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AMPLIFICATION OF THE BENEFITS OF A RELIABLE AND MAINTAINABLE DESIGN BY ADEQUATE MAINTENANCE AND SUPPORT CONCEPTS

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0. Scope

A reliable and maintainable design has obvious benefits with respect to Life Cycle Cost. However, in order to make full use of these design features, adequate alternative maintenance & support concepts - which are only viable in case of excellent Reliability and Maintainability of the Weapon System - must be considered.

The traditional 4-level maintenance concept does not satisfy the requirement for low Life Cycle Cost if a Weapon System featuring a reliable and maintainable design is to be supported. This requirement is fulfilled if the more advanced 2-level maintenance concept which is characterised by the limitation of base level maintenance to on A/C tasks and transfer of the remaining activities to a single source supplier, i.e. industry.

In order to make the 2-level maintenance concept a viable solution, aircraft availability and Airforce self-sufficiency need special attention but can be ensured via an adequate support concept and integration of military personnel in industry maintenance.

The 2-level maintenance concept was analysed for the Eurofighter/Typhoon to be operated by the German Airforce. A thorough comparison with traditional maintenance concepts revealed that the 2-level maintenance concept is much more cost-effective, therefore this advanced concept is now applied by the German Airforce.

1. Reduction Of Life Cycle Cost

1.1 Ways For Reduction Of Life Cycle Cost

In the last decades tremendous effort has been spent in reducing the Life Cycle Cost of Weapon Systems. Considering the increasing complexity of the Weapon Systems the Life Cycle Cost were reduced dramatically by improved design. A number of different areas contributed to these reductions, however, they all can be allocated to one of the following groups:

- Design improvements affecting the production investment, e.g. design allowing more simple tooling
- Design improvements affecting production, e.g. design for easier assembly
- Design improvements affecting operation, e.g. engines consuming less fuel
- Design improvements affecting support, e.g. design for better reliability and maintainability

Naturally the above areas, as well as the design and development process itself, contribute to the Life Cycle Cost - and their reduction - through their inherent features.

Examples of the improvements of the processes are:

- Design and Development: use of Computer Aided Design (CAD)
- Production Investment: use of tooling allowing rapid change of the item to be produced
- Production: pre-assembly of groups prior to installation
- Operation: optimised planning of inspection intervals
- Support: use of optimised maintenance and support concepts

However, the highest reductions in Life Cycle Cost can be achieved if the design issues and the processes are not looked at in isolation. An integrated approach is used today to ensure that possible improvements e.g. in the production are supported by an adequate design.

With respect to the support of a Weapon System, the first step towards low Life Cycle Cost is a design featuring good Reliability and Maintainability. For the Eurofighter/Typhoon Weapon System this lead to the requirement that equal priority was given to

- Performance,
- Cost,
- Reliability, Maintainability and Testability (RM&T)

of the aircraft.

1.2 The Role Of Integrated Logistic Support In The Optimisation Of Life Cycle Cost

The overall aim of Integrated Logistic Support (ILS) is the cost-effective support of a Weapon System through integration of design and logistic disciplines. In order to achieve this, ILS ensures on the one hand, that the requirements leading to cost effective operation and support are considered in the design phase. This is achieved in particular by monitoring and controlling the Reliability and Maintainability features of the design.

On the other hand, ILS develops the optimised maintenance and support concepts and associated products, e.g. technical publications, for the resulting design and ensures their timely availability.

The following considerations have been made based on the ILS principle, thus ensuring the integration of design and support which ultimately leads to an overall reduction in Life Cycle Cost.

2. Improved Reliability and Maintainability

2.1 Improvements Achieved In Reliability And Maintainability And Their Limited Direct Positive Effect On Life Cycle Cost

When considering the Life Cycle Cost of a Weapon System, Reliability and Maintainability are of paramount importance because these features are determined very early in the design process. In order to allow an early assessment of these features, convincing characteristics for Reliability and Maintainability are taken into consideration.

Reliability is normally expressed by the Mean Time Between Failures (MTBF) while a good measure for Maintainability is the Mean Time To Repair (MTTR). Since the MTTR is measured in elapsed time, it provides a good measure for the availability of a Weapon System. However, when considering the cost of operation and support, the Maintenance Manhours (MMH) per flying hour for scheduled and unscheduled maintenance are of greater importance.

