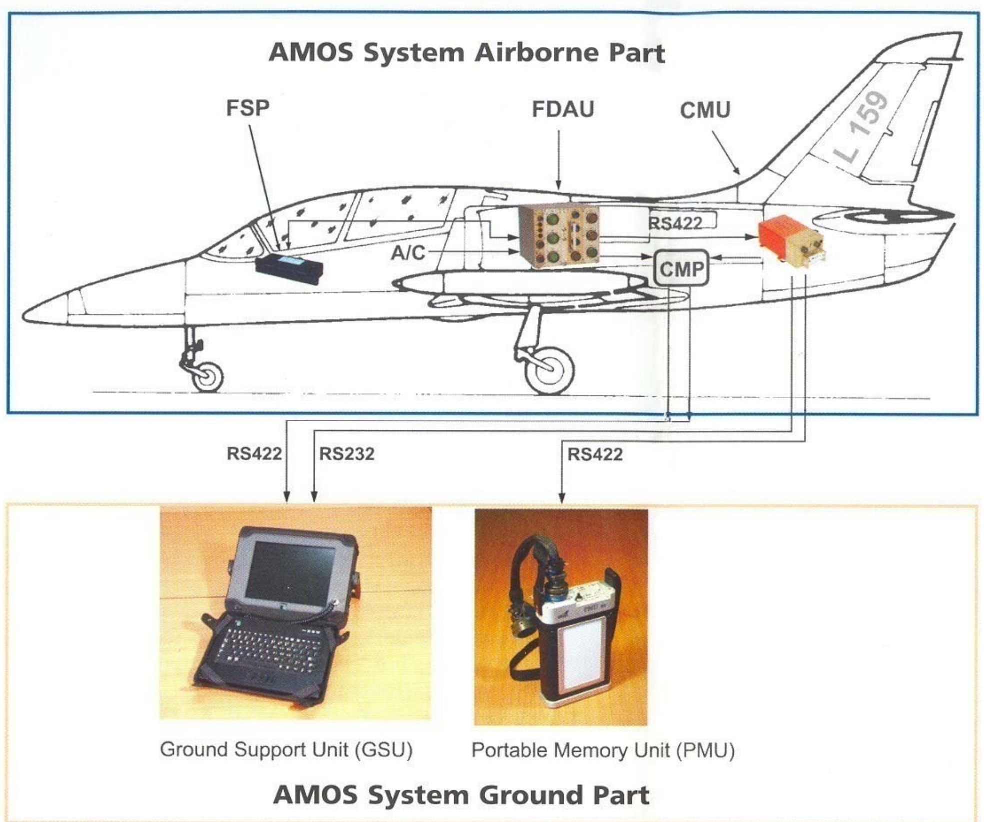

Figure 5: Aircraft Monitoring System.

7.2 Engine Monitoring System

An Engine Monitoring System (EMS) is embedded in the FADEC providing data for engine and modules life management, hardware tracking, and performance trend monitoring. The EMS reduces support and life cycle costs through computer-aided maintenance and fleet management. The EMS, combined with the long design life of the F124, eliminates the need for scheduled overhauls. This enables the F124 engine to follow an on-condition maintenance philosophy.

The dual FADEC system of the F124 engine provides:

- Optimized performance and operability.
- Automatic relight.
- Reduced pilot workload.
- Built-in test (BIT).
- Performance trend monitoring.
- Engine Event Recording (EER) capability for ease in maintaining and troubleshooting the engine system.

8.0 FRAME159

The FRAME159 system is intended for determination of safe service life of the individual L-159 aircraft units according to real operational load and the control of the scope of inspections within the frame of phase inspections. The system is a part of the AMOS aircraft monitoring system. It consists of an on-board part intended for recording of operational loads of the aircraft in fatigue critical points, and of ground means for calculation of the consumed fatigue life based on the loads recorded. The data of the consumed fatigue life for each aircraft unit are stored in a database and they can be processed for further analyses.

