The Integration of an Aircraft Availability Performance Program with Life Cycle Management in the Swedish Air Force

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ABSTRACT

This paper presents briefly the FMV: s approach to improve systems availability by using an "old", but still very efficient process: Life Cycle Management (LCM) process. Naturally the process was improved during the last past years due to the changes, both conceptual and structural, of the Swedish Defence. After a short introduction about these changes and transformations, it presents to the reader the impact of the APP to the Swedish Air force. It follows a more detailed presentation of the Availability Performance Program, its concepts to improve availability and to reduce the costs. Finally it ends with a few words about how the program was performed during the acquisition of two major systems of the Swedish Defence: JAS 39 Gripen and NSHP-Nordic Standard Helicopter Program (NH-90).

It should be mentioned here that APP is not a program specifically designed for the Air Forces, even if this paper shows its applicability only in this area. Also this paper should not be interpreted as a dissertation about LCM or about the APP, but a simple clarification of the slides which already had been shown at the workshop.

1.0 INTRODUCTION

FMV is an independent, civil authority, with a focus on high technology. Our work takes care of the needs for technical solutions and material for Sweden's security. You can also summarize FMV with these words: business skills and technology – for people, security and the environment. FMV contributes to strengthening Sweden's security and defence ability through advanced, flexible (interoperability) and cost efficient materiel. FMV is changing and renewing to adjust for the restructuring of the Swedish defence from an invasion-based to a task force-based defence.

Our primary task is to provide the Swedish Armed Forces with equipment, systems, and methods that are effective today as well as tomorrow. FMV also represents the government in complex international transactions and businesses.

For us, it is important to have an overall perspective with focus on our customers. Based on our clients' needs, we identify, develop and supply materiel and technical solutions. We have technical, commercial and international competencies that act together under the supervision of experienced project managers.

FMV delivers complex products for both military and civilian use, and has an extensive service portfolio:

- Commercial support and procurement – To secure FMV's business focus, we work continuously with coordination and commercial tracing from strategy to delivery, during both national and international collaborations.
- Modelling and simulation – FMV offers an advanced environment for simulation based acquisition, for example systems and enterprise analysis, business modelling, crisis management analysis, analysis of future international operations and technology demonstrators.
- Investigations – FMV investigates, for example the effects of outsourcing, on assignments from the government. We advise, support and offer analyses.
- Validation and verification – FMV has test ranges in several places in Sweden. Each of them has different capabilities and focus for testing. Examples of our resources are that we have the larges test ranges in Europe on land, the most modern dynamic field simulator and highly skilled and experienced personnel.
- International materiel cooperation and export support – FMV participates in a wide range of collaborative forums in which possible collaboration is discussed. EDA's work has been comprehensive and has covered research matters, defence materiel and the defence market. NATO activities have been expanded through the inclusion of new programmes in fields including security and anti-terrorism measures.
- Certification services – The certification activity has been established as an independent function within FMV with the designation "Swedish Certification Body for IT Security", short title CSEC. CSEC is ready to undertake its first certification assignments. Building up this activity has taken three years reckoned from the start in 2003. International recognition of the certification scheme according to the Common Criteria Recognition Arrangement is anticipated before the end of 2006.
- Qualified advisement to owners and customers, primarily within commercial, technical and legal areas.

Some of the larger projects in which FMV participates extensively are shown in Figure 1.

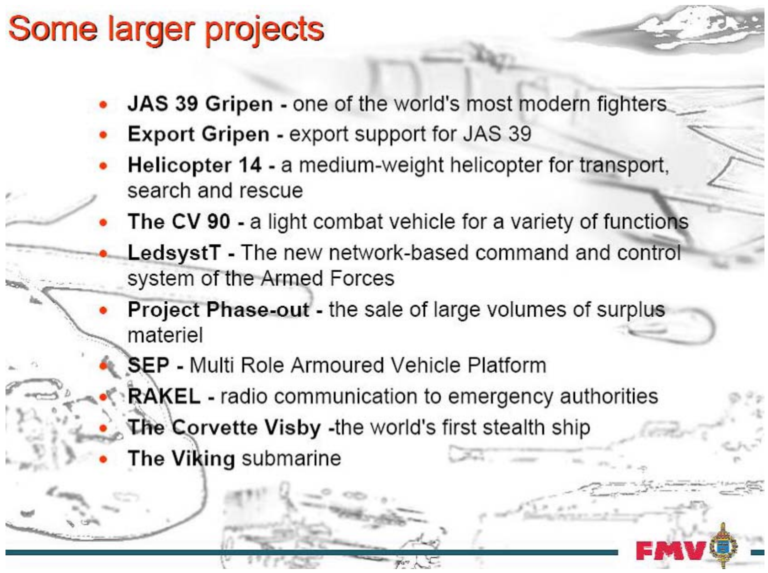


Figure 1: Some of the larger Swedish defence projects in which FMV participates.

Figure 2 shows the FMV's contribution and an idea about the amount of work we spend during the materiel system life cycle as well as how the amount of work is divided between FMV and industry. The picture is also trying to show what we do and a little about how we do it. In the same time the picture is changing quite fast as a result of the transformations which take place both within the Swedish Defence and within FMV.

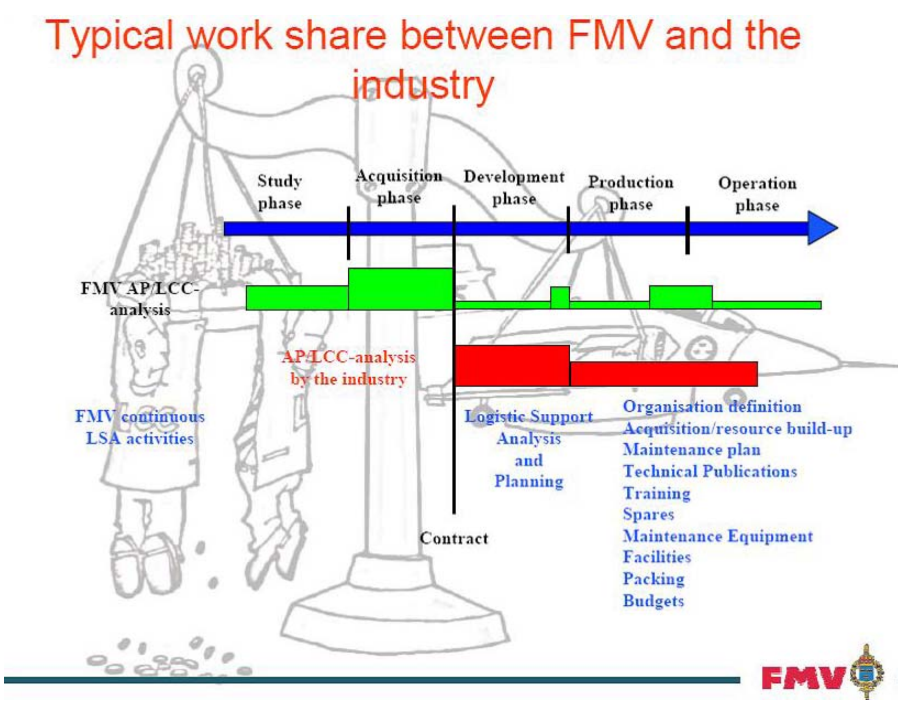


Figure 2: Typical work share between FMV and industry.

Today's defence systems involve materiel which is more complex and which embodies more integrated functions than in the past. As a result, maintenance costs in many areas are comparable with, and in some cases exceed, the original purchase price of a system. This requires focusing more closely on maintenance in the overall materiel process. Good planning in this respect can ensure that both the investment in maintenance resources and the future costs of operation and maintenance can be held down. Success in this depends on the close integration of availability questions as part of the overall activity throughout the useful life of the materiel system.

The way in which this work is approached within FMV is known as Life Cycle Management or LCM. LCM is a method of conducting a continuous logistic support analysis in a structured and controlled way, i.e. a procedure designed to control the procurement, development and operation of a materiel system in order to achieve high reliability and low through-life costs. The LCM activity is conducted mainly in project form where a high degree of adaptation to the particular requirements of the project concerned, combined with clear objectives and milestones, are important ingredients.

The scope of this paper is not to define or describe in details the LCM process. There are already a lot of different documents around the world which do this. The scope is mainly to show very briefly how the work is done within FMV.

During the last ten years a lot of changes took place in the world. Some of these changes have a political nature some of them have a technological nature but even changes on a more philosophical nature took place. All these changes influence naturally even Sweden and the Swedish Armed Forces (SwAF).

The Operational Concepts which are general descriptions of how military forces intend to fight and conduct their operations in the future changed. These new concepts originate from innovative ideas about how to fight as well as notions concerning how advances in technology might be applied to warfare. All this generated the needs for new processes, new requirements for new or modified weapons systems or equipment, as well as for new doctrine, force structure, training, and education. The SwAF are discussing now and implementing as well, about concepts as Network Based Defence. The SwAF in its acquisition process is looking to acquire functions rather than systems (Figure 3).

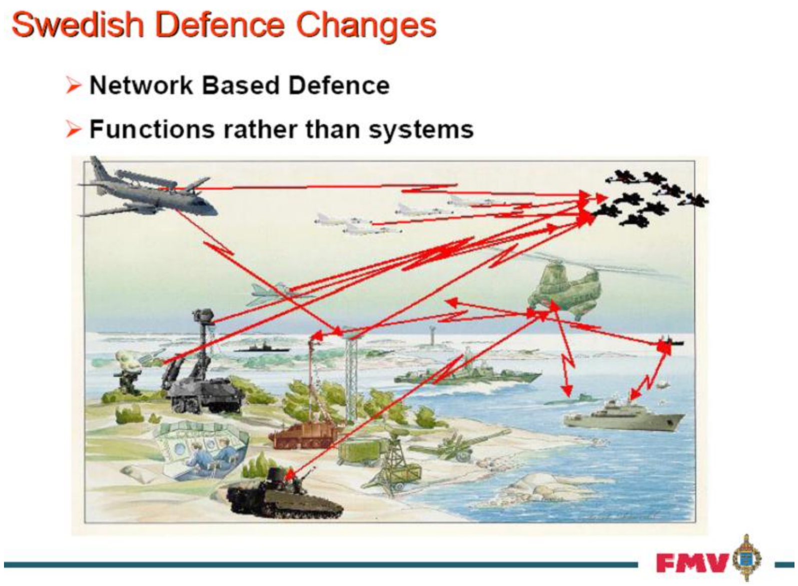


Figure 3: The Swedish Armed Forces (SwAF) in its acquisition process is looking to acquire functions rather than systems.

Figure 4 reveals only a few of the other factors which increase the needs of reshaping the Swedish Defence.