These features have been improved a lot in the recent. As an example, the Reliability and Maintainability characteristics of various aircraft over the last decades are shown in Table 1 below.

	First Flight	MTBF	MMH/FH
Aircraft 1	1958	0,6	57
Aircraft 2	1974	0,7	53
Aircraft 3	1977	1,2	55
Aircraft 3	1994	1,5	24

Table 1: Improvement of Reliability and Maintainability in the recent years

These improvements in Reliability and Maintainability result in decrease of effort required for the maintenance of the aircraft. Unfortunately, when considering the Life Cycle Cost of an aircraft, only a relative small portion is directly influenced by Reliability and Maintainability. An overview of the composition of the cost of operation and support for a traditional 4-level maintenance concept is provided in Table 2. The table also shows to what extent the individual cost elements are directly influenced by Reliability and Maintainability.

	Percentage of O&S Cost	Percentage influenced by R&M	Combined Percentage
Initial Investment	13 %	25 %	3 %
Operation	24 %	5 %	1 %
Military Support	42 %	70 %	29 %
Industry Support	4 %	100 %	4 %
In-Service Modifications	17 %	0 %	0 %
Total	100 %		37 %

Table 2: Distribution of Operation and Support Cost for a traditional 4-level maintenance concept and how they can be influenced by Reliability and Maintainability

Table 2 suggest that the influence of Reliability and Maintainability on the cost of operation and support is limited to only 37%. It can be seen that most cost contributors are not directly linked to the Reliability and Maintainability performance of the Weapon System, e.g. the cost for operation and modification are in principle not affected and also the cost for initial investment are only influence by 25%, mainly through a reduced number of spares. With respect to operation and modifications it is obvious that they are not influenced by Reliability and Maintainability, the reason for the limited influence on initial investment is due to the fact that the majority of investment is related to the maintenance concept, e.g. the facilities, support equipment, technical publications and training.

However, the maintenance concept is also driven by the Reliability and Maintainability performance of the Weapon System. Therefore, improvement in the Reliability and Maintainability features of a Weapon System offers further potential for reducing the Life Cycle Cost.

2.2 Further Potential For Reduction Of Life Cycle Cost Based On Improved Reliability and Maintainability

Excellent Reliability and Maintainability features of a Weapon System are a prerequisite for low Life Cycle Cost. The positive effects and their limitations with respect to Life Cycle Cost reduction have been explained before. The following concentrates on the further possibilities of LCC reduction.

It needs to be pointed out that the potential of further reduction of Life Cycle Cost is extremely subject to a very reliable and maintainable design. The further potential for Life Cycle Cost reduction lies in the development of maintenance and support concepts which take full advantage of these design features.

Traditional maintenance and support concepts are optimised to ensure maximum availability of the Weapon System based on a high effort for scheduled and unscheduled maintenance. In order to satisfy this high demand of maintenance, the traditional maintenance concepts employ large resources which are expensive in acquisition as well as in operation and maintenance.

Since newly developed Weapon Systems do not require – through improved Reliability and Maintainability – as much maintenance, the amount of resources can be reduced. However, a simple reduction does not meet the requirements of the complex environment a Weapon System is operated in. Mainly the target of a high availability is contradicting the simple reduction in resources. Therefore, new concepts, e.g., the 2-level maintenance concept needed to be developed in order to ensure high availability and reduced cost.

3. The Traditional 4-Level Maintenance Concept

The maintenance concepts to be used for a particular aircraft need to serve several aspects. The most important are:

- cost-effective operation & support
- aircraft availability
- adequate self-sufficiency of the Airforce

In the past these criteria have been fulfilled by the traditional 4-Level Maintenance Concept described in the following.

3.1 General Layout Of The 4-Level Maintenance Concept

The 4-level maintenance concept relies mainly on the capabilities of the Airforces which performs the following levels of maintenance:

- Organisational Level (O-Level)
- Intermediate Level (I-Level)
- Depot Level (D-Level)

The 4th level of maintenance is performed at industry. Sometimes this 4th level is not counted individually. In these cases, the D-Level and industry are considered one level implying a 3-level maintenance concept.

