THE ROYAL NETHERLANDS NAVY'S APPROACH TO LYNX LIFE EXTENSION

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Abstract

This paper briefly describes how the Royal Netherlands Navy (RNLN), as a relatively small Lynx operator, felt the need for and found the way to an Europe-wide Lynx life extension program. What originally started in 1986 as a national project was accelerated during 1995 to an international goal by coöperating with the design authority (GKN-Westland) and other European Lynx users. The ultimate goal is an "on-condition" status of the Lynx airframe without heavy maintenance- and or modification-penalties.
The way the project is progressing gives a positive feeling that the goal will be achieved before the end of the year 2000.

Introduction

The RNLN Helicopter group is a relatively small helicopter operator. Since 1976 a fleet of 22 Westland Lynx helicopters have been used in a variety of mostly maritime roles. Operational demand since then, in ground- as well as in ship-based missions, has led to a high degree of utilisation, consuming the 7000 hours airframe life that was issued with the helicopters upon delivery to the RNLN. To date, fleet leader airframes have aquired more than 5000 flying hours with an average usage that lies at some 300 to 400 flyinghours per year.
National and international political developments in recent years have imposed a remarkable change in operational tasks for the RNLN (i.e. UN-embargo tasks resulting in ships interrogating and boarding actions; coastguard tasks especially fishery-inspection and drug-enforcement). All this leads to an increasing operational demand in flying hours and a change in usage-pattern of the Lynx-helicopter. The above situation must be considered against budget-cuts and personnel reductions for economical reasons and an increase of maintenance requirements due to ageing and wear.
Operating their Lynx helicopters the RNLN still need to bridge a gap of many years before NH-90, as a successor , is delivered into service.

For this purpose RNLN feels the need to monitor and control usage of its Lynx fleet, i.e. gaining more insight into fatigue loading characteristics of the airframe, rotorsystem and engines to enable Lynx operation beyond the 7000-flying hour limit. Possibly this can lead to a rationalisation of maintenance schedules: more specific to usage, thus reducing the maintenance efforts.

Historic actions until late 1994

1986 - Feasibility study

During 1986 a first feasibility study was carried out into the subject of life extension of the main lift frame and some specific components.The study was initated due to the fact that RNLN