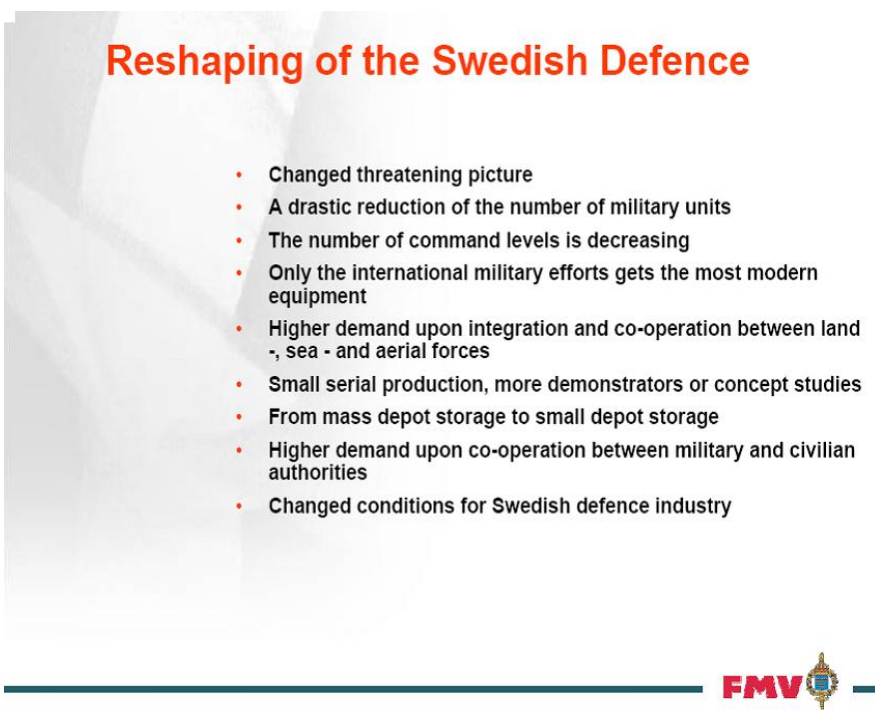


Figure 4: A few of the other factors which increase the need to reshape Swedish defence.

The acquisition process has to change too. Usually the defence systems acquired in the past had a life length of more than two decades. Today a system design allows continuous growth and adaptation to new task and new technology without extensive reconstruction, with other words an evolving system.

We can get in just a few years a whole new system with a whole new functionality. That means that the system we bought today is not the system we will operate tomorrow. Practically the systems life length is unknown.

If the system will increase its capability in a very short period of time, do I need in the near future as many systems as I intend to purchase today in order to achieve the same goals? How we will handle the spare parts for the system is even more complicated!

The technology development is no longer linear! That gives us less and more unreliable data for prediction of the failure rates. The life length of the components is even shorter. The cost of hardware and software development is changing with age.

All of these facts enforce changes in our LCM process and in our models too. How we will handle the LCC model in the future will probably change.

Even the procurement agency (FMV) is affected by all the transformations above. That is shown by:

- A higher demand on systems co-ordination – capability to build system of systems;
- No longer land, sea and aerial forces just one defence;
- A changed acquisition process;
- The necessity of an overhaul of the interface with industry;
- A higher demand on interoperability;
- New demands to change the competence profile; and
- Adjustments of the boundaries between the actors involved.

2.0 LIFE CYCLE MANAGEMENT – FMV’S ROLE

With all the above changes and challenges in mind FMV still has to provide the Swedish Armed Forces with the necessary material system for future operations, i.e. both the technical system and the integrated Operational and Support (O&S) system.

And the LCM process (Figure 5) is still the right tool for the job. Now, it may be so that LCM process has evolved from the “old days” and there are a lot of different definitions and approaches which one can find around the world but in the view of the author, even if we are talking about functions or systems of systems or capabilities, at the end of the discussions we still have to acquire a material system. We may have to do a lot of other things before a procurement decision is taken but when it does we should apply the “old” LCM process to the materiel system throughout the whole of its useful life, from the earliest studies until phase-out, and it should entails, among other things:

- Influencing the operation and logistic support assumptions and the availability performance (AP) requirements for both the technical system and the logistic support system.

- Analysing the economical consequences of the AP requirements to ensure that adequate financial provision is made in the budget. This should applies both to the procurement of logistic support system resources and to the subsequent operating and support costs.
- Controlling the activities of the supplier during the design, development and production phases. This is made possible by writing into the contract an appropriate Statement of Work, a so-called Logistic Support programme, for the purpose of ensuring that the reliability, maintainability and logistic support requirements are taken into account at the design phase.
- Iteratively develop an optimized maintenance concept.
- Realising the support concept through an optimized acquisition of logistics support resources.
- Integration of the support system specific to the materiel system concerned with the existing Operating, Support and Maintenance system (O&M system).
- Gather and analyse experience data from the operation to monitor the AP and the remaining LCC.
- Systematically, at an early stage, plan for the systems last period of operation and phase-out.

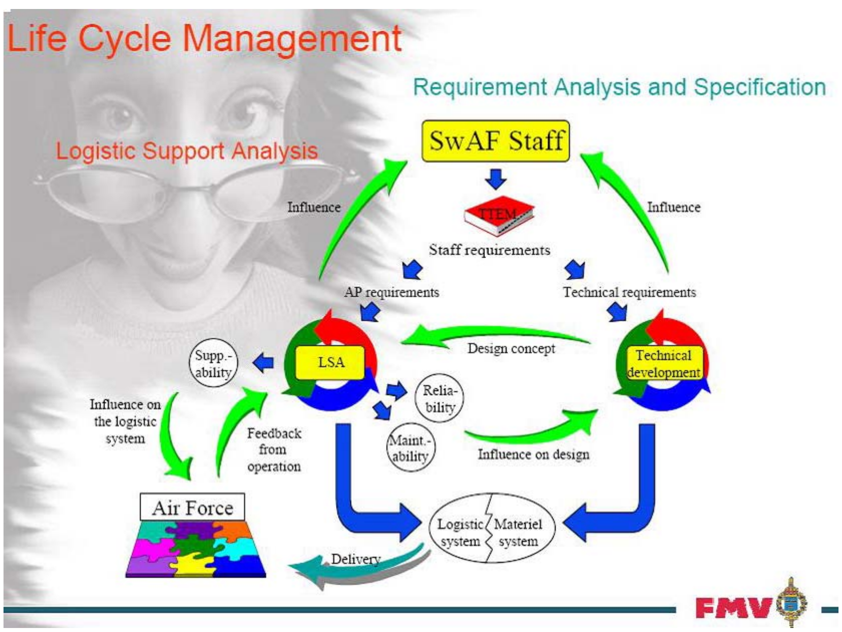


Figure 5: Life Cycle Management (LCM concept in the Swedish Armed Forces.

Figure 5 illustrates the LCM process as FMV is applying it. The picture enlarges the process during the acquisition phase that is mainly because the department I am working with has this part of the process in its focus. The focus it's changing depending on the department within the agency.

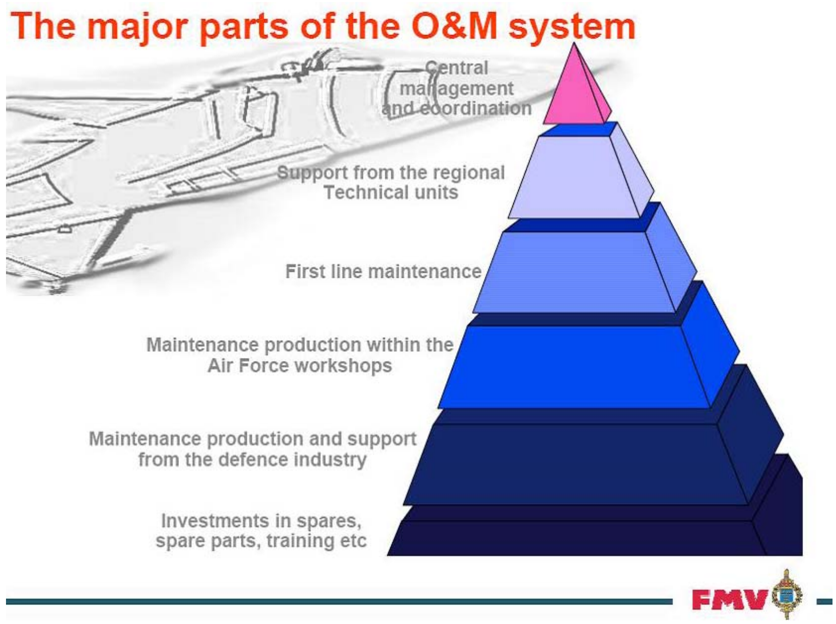


Figure 6: The major parts of the Operation and Maintenance (O&M) system.

Actually FMV is working with the entire O&M system, or the logistics support system, which is described in the figure above. The agency is doing that by covering three main functions shown in Figure 7.

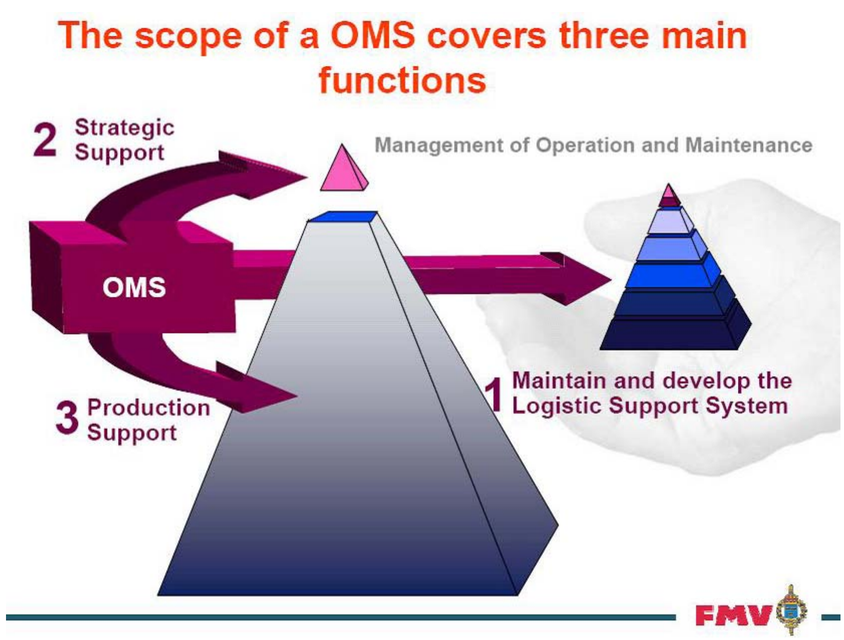


Figure 7: The three main functions of O&M.

These functions are described as follows:

a) *Maintain and Develop the Logistic Support System* – The purpose of this function is to provide the Swedish Armed Forces with a flexible and efficient operation and maintenance support in war, crisis and peace. This function consists of short- and long-term adjustment of the Logistic Support System to new technical systems and activity demands and continuous coordination and integration of the Logistic Support System. These tasks are accomplished by producing development strategies for and actively develop the Logistic Support System. The objective will be obtained by:

- Creating development strategies;
- R&D in LCM;
- Actively utilize new IT possibilities; and
- Actively develop existing rules and routines.

b) *Strategic Support* – This function involves a continuous support to responsible persons within the Swedish Armed Forces related to preparation for basic decisions concerning long- and short-term planning regarding materiel, operation and maintenance. The basic decision includes technical, structural, economical as well as commercial areas. The task is accomplished by identifying problems and possibilities in due time, and with established and new methods/models present a basic decision with the right quality.

c) *Production Support* – This function involves a direct and continuous support to personnel engaged in accomplishing operation and maintenance. This is done by supplying support systems as well as technical and economical competence. The assignment is accomplished by securing the unity of and balance between tasks, organisation and resources. Possibilities are thus created for high production efficiency.