Although the levels of maintenance are tailored to the individual needs of the Airforce and Weapon System in general the following tasks and locations are associated with the respective level:

O-Level

This level of maintenance is performed on aircraft at the flight-line. It includes mainly servicing of the aircraft and maintenance by exchange of Line Replaceable Units (LRIs)

I-Level

This level of maintenance is performed at the shop located at the base. In general, the defective LRIs are restored by exchange of Shop Replaceable Units (SRIs) and minor

scheduled inspections as well as minor repairs of the structure are performed here.

D-Level

This level is performed at a central depot operated by the Airforce. Depending on the skills and capacity available at the depot, repair of SRIs, major (depot) inspections and major repair of the structure are performed here.

Industry

At industry the repair of SRI beyond the skills and/or capacity at the military operated depot is performed. Furthermore, the following large-scale tasks are performed:

- overhaul of equipments
- major repair of the structure
- major (depot) inspections
- modification of equipments
- modification of structure

A generic overview of the 4-level maintenance concept is provided in Figure 3.

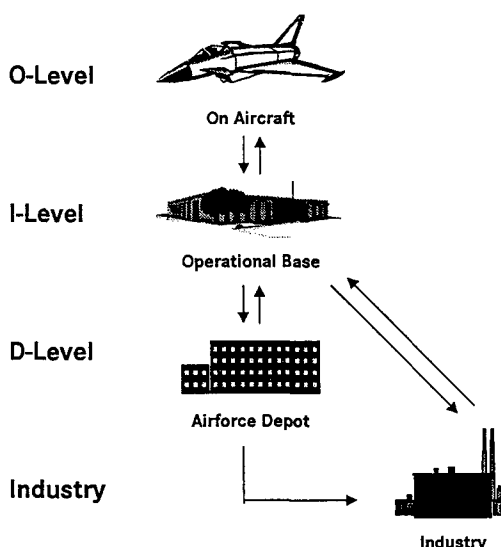


Figure 3: Generic overview of the 4-level maintenance concept

3.2 Main Advantages And Disadvantages Of The 4-Level Maintenance Concept

As already mentioned, the tasks performed at the individual levels may vary for certain applications, however, the principle of de-centralisation of O- and I-Level and sharing of tasks between the military operated D-Level and industry remains.

These two features are also the key areas for the advantages and disadvantages of the 4-level maintenance concept:

On the one hand, the de-centralisation of O- and I-Level allows a fast response to defects by repair of the defective LRI at the base ensuring a high availability of the Weapon System for a given number of LRI spares. On the other hand the resources required for repair, e.g. test equipment, must be available at every base.

With respect to the sharing of tasks, the advantages are the flexibility of the system by using industry resources in case the capacity at the military facilities is exceeded and the build up of knowledge at military facilities ensuring self-sufficiency of the Airforce in times of crises. Again the disadvantage is the duplication of resources at military and industry facilities.

Obviously, the disadvantages of the 4-level maintenance concept are mainly the high number of resources required resulting in high Life Cycle Cost associated with the acquisition and operation/maintenance of these resources.

With the increasing pressure to reduce Life Cycle Cost investigations for more cost-effective maintenance concepts were initiated. At this point in time it came in handy that the requirement for low Life Cycle Cost has already had a very positive influence on the Reliability and Maintainability of the newly developed Weapon Systems. These improved features opened the possibility for a more advanced maintenance concept.

4. Cost-Effective Support For Modern Weapon Systems: The 2-Level Maintenance Concept

With the increasing pressure on military budgets, the requirement for cost effective support is of utmost importance. However, the other important factors aircraft availability and self-sufficiency of the Airforce need also to be considered. Therefore, a maintenance concept needed to be developed which considered all these aspects. Since the main disadvantage of the traditional 4-level maintenance concept are the high Life Cycle Cost, this aspect was addressed first.

4.1 Centralisation Of Maintenance Due To Improved Reliability And Maintainability

The 4-level maintenance concept features widely spread logistic resources at the de-centralised base level maintenance facilities (O-Level and I-Level). This is necessary because of the high effort for scheduled and unscheduled maintenance required to operate and maintain the Weapon Systems to be supported. Under these circumstances it is cost effective to have all logistic resources available close to the place where the Weapon System is operated because their utilisation at these de-centralised facilities is ensured.