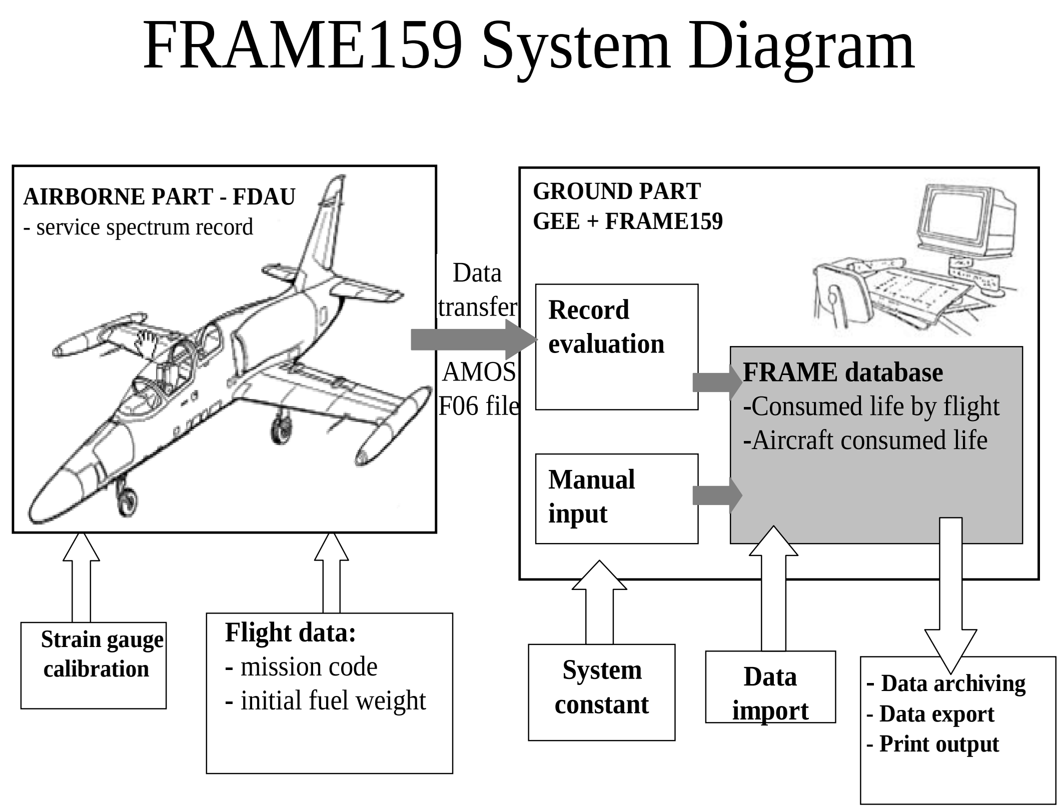

Figure 6: FRAME159.

The on-board part of the FRAME159 system senses, filters and records the data of the aircraft loading as well as the subsidiary data of the aircraft configuration and flight parameters, from which the consumed fatigue life is subsequently calculated in the ground part of the system. The on-board part of the FRAME159 system is one of the modules of the AMOS aircraft monitoring system.

The following parameters are used for calculation of the consumed fatigue life:

- Vertical load factor in the aircraft COG (N_Z).

- Mechanical stress on the left fuselage longeron No. 16.
- Mechanical stress on the lower flange of the left half of the wing spar at the rib No. 3.
- Mechanical stress on the lower flange of the right half of the wing spar at the rib No. 3.
- Mechanical stress on the shaft of the left main landing gear leg.