To enable the materiel to be utilized correctly in peacetime as well as in time of crisis or war, there is a need for properly functioning common O&M system which does not necessarily require to be changed for each new type of materiel. When future operation and support of a materiel system is being planned, it is important to find an optimum trade-off between the general elements of the O&M system and the additional elements specific to that particular materiel system. This trade-off is addressed in the LCM process.

As en example the O&M system is largely common to all Air Force materiel but it also contains components specific to some particular materiel systems. The task of the Swedish Air Force requires a good interaction between many different systems as Figure 8 is claiming. Sweden has only in the Air Force over 500 different operational systems but only one integrated operation & maintenance system.

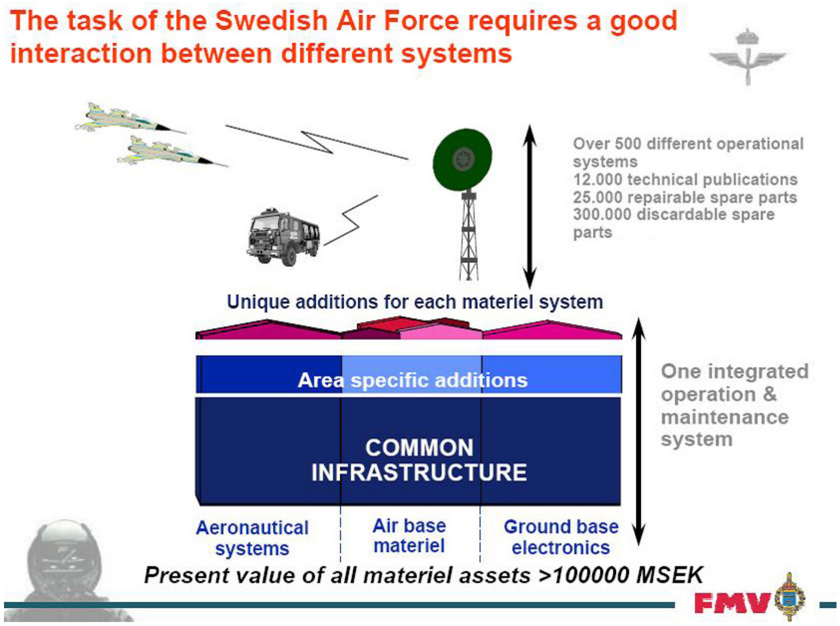


Figure 8: Single integrated O&M system covering all Swedish Air force materiel.

Translating this in economical terms it means that the Swedish Air Force turnover is about 3,000 million Swedish kronor (SEK) per year while the maintenance costs are approximately 3 % of the materiel value. The "old" LCM process did his job well here!

3.0 AVAILABILITY PERFORMANCE PROGRAM (APP)

An APP consists of a number of engineering methods and organizational routines that will control the logistic support analysis work to be performed within a specific project, or for a specific product.

The aim of the APP (Figure 9) is to ensure that the delivered materiel system will fulfil the contracted requirements on availability performance and that LSC is being minimized. It should describe the statement of work to be performed during development and production and also produce all the data needed for optimization and acquisition of the necessary maintenance resources.

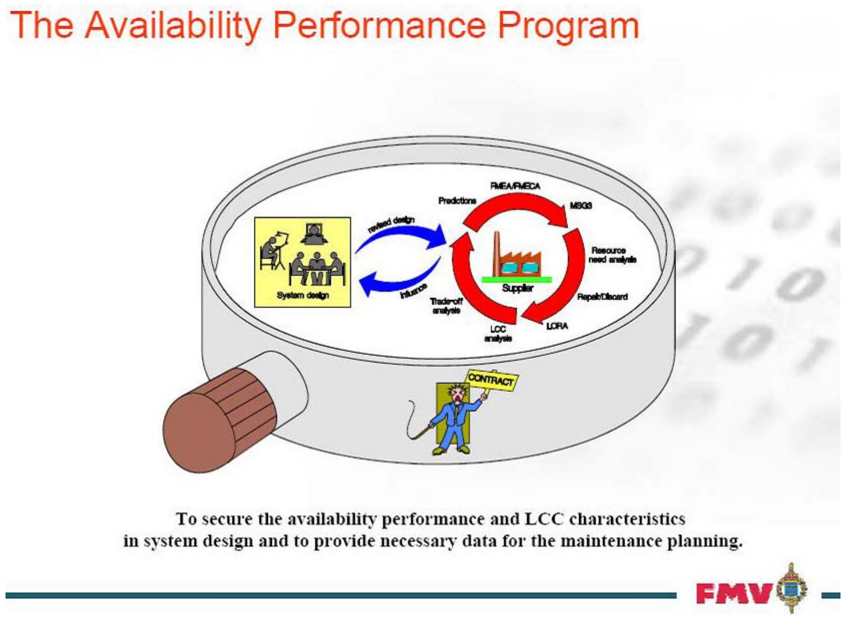


Figure 9: The Availability Performance Program (APP).

The availability performance program is a very important part of the LCM process but one should be aware of that the program cost a lot of money to perform and that is why it should to be tailored to the need of the specific project. APP requires that qualified personnel are available both at the contractor and the customer and also, very important, that the program is accepted within the contractors organization.

Some of the performed tasks and subtasks throughout the program are listed below:

- Requirements specification and breakdown.
- Reliability analysis:
  - Reliability block diagrams.
  - Predictions.
  - FMEA/FMECA.
  - Fault Tree Analysis (FTA).
  - Software reliability.
- Maintainability analysis:
  - Test and fault localization analysis (BIT).
  - Methods for corrective maintenance.
  - Methods for preventive maintenance.
  - Design features.
  - Predictions of MTTR and BIT effectively.

- Supportability analysis:
  - Configuration analysis (define MSIs).
  - Modularization/ standardization.
  - Maintenance need analysis (RCM).
  - Repair/discard analysis.
  - Level of repair analysis (LORA).
  - Identify and dimension the logistics resources.
- LCC analysis:
  - Evaluation of proposals and design alternatives.
  - Identify cost driving characteristics in both the technical system and the maintenance system.
  - Control the development towards a low LCC.
- Test and evaluation.
- Feedback from tests and prototypes (FRACAS).
- Verification.

Did someone find something new in the list above? I do not think so! Everything is “old”!

The problem is not how you verbalize the task but in how you do, carry out, the task today. The information technology today increases the possibilities to performer better analyses with better and more accurate results. And there a lots of analyses to perform! That is why the program can be expensive because of all these analyses which can take a lot of time and resources. The information technology gives to the analyst today a lot of powerful tools and a lot of information to investigate. Sometimes too much information! On the other hand shortage of exact data is not a limitation or an excuse. There are always possibility to do sensitivity analysis on “cost drivers” that gives sufficient result for decisions on distribution of requirements and requirement levels.

The first thing to do is to analyse the requirements. It is very IMPORTANT that the contractor will understand your organization, your definitions and your requirements as well as how you are going to use the system!

The requirements must not be missed or misunderstood and must be possible to verify too.

Be distinct about your operation profile too, because different operational profiles give different requirements on availability performance.

A poor analysis of the requirements leads to poor material system and expensive logistics system. If the requirements are on a too high level the acquired system will be too expensive.

Therefore the requirement analysis should consist of two major parts:

1) Select type of requirement, and here the selected requirements should:
   - Fit the user; and

- Be possible to put out as requirement on the technical system.

2) Select an optimal requirement level due to :
   - Possible technical solutions;
   - Maintenance organization;
   - Transport organization; and
   - Costs, etc.

Figure 10 and Figure 11 exemplify the requirements break down process, and the picture themselves are pretty much explanatory as they are. Availability performance requirements for the technical system are refined to form requirements for the products to be procured. This results in detailed reliability, maintainability, logistic support requirements and requirements for Statements of Work.

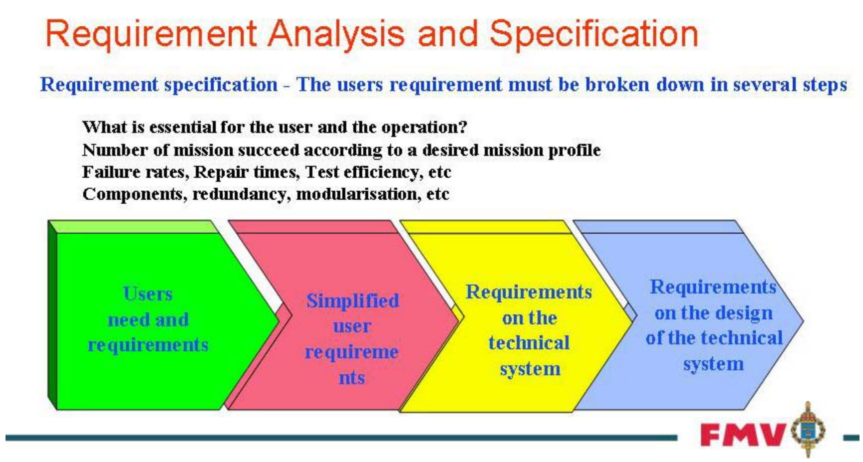


Figure 10: Requirement analysis and specification.

