

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Dependability management –
Part 3-12: Application guide – Integrated logistic support**

**Gestion de la sûreté de fonctionnement –
Partie 3-12: Guide d'application – Soutien logistique intégré**



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DEPENDABILITY MANAGEMENT –**Part 3-12: Application guide –
Integrated logistic support**

FOREWORD

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International Standard IEC 60300-3-12 has been prepared by IEC technical committee 56: Dependability.

This second edition cancels and replaces the first edition published in 2001 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- provision of a better overview of the whole ILS process;
- updating of the document to align with associated dependability standards that were introduced after the previous edition.

The text of this standard is based on the following documents:

FDIS	Report on voting
56/1398/FDIS	56/1410/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60300 series, under the general title, *Dependability management*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The successful operation of an item in service depends to a large extent upon the effective acquisition and management of logistic support in order to achieve and sustain the required levels of performance and customer satisfaction over the entire life cycle.

Logistic support encompasses the activities and resources required to permit operation and maintain an item (hardware and software) in service. Logistic support covers maintenance, manpower and personnel, training, spares, technical documentation, packaging, handling, storage and transportation, logistic support resources and disposal. In most cases, maintenance support is considered to be synonymous with logistic support. Logistic support may also include operational tasks but the differentiation between operational and maintenance tasks varies with industry and individual practices.

The cost of logistic support is a major contributor to the life cycle costing (LCC) of an item and increasingly, customers are making purchase decisions based on life cycle cost rather than initial purchase price alone. Logistic support considerations may therefore have a major impact on item sales by ensuring that the item can be operated and supported at an affordable cost and that all the necessary resources have been provided to fully support the item so that it meets the customer requirements.

Quantification of logistic support costs allows the manufacturer to define the logistic support cost elements and evaluate the warranty implications. This provides the opportunity to reduce risk and allows logistic support costs to be set at competitive rates.

Integrated logistic support (ILS) is a management method by which all the logistic support services required by a customer can be brought together in a structured way and in harmony with an item. ILS should be applied to ensure that supportability considerations influence the concept and design of an item and to ensure that logistic support arrangements are consistent with the design and each other throughout the item's life.

The successful application of ILS will result in a number of customer and supplier benefits. For the customer, these can include increased satisfaction, lower logistic support costs, greater availability and lower life cycle costs. For the supplier, benefits can include lower logistic support costs, a better and more saleable item with fewer item modifications due to supportability deficiencies.

This part of IEC 60300 provides guidance on the minimum activities necessary to implement an effective ILS management system for a wide range of commercial suppliers.

DEPENDABILITY MANAGEMENT –

Part 3-12: Application guide – Integrated logistic support

1 Scope

This part of IEC 60300 is an application guide for establishing an integrated logistic support (ILS) management system.

It is intended to be used by a wide range of suppliers including large and small companies wishing to offer a competitive and quality item which is optimized for the purchaser and supplier for the complete life cycle of the item.

It also includes common practices and logistic data analyses that are related to ILS.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-191, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60300-3-1, *Dependability management – Part 3-1: Application guide – Analysis techniques for dependability - Guide on methodology*

IEC 60300-3-2, *Dependability management – Part 3-2: Application guide – Collection of dependability data from the field*

IEC 60300-3-3, *Dependability management – Part 3-3: Application guide – Life cycle costing*

IEC 60300-3-4, *Dependability management – Part 3-4: Application guide – Guide to the specification of dependability requirements*

IEC 60300-3-10, *Dependability management – Part 3-10: Application guide – Maintainability*

IEC 60300-3-11, *Dependability management – Part 3-11: Application guide – Reliability centred maintenance*

IEC 60300-3-14, *Dependability management – Part 3-14: Application guide – Maintenance and maintenance support*

IEC 60300-3-16, *Dependability management – Part 3-16: Application guide – Guidelines for specification of maintenance support services*

IEC 60706-2, *Maintainability of equipment – Part 2: Maintainability requirements and studies during the design and development phase*

IEC 60706-3, *Maintainability of equipment – Part 3: Verification and collection, analysis and presentation of data*

IEC 60706-5, *Maintainability of equipment – Part 5: Testability and diagnostic testing*

IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*

IEC 61160, *Design review*

IEC 62402, *Obsolescence management – Application guide*

IEC 62508, *Guidance on human aspects of dependability*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms and definitions given in IEC 60050-191, as well as the following terms and definitions, apply.