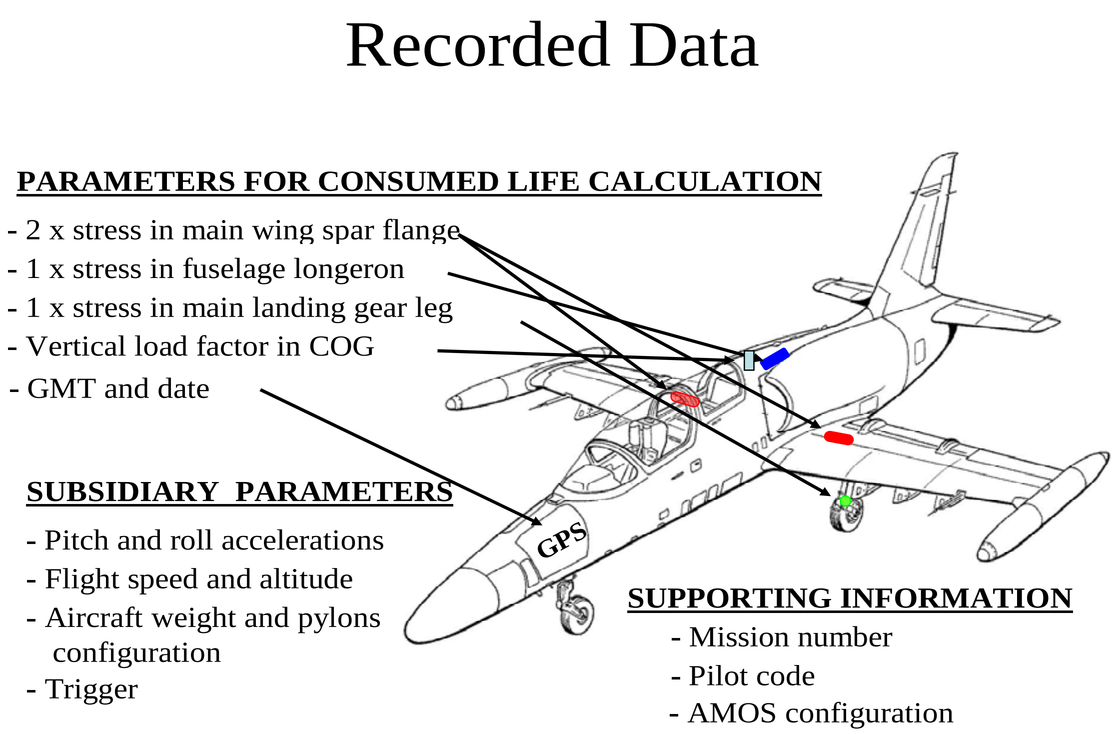

Figure 7: FRAME159 recorded data.

The purpose of implementation of the FRAME159 system:

- To determine the moment of expiration of the safe fatigue life of the airframe of individual aircraft units.
- To take decision on performance of inspections of fatigue critical points within the frame of the phase inspections – the value of the consumed life does not decide on when a periodic work operation to be performed, but whether critical points of the airframe to be inspected during the work operation.

Knowledge of operational loading for each aircraft unit enables to decrease the safety factors to determine safe technical life and intervals of inspections.

9.0 DATA COLLECTION SYSTEM

The Data Collection System was established between the CzAF and producer for mutual exchange of the data and reports. The CzAF collects operational AMOS, FRAME159 and EMS data and provides them to producer for further analyses. Producer provides quarterly reliability, fatigue life, LSA and LCC reports.

10.0 PARAMETERS ACHIEVED

According to the Tactical-Technical Requirements and Use Study requirements, the entire logistic support was prepared for the operation of 72 aircraft units from two air bases with the planned AOR of 250 flight hours. Based on the decision of the Czech MOD, the number of operated aircraft units was reduced from 72 units to 24 units operating from one air base (Caslav AFB) in 2004. Further, AOR was reduced in average to 160 flight hours. Even this reduced value of AOR is not currently achieved which impacts all parameters under monitoring.

With respect to reduced and irregular number of flight hours of the fleet of the 24 aircraft units, also the maintenance concept was modified as described in para. 6.2.2.

10.1 Reliability and Availability

10.1.1 Aircraft

The aircraft MTBF was influenced by gradual fielding of the L-159 fleet and systematic Reliability Programme application. The $MTBF_{TOTAL}$ increased from 2.7 FH in 2001 to 6.6 FH in 2004. In 2005 the slight decrease of MTBF was noted down. It was caused by the fleet reduction. Due to the systematic logistic support improvement, Reliability Programme application and AOR increase it is real to achieve MTBF 8 FH in the future.

Figure 8 below shows the course of cumulative numbers of failures depending on flight hours of the fleet of the currently operated number of aircraft. It is apparent from the figure that $MTBF_{TOTAL}$ trend was already stabilized.