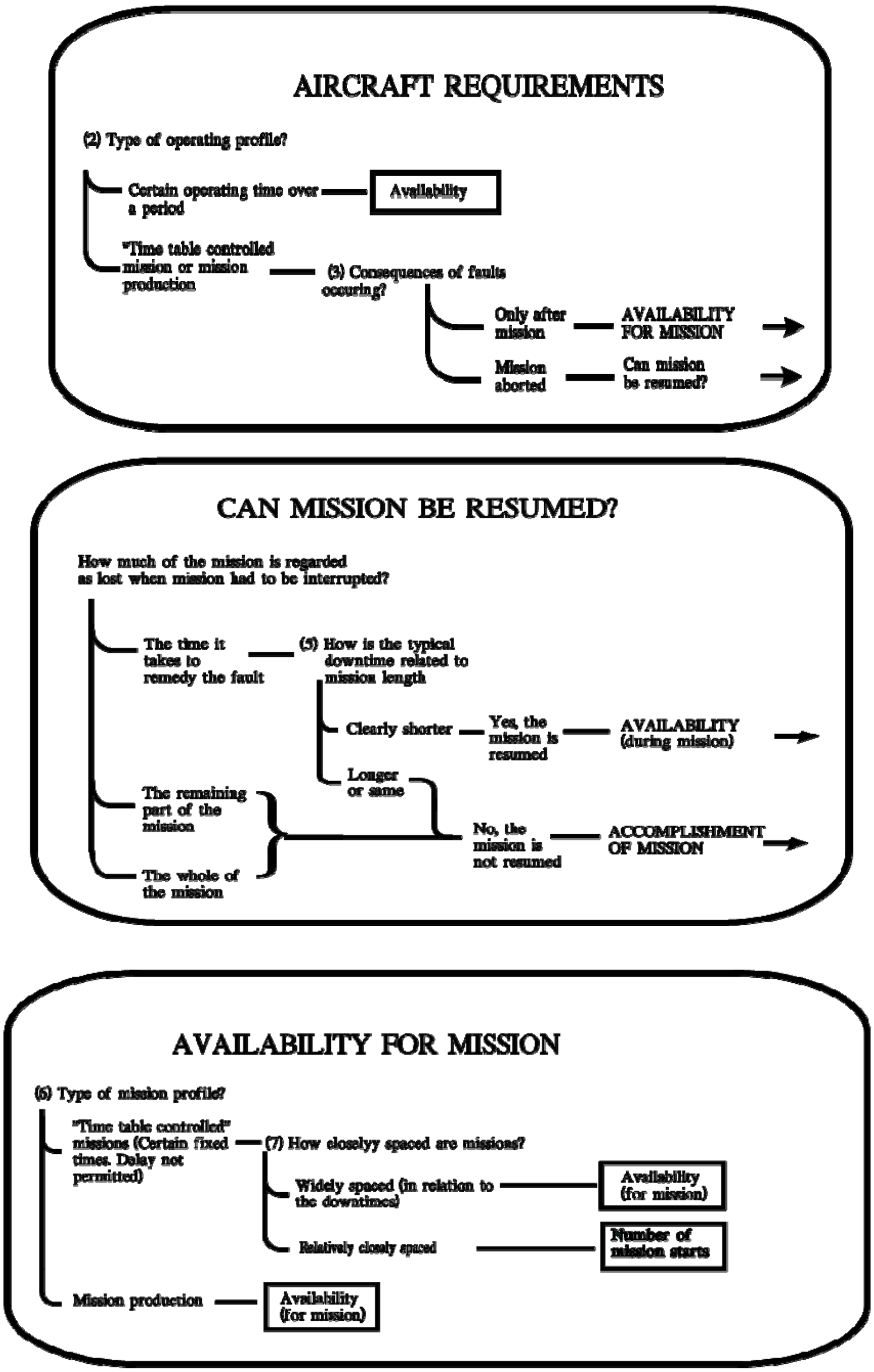


Figure 11: Breakdown of availability requirements.

The only thing we want to add here is that the following areas must be covered in a specification of availability performance to do a good acquisition:

- Evaluation principles.
- Assumptions.
- Requirements on the system – availability performance.
- Requirements on data and information to be delivered in the proposal.
- Requirements on deliveries of the support system.
- Requirements on the contractor, availability performance program.
- Requirements on verification.

The objective for all defence materiel systems is to achieve the required operational performance within the constraints of the funding available. Operational performance can cover both the strict requirements specified and the user's experience of operating the materiel concerned, e.g. how easy it is to use and maintain, aspects which taken together characterise a functioning system.

Operational performance includes both technical and availability performance (see Figure 12). By technical performance we mean the technical characteristics of the system which describe how it functions. This could refer, for example, to speed or radar range.

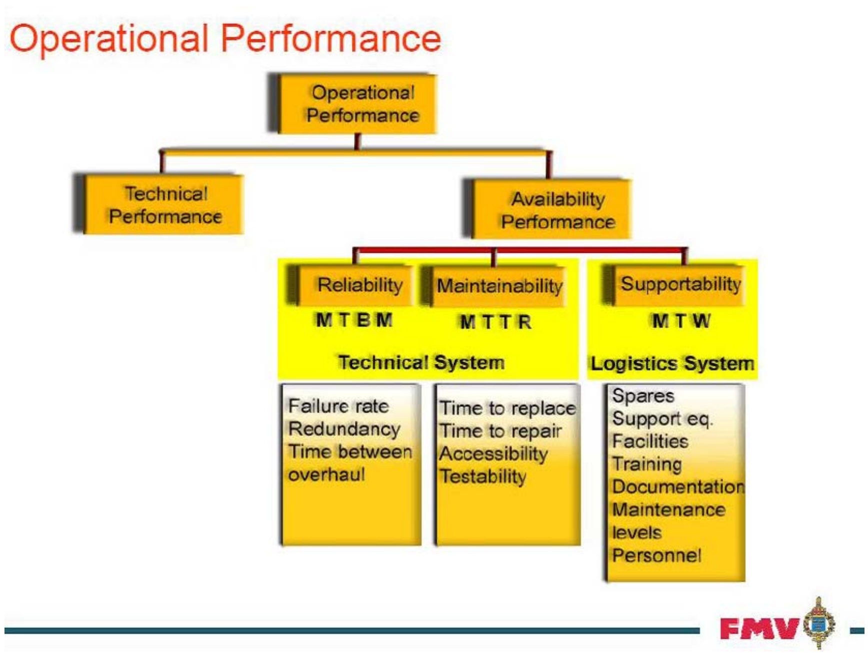


Figure 12: Operational performance breakdown with examples of parameters which affect it.

The LCM process applies primarily to availability performance, i.e. those characteristics which determine when the system is functioning and how the situation is handled when it ceases to function.

Availability performance thus depends both on the characteristics of the technical system and on the capacity of the maintenance system. This enables trade-offs to be made between these characteristics so that the reliability performance can be achieved at the lowest possible cost.

The analyses that have to be performed are related to this trade-off. In fact we do almost simultaneous analyses regarding how much effort shall be put into the technical system and how much into the logistics support system as well as analyses to adjust, to balance, the logistics system itself (see Figure 13). All these analyses are enriched by LCC analyses.

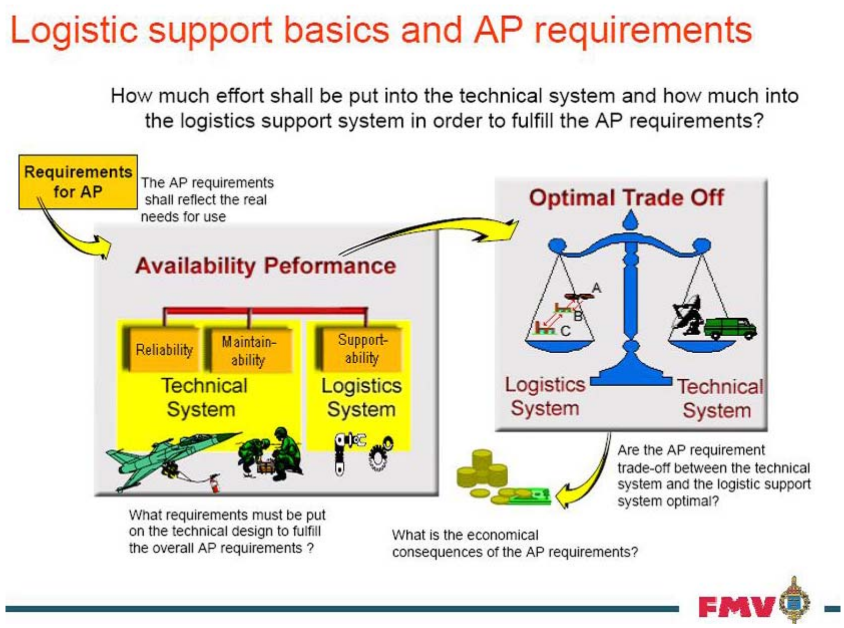


Figure 13: The process of analysing the availability requirements.

These analyses can apply both to future materiel and to the modification of a materiel system or a support concept, e.g. prior to a reorganization.

Studies preceding the selection of a future materiel system are largely concentrated on determining the right requirements and the right levels for these requirements.

During the study phase, work on determining the necessary financial provision is also carried out. On the basis of the preliminary support system assumptions, the financial implications are clarified with regard both to the LCC and to the budget.

Life Cycle Cost (LCC), another concept that is central to APP, is a measure of the overall financial consequences of a system or equipment over the whole of its useful life. By the overall financial consequences we mean not only all the costs associated with procurement and development of the materiel system but also the cost of procuring various support system resources and the future costs of operation and support. These latter costs of procuring support system resources and the future costs of operation and support are known as the Life Support Cost (LSC), and it is this part of the LCC which is most often used in the LCM process.

Using LCC methodology implies that all decisions on, for example, requirement levels, time out for maintenance etc., technical design solutions and support concepts are based on an overall assessment of all the cost implications of the decision concerned. This applies to decisions relating to procurement costs and to the future costs of operation and support. The importance of this methodology remains the same regardless of where in the life cycle of the materiel system the particular decision is to be taken. Thanks to this approach, we will always have an overall picture of all the costs which will arise throughout the life cycle for a materiel system and unnecessary surprises can thus be avoided.

The LCC approach is a precondition for being able to make the right trade-offs between the operational performance of a materiel system and its costs.

The principle of the LSC analysis is illustrated in Figure 14.

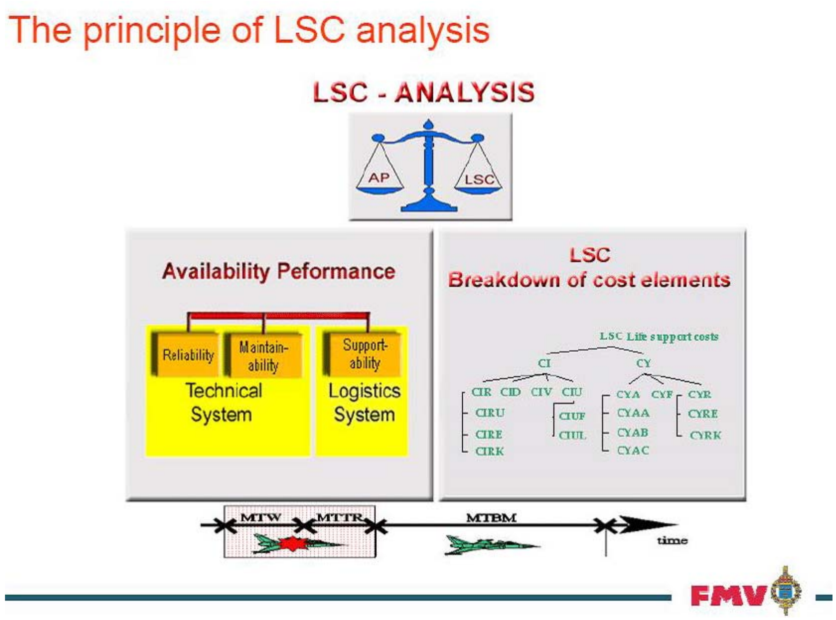


Figure 14: Life Support Cost (LSC) analysis for trade-off between O&M cost and aircraft availability.