3.1 Terms and definitions

3.1.1

design life

period during which an item is expected to perform according to the technical specifications to which it was produced

NOTE The specification should define the environment, usage and level of logistic support. The period may be time related, distance related or number of cycles related.

3.1.2

integrated logistic support

ILS

management method by which all the logistic support services required by a customer can be brought together in a structured way and in harmony with an item

3.1.3

item

part, component, device, functional unit, equipment, subsystem or system that can be individually considered

NOTE 1 An item may consist of hardware, software, people or any combination thereof.

NOTE 2 In French the term "individu" is used mainly in statistics.

NOTE 3 A group of items, e.g. a population of items or a sample, may itself be considered as an item.

3.1.4

line replaceable item

LRI

replaceable hardware or software item which can be replaced directly on the equipment.

NOTE LRI is sometimes referred to as line replaceable unit (LRU).

3.1.5

logistic support

all material and resources required to permit the operation and undertake the maintenance of an item including both hardware and software

3.1.6

logistic support analysis

LSA

selective application of a range of activities undertaken to assist in complying with supportability and other ILS objectives

NOTE 1 Data generated during LSA are normally stored in a dedicated software application for calculating, determining and optimising the adapted logistic elements which are identified to perform the logistic support for a system during its life cycle. Such an application is often referred to as an LSA database.

3.1.7

maintenance support

resources required to maintain an item under a given maintenance concept and guided by a maintenance policy

NOTE Resources include human resources, support equipment, materials and spare parts, maintenance facilities, documentation, information and maintenance information systems.

3.1.8

provisioning

process of determining and acquiring the range and quantity of spares (consumables or repairable items) required to operate and maintain the item

3.1.9

supportability

extent to which item design characteristics and planned logistic support resources meet operational utilization requirements

3.1.10

support concept

recommended support policy and procedure for a particular item, specific to a particular user or application

3.1.11

trade-off

determination of the optimum balance between item characteristics (cost, performance and supportability)

3.2 Abbreviations

AR&M	Availability, reliability and maintainability
BITE	Built-in test equipment
CP&S	Customer profile and supportability
EDI	Electronic data interchange
FMEA	Failure mode and effects analysis
FMECA	Failure mode, effects and criticality analysis
FRI	Functional requirement identification
ILS	Integrated logistic support
LCC	Life cycle costing
LORA	Level of repair analysis
LRI	Line replaceable item
LSA	Logistic support analysis
LSI	Logistic support improvement
MDT	Mean down time
MTBF	Mean time between failures
MTTR	Mean time to repair
MST	Maintenance support task
PHS&T	Packaging, handling, storage and transportation

PPS	Post production support
R&M	Reliability and maintainability
RCM	Reliability centred maintenance
REACH	Registration, evaluation, authorization and restriction of chemicals. European Directive
RoHS	Restriction of hazardous substances. Directive 2002/95/EC
STTE	Special tools and test equipment
T&E	Test and evaluation
WEEE	Waste from electrical and electronic equipment. Directive 2002/96/EC

4 Principles of integrated logistic support (ILS)

4.1 ILS objectives

The integrated logistic support (ILS) should ensure that

- logistic support considerations are integrated into item design at a very early stage in the design process – preferably at the concept stage,
- logistic support arrangements are developed that are consistently related to design (including intended use and intended environment of the item) and to each other,
- the necessary logistic support is provided at the beginning and during customer use and disposal at optimum cost,
- improvements are allowed to be made in the logistic support of an item throughout its life – and to support necessary modifications; for example, changes required to deal with obsolescence.

ILS should improve the item (by influencing the design to provide the most economic and efficient logistic support solution), improve the logistic support system and minimize the life cycle cost while ensuring that the needs of the customer and business are met.

4.2 Application of ILS

ILS should be applied to the design and development of an item to ensure that all the logistic implications of introducing the item have been properly considered so that it can be supported in the most cost effective manner.

