PAPER Nr.: 44

INTEGRATED LOGISTIC SUPPORT
in the
NATO HELICOPTER NH90 PROGRAMME

by

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TWENTIETH EUROPEAN ROTORCRAFT FORUM
OCTOBER 4 - 7, 1994 AMSTERDAM

Printed by the Technical Highschool Haarlem

Integrated Logistic Support (ILS) in NATO Helicopter (NH90)

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ABSTRACT

Integrated Logistic Support is presented as a twofold activity, influencing the design on one hand and designing the Integrated Logistic Support System on the other.
It is conceded, that these tasks are strongly influenced by the design and also by the operational requirements.
Taking these sometimes opposing forces into account, is the basis for a strongly design related task and in a certain field a design task itself.
All activities are covered by the special arrangements of the Design & Development (D&D) Contract for NH90, where intentionally the ILS responsibility was extended to the fields of Reliability, Availability, Maintainability and Testability (RAMT).
Reliability and Maintainability characteristics of a system become evident from the first Preliminary Design Review. ILS related issues are discussed in dedicated RAMT working sessions. The Testability issue is of specific interest. The on-board Testability tool, the Monitoring and Diagnostic System (MDS), is the essential means to achieve acceptable supportability characteristics in view of the In-Service phase.
The unique NH90 requirement for a state-of-the-art MDS, the perception for its realisation and the benefits of such a system for operation and support are discussed.
The integration of digitised information of all departments, which participate in the D&D of the NH90 is the prerequisite for reaching supportability-goals and thus the affordability of new Weapon Systems.

INTRODUCTION

The paper consists of two parts.

In the introduction, some information is given on the NH90 Programme, limited to the key-characteristics and the present status of this 4 Nations joint venture.

The second and naturally the main part of the paper is devoted to the author's speciality, ILS in NH90.

Starting with the contractual situation, the present status, including the tasks fulfilled so far and the difficulties encountered, is reported. Finally, the expectations the Users have in the field of ILS for the In-service phase are stated.

THE NH90 PROGRAMME

The aim of the NH90 Programme is to develop two Weapon Systems, the NATO Frigate Helicopter (NFH) and the Tactical Transport Helicopter (TTH), using a common Basic Helicopter of the 8 to 10 tons' class.
A Feasibility/Pre-Definition Study performed by European Industries has confirmed this concept.
The requirements of (in 1987 still) 5 Nations and 9 Services were harmonised and laid down in two separate NATO Staff Requirements (NSRs). Great Britain unfortunately left the Programme in the same year.
So the remaining countries France, Germany, Italy and The Netherlands prepared the D&D contract, which finally was signed on 1 September 1992.
The Partner Companies Eurocopter France, Eurocopter Deutschland, Agusta and Fokker on one hand set up NATO Helicopter Industries (NHI), the Governments NATO Helicopter Management Agency (NAHEMA) on the other as the respective management bodies for the Programme. In fact it was the General Managers of these two bodies, who signed the Design and Development contract to demonstrate, that NHI and NAHEMA are the contractual partners in the NH90 Programme.
It must be stated here, that both Agencies have been intentionally kept small, to 32 and 45 Personnel respectively. For ILS exist at NHI only the ILS manager, at NAHEMA a section consisting of four Officers, one of each participating Nation.
The **scope of the contract by value** is 1376 MECU (e.c. 01/88) and it is the meanwhile common applied Fixed Price type contract. It includes also ILS, which is different to some other major Programmes.
The **scope by foreseen Production Numbers** i.a.w. the requirement of the participating Nations runs presently up to 726 Helicopters, not taking into account any likely exports and a possible civil version.
The Schedule for the D&D phase extends till the end of the century, the first flight of Prototype (PT) 1 is planned for the end of 1995.
The following viewgraphs shall picturise the **Technological key characteristics**.

General Characteristics

ILS is considered as one of the noteworthy characteristics of the NH90. Adding the items Maximum Commonality, Interoperability and Integrated Weapon System the logistic requirements seem to be well-taken care of.