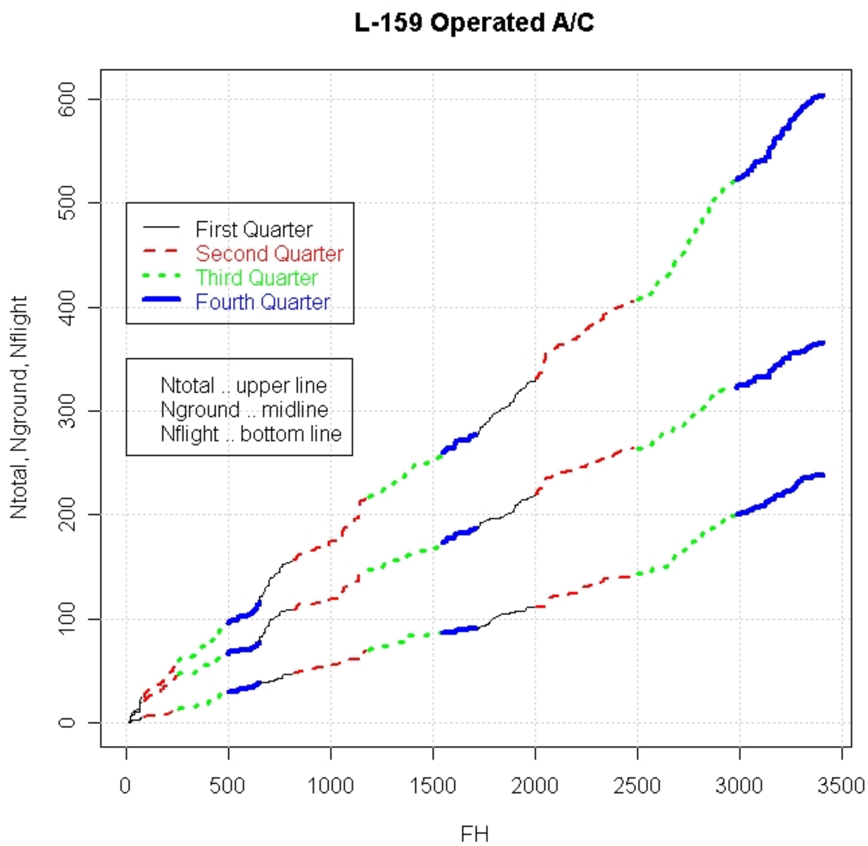

Figure 8: Operational A/C cumulative failure numbers for period 2003 to 2005.

The availability parameter achieved is within the range of 60 % through 65 % at the Mean Corrective Maintenance Time (MCMT) of 4 hours. The goal availability of 80% is supposed to be accomplished by MTBF and MCMT improvement.

10.1.2 Avionics Systems Example

In the beginning of operation of the L-159 aircraft, the system under analysis did not reach the required value of reliability, and therefore, the Reliability Programme was prepared. Corrective actions from the manufacturer side resulted in MTBF increase from 30 FH to the current 60 FH.

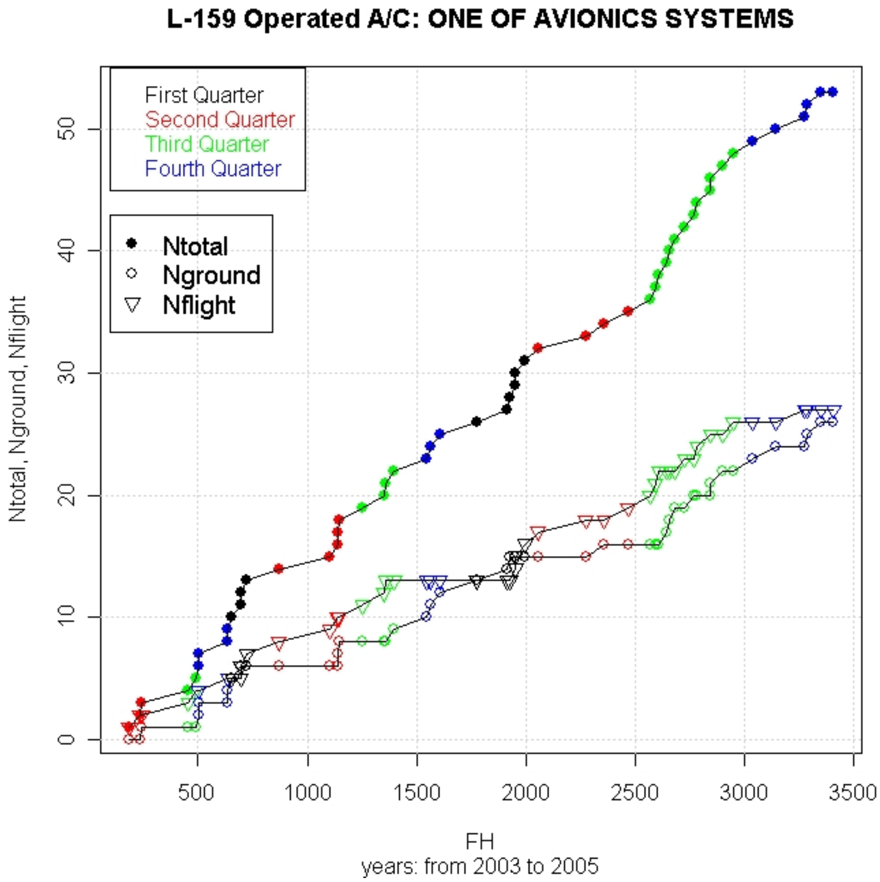

Figure 9: Cumulative failure numbers of avionic system.