All these analyses, or main activities, in the program covers the work required to ensure that the availability performance and maintenance characteristics of the technical system are defined and verified to the best extent possible taking account of the project’s phase of life. The focus is on the technical system as well as on the logistic support system. We mention here some of the analyses which should be performed:

- *Analysis of Incidence of Faults*. This is an analysis of the reliability characteristics of the technical system. The analysis is based on information relating to use (operating and support assumptions) and to the design of the technical system and experience of its use. It covers such activities as:
  - Predictions;
  - Fault modes, effects and criticality analysis (FMECA); and
  - Statistical analysis of operating data, etc.

- *Analysis of Maintenance Actions***. I**nformation relating to the incidence of faults needs to be complemented by the identification and description of the maintenance actions (corrective and preventive) required to be performed on the technical system. Analysis of maintenance actions involves, for example:
    - Maintenance requirement analysis using methods such as Reliability Centered Maintenance;
    - Level of repair analysis (LORA); and
    - Testability analysis.
- *Analysis of Resource Requirements***.** Following on from the maintenance requirements, defined in foregoing activities, the maintenance resource requirements (personnel, equipment, documentation etc) needed for the performance of the maintenance actions are then identified.
- *Verification of the Reliability Performance***.** Verification involves comparing the availability performance data obtained by analysis of the technical system with the requirements specified. Verification can be carried out either theoretically, by comparing analysis data with requirements, or by means of practical tests and demonstrations, e.g. by subsequent follow-up of operating experience or by accelerated life testing.

The main product of the APP consists of defining a logistics support system which in an optimum way meets the system requirements with the given availability performance for the material system. The logistics system is both outlined in a support system concept which describes briefly, how system support will be approached, and detailed in the final documentation. This contains information as to how logistic support is to be organised and what resources will be required.

Figure 15 shows a part of the iterative process involving the optimization and acquisition of the maintenance resources and is trying to illustrate the connection between different studies. The point is that the planned maintenance concept shall be realized through an optimized acquisition of resources.

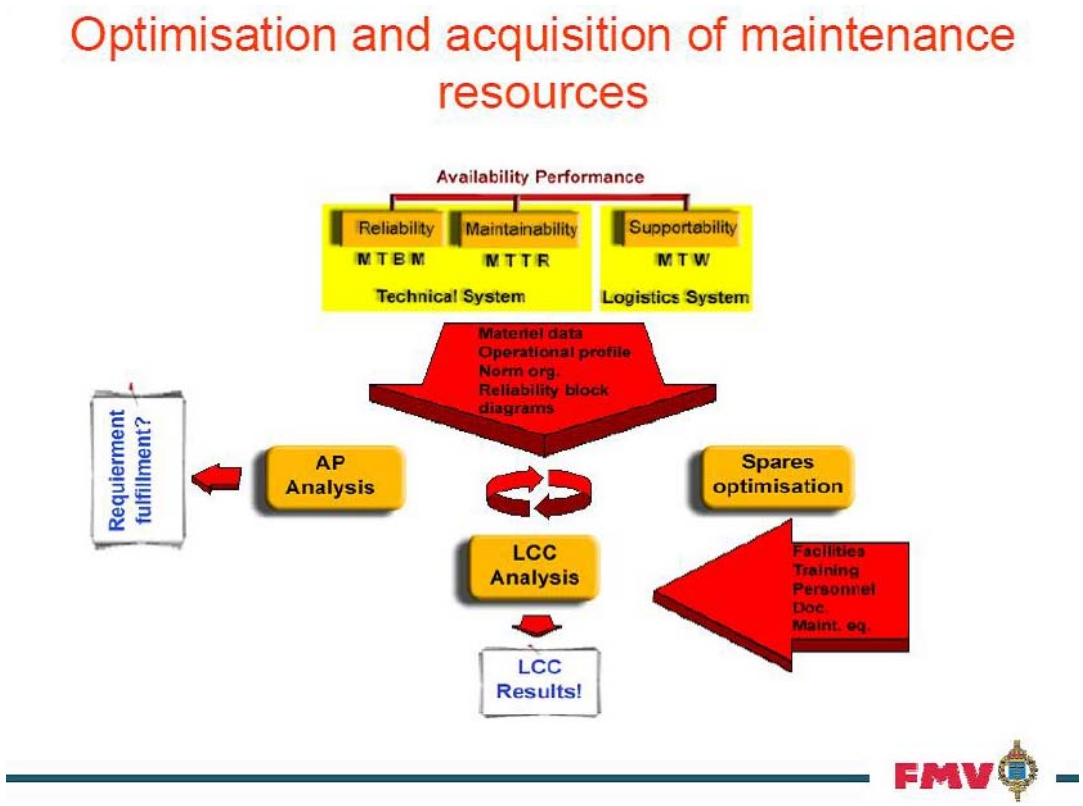


Figure 15: Part of the iterative process involving the optimization and acquisition of maintenance resources.

Tender evaluation of availability performance and maintenance (Figure 16) is also a part of the LCM process intimately connected with APP (se next figure). The activity gives you the opportunity to perform both a qualitative evaluation and quantitative evaluation of the contractors. And this is done by reviewing the tenders regarding data and completeness, evaluating the project risk, LCC and fulfillment of the requirements and not in the least how well does the offered solution fit into our existing infrastructure.

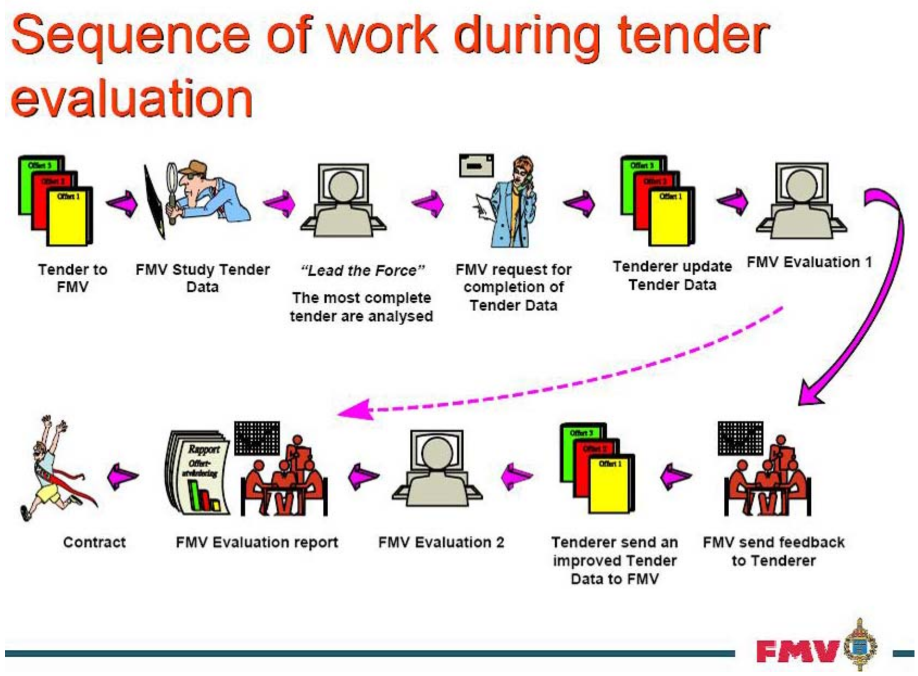


Figure 16: Sequence of work during tender evaluation.

4.0 SOME EXAMPLES

4.1 The Jas 39 Gripen

When the first studies to replace the old airplane system, Viggen, once upon a time in the 70's, the Swedish government demanded that the trend that showed increased costs with every new airplane generation should be broken. The new aircraft system should be developed towards a much lower LCC despite the new and much more sophisticated technology involved.

Bearing this in mind, FMV started the studies to find the solution for the new operational performances required with a very restricted budget. Pretty soon everybody understood that without a very accurate and careful execution of the availability performance program the assignment was almost impossible to achieve.

Jas 39 (Figure 17) is one of the most successful LCC projects with reference to design to budget and the availability performance program in the FMV's history. And the trend was broken as Figure 18 shows.

Figure 17: Jas 39 Gripen aircraft.

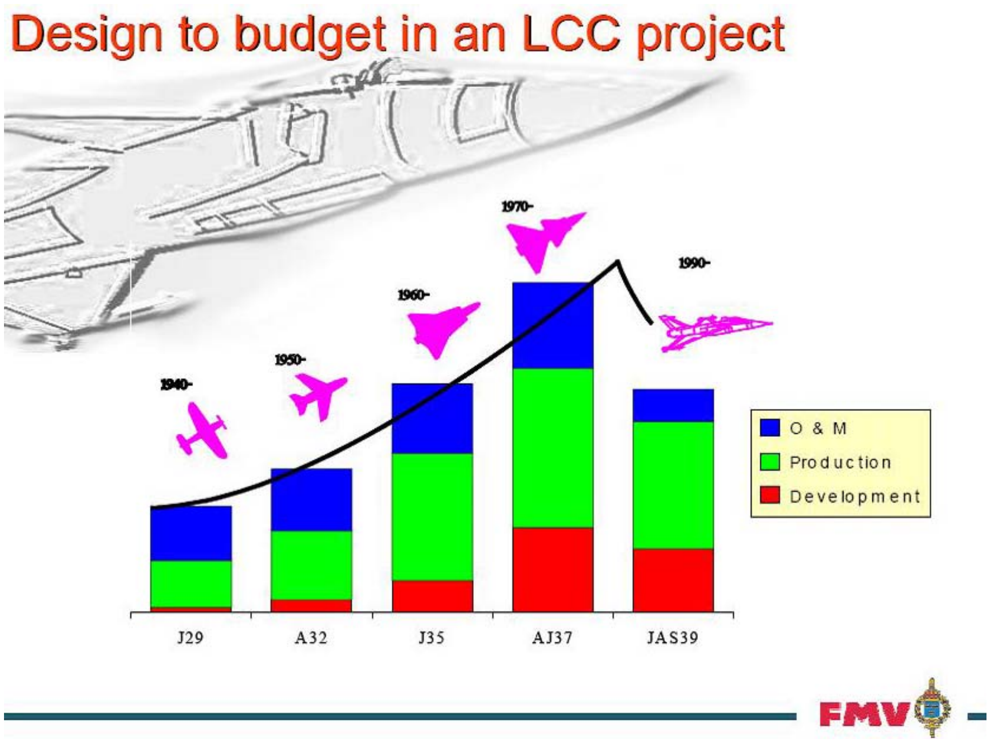


Figure 18: Trends in Swedish fighter aircraft development, production and O&M costs.

Analyses and studies made at the beginning of the project gave a prerequisite picture which included both availability and capability requirements. These requirements were described in a" System Development Plan" which became in facts the Swedish Air force order to FMV.

Some of the parts of the System development plan, stipulating even which analyses to be made are outlined below:

- References to contractual requirements.
- A norm organization and other prerequisites regarding operations and maintenance.
- Formulae and rules for calculations requirements (e.g. the LCC-model).
- The contractual status of all input parameters.
- Definitions.
- Requirements breakdown.
- Predictions.
- Maintenance needs studies.
- Maintenance task analyses.
- LORA.
- Repair/discard analyses.
- LSC analyses.
- System analyses.
- Development of a maintenance plan.
- Recommendations of spares, ground support equipment, packing, training, etc.