Advanced technologies

In this field, it becomes evident that the aspect of Integration is dominant here (e.g. Avionics and Vision System). For ILS the full composite fuselage is seen as a challenge in view of Maintenance/Support, since it is the first application for a helicopter (H/C) of this class.

NFH/TTH: Main Systems and Sub-systems

The following pictures shall promote a better understanding of the complexity of the two weapon systems, the commonality and also the differences between NFH and TTH.
The status of the Programme in 1994 is characterised by the Preliminary Design Review (PDR) on Major Items and the Equipment Selection Process.
A cost reduction campaign, focusing mainly on the Production Unit Prices for the NFH- and TTH-Weapon Systems is presently under way.
With regard to the characterising tasks of 1994, the involvement of the logistician is indicated in the following paragraphs.

1 The PDR involvement

The PDRs are performed to the major part on documents, describing the design solutions based on the Customers requirement. So the ILS task focuses on checking, whether Industry's interpretation is consistent with the perception of the Customer, in particular w.r.t. supportability at In-Service.
This is done in a separate working session on RAMT characteristics of the design. Some examples will highlight the scope of activities.

a. In the fuel system PDR it was stated, that due to the design the necessity for a periodic drainage would arise. Since the contract states a requirement for maximum exploitation of automatic on-board Testability through a sophisticated MDS, ILS opened a query aimed at the integration of a device for automatic indication of water in the fuel (drainage only as it becomes necessary). At the same time, ILS insisted on the limitations of Special-to-Type Test Equipment (STTE) and of the maintenance effort by state-of-the-art technology.

b. The accessibility of a generator for the necessary periodic exchange of time-limited bearings was not acceptable (removal of cowlings, etc.). So ILS asked for a re-design, which was accepted at the end.

c. The allocation of inspection intervals in the Dynamic System PDR to a "daily inspection" rather than to a t.b.d. Hourly Post Flight (need only after 50 FH initially) was proposed by Industry, since no periodic inspection interval $\leq$ 600 FH is contractually allowed. Here a compromise has to be found.

2 Equipment Selection Panel (EQSP) involvement

For all the equipment, dedicated sections are included in the technical as well as in the commercial selection report, which have a direct impact on Life Cycle Costs (LCC) and thus on supportability-characteristics of the specific equipment. ILS checks and comments as needed the consistency of the selection with the perception of the contract and the specifications (which also were checked before). The acceptance of the industrial selection

is checked by ILS. It is evident, that Reliability-, Maintainability- and Testability-values as the cause for any support requirement, the commitments for ILS for the In-Service phase and the seriousness of the LCC calculations/values are the main criteria for this evaluation. To avoid surprises in the future, ILS insists on making e.g. Mean Time Between Failure (MTBF) values contractual.

THE ILS TASK

To avoid misunderstandings from the very beginning, I will not discuss Instrument Landing System of the NH90. No, the acronym ILS in my speech reads Integrated Logistic Support.
Consequently you might ask: what is the reason than for assigning this lecture to Aircraft Design?
And you might also ask: can this forum benefit from such a lecture, what does this guy have to tell concerning design?
In the following minutes I will demonstrate, that the logistician is also somewhat of a designer w.r.t. the ILS System (ILSS) on the one hand and on the other is heavily dependent on the Aircraft Designer. The main goal of my lecture is to show that and how

ILS is caught between the conflicting forces of Operations and Design

Of course it is the desired operational performance of any new Weapon System, which rules the activities of the designer. During the economic boom, hardly any constraints were existing for the designers: what was technically feasible was aimed at, regardless of the operational cost for the new system, mainly to take advantage of the technological edge w.r.t. the potential enemy.
The "environmental scenario" for Armed Forces and new Weapon Systems has changed drastically in terms of

- reduced military threat,
- increasing constraints on defence budgets and on military personnel,
- new requirements for out-of area missions in international cooperation,
- shifting emphasis to world-wide peacekeeping and humanitarian missions.

Resulting from the above, any future User of Weapon Systems puts his prime focus on the

Affordability of Weapon Systems.
"Slogan of Reduced Life Cycle Cost"

To contribute to and to assure this affordability is the main task of Integrated Logistic Support.
The question arises, how to approach this task?
The approach is twofold:

- trying to influence the design of the logistic related features,
- establishing a cost-optimised ILSS.