10.1.3 Fuel System Example

As representative of positive course of aircraft system the fuel system was selected. Successful introduction of the Reliability Programme brought positive effect on. Since 2005 rate of occurrence of failures is stabilised.

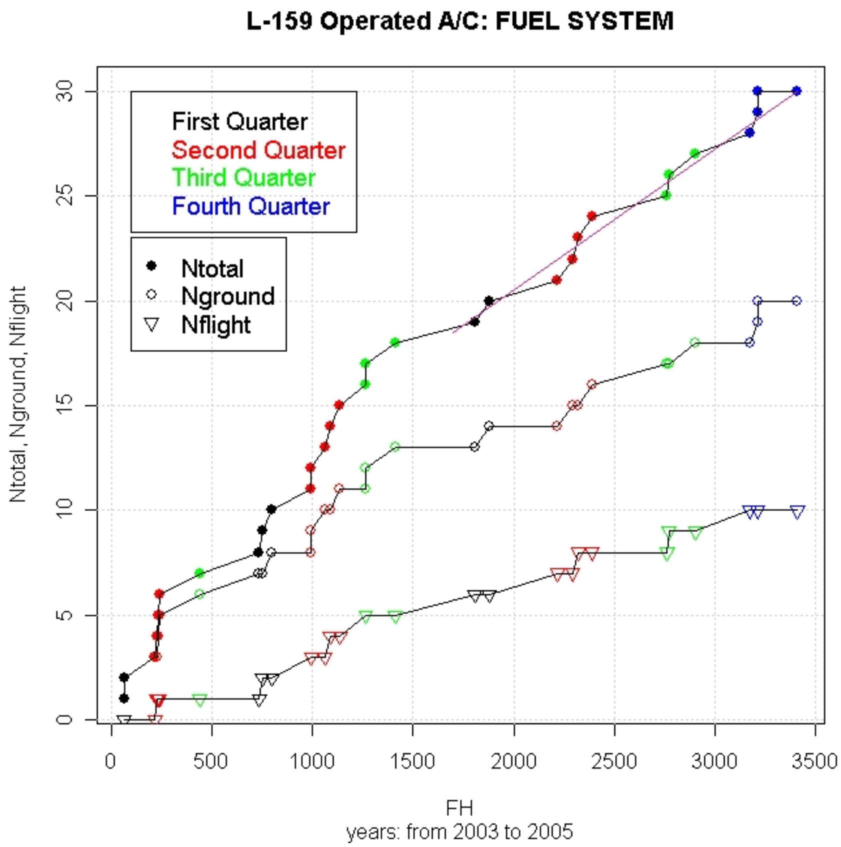

Figure 10: Cumulative failure numbers of the fuel system.

10.1.4 Deployments

Suitability of the proposed maintenance concept for the light combat aircraft was demonstrated during common exercises like the NATO Air Meet (NAM). Higher reliability values were achieved there during intensive operation and concentrated support than during operation at the home air base.

Table 4: Table of reliability parameters during selected exercises.

Mission	Number of a/c	Number of FH	Number of Landings	Failures		MTBF (Total)	$MTBF_F$ (Flight)
				Flight	Ground		
NAM 2003	6	31:33	26	16	7	1:22	1:58
NAM 2004	6	120:56	80	8	3	10:59	15:07
NAM 2005	6	75:17	59	18	6	3:08	4:11
Squadron Exchange 2005	6	90:53	76	7	2	10:05	12:58
Brilliant Arrow 2006	3	38:21	29	6	3	4:16	6:23

10.2 LCC

For LCC calculation, the assumptions were defined and the model was prepared for monitoring of operational and maintenance costs. Inputs of the calculation were: number of operated aircraft units, Annual Operating Requirement (AOR) and MTBF. Since 2005 only the aircraft units of the new production are in operation with yet lower value of MTBF. By the fleet downsizing and by the reduction of AOR, the deviation from the planned trend occurred in the year 2005.

Further factor of influence is that the operated aircraft units are not in the bathtub curve region of constant failure-rate. It can be assumed that after stabilization of the MTBF value, the forecast curve of the LCC values will be achieved again.