In other words the whole Availability Performance Program. It was actually the first time when the program was executed entirely, every bit of it.

Most of the availability requirements turned into critical constraints for the way in which the logistics system was accomplished. That because the Air force requirements referred mainly to the mission production during military readiness period of the system and the operation profile through this period is much tougher than the peace time period. Consequently the maintenance work – flow is larger.

These requirements could be express as follows:

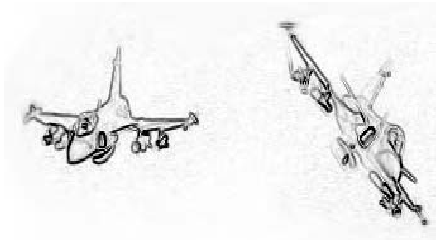
> *"A squadron JAS39 with X a/c shall be able to produce Y missions of Z ordered with a probability of P%."*

This requirement is of course specified more in detail regarding definitions of what is meant with a mission, a squadron and some additional prerequisites. But it was in facts the requirements on the mission production which formed the foundation of FMV's tender documents to the contractors.

The availability requirements breakdown was made in such a way that gave the contractor the opportunity to weigh himself between different requirements and in the end to choose the most profitable solution.

In other words the requirements was formulated such as the most cost-effective solution for the Air force will be the most profitable for the contractor.

The contractual requirements included:



- Total failure rate (failures/fh) – reliability.
- Mission success probability – reliability too but intended to steer the number of critical failures.
- Downtime (h/fh) – this requierment is a combination of reliability and maintainability aimed to influence the design of the technical system towards a planned mission production during war time.
- Maintenance work load (mh/fh) – aimed to control the labour costs during peace time.
- Turn-around times.
- LSC – designed as an incentive (bonus/fine) for the contractor to develop a system with low support costs during its life lengh. This kind of requirement should be carefully formulated - you have to consider the consequences.

The contract incorporated even some warranties:

- Design guarantee.
- Production guarantee.
- Special guarantee on the control system.
- User cost guarantee during the initial period of operation (500 fh per a/c).
- *Options:*
  - Maintenance cost at central workshop.
  - Turn around times at the central workshop.

And also some requirements regarding the verification which included:

- Mainly a theoretical verification;
- Some practical demonstrations;
- 3000 first flight hours; and
- Discrepancies to be fixed in mod-line at no extra cost for FMV.

As a result of the efforts involved in all the analyses made during the fulfilment of the Availability Performance Program the LSC was drastically reduced, if an evaluation is made with the previous airplanes in the Swedish air force, as shown in (Figure 19 and Figure 20).

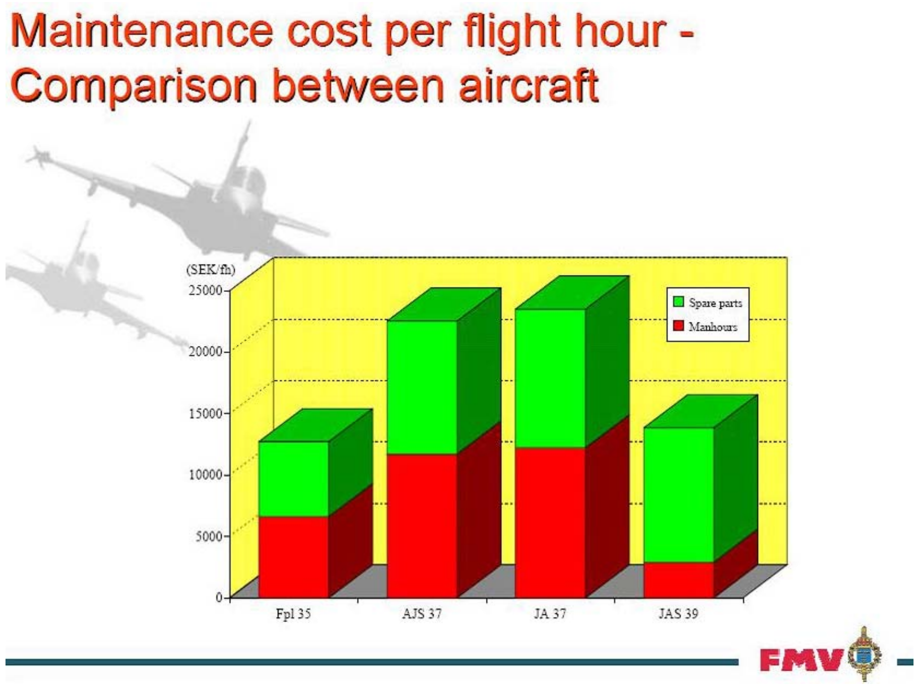


Figure 19: Trend in maintenance cost (kronor) per flight hour in Swedish fighter aircraft.

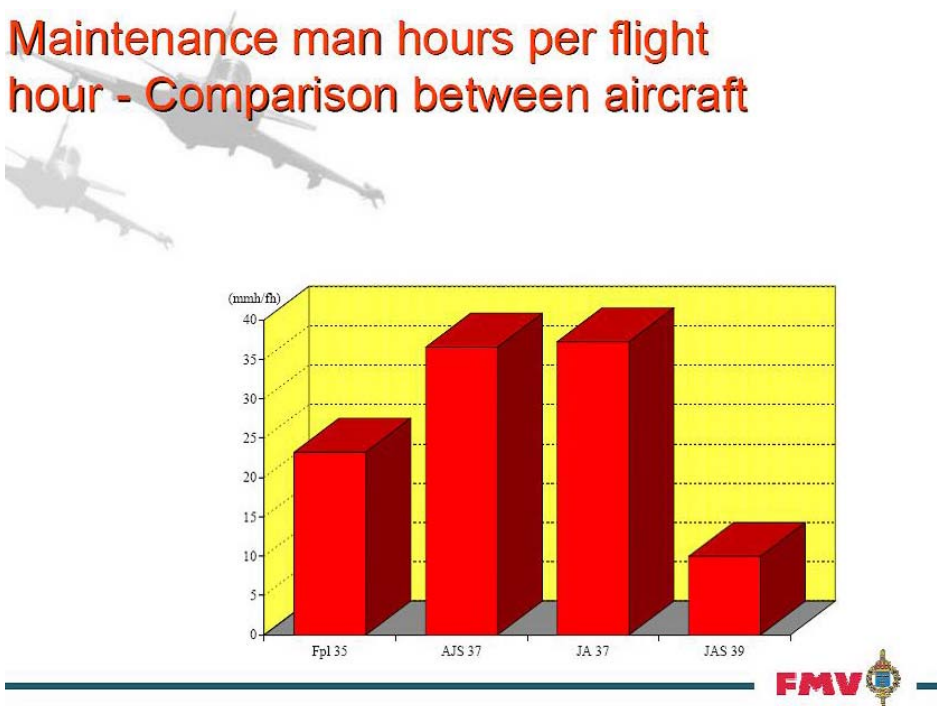


Figure 20: Trend in maintenance manhours per flight hour in Swedish fighter aircraft.

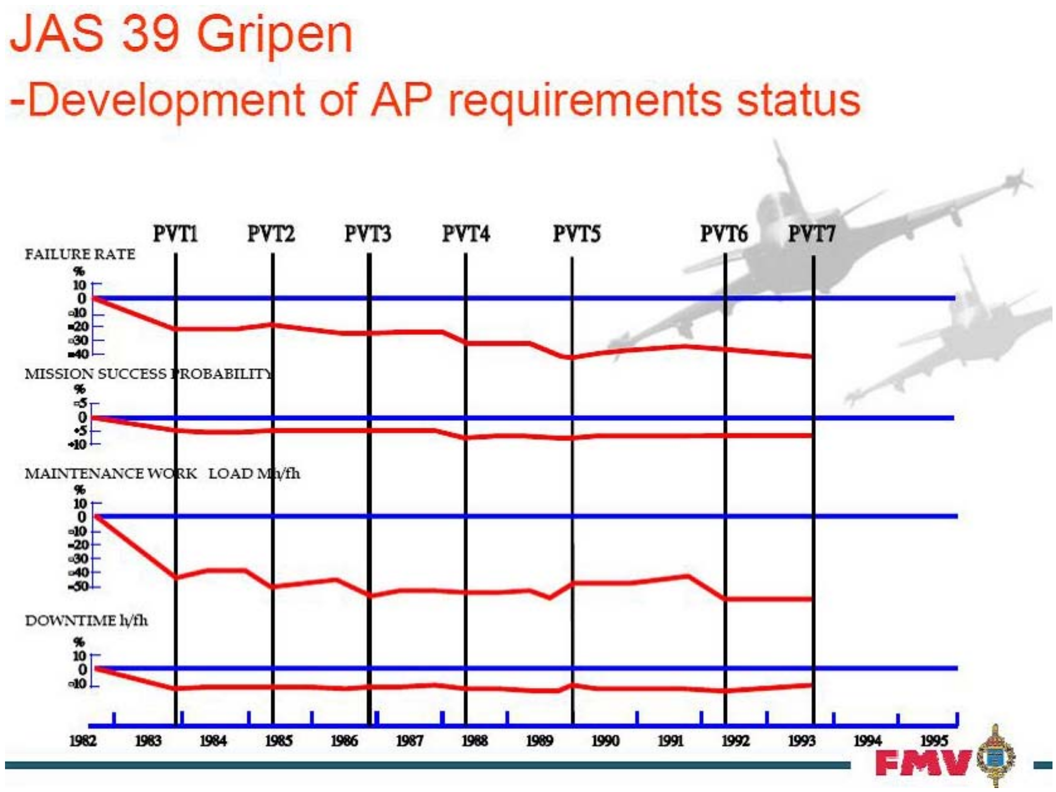


Figure 21: History of achievement/shortfall in key reliability, availability, and mission success metrics on the Jas 39 Gripen program compared to aircraft specification.

The project has during the development years reported directly to the Swedish government the results of the contractual agreed business meetings with the industry (PVT – Project evaluations meetings). These meetings were aimed to verify and evaluate the availability requirements and if necessary to modify the design in order to fulfil the requirements. These meetings continue even today, only the name is changed, SVT – system evaluation meetings. The project's remaining risks was also debated. The figure also shows that some of the requirements were more difficult to accomplish, because the interaction between requirements.

The same evaluation was made for the marginal value of the support costs. As we see in Figure 22, the costs are almost 15 % under the contracted value at PVT6, 1992, which entitled the industry to a substantial bonus.