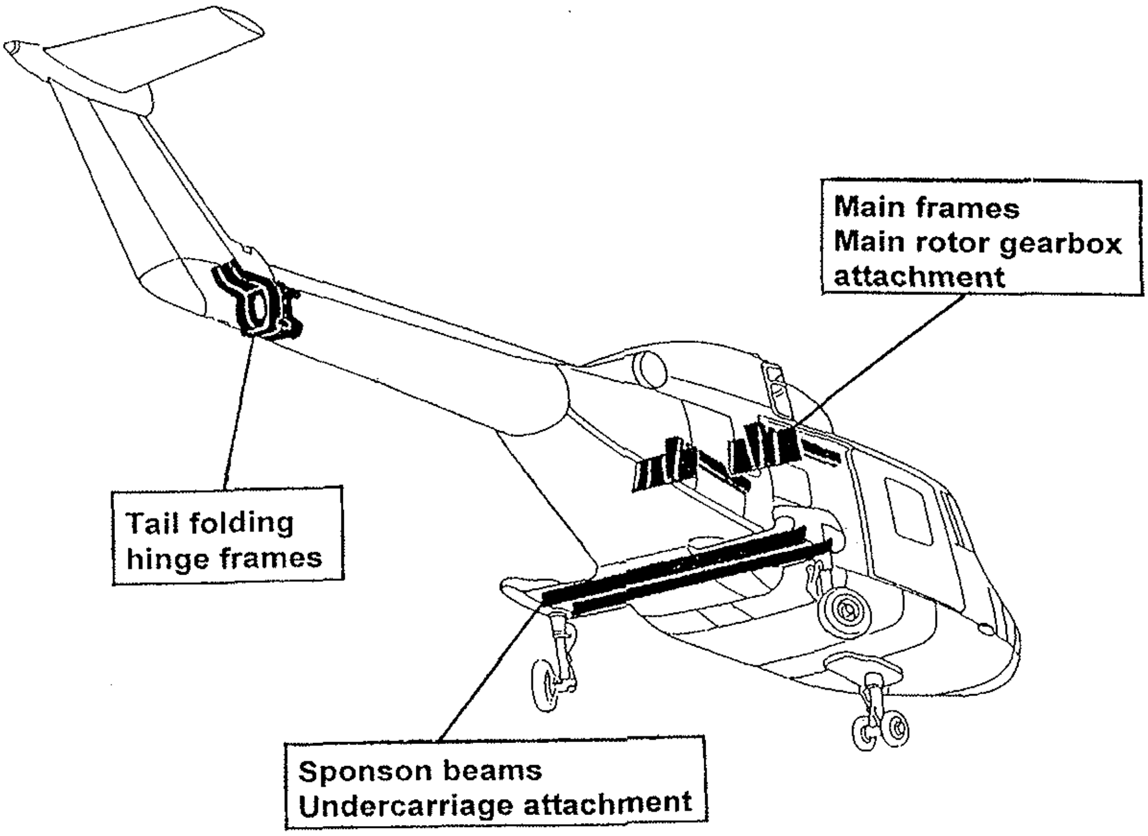

Figure 1: Fatigue sensitive and life limited area of Lynx airframe.

was convinced that their usage spectrum was less than that forseen during design. It was also an inventory of fatigue-sensitive and life-limited areas and it aimed for insight into the fatigue-behaviour of the airframe and main components.
This study, carried out in co-operation with the National Aerospace Laboratory (NLR) had the following objectives:

1. to setup an actual usage monitoring program;
2. to extend engine module lifes by cycle counting techniques;
3. to extend sponson spar (undercarriage attachment) life, counted in landings based on actual usage in comparision with the design usage;
4. to be able to recalculate the actual safe life of the tailfold hinge frame after modifications and repairs (corrosion removals). In the calculations the actual usage would be taken in acccount;
5. to determine an on actual calculated facts based safe life for the fuselage structure under the gearbox to avoid an intensive damage tolerance inspection penalty when reaching the assumed 1250 hours safe life (this 1250 hours was mentioned when consulting WHL).

The above study resulted in:

1. An actual usage monitoring program was setup. Using interview techniques, 13 different mission types were defined, which from that point in time started to be monitored administratively until today. Available usage data from the years before the starting date were also added.
2. A cycle counter was introduced to be able to monitor engine life cycles; resulting in an engine module life extension of approximately 500 hrs. *Note: The latest results of this part of the program are presented in another paper at this Forum.*
3. A 30 % life extension of the undercarriage attachment structure was achieved by comparision of the actual usage with the design-usage, which showed that landings took place with a much lower all-up weight than initially assumed and with a lower amount of landings per flighthour. A part of

this life extension was obtained simply by counting landings (= cycles!) instead of flying hours. The design usage spectrum average flying hours landing rate appeared overestimated for the RNLN usage.

4. No accurate recalculations of the tailfold hinge frames appeared to be feasible due to lack of accurate and / or detailed usage spectrum. The distribution of missiontypes was sufficiently clear but quantity of the actual manouvres and loads was not known in enough detail. This means that these parts of the airframe need replacement when their lives have been consumed. Because of the already reduced lifetime (calculated after modifications and repairs) it resulted in several hingeframe replacements. Beside the significant expenses of this replacement it also had and still has its impact on the operational availability!
5. No actual safe life of the structure under the main rotor gearbox could be determined. The complexity of structural loads makes it impossible for the designer to produce fatigue data. A damage-tolerant approach was proposed. WHL was consulted to determine the subsequent traject and they advised to start with one or more structural surveys of fleetleader aircraft.

MISSION TYPES
1. Transport / Navigation
2. Jumpex (= Sonar operations)
3. Deck landing practices
4. General
5. Instrument
6. Test
7. Towing
8. Demo
9. Search and Rescue
10. External load
11. Confined area / Slopes
12. Flyex (= ships operations)
13. Ships interrogation / boardings
14. Other

Table 1: Defined missiontypes

<u>1991 - Structural Survey</u>

Following WHL's advise and in close co-operation with them, during 1991 a structural survey was carried out on two representative fleetleaders with the WHL-defined objectives:

1. To confirm the adequacy of the current scheduled maintenance procedures; and to enhance, if faults are found, the scheduled maintenance program with directed inspections of defined areas.
2. To assist the Lynx in achieving the presently declared life of 7000 hours and enable it to continue beyond this point.