Because of the dramatic improvement of Reliability and Maintainability, the latest generation of aircraft do not create enough maintenance to ensure a constant utilisation of the logistic resources at the de-centralised maintenance facilities. Analyses showed that the cost associated with additional spares required to guarantee the same operational availability compared to the traditional 4-level maintenance concept are less than the additional Life Cycle Cost of logistic resources at decentralised facilities.

4.2 Maintenance At Single Source Supplier

Next to the de-centralised maintenance, the availability of full depth maintenance at the military facilities is the most outstanding peculiarity of the 4-level maintenance concept. The reason for maintaining the capability for the performance of major inspections and full depth repair at the military depot was the requirement of self-sufficiency of the Airforce.

However, the budgetary restrictions and other factors put this requirement on the touchstone. One of these additional factors is the long-term production of current and future Weapon Systems, dictated by restricted budgets. This ensures the availability of production tooling and test equipment over a very long time without additional cost involved if used in parallel for production and repair of airborne equipment and aircraft itself. Therefore, performance of in depth maintenance of equipments and structure of a Weapon System at the manufacturer is more cost effective because the investment in support and test equipment is already funded by the production.

Additional to this obvious effect, two further considerations need to be made. First of all, current Weapon Systems are normally operated by a number of Airforces. Therefore it is much more efficient to return all defective equipments to a single source supplier for repair rather than building up a maintenance facility at each individual Airforce. With the improved Reliability of the equipments this centralisation is even more effective. Additionally, the knowledge gained from the maintenance of equipments and structure can be used by the supplier for modifying the equipments with the target of improved Reliability and Maintainability.

Of course, the idea of performing a significant amount of maintenance at industry contradicts the requirement of self-sufficiency of the Airforce. In order to mitigate this shortfall, ways of involvement of military personnel have been established. One of these ways is the involvement of military personnel in the maintenance of the Weapon System at industry facilities. This so-called co-operative concept is explained in para 6.2.

4.3 Layout Of The 2-Level Maintenance Concept

Based on the above considerations a maintenance concept based on limitation of the tasks performed at the de-centralised facilities at base level and the usage of single source suppliers for maintenance has been generated. This maintenance concept, called the 2-level maintenance concept, features the following levels:

Base-Level

At base level all the tasks necessary for the daily operation of the Weapon System are performed. This includes:

- Flight line servicing
- Stores loading and Role changes
- Rectification of defects by exchange of Line Replaceable Items or major components such as engines and ejection seats
- Software loading on- and off-aircraft
- Aircraft battle damage repair
- Routine daily maintenance actions like wheel/tyre
- Remedy of simple sealing problems and malfunctions for hydraulics, environmental control, oxygen supply, fuel supply and electric systems
- Minor repair of airframe parts.

Industry-Level

All activities beyond on-base maintenance are performed by industry, following the single source repair principle by using the manufacturer's facilities and assets from production. These activities include:

- Periodic aircraft inspections
- Structural repairs

- Engine repair and overhaul by module exchange
- Full depth equipment and engine accessories repair
- Module repair and overhaul including component repair

This procedure eliminates the build-up and the duplication of maintenance facilities. Instead, most of the facilities which in case of the 4-level maintenance concept are required at the de-centralised I-Levels are eliminated. Together with the D-Level maintenance facilities these facilities are now located at industry level. For the equipments this means that full depth repair is performed at a Single Source Supplier. The same applies for the engine, while with respect to the airframe all major repairs and inspections are performed at the manufacturers facilities.

Additional to the higher cost effectiveness of the 2-level maintenance concept it offers the advantage that the Airforce can concentrate on its main task: flying missions. Supporting effort is limited to on-base activities thus providing more flexibility with less personnel resources.

A generic overview of the 2-level maintenance concept is provided in figure 4.

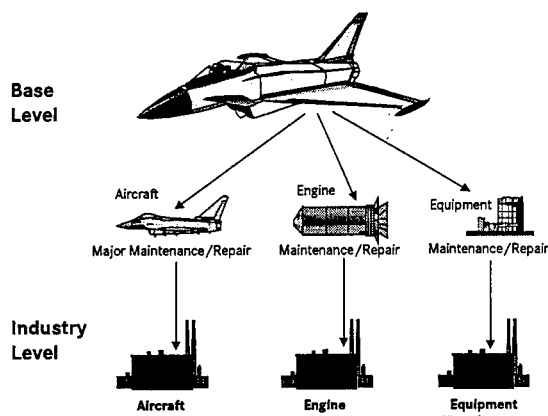


Figure 4: Generic overview of the 2-level maintenance concept

5. Safeguarding Aircraft Availability: The Associated Support Concept

5.1 Drivers Of The Operational Availability

In order to ultimately judge the effectiveness of a maintenance concept, not only the cost of maintenance facilities need to be taken into consideration. An important factor is the operational availability of the Weapon System. This operational availability is to a large extent driven by the maintenance concept and the associated support concept.