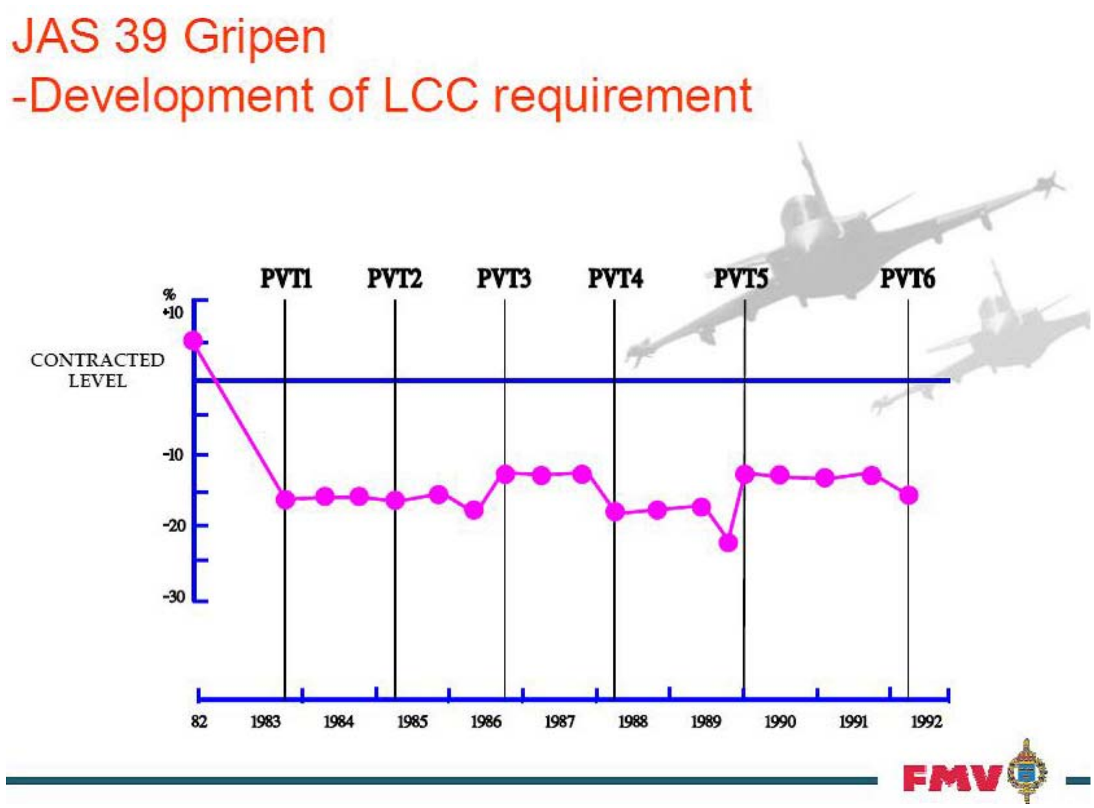


Figure 22: Ongoing estimates of Life Support Cost (LSC) compared with the contracted level.

4.2 Nordic Standard Helicopter Program (NSHP)

In 1999 the Armed Forces of Denmark, Finland, Norway and Sweden decided to purchase a multipurpose medium-heavy helicopter, capable of being furnished for different missions required by the Nordic countries. The concept covered a National Core Helicopters based on one Common Nordic Standard Helicopter. The Nordic countries involved have agreed upon that the procurement process up until contract award will be done in accordance with Swedish laws and regulations. According to the Program Agreement, Försvarets Materielverk (FMV), Sweden, was the Executive Agency for the NSHP.

From a Swedish point of view the procurement effort started because the Swedish Defence searched for a common solution to replace the old Swedish Hp 3 used by the Air Force and Hp 4 used by the Navy.

At that time the other Nordic countries was also searching for similar systems, which led to the idea of a common Nordic procurement in order to strive for advantages concerning procurement, maintenance, education, interoperability and cooperation.

The concept implicated also the fact that most of the helicopters should operate from land, but some of them should operate from ships too, with additional requirements. This generated different versions, but in order to achieve the over all objectives, the helicopters still should have a high degree of commonality.

Figure 23 shows the different systems which were subject to the procurement studies.

Figure 23: Candidate aircraft for the Nordic Standard Helicopter Program (NSHP).

The multi-national Nordic Standard Helicopter Programme is an example of how the life cycle costs can support the tender evaluation process.

This example is focusing on the acquisition phase of the LCM process again, and again it shows the importance of the LCC in the APP. It may be a little bit monotonous but this case is different and it shows that there is no universal solution for how you put the LCM process into practice.

Figure 24 shows the different types of helicopter the project planned to procure. It was declared that FMV´s experiences and competence concerning LCC-evaluations should contribute to the NSHP -project. Each nation had different Flight hour usage and Helicopter basing, which made the LCC -evaluation procedure complex. The acronyms used in the figure are as follows:

- TTT (Tactical Troop Transport).
- OTT (Operational Troop Transport).
- SAR (Search And Rescue).
- CSAR (Combat Search And Rescue).
- ASW (Anti Submarine Warfare).
- MEDEVAC (MEDical EVACuation).
- CG (Coast Guard= Norway).
- National Fixed (National variant).
- National CP (Complete Provision, national variant).

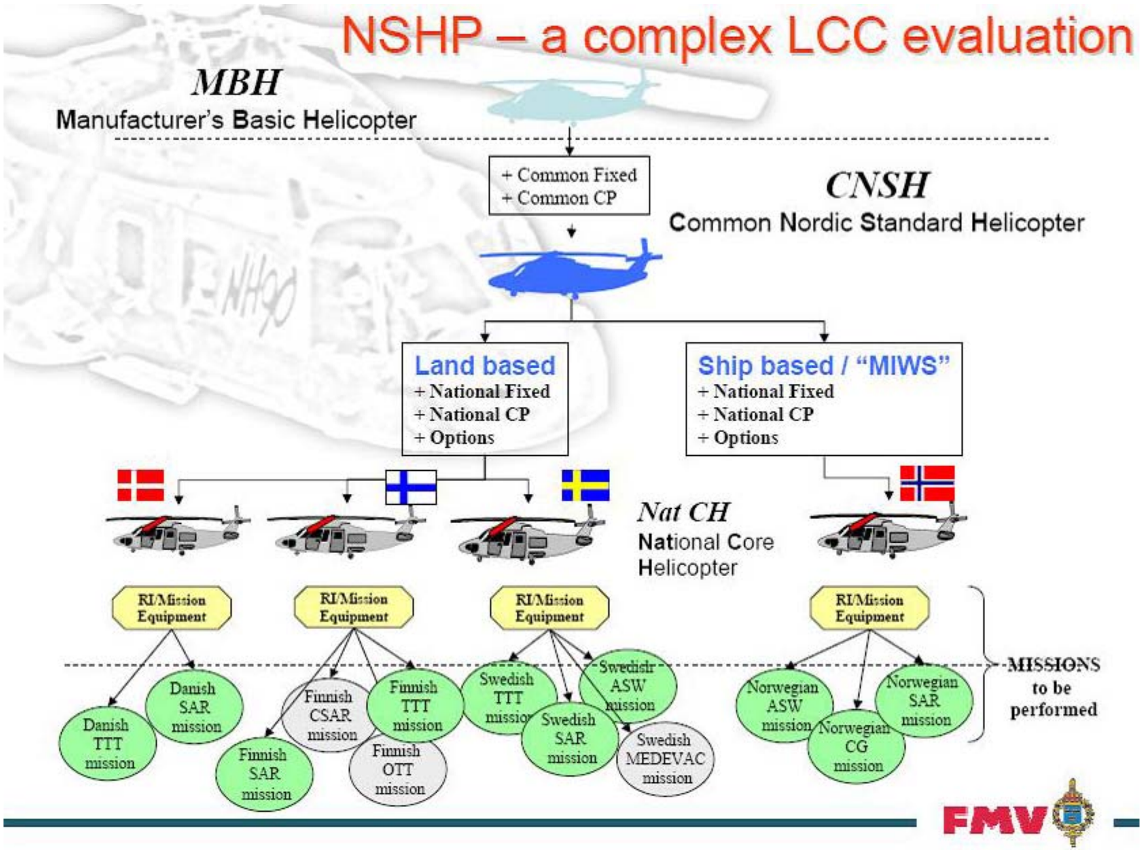


Figure 24: Proposed variants of the Nordic Standard Helicopter.

All the participating nations' requirements were implemented in a common Nordic Requirements Document. This document defined those requirements that were considered common and those which were specific to a particular nation. The request for quotation stipulated prospective contractors to provide detailed data to enable the evaluation of performance and reliability. In addition, this information would be used to estimate the life cycle cost. The evaluation of system availability and life cycle cost were performed for each participating nation's individual life cycle cost model.

A summary of user data and tender data that was included in each nation's life cycle cost model is shown in Figure 25. The figure also shows how the calculated estimates for cost of spare parts were used as input to the model. All the nations' specific life cycle cost models were then combined in a total life cycle cost model, representing a combined life cycle cost for all the participating nations.

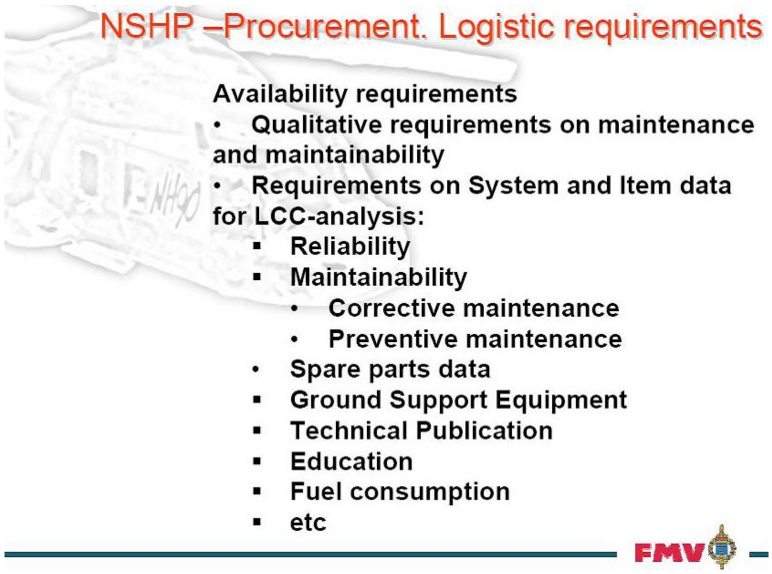


Figure 25: Summary of user and tender data included in each nation's life cycle cost model.

LSC analysis defined in this way aimed to:

- Identify cost-driving characteristics such as critical items and actions to improve LSC; and
- Evaluate alternative design solutions.

The LSC analysis produced a basis for trade-off between different alternatives referring to the technical system; logistics support resources and maintenance organisation levels. LSC and availability performance characteristics had been calculated and evaluated against stated system requirements and undertakings. It was the supplier's responsibility to identify cost-driving characteristics of both the NSHP System and the logistics support system and to derive actions to minimise LSC.

Analysis to identify and document the need of logistics support resources to operate the NSHP in accordance with stated requirements as well as analysis of the need of maintenance and associated resources in combination with the results of the Availability Performance and Life Support Cost (LSC) analyses was performed by both the suppliers and FMV. These analyses gave a cost-effective recommendation for the Maintenance Plan and for dimensioning of the support system.

The suppliers also needed to perform Reliability-Centred Maintenance (RCM) analyses in order to identify and document the preventive maintenance task requirements. The need for preventive maintenance was correlated to the reliability performance of the system.