10.3 Service Life

The FRAME159 system analyses result in the overview of the fatigue life consumption of the individual aircraft and the mean value for the fleet, which is 7,890 FH. This fully corresponds to the value of required service life (see Figure 11).

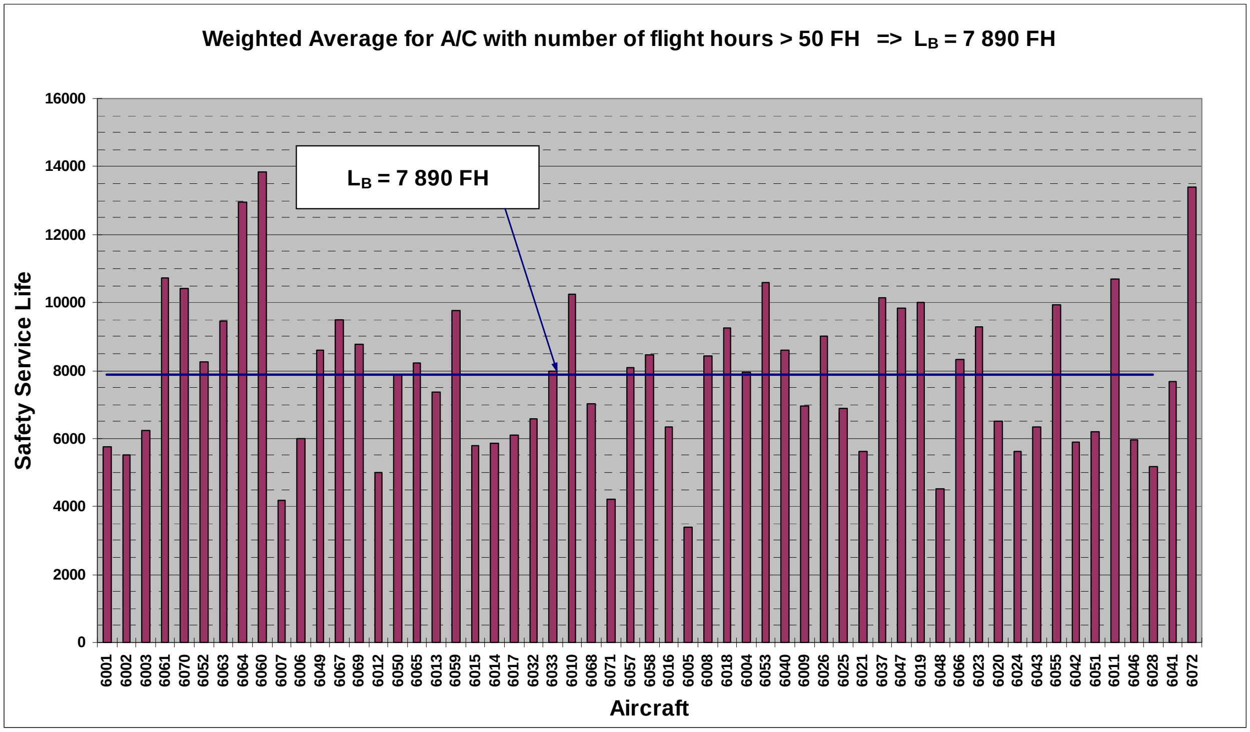

Figure 11: Aircraft Safety Service Life.

It is evident which aircraft are flying under aggressive conditions and vice versa. This FRAME159 output is used for Fleet Management.

Figure 12 presents comparison of design and service spectra. The L-159 fleet is operated very close to design spectrum.