Influencing the design

Influencing the logistic related design is a difficult task, since it is the logistician, who has to quite often "shoot the high-flying designer out of the sky" by down-to-earth questions concerning standardisation and material characteristics, reliability, maintainability, Testability, interchangeability and accessibility of items, to just name the most important logistic related features.
Incidentally, in the NH90 Programme Organisation the responsibility for the so called "ilities" (RAMT) of the design has been allocated to the ILS Managers of Customer and Contractor.

The idea behind this was, to give ILS more power to insist on fulfilment of the supportability requirements.
This is in consequence of the prime intention of the participating Nations in the NH90 Programme, already stated in the NSRs for the Weapon Systems NFH and TTH, namely to give

Equal Emphasis to Performance, Reliability, Maintainability, Safety, Cost and Time

This lead finally to the integration of serious and stringent logistic requirements into the D&D contract [e.g. the Statement of Work, the Weapon System Design Specification (WSDS) and the Programme Management Specification].

As examples, I would like to show you the **Logistic key requirements** extracted from the WSDS

- Availability ≥87%
- Design life of any Item ≥5000 hrs
- Mission reliability ≥97.5%
- Failure Rate ≤250/1000 FH
- MMH/FH ML 1+2 ≤2.5 hrs (excluding engines)
- On Condition maintenance to be achieved by extensive use of the MDS
- Detailed Performance requirements of such an MDS
- Limitations of effort for Corrective maintenance
- No Overhaul interval
- Lubrication Interval ≥600 FH (after maturity)
- Maintenance Interval ≥900 FH (after maturity)
- Manpower/Time Limitations for 1st Line Maintenance and Engine replacement
- Aerospace Ground Equipment (AGE) requirement to be minimised
- STTE requirement to be justified
- Modularity, Accessibility and Interchangeability requirements

One other significant aspect of the contract shall be mentioned also, in particular with regard to this forum.
The contract has also tried (and I must admit, that if I could have foreseen some of the difficulties we encountered to put the intentions of the contract into effects, we would have been much more detailed and precise) to stress the **standardisation goals** by quoting standards as binding prerequisites.
This requirement gains more and more impetus with the change of "environmental scenario" w.r.t. Humanitarian or Peace-keeping missions. Just consider the difficulties of operating different H/Cs in joint United Nations-, Western European Union- or NATO-missions. Remember how long it took and what enormous effort it involved, to set up the forces and in particular the logistic support for "**Desert Storm**"?
Can you guess, what the Technical Publication (TP) needed by e.g. the French United Nations Forces in Bosnia amounts to presently? It is a whole truck-load of books. This is something, we have to change in view of the changing mission requirements.
The minimum we can aim at is commonality of parts in TTH and NFH to assure Interoperability within NH90. But also here we have to broaden our view. Italy plans to introduce the EH101 H/C in their inventory and France/Germany to field the Tigre H/C. Wouldn't it make sense to widen the goals of interoperability or standardisation including these new H/Cs. To be very brave, why not look for EURO JET 2000 as well, or AIRBUS to think big? We promote again and again the slogan

Don't invent the wheel another time!

or to put it in another context:

Create once, use many times

which is incidentally the slogan for **Concurrent Engineering,** which is part of the **Continuous Acquisition and Life Cycle Support** (CALS) philosophy.
In fact in the equipment selection process, we try to cover also this aspect as well as the ones mentioned previously ("ilities", ILS, LCC)
I have titled this chapter "Influencing the design". Trying to do that, of course we are aware of the fact, that we are more influenced by the design, than we can influence it.

Everything in life is a compromise

And the design does not divert from that rule. But to minimise the draw-backs of the design for operation and support is our intention. By the way, isn't it true, that logisticians are only existing as a consequence of design compromises?
I trust, that designers could theoretically develop a H/C with almost 100% reliability thus not requiring any maintenance except for filling the consumable, but most likely such a H/C could probably hardly fly or would have an unacceptable low performance.
As you have seen before, we have raised quite demanding requirements concerning RAMT. What is to be done following the responsibility allocation to ILS?