When considering aircraft availability it is necessary to know what factors are driving the operational availability. These are in general the frequency and duration of maintenance. While the frequency of maintenance is mainly driven by the design-feature "Reliability", the duration is driven by the design-feature "Maintainability" and the logistic system in which the aircraft is operated in.

5.2 Requirements For The Logistic System

In order to achieve a high operational availability, the logistic system must feature fast repair response times. Given a certain number of spares, these response times have been kept low in the 4-level maintenance concept via the de-centralised maintenance which is characterised by short waiting times for repaired items. In case of the 2-level maintenance concept, the centralisation has an adverse effect on the operational availability of the Weapon System. However, this problem can be solved by a very responsive transportation process and fast repair of the defective item at the Single Source Supplier.

In order to establish this responsive support environment, the following criteria must be met:

- progressive control of the movement of spares
- avoidance of intermediate storage times of spares
- fast transport of the LRJs to and from the repair facility
- short repair turn around times at the Single Source Supplier

5.3 The Support Concept Associated With The 2-Level Maintenance Concept

Of course all the requirements stated above can be fulfilled by the Airforce. However, due to the high management effort the required staff is quite high and the current structures and processes at the Airforces are not really predestined to perform these tasks. Moreover, this is a domain of industry which can be tasked via appropriate contracts. In this case industry can use commercial procedures e.g. for transportation to ensure the responsiveness of the support system. Within these contracts the required response times must be guaranteed.

An example of a support system in conjunction with the 2-level maintenance concept can be found in figure 5.

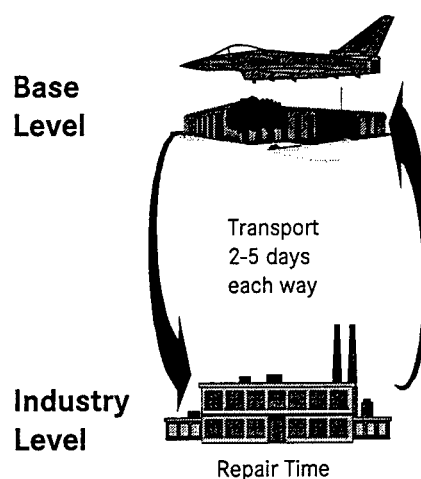


Figure 5: Support concept associated with the 2-level maintenance concept

6. Adequate Self-Sufficiency Of The Airforce

6.1 Requirement For Self-Sufficiency

With the 2-level maintenance and support concept two main criteria for the maintenance concept are fulfilled: cost-effective support and high operational availability of the Weapon System. However, the third requirement of adequate self-sufficiency has not been addressed so far.

With the transfer of most of the activities to industry, the self-sufficiency of the Airforce is naturally decreased. However, today the Airforce requirement of getting involved in the maintenance of a Weapon System is not only driven by the desire to be in position to ensure the operation without the support of industry. Of increasing importance is the requirement to have a certain degree of knowledge of the Weapon System available at the Airforce. This knowledge is needed to ensure optimum operation of the Weapon System as well as the ability to decide on modifications required to improve the operation and support.

6.2 Co-operative Model

In order to ensure the building up and preservation of knowledge at the Airforce, the Airforce needs to be involved in the maintenance of the Weapon System. This can be ensured by establishing so-called co-operative models in which military personnel is located at industry facilities and works together with industry personnel in the maintenance of the Weapon System.

This proceeding has on the one hand the advantage of avoiding additional logistic resources to be procured by the Airforce with all its disadvantages discussed before. On the other hand Airforce personnel can be involved in all levels of maintenance from full depth equipment repair to airframe maintenance and major scheduled inspections.