ILS is applicable to all items, including very large items (such as a power plant or a paper mill) and provides a methodology for the identification and optimization of the logistic support requirements for the individual items that constitute the plant.

The degree of application of ILS and the associated LSA will vary accordingly with regard to the degree of design freedom, technical complexity, cost of the item and other factors.

A logistic support analysis (LSA), which comprises the selective application of a series of analysis activities, should be used to assist the design in complying with supportability and other ILS objectives.

If an item is a completely new development it may be necessary to apply most of the LSA activities, but where an item is identified as an existing item, it may not be necessary to apply all the activities. This is referred to as tailoring and addresses the depth of analysis to a cost-effective level based on maturity and the type of item.

ILS results usually have to be modified and updated over the life cycle since changes are likely to occur due to

- experience gained from failures,
- changes in logistic support resources such as suppliers of spare parts,
- improvements in maintenance technology and procedures,
- changes in failure modes and resultant maintenance tasks as equipment ages,
- modifications incorporated in the items,
- human aspects associated with operation and maintenance activities (IEC 62508),
- changes in operating conditions or environment.

4.3 Elements of ILS

The following elements of logistic support are covered by ILS, and may include, but are not limited to:

- maintenance planning;
- spares/materials;
- support equipment (including tools and test equipment);
- technical documentation;
- manpower and personnel;
- training;
- packaging, handling, storage and transportation;
- facilities;
- software support.

Key areas that interface with ILS:

- systems and design engineering;
- reliability analysis (IEC 60300-3-1);
- maintainability of equipment (IEC 60300-3-10 , IEC 60706-2 and IEC 60706-3);
- maintenance and maintenance support (IEC 60300-3-14);
- testability and diagnostic testing (IEC 60706-5);
- life cycle costing (LCC) analysis (IEC 60300-3-3);
- reliability centred maintenance (IEC 60300-3-11);
- specification of maintenance support services (IEC 60300-3-16);
- dependability requirements (IEC 60300-3-4).

In addition, ILS interfaces with

- project management,
- risk management,
- safety and hazard analysis,
- human factors analysis,
- trials and acceptance,
- configuration management,
- quality,
- environmental requirements,
- design reviews (IEC 61160) ,

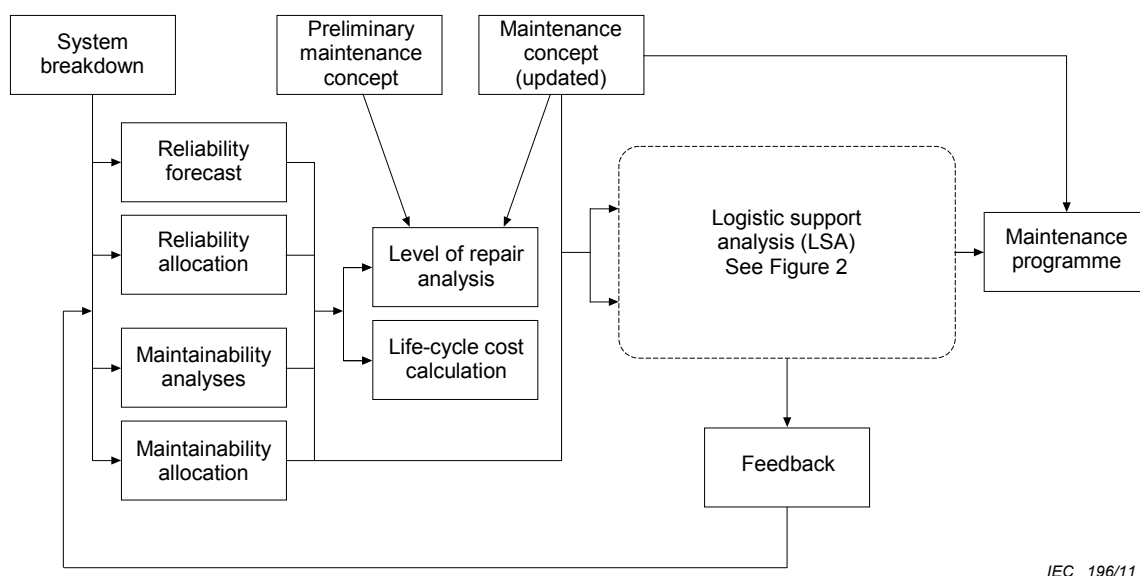
– contracting of maintenance support services (IEC 60300-3-16),

and will reflect and contribute to the approach in these areas.