1 Reliability (R) activities

The first thing to do was to agree on the Reliability/Availability (R/A) plan between Customer and Contractor. The draft of Industry, which contained methods, means and procedures w.r.t. the R/A tasks during D&D, was commented after a harmonisation process within the ILS Working Group. The main interest of the Customer also here was the Integrated approach, which means clearly addressing the mutual interfaces and influences [e.g. Failure Mode Effect and Criticality Analysis (FMECA) results to be included in the Logistic Support Analysis (LSA) database]. The completeness of the tasks [e.g. Failure Reporting, Analysis and Corrective Action System (FRACAS) and Environmental Stress Screening to be performed for newly developed equipment] and adequate Customer involvement were also commented. After extensive discussions within the working Sessions of the Prime Item (PI) PDR, a compromise, resulting in extensive rewriting of the plan, was reached.
The most important aspect was the what and how of Reliability Demonstration. Here we have one of the significant interfaces to Qualification, since R-demonstration is part of the qualification process (Design Responsibility).
Finally the schedule for reports on the R-activities had to be agreed in the plan as well. The first one of these reports, the Preliminary System Reliability Analysis, has just been issued, assessing the feasibility of complying with the basic and mission reliability requirements. This is of elementary importance, high Reliability results in little maintenance needs. Since Availability is a direct result of the R-activities, I will not go in further detail.

2 Maintainability/Testability (M/T) activities

The M/T plan was established in the same way as the R/A plan. The comments and discussions also here were on subjects like exhaustiveness of tasks, Customer involvement and the integrated approach w.r.t. mutual interfaces and influences.
Problems here arose in the field of Testability, where we had long and very hard discussions to reach a common perception and approach concerning the **on-board Testability** programme.
Initially the integration of the concept for the MDS as the on-board Testability tool into the M/T plan was aimed at by the Customer. A reference in the M/T plan and an additional

dedicated MDS plan called MDS Global Objectives were finally accepted to meet our requirements. Also this document was on the agenda of the PI PDR. This document is still under discussion, since it obliges all the Partner Companies in NH90 to a new quality of integration w.r.t. automation of on-board failure management.
Even though Health and Usage Monitoring Systems are standard in present Aircraft and H/C, the additional In-Flight Diagnostic capability with its needs for a new sensor concept, information distribution and integration resulting in on-board computing requirements, seems to have created a difficult and lengthy discussion and harmonisation process in the design offices of the different Partner Companies.
We, as the Customer, have to insist on the capacities of such a system, if we want to succeed in the application of "On-condition-maintenance" concepts. We keep telling the contractor, that such a system will put him in the position to meet the stringent logistic requirements w.r.t. MMH/FH, AGE, Failure rates, etc.
Another field of interest for ILS is due to the fact, that the MDS concept is part of the specific designer document System Segment Specification (SSS). Elaborating this part of the SSS was also delegated to the RAMT Working Sessions of the PI PDR, such allocating it to the ILS sphere.

3 MDS responsibility with ILS

So to state it again: the design responsibility for the MDS of the NH90 was given to ILS, this mainly, since the MDS is the on-board Testability tool.
Let me dwell a little on the principles and the goals of the Monitoring and Diagnostic System.
We consider this System to be the corner stone of the Integrated Logistic Support System.
The basic idea is that with recording and computation of wear- and tear-parameters we finally reach the situation where the systems down to the Line Replaceable Unit (LRU) level will themselves give timely warning when the performance is degrading to a level, which does not allow further usage of the particular LRU or when a maintenance action becomes necessary.
This in fact will mean:

- Maximise the exploitation of usage time of the systems and sub-systems,
- Minimise preventive maintenance
- Eliminate hard time parts as far as feasible.

We have based our expectations on such systems, which are state-of-the-art in Civil Aviation (e.g. AIRBUS 330 and 340, BOEING 757 and 777, etc.) and developed rather challenging requirements out of that. But all of our requirements were driven by the clear conception, that this approach is the most promising one to minimise LCC at the end.
Consequently to these perceptions, it is the goal of ILS, to bring this message across in PDRs, by insisting on Integration of the MDS-aspects in all Specifications, all Plans, etc., even if they are not truly Logistic documents.