The co-operative model ensures that:

- The Air Forces are involved in intermediate and depot level maintenance although under industry control
- Airforce personnel with the required know-how for maintenance is immediately available in times of tension, crises and war.
- In depth knowledge of the equipments is gained by military personnel due to their close co-operation with industry personnel.

6.3 Deployed Operations

In case of deployment the Airforce capabilities are limited to the tasks normally performed at base level. For the 2-level maintenance concept this implies that mainly on A/C tasks, e.g. exchange of defective LRIs, are performed. Further repair of these LRIs cannot be done at the deployed location due to the limitation of Support Equipment available at the Airforce.

However, even in the case of a traditional maintenance concept, in-depth maintenance of defective LRIs is not always performed at the deployed location because major support equipment is in often not available in enough quantity to allow it to be shipped to the deployed location. Moreover, the defective LRIs are sent back to home-base for further repair. This proceeding can also be used in case of the 2-level

maintenance concept with the difference that the defective LRIs are then forwarded to industry for repair. In summary there is no real difference in case of deployment between the 2-level and traditional maintenance concept.

7. Summary Of The 2-Level Maintenance And Support Concept

7.1 Prerequisites

Based on the following trends for airborne Weapon Systems the 2-level maintenance concept offers more cost-effective support compared to a traditional 4-level maintenance concept:

- Improved Reliability leading to a low number of defects which can be dealt with at a centralised maintenance facility, making the costly requirement for de-centralised maintenance facilities obsolete.
- Low Maintenance Manhours per FH achieved by high Reliability and long scheduled maintenance intervals again leading to centralised maintenance facilities.
- Availability of Production Facilities For Maintenance Purposes without additional cost is ensured because of the long overlapping between production and in-service phases, making the procurement of resources for maintenance unnecessary.

If the above facts are given the 2-level maintenance concept proves to be more cost-effective compared to the traditional 4-level maintenance concept.

7.2 Characteristics

In summary the 2-level maintenance and support concept consists is characterised by the following:

- On Base Maintenance limited to those tasks absolutely necessary for the immediate logistic support of missions, i.e. the main scheduled and unscheduled on-aircraft work and some limited off-aircraft work.
- Off Base Maintenance where all activities beyond on-base maintenance are performed by industry, following the single source repair principle by using the manufacturer's facilities and assets from production.
- Responsive Support Concept ensuring a fast transportation and repair turn around in order to safeguard a high operational availability of the Weapon System.
- Co-operative Models in order to build-up and maintain the required level of knowledge at the Airforce.

7.3 Benefits

The benefit of the 2-level maintenance concept opposed to the 4-level maintenance concept is in the Life Cycle Cost.

The investment cost are dramatically reduced because a number of logistic resources normally necessary at I- and D-

Level must not be procured. This applies to the following disciplines:

- Support and Test Equipment: not required because production facilities at single source supplier can be used
- Documentation: industry documentation can be used for maintenance
- Training: industry personnel is already trained as part of the production process

But not only the investment cost are positively affected. Since the logistic resources which need not be procured do not create cost for their maintenance and modification, additional savings are made.

Although there are minor disadvantages like the increased requirement for pipeline spares (which can be reduced by a responsive support concept) and the sometimes higher cost for the repair of a defect at industry compared to the military organisation, the positive effect on Life Cycle Cost is outstanding. This can best be shown by a worked example.

8. Example For The Application Of The 2-Level Maintenance Concept

8.1 Eurofighter/Typhoon for the German Airforce

As successor for the F-4 Phantom currently operated by the German Airforce (GAF) the German government decided to procure Eurofighter aircraft. The Eurofighter/Typhoon is developed for the Airforces of the United Kingdom, Germany, Italy and Spain. The development and production is contracted to the major aerospace industry of the participating Nations: British Aerospace plc, DaimlerChrysler Aerospace AG, Alenia S.p.A. and Construcciones Aeronauticas S.A.

Due to military budget restrictions there is a high pressure on the German Airforce and industry to explore all possibilities for minimum Life Cycle Cost of the Weapon System. Further to the stringent requirements of the aircraft design this resulted in a detailed assessment of the maintenance and support concept to be adopted for the GAF.