The activities and procedures for these interface areas are covered in other IEC standards.

4.4 Structure of ILS

ILS is structured so that it can assimilate key areas and logistic support elements to optimize the logistic support required for a system. A simplified diagram illustrating this structure is shown in Figure 1.

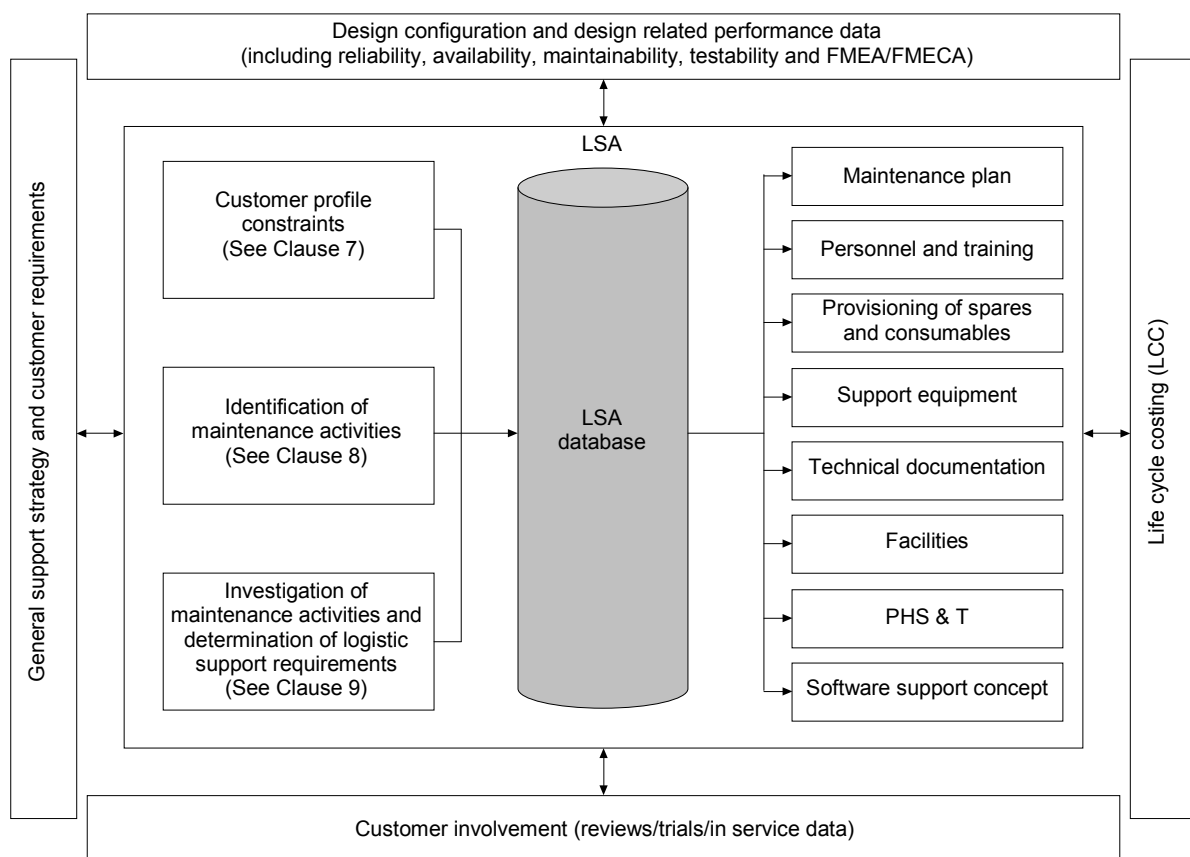


IEC 196/11

Figure 1 – Structure of ILS

The initial stages involve the breakdown of the system into LRIs and the identification of LRIs which require detailed analysis (sometimes referred to as LSA candidates or maintenance candidates). In some cases, the selected LRI is composed of numerous items and it may be necessary to conduct further analyses to optimize maintenance.