The Integrated Logistic Support System

I said before, that the ILS specialist is somewhat of a designer himself. But what is his field of interest?
To answer this question, let us first define the scope of ILS. In the present understanding, ILS is composed of the following disciplines:

- Logistic Support Analysis
- Maintenance
- Technical Publications
- Aerospace Ground Equipment

- Material Support
- Training
- Automated Data Processing (ADP) Support for ILS

All of these disciplines are directly influenced by the Aircraft Design and vice versa, as I have pointed out before. In the following I will limit myself to those disciplines, which I consider to be of most beneficial in view of ILS and reduced LCC. At the same time, I want to emphasise the aspect of Integration as the "I" in ILS.

1 ADP Support for ILS

So let me first talk about ADP Support for ILS, since I consider the improvements of information technologies to be the prime element, on which Integration and Improvement are based. In fact it is the ADP Support, which enables a revolutionary approach in ILS.
Looking at the way nowadays the design is performed, we are in a **digitised world**. All the drawings are produced in Computer Aided Design (CAD) (including 3D Mock-ups and simulation models), Computer Aided Manufacturing is applied in production, Computer Aided Training (CAT) and Computer Aided Instruction (CAI) technologies are applied for Training. TP in paperless Interactive Electronic Technical Manuals (IETMs) are already available for some projects. Also Illustrated Parts Lists (IPLs) exist in a digitised form. The LSA provides the description of all maintenance actions resulting from the FMECA.
Integration of information is nothing else than applying Concurrent Engineering principles and hence in the widest sense CALS principles.
This integration of information is of highest importance in our days of limited resources.
The advantages of integration, i.e. the link of information in one or several relational databases are on both, the Contractor and Customer, sides.
For the Contractor data will be created once only, and then distributed to all Users. This safeguards the integrity of the data. As a result for the Customer, a comprising database can be made available for the In-Service phase.
The prerequisite however is standardisation of data-structure/-formats and data-language.
To achieve an integrated approach (rather than the previous applied departmental one) is nowadays the main difficulty, as well on Industry's as Government's side. Here we have to fight the effects of Newton's 1st law (any body will persist in rest or motion as long as no force is acting on him).
So it is the permanent action of ILS in our program to be the acting force, in order to change the approach. You can probably imagine, that we are winning new friends every day that way and in particular on the side of the designers.
But since we live according to a principle of Ernest Hemingway

Never to be discouraged - Secret of my Success

we keep on fighting for the future.

2 LSA

LSA i.a.w. MilStd 1388 provides a disciplined and structured approach to enable supportability, to influence the design and to identify cost-effective support.
LSA is the dominant tool for ILS to verify the achievement of the supportability goals and at the same time a tool for Concurrent Engineering. LSA ascertains the integrated approach in particular with Safety and RAMT, based on steady communication and exchange of data.
The process of LSA starts with the collection of all logistic data for all LSA candidates, a selection of equipment to be mutually agreed by Customer and Contractor. On the basis of

a scientific analysis of these data, the most cost-effective maintenance concept for each individual candidate is proposed to be accepted by the Customer. Re-design requests can result for identified cost-drivers.
The LSA database is considered to incorporate the central storage of data for all support requirements, not only for D&D, but particular in view of the In-Service phase. That is why the LSA database is a deliverable in NH90. Storing all support data, LSA will also be used as a basis for the production of Technical Publications, where only the necessary illustrations, produced by the designers i.a.w. CAD principles and procedures (CATIA Software) have to be added.
A Software Support Analysis to be carried out also utilising the MilStd 1388 as a guideline, shall indicate the support requirements for Software (SW) in an identical way as the LSA does for Hardware.