The Supplier analysed the configuration of the technical system for identification and classification of its spares, which were classified in LRU, DU, SRU and DP respectively.

The Supplier analysed also the cost-effectiveness of the recommended repair/discard decision on LRUs and SRUs. The following had to be considered:

- Number of failures expected during the life cycle and need for preventive maintenance.
- Cost of repair (manpower and discardable parts).

- Cost of investment in support system (spares, test equipment, instruments, tools, training, documentation, etc.).
- Utilisation of common used support resources.
- Acquisition cost of each LRU and SRU.

A basic thing in FMV's way of doing LCC-evaluation is to make your own LCC-calculations based on the data given by the Tender. Figure 26 shows how this data was assorted in the LCC-model called LISA. LISA was used manage the amount of different LCC-calculations caused by the different Tenders and countries involved. Concerning optimization of Spares, FMV/NSHP used the OPUS-model. As indicated in the figure, the "availability requirement" is expressed as "Maximum Waiting Time" which was one important criterion in the LCC-evaluation.

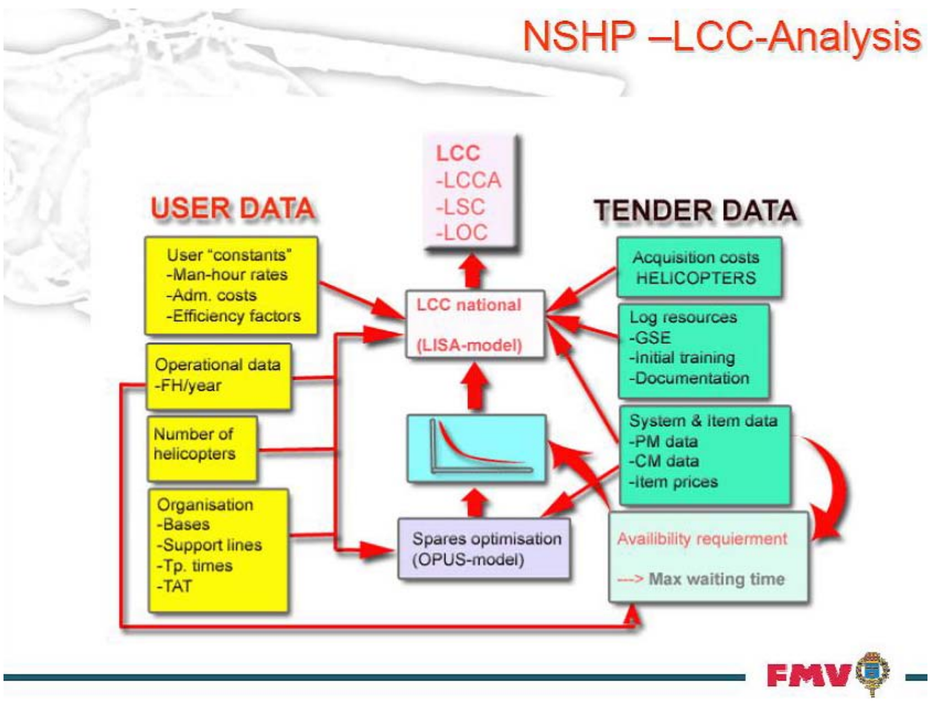


Figure 26: Schematic of the life-cycle cost (LCC) model for the Nordic Standard Helicopter Program (NSHP). Aircraft availability, expressed as the maximum allowable waiting time, is an important input to the model.

The requirement for spares was calculated, by the agency, using a logistics and spares optimisation model, based on the individual nation's operational profile. The criterion for the cost modelling was based on the MWT (Mean Waiting Time) for spare parts together with the unavailable time due to preventive and corrective maintenance. The system availability requirement was given as 80% (see Figure 27). By using this approach all the tenders were normalised and compared using the same performance level. The calculated costs for spare parts were used as an input to the life cycle cost evaluation.

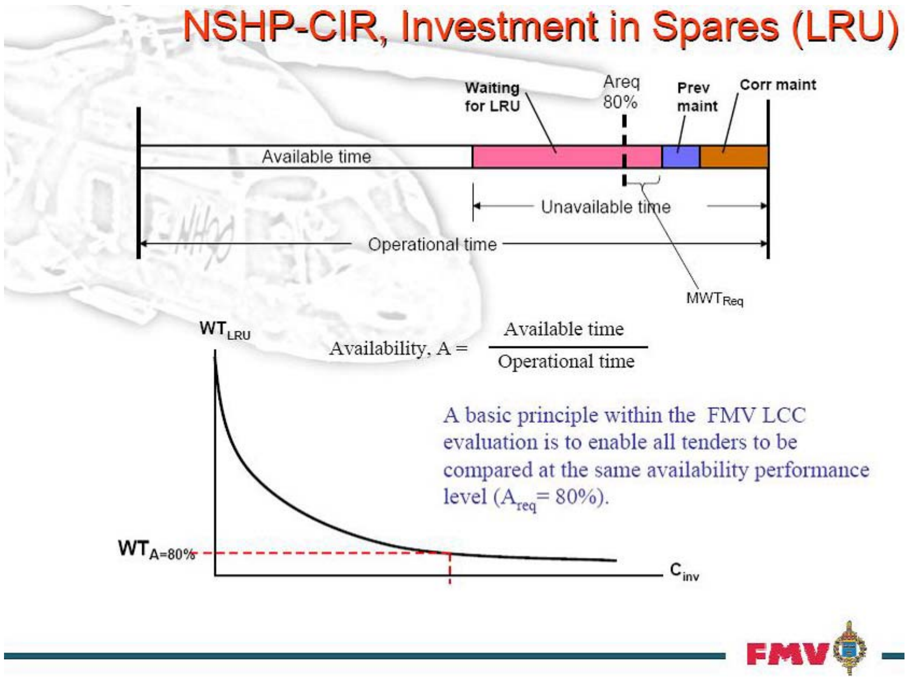
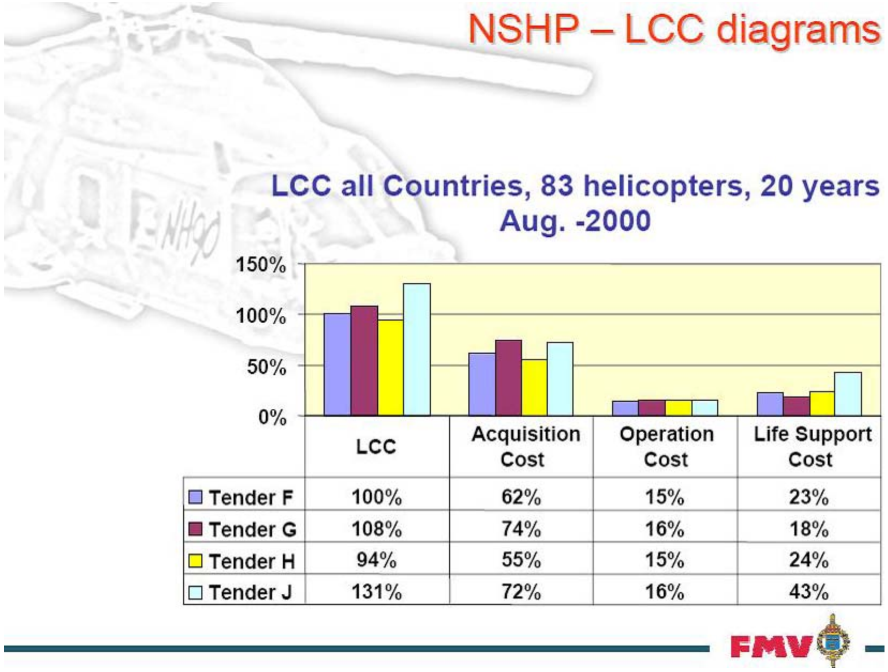


Figure 27: For evaluating tenders for spare parts, the life-cycle cost of the aircraft was estimated for an aircraft availability of 80%.

This means that a tender with a lower technical availability in comparison with other tenders would have to "pay" the difference by adding a higher cost for spares to the LCC. This will lead to different MWTreq for different tenders, during the evaluation. Since size of the areas in the picture will look different for different Tenders, also the MWTreq will be different.

Some of the results from the life cycle cost tender evaluation are presented in Figure 28. The figure shows the sum of all the participating nations' life cycle costs per tender. The cost for total life cycle cost, acquisition, operation and life support have been normalised to Contractor F to provide a relative comparison.



	LCC	Acquisition Cost	Operation Cost	Life Support Cost
Tender F	100%	62%	15%	23%
Tender G	108%	74%	16%	18%
Tender H	94%	55%	15%	24%
Tender J	131%	72%	16%	43%

Figure 28: Comparison of estimated life-cycle costs for four of the NSHP tenders.

The life cycle cost tender evaluation process generated many different diagrams that presented different aspects and the cost drivers for each tender.

When analysing the life support costs in more detail it became clear that the investment in spare parts differed significantly between the tenders. The difference was explained by the different maintenance concepts offered by each contractor. The analysis showed that Contractor H had the lowest costs; however Contractor F was selected as the winning tender due to other considerations. The life cycle cost analysis results were used as a baseline for negotiating the contract. In addition, the life cycle cost analysis was also used to establish a support cost baseline prior to negotiating a contractor logistic support contract.

The results from LCC (LSC)-evaluation did in practice not separate the choice for those helicopters that Sweden took interest in. Sweden bought 18 NH-90 helicopters with an option on another 7 aircraft. The Contractor is not bound up to any LCC (LSC)-commitment such as bonus/fines for example. However, the contractor is committed to warranties concerning certain requirements on failure rates, MTTR, man-hour/flight-hour and on requirements on corrective and preventive maintenance on aircraft-level. The failure rates will be verified but the verification will be made only on those LRUs that are common for Sweden and Norway.

No" feed-back meetings", involving any attempt to make the contractors to do modifications to lower the helicopters failure rates etc, took place. However the project did have more than one meeting per Contractor in order to get enough accurate and complete data to make complete and comparable LCC-calculations.

After the NSHP project declared that it had no further need of LCC-evaluations, Sweden in a later stage, continued to do LCC- evaluations. These evaluations were caused by planned changes in the amount of procured helicopters and updated logistics data from the contractor.

The calculations had a meaning to supervise that the LCC-results contractors were consistent. The results as said did not affect the choice of the supplier.

Although that the LCC-results did not point out any helicopter in particular, it is an advantage to know that LCC is pretty similar and independent of what choice you do.

As a consequence of that the NSHP-project accomplished a LCC-evaluation, made it possible to create a High Cost Item Ranking list with 4 relevant criteria:

- Availability (actually the technical availability).
- Investment costs for LRUs and spare parts.
- Cost of LRU-repair and/or cost for consumption of spare parts.
- Purchase price/LRU.

When the evaluation process was finished and the NSHP-project had chosen a supplier, negotiations started to compel him to do such a list based on the above criteria. An examination embracing the top 20 – 30 % (70 – 80 LRUs) was made for each criterion and as a result a specific warranty for the failure rates of these items was established.