Figure 2 illustrates at a high level how the LSA activities interrelate with each other and with the design activities.



IEC 197/11

Figure 2 – Interrelationship of LSA analyses and other design activities

The general logistic support strategy and customer requirements logistic support concept is a basic description of the maintenance support expected to apply to the item. It is usually defined within the customer profile and should be provided to both the design and logistic support team to ensure that the item will be supported in its intended environment. As the design progresses, the initial logistic support concept will be confirmed and expanded.

The design configuration and design performance data provides basic design and performance information. The design information is progressively analysed in terms of its logistic support implications under the LSA in Clause 6. Reliability and maintainability characteristics and FMEA/FMECA are fundamental inputs to these analyses. The R&M characteristics indicate the likelihood of item failure and time to restore and hence the maintenance and logistic support effort and resources required. The FMEA/FMECA indicates the likely causes of failure of the item and provides feedback to improve the design. For the final design and logistic support concept, the FMEA/FMECA provides the input for the systematic identification of all the maintenance and logistic support resources required for the item through the use of maintenance activities and logistic support activities described in Clause 8.

Evidence gathered during operation (customer involvement), provides feedback to improve the item. Proving trials are normally conducted on new items to demonstrate stated performance or fitness for purpose; such trials should include the logistic support arrangements. The testing of the design and proving of the logistic support arrangements are covered under verification of logistic supportability (see Clause 10).

Analyses associated with life cycle costs, ensure that cost considerations (throughout the life of the item) are included when establishing the preferred solution.

Integral with the LSA activities is the LSA database which provides the mechanism and repository for the LSA and documents the detailed logistic support to be provided as a result of the logistic support activities enumerated in Clause 6. To maximize the benefit, the outputs and results of the LSA should be recorded in a controlled and structured LSA database. The creation of an electronic LSA database is recommended as the most viable means to store and control the information obtained. Further details covering interfaces, tailoring and configuration management are discussed in Clause 12.

5 Planning and management of ILS

5.1 General

The planning and management of ILS addresses the programme of work required to carry out the ILS activities. For a complex item, this is a major factor in the success of the ILS programme. The planning of ILS should ensure that all ILS and LSA activities, responsibilities and internal and external interfaces at each phase of the design and ongoing life of the item are clearly defined. The type of maintenance task (for example, preventive – condition based, preventive – pre-determined, corrective – immediate, and corrective – deferred) may require different ILS approaches to be adopted. Examples of the ILS management and planning activities are listed below:

- determine and agree on ILS responsibilities, including logistic information, and interfaces with the owners, users, operators, manufacturers, item design teams, suppliers and/or customers;
- define programme of LSA activities to be undertaken (see Clauses 6, 8 and 11);
- determine method for providing design guidance;
- define maintenance support resources;
- plan and put in place review processes, both informal and formal, to audit the design and the ILS programme;
- apply operational improvement processes for the maintenance and maintenance support resources during the operation and maintenance phase;
- produce and maintain ILS planning documentation to control the ILS programme;
- provide input to decisions on trade-offs between functional needs, capability, life cycle cost and dependability;
- monitor and control the ILS programme of work;
- identify risks associated with the ILS programme and propose actions to address these risks.

It should be noted that ILS management and planning activities require an understanding of the legislative requirements. Examples are WEEE, RoHS and REACH¹. Where a global service is intended, these requirements may differ across countries.

5.2 Management structure and responsibilities

A single person is normally appointed, usually referred to as the ILS manager, with responsibility for the overall programme of ILS activities. The responsibilities of the ILS manager are the ILS management and planning activities defined in 5.1 and other detailed activities as allocated. The principal activities of the ILS manager are to

- meet the requirements of the ILS/LSA plans,
- develop the logistic support-related technical characteristics of the item,
- coordinate and integrate inputs from the specialist disciplines,

¹ WEEE: Waste electrical and electronic equipment; RoHS: Restriction of hazardous substances; REACH: Registration, evaluation, authorisation and restriction of chemical substances.

- coordinate maintenance support provided by contractors and subcontractors,
- coordinate cost related studies.