3 Maintenance

W.r.t. First Line Maintenance the implication for the designer should be: Define an inspection, which ensures flight safety for at least 15 flight hours for a helicopter operating at normal flying rates (i.a.w. Use Study 330 FH and 200 Missions per Year). To be very clear, we do not request to have a Pre-, Through- and Post-flight inspection, but if those inspections would result from analysis [e.g. LSA, FMECA, Maintenance System Guide-3 (MSG)], they have to honour the constraints w.r.t. personnel and time as stated in the WSDS. We are certain however, that a solution better than a "Daily Inspection" after the last flight of the day is feasible, utilising state-of-the-art capabilities of Monitoring and Diagnostic techniques. But to make the operators among you happy, they shall do their morning exercise of a Walk Around Check unchanged for nostalgic reasons.
W.r.t. Preventive Maintenance the MDS can provide for indication of degradation of system operability, hence giving timely warnings for maintenance actions to be planned and to be performed. That is why we required "No Overhaul Interval". The same philosophy in fact permits the deletion of any preventive maintenance, if this concept is applied in full depth. So we would prefer to have no Preventive Maintenance at all, provided Availability, Mission Reliability and Safety requirements can be met. If analysis however determines the necessity of Preventive Maintenance, the requirements/constraints of the WSDS (e.g. 2.5 MMH/FH and an interval not less than 600 FH/900 FH after maturity) have to be respected. At the same time we expect indication of Maintenance Planning data to be part of the MDS/Ground-based Logistic Information Management System (GLIMS), so these systems have to give timely warning of maintenance actions to be performed.
A remark concerning Corrective Maintenance: the times allowed for On- and Off-Aircraft rectification of failures can only be met in our understanding, if the Diagnosis- and Fault Isolation-task is attributed to the MDS and will be performed automatically, so that the rectification should be possible with only basic Weapon System Training and by applying standardised Maintenance Techniques (i.e. reduction of training, tools, etc.). Design features like Modularity and Accessibility are also considered to be indispensable prerequisites.
Single source repair for Maintenance Level 3 is also a concept, which could contribute to LCC-reduction. Here is in fact the field, where Industries could participate in the Logistics of the In-Service phase of the NH90. We are looking forward to attractive proposals, which can reduce the logistic effort w.r.t. Maintenance Installations, Manpower, Training, Storage, etc.
Finally a remark to Software Maintenance: Most of the problems related to SW result from the fact, that SW is looked at as something mystic and the SW specialists invent new

ANNEX

List of Acronyms

ADP	Automated Data Processing
AECMA	Association Européenne des Constructeurs de Matériel Aérospacial
AGE	Aerospace Ground Equipment
ATE	Automatic Test Equipment
CAD	Computer Aided Design
CALS	Continuous Acquisition and Life-Cycle Support
CAT/CAI	Computer Aided Training / Computer Aided Instruction
D&D	Design and Development
EQSP	Equipment Selection Panel
FH	Flight Hour
FMECA	Failure Mode, Effect and Criticality Analysis
FRACAS	Failure Reporting, Analysis and Corrective Action System
GLIMS	Ground-based Logistic Information Management System
H/C	Helicopter
IETM	Interactive Electronic Technical Manual
ILS	Integrated Logistic Support
ILSS	Integrated Logistic Support System
IPL	Illustrated Parts List
LCC	Life Cycle Cost
LRU	Line Replaceable Unit
LSA	Logistic Support Analysis
M/T	Maintainability/Testability
MDB	Maintenance Database
MDS	Monitoring and Diagnostic System
MMH	Maintenance Man Hour
MSG	Maintenance System Guide
MTBF	Mean Time Between Failures
NAHEMA	NATO Helicopter D&D, Production and Logistic Management Agency
NFH	NATO Frigate Helicopter
NH90	NATO Helicopter for the Nineties
NHI	NATO Helicopter Industries
NSR	NATO Staff Requirement
PDR	Preliminary Design Review
PI	Prime Item
PT	Prototype
R	Reliability
R/A	Reliability/Availability
RAMT	Reliability, Availability, Maintainability and Testability,
SSS	System Segment Specification
STTE	Special-to-Type Test Equipment
SW	Software
TP	Technical Publications
TTH	Tactical Transport Helicopter
WSDS	Weapon System Design Specification