The results gave sufficient confidence in the airframe to reach the 7000 hours without major changes in the maintenance concept. No conclusions of the life beyond 7000 hours could be drawn due to the fact that those surveys were not real fatigue-sampling:
The entire survey was carried out with visual means except for a few specific NDT-inspections and no main-load-path items were removed for further detailed investigation.

<u>1993/1994 RNLN Lynx usage control program</u>

The initial RNLN Lynx fleet did not originally consist of equally equipped helicopters; a part of the fleet was tailored for training-, transportation- and SAR-tasks whilst another part of the fleet was prepared for two different and non matching ASW-tasks (Dunking sonar and MAD). The differences - in fact three different types of Lynx were in use - were a burden for operational availability. The dedicated division in role related types led to a significant difference in usage and flying hour consumption. During the years 1989 - 1992 an extensive Standardisation and Modernisation program "STAMOL" had to be carried out to meet future operational requirements and to make a more even useage of the Lynx possible.

In 1993 it was realised that to be able to bridge the years until the introduction of NH-90 under the current 7000 hours airframe life restriction,

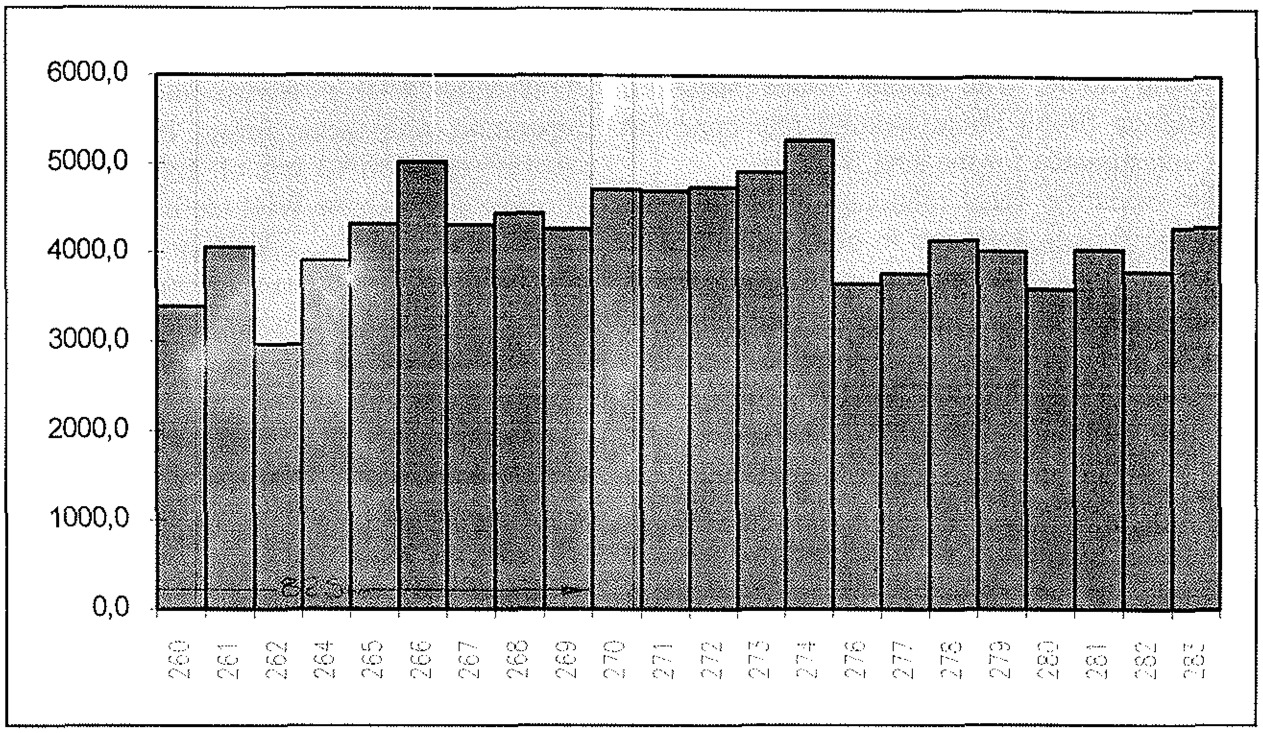

Figure 2: Distribution of consumed life over fleet: flying hours vs.aircraft registration number.

but without any concession of operational tasks, a fleet usage control program had to be set up and followed very strictly.