The ILS manager, who might have other responsibilities, should report directly to the project manager and have the same level of authority as the design and manufacturing managers. This is to ensure that logistic support issues are given equal weight in the design process. For projects involving lower tier subcontractors and/or suppliers, a similar management structure should apply. The subcontractor and, where applicable, supplier ILS managers should report to the overall item contractor ILS manager in a management tier structure. When applicable, the ILS manager should have authority to achieve effective cooperation with the customer and with any subcontractors. Establishing an integrated team needs to be considered.

Clear terms of reference and methods of operation should be identified and agreed between the ILS manager and the designers to ensure that supportability considerations resulting from the LSA studies can fully influence the design. The ILS manager should understand the design process, objectives and programme and relate the ILS programme to it. A concurrent engineering approach is recommended with the design and logistic personnel working closely together to evolve the design and logistic support arrangements in parallel.

The ILS manager may have a team of specialists in LSA, R&M, LCC and logistic support techniques. The number of specialists required will depend upon the size of the project and programme of work; any such specialists would assist the ILS manager by performing detailed activities as directed in the ILS/LSA plan.

5.3 Controlling documentation and review processes

5.3.1 Planning documentation

It is recommended that an ILS plan be produced which may be updated for each phase. This should define the ILS programme activities to be completed, as selected in the tailoring process, and the management controls to be put in place for the success of the programme.

The ILS plan should be sufficiently detailed to ensure a clear understanding of the various management responsibilities, objectives and aims of the programme, the LSA studies to be completed and supportability outputs to be produced. The ILS plan may be supported by a number of associated planning documents, for example, R&M plan or LSA plan. These can be issued separately or, more beneficially, annexed to the ILS plan to provide improved visibility of the total set of planning requirements and to ensure that they are correctly scheduled. The number and content of plans should be limited to those required to adequately control the ILS programme. For small projects, ILS planning can be an activity in the overall project plan.

5.3.2 Recommended review procedures

ILS should be an agenda item at all major design reviews, in which the ILS manager should summarize the current findings and results of the ILS programme activities. The presentation of the design should also discuss any impact on supportability and the logistic support provision from the design studies and trade-offs which have been performed. ILS aspects should be included as a specific element within design reviews, for example, type of packaging, type of transportation, lot size, traceability, etc.

NOTE Further information on design reviews is given in IEC 61160.

ILS reviews should also be held at key stages in the programme to discuss and review the detailed results and progress of the various activities, for example, LSA, R&M, LCC.

5.3.3 Identification of supportability issues

Supportability assessment considers the item design characteristics and planned logistic support resources ability to meet the operational utilization requirements. It is recommended that a procedure should be introduced to document issues and risks to supportability.

provides a further management tool for ensuring that supportability and any other design related issues and risks are highlighted in a project,. These would be monitored by the project team through actions to investigate and mitigate the issues and risks.

6 Logistic support analysis (LSA)

LSA comprises a series of analysis activities that are selected, or tailored, as necessary to meet the requirements of the item. Many of the analyses are iterative and are updated during the item design process in order to ensure that the item can be supported in accordance with the requirements of the customer. The results of these analyses are retained for future use throughout the life cycle of the item. Figure 3 shows the typical applicability of the LSA activities by life cycle phase.

Activity	Concept	Design	Production	Operation	Disposal
Customer profile constraints (7.2)		Update as necessary			
Supportability factors (7.3)		Update as necessary			
Identification of maintenance and logistic support activities (8)	Outline	Detail	Update as necessary		
Maintenance support task (9.2)			Update as necessary		
Potential impact on existing support for new items (9.3)					
Post-production support (9.4)					
Verification of logistic supportability (10)					
Monitoring of field data (10.3)					
ILS outputs (11)					
LSA database (12)					
Feedback to future design					

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NOTE Numbers in brackets refer to the relevant clauses of the standard.

Figure 3 – Applicability of LSA activities by life cycle phases

The starting point of the analysis is to identify the customer profile and supportability (CP&S) constraints. The CP&S constraint is the framework of how the item should be supported: for example, customer or supplier repair capability, the skill level of technicians, available facilities. These all have a bearing on the complexity of any maintenance tasks that can be performed.