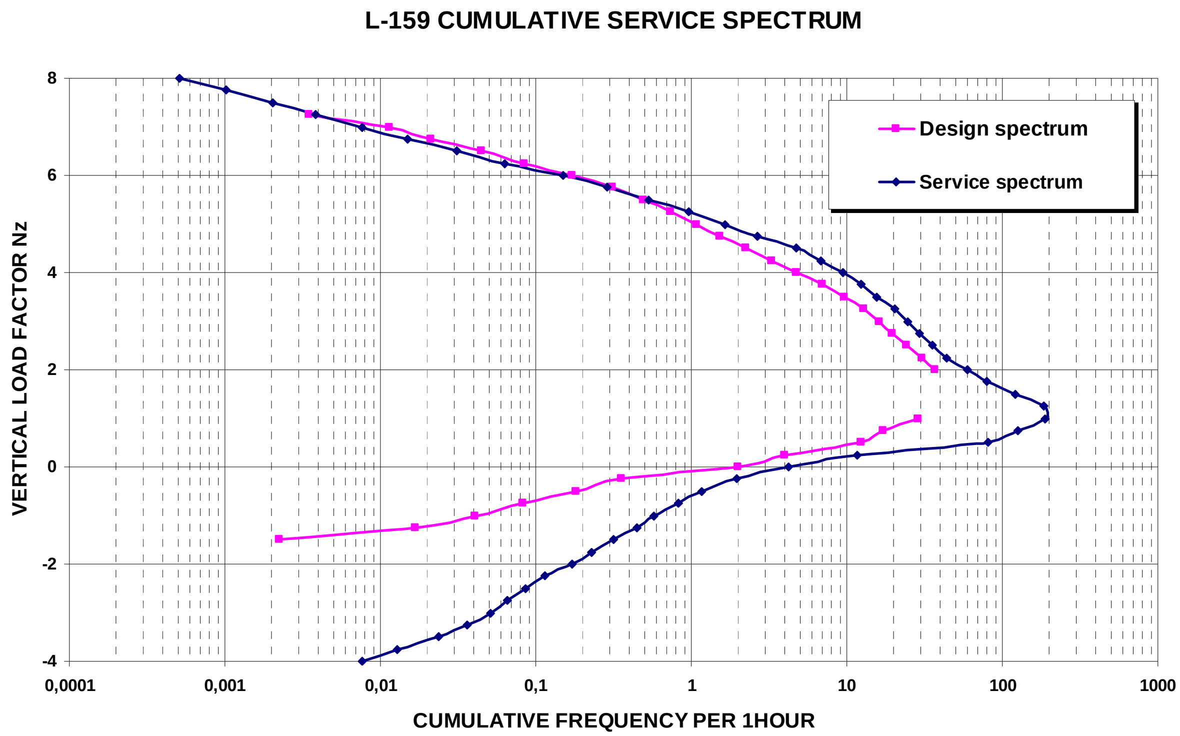

Figure 12: L-159 Design and Service Spectra.

There was no significant fatigue problem during whole time of the L-39/L-59 family operation. Conservative life assessment programme provides sufficient reserve to allow future service life extension.

11.0 CONCLUSIONS

This paper describes current support model and maintenance concept applied on the CzAF L-159 as a representative of the CzAF fleet because it is a product of domestic industry with international participation. Gained experience could be further utilized within the whole air force.

Within the project, the user requirements of concerning on-condition maintenance system were resolved. After implementation in the CzAF, the system has been optimized according to actual number of operated aircraft units with focus on low LCC.

The paper outlined the experience with implementation of the L-159 into the CzAF inventory, where the requirements on NATO compatibility were solved for the first time:

- The possibility of fulfilment of the CzAF requirements to convert from previously used standards to NATO standards and US Mil specs has been practically verified.
- The maintenance concept has been changed from the scheduled maintenance to the combined one (engine, avionics and airframe have the on-condition maintenance and the aircraft systems have the scheduled maintenance).

- New facilities have been built and equipped (engine test cell, avionics shops).
- The CzAF system of maintenance personnel skills (CVO) was harmonised with the Skill Speciality Code (SSC) system with linkage to training syllabuses.
- The technical publication acquisition process according to TO system has been realized.
- Pipelines for repairs and spare parts delivery have been determined. The TAT and lead times, which were long in the beginning of the programme, have been reduced.
- The data collection system and subsequent data processing and utilization have been improved.

The reliability parameters achieved by the CzAF during allied exercises indicate future potential for further enhancements.

In the course of the preparation of this paper we came to a conclusion that the L-159 project did not cover all the specified fields of this workshop. There are still open areas for the maintenance support improvement in the CzAF environment. For instance applying the RCM method in the current maintenance system enables its simplification and cost reduction.

Further intention is to concentrate on the following areas:

- Terminology unification (availability, readiness, mission capability rate, etc.).
- Scheduled maintenance concept modification.
- Reliability Programme improvement.
- Data sharing and fleet management (reliability, fatigue life, LSA, LCC).
- Application of the D-level Feasibility Study results to the maintenance concept.
- Conversion of the technical publications to interactive electronic type.

The purpose of this document is to briefly inform about the results achieved by the CzAF in the field of logistic support and to address the areas for further improvements.