The danger became apparent that if this was not achieved the older airframes would have consumed their lifes early, resulting in a higher demand on younger airframes. From a certain point in time those remaining aircraft would not be able to "produce" enough flying hours to fulfil the operational tasks (the same or even more has to be done with less aircraft). The mentioned point in time was calculated and forseen well in advance of the (late?) introduction of NH-90.

In reality, during 1993 - 1994, the strict control program appeared not to be feasible, leading to the conclusion that a life extension became a must!

In the meantime WHL offered an extensive retrofit airframe strengthening program together with the introduction of state of the art dynamic components. A positive spin-off of this program was a foreseen life extension to possibly 10000 hours. Although the proposed modifications seemed to be sensible, the expected costly and time consuming modification program gave reason to look for another solution for the life extension program.

RNLN life extension project during the year 1995

National working group

The last conclusion, at the end of 1994, resulted in the installation of a national working group tasked to determine the way to extend Lynx life. Both the "safe life" and "damage tolerant"(= fail safe) approaches were to be investigated. The ultimate goal should be an extended "safe life" followed by an "on-condition" (fail safe) status without heavy maintenance penalties.

A secondary task of the working group was to investigate the possibility to combine efforts and share costs with other international Lynx users.

Safe life approach

The basis for any safe life determination is the accurate knowledge of the actual usage spectrum.
To determine this actual spectrum a usage monitoring program was setup based on the already mentioned mission types with addition of a 14th mission (UN ships interrogation / boarding action). Whereby during the 1986 project interview techniques were used, during this investigation the actual manoeuvres and flight-conditions were counted and recorded by using a simple lap top computer as a means of administration, during sample-flights of each defined missiontype. The results were recalculated into an average profile per flyinghour, typical to RNLN. RNLN is confident in the accuracy of the final results.

Comparing the 1986 with the 1995 usage spectra revealed that:

1. in the outline, the 1995-measurements confirm the 1986-interview results.
2. the distribution of the different mission types has changed over the years resulting in a more severe usage with respect to landing rate and all-up-weight.

Comparing the 1995 usage spectrum with the initial design spectrum also revealed that the RNLN still uses their Lynx helicopters less severe than what they were designed for.

Based on the above findings the working group became convinced that an extension of the safe life of both airframe and components should be possible. Therefore, the latest usage spectrum was handed over to WHL with the task to evaluate and to come with recommendations with respect to safe lifes based on this spectrum. WHL expects some gain in the life of transmission components. Regarding airframe components, a life-extension is not expected due to the dominant influence of the so called "gust"-factor.

Note: Firm results of the above evaluation are not yet available when composing this paper.

Mission mix 1994	**recalculated to 1 Lynx hour**	
	kg / n / s	**% flight**
AUW	**4511 kg**	
TOCG	**mid**	
FUEL	**728 kg**	
Cruise High	**81 s**	**2.25 %**
Medium	**1664 s**	**46.23 %**
Low	**1022 s**	**28.40 %**
Hover	**471 s**	**13.07 %**
Sonar Hover	**201 s**	**5.59 %**
Hoist 10N	**112 s**	**3.10 %**
Hoist 20N	**23 s**	**0.64 %**
Sideways 0-10 kn.	**19 s**	**0.54 %**
10-20 kn.	**1 s**	**0.04 %**
20-30 kn.	**1 s**	**0.02 %**
Backwards 0-10 kn.	**2 s**	**0.07 %**
10-20 kn.	**1 s**	**0.03 %**
20-30 kn.	**1 s**	**0.02 %**
Autorotations	**0.24 n**	
Running Landings	**0.16 n**	
Max Power Climb	**3.12 s**	**0.09 %**
Transitions	**10.25 n**	
Turns > 30 number	**5.06 n**	
time	**34.56 s**	**0.96 %**
Turns > 45 number	**1.62 n**	
time	**6.80 s**	**0.19 %**
Landings ship	**0.34 n**	
land	**1.73 n**	
dummy deck	**0.78 n**	

Table 2: Results of usage monitoring program

Damage tolerant approach

The basis for any damage tolerant technique is to know the Structurally Significant Items (SSI's) of the aircraft and the accumulated damage to those SSI's during the already consumed service lives.
Therefore the following actions were taken:

1. Determination of the structurally significant items, by means of using WHL's damage-categorisation in their structural repair

manual mixed with service experience and damage history. The determined SSI's were laid down in a document. In this document all airframe parts were classified into five damage tolerant categories and color-coded. The document was agreed upon by WHL.
Note: The highest (red) category being the WHL-lifed airframe structures extended with the remaining highly loaded items; the lowest (green) category were the cosmetic, non stressed parts of the airframe.
2. A second set of two structural survey's was decided upon. One survey to be carried out by WHL on a damaged aircraft currently undergoing repair. The other survey to be carried out in de course of 1996 by RNLN personell themselves. The difference with the previous survey's is that these are now focussed on how the airframe life philosophy could be changed from "safe life" into "fail safe" with a limited on-condition maintenance.

International Working Group
Multilateral Lynx Support Comittee (MLSC)*

Members of the national working group strongly proposed and succeeded in installing an international working group: "Life extension Lynx" under the umbrella of the MLSC. The task of this working group was to combine participing nations efforts, to share costs and to commit WHL to the common need of a life extension.

During the first meeting of the working group (november 1995) it was agreed that:
1. A common contract to be placed at WHL to determine a damage tolerant approach in all its aspects with the ultimate goal to reach the on condition status without major maintenance- and / or modification- penalties.
2. Participating nations to offer aircraft to enable WHL to carry out structural surveys.
3. Safe life programs to go on parallel under each nations own responsibility and expenses, but still within the main MLSC-project.

During this first meeting WHL already stated that based on current experience and knowledge, no features were apparent which would give reason for concern for an eventual clearance beyond 7000 hrs. The terms and conditions still have to be determined.

Life extension results achieved until half 1996

During the first months of 1996 the following emerged as the result of the national and international actions and is also the current status of the project:
1. The RNLN-SSI-document as agreed upon by WHL was now introduced as a basis for the international damage tolerance program.
2. The structural survey carried out by WHL on the first Dutch Lynx concluded a good condition of the aircraft and no obstructions passing the 7000 hours threshold. The second structural survey has been started. No firm results are yet available, but this aircraft seems to be in good condition too. In this particular case the structural survey was used as an opportunity to try out a Midlife Airframe Corrosion and Husbandry Overhaul (MACHO). This in anticipation of the on-condition status of the airframe.
3. The international MLSC project was agreed to finish ultimately 36 months after the contract date. The contract is expected to be placed late 1996.
4. Nationally, a small fatigue awareness program was launched to give aircrew a better feeling of the concequences of certain manoeuvres and all-up-weight (fuel) regarding fatigue.

* The governements of the Western European Lynx operaters have agreed upon exchanging technical information and to coöperate on technical and logistic matters under the Memorandum Of Understanding called the Multilateral Lynx Support Committee.

The way ahead

The project came to a stage where the damage tolerance approach of the life extension could be regarded as the international goal and the safe life approach as the national addition to it. Therefore the following is intended:

1. To continue with the active participation in the international working group on the damage tolerance project.
2. To continue, as a national project, with the safe life approach based on the RNLN usage spectrum to gain the ultimate in component and airframe lives.
3. To look for a simple verification method of the usage spectrum; for instance by introducing a "mini-HUMS" or extended cycle counter.

Concluding remarks

Due to operational pressure the RNLN became aware that a life extension for their Lynx airframes was necessary. The RNLN realized that extending the life of the Lynx was beyond reach for them as a relatively small operator on its own. Therefore it was decided to use the MLSC as a forum to convince other Lynx operators of the need for, and the benefit of a common life extension project. WHL also became very interested in this common approach which recently resulted in the publication of their proposal of the programme. This proposal describes the activities and milestones WHL would undertake to change from a fixed 7000-hours safe life to an on-condition status and is expected to be finalized during the year 2000.

By reaching the expected results, RNLN will realize the following objectives:

1. The full RNLN-Lynx fleet can stay in use, irrespective the age of individual airframe hours, bridging the gap until the NH-90 is delivered into service.
2. After finishing their service within RNLN the airframes will still have some economical value.

During the project two lessons have been learned already:

1. Never purchase an aircrafttype having a fixed (fatigue-)life without the prospect to change relatively easily from safe-life to on-condition status.
2. Always introduce a form of usage monitoring; even the most simple method will be of great benefit when evaluating the status of the airframe.