8.2 Analysis Of Different Maintenance Concepts For The German Airforce

In order to have a sound basis for the decision on the maintenance concept of the Eurofighter/Typhoon for GAF, a detailed study conducted by DaimlerChrysler Aerospace AG (DASA) was performed. The following maintenance concepts have been assessed in this analysis:

Traditional Maintenance Concept

The traditional maintenance concept considered by the GAF employed the 4-level maintenance concept as described above. The only peculiarity is that the tasks performed at D-Level and industry is generally allocated as follows: 30% of the tasks to be performed at D-Level, the remaining 70% to be performed at industry.

Modified Traditional Maintenance Concept

This maintenance concept is based on the traditional maintenance concept described above with the exception that the I-Level tasks for avionic equipments are not performed at de-centralised avionic shops at base-level. Instead the repair of avionic LRIs is performed at a central depot.

2-Level Maintenance Concept

As an alternative, the 2-level maintenance concept as described above has been considered. As an exception to the straight forward application of this concept, some maintenance on systems like Crew Escape, Environmental Control, Battery, Gun and Role Equipment is performed at base-level.

The analysis is based on the following parameters:

- 175 A/C operated in 5 Wings
- 167 flying hours per A/C per year
- The A/C are put into service over a period of 12 years
- Each A/C is operated for a period of 25 years

The study analysed the Life Cycle Cost of the Weapon System, however, the difference for the individual maintenance concepts was of course limited to the cost of operation and support including their initial investment (e.g. initial spares, ground support equipment, publications etc.).

8.3 Study Results

A comparison of the cost of operation and support including initial investment as calculated in the analysis is provided in Table 6 below.

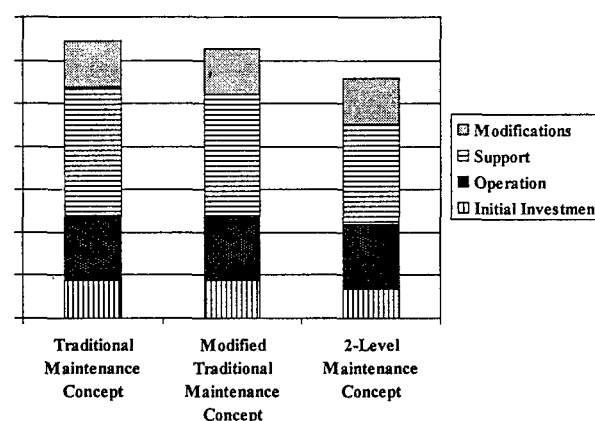


Table 6: Comparison of cost of operation and support for the 2-level maintenance concept versus the 4-level maintenance concept

It can be seen that there is an large advantage for the 2-level maintenance concept for both, initial investment and support cost. In terms of total cost for operation and support of the Weapon System this advantage is around 15% for the 2-level maintenance concept compared to the traditional concept. Bearing in mind that roughly 40% of these cost are associated with the operation and modification of the Weapon System, e.g. fuel, pilot manuals and training, role equipment, operational ground crew, facilities etc., and are therefore not influenced by the maintenance concept, the advantage of the 2-level maintenance concept increases to 23%. This equals some Billion DM.

In order to judge if the result of the analysis changes when important parameters are changed, a sensitivity analysis against a number of these parameters has been conducted including:

- Number of flying hours
- Number of defects

- Repair Turn Around Time

In all cases the 2-level maintenance concept proved to be the most cost-effective alternative.

Therefore, the German Airforce decided to apply the 2-level maintenance concept for their fleet of Eurofighter/Typhoon aircraft.

9. Summary And Conclusion

The 2-level maintenance concept is characterised by

- A reduction of the maintenance tasks to be performed at base-level, mainly on A/C and very limited off A/C tasks
- Transfer of the majority of off A/C maintenance and major scheduled maintenance to a single source supplier (industry)

The 2-level maintenance concept offers significantly reduced Life Cycle Cost compared to the traditional 4-level maintenance concept if certain prerequisites are fulfilled. These prerequisites are:

- A reliable and maintainable design featuring low defect rates and long scheduled maintenance intervals
- Availability of assets and tools required for maintenance at industry without additional cost
- An efficient support concept keeping the turn around times short

On the one hand, excellent Reliability and Maintainability are a prerequisite to make the 2-level maintenance a viable solution. On the other hand, a great potential for reduction of the Life Cycle Cost is not used if the advantages of a reliable and maintainable design are not amplified by the application of the 2-level maintenance concept.