Use is made of logistic support experience and data on previous items in early design phases to understand and establish where the logistic support drivers may be for the new item and to prompt changes to improve availability and reduce life cycle cost. Design and logistic support options that are not favourable are discarded and favourable options are progressively detailed and subject to a more detailed analysis (Clause 8). Life cycle costing analysis and the level of repair analysis (LORA) are used as quantitative techniques to compare options and may also be used to provide predictions of long-term costs to assist customers with future financial planning or the identification of warranty costs and decide on the optimum level of repair in a given application. The results in terms of recommendations and requirements for the best logistic support solution are fed back into the design studies and reflected in design documentation. In some circumstances, the results of the LSA may cause the logistic support

concept and/or the design concept to be modified. In the logistic support analysis approach, only certain items are selected for detailed logistic support analysis; each project should develop criteria (such as item cost, quantity, reliability, maintenance effort) to select items for LSA.

The various LSA studies are described in subsequent clauses of this standard.

7 Customer profile constraints and supportability factors

7.1 General

The purpose of the customer profile constraints and supportability factors of LSA activities is to identify the customer's constraints and goals for logistic support. Annex A contains illustrative examples of LSA activities.

7.2 Customer profile constraints

The application of ILS will vary to some extent with each type of item, depending on the way it is operated and maintained, and the relationship of the manufacturer to the customer.

There are a number of different scenarios where ILS may be applied, ranging from an item developed specially for a customer to meet a particular requirement, to a domestic item where the ultimate customers are the public at large who have no direct link with the item manufacturers. In all cases, the ILS process will be largely similar but it is important that a full understanding is established of how the item is intended to be used and the various constraints under which it is likely to be operated and maintained.

In each case, it is the manufacturer who initiates the ILS activities and who has to apply the results of the analysis to produce a recommended logistic support policy and infrastructure to maintain the item in the condition that will enable it to carry out its function. The customer may play an active part in establishing the logistic support structure where the item is a unique development to a particular requirement. At the other end of the scale, the customer may have no input to that process, as in the case of the domestic item which is serviced and maintained by a separate repair organization. Here, the LSA will enable the maintenance procedures to be established and the necessary tools and test equipment to be provided to the repair agents.

A full understanding of how the item is intended to be used and the various constraints under which it is likely to be operated and maintained should be established or a general set of assumptions may be defined. The information may be derived from suppliers' customer records and/or market research, or by visits to existing or potential customer's operation and maintenance facilities. As part of this understanding, the availability of a system can be of major importance. Logistic delays and the time to repair/replace an item can have a critical impact on the overall availability. This needs to be understood so that these 'critical' items can be considered as LSA candidates.

It is recommended that studies are made on the use and application of the proposed item in order to obtain the following information:

- operating cycle, including number of operating days or cycles per unit of time;
- intensity of operation;
- skill and capabilities of users;
- safety requirements;
- number of items to be supported;
- number of customer sites and maintenance levels;
- availability and/or repair/re-supply time requirements;

- allowable periods for undertaking maintenance;
- commonality with other customer systems and equipment;
- effect of item use on the environment;
- definition of the item's operational and storage environment;
- likely numbers, competence and skill of operators and maintenance personnel;
- transportation considerations, for example, mode, type, quantity to be transported, destinations, transport time and schedule;
- service and design life;
- availability of support equipment and facilities on customer sites;
- any other relevant use-related constraints.

Some of this information may not be available but will be determined in the analysis process. For example, where the item is on sale to the public through retail outlets, the manufacturer should consider setting up a servicing organization, if it does not already exist, to provide a repair facility to the customers. If this is necessary, the manufacturer should establish the locations and levels of logistic support required and it is therefore important that the information is as accurate as possible, as the output of the LSA will provide the scale of the required logistic support, the cost of which could be a significant factor in the financial viability of the item. Consideration should be given to the repair by the user, by the manufacturer or by some other qualified maintainer.

The data collected can be used as a common reference for design, reliability and maintainability analysis, performance assessment, and as a definition of the environmental envelope to ensure consistency of analysis. An example is shown in Table A.1.

The customer profile constraints report is produced to define how an item is, or will be, used and supported. It provides the basic information to the design team about the existing logistic support organization. The report may be provided by the customer to describe his own logistic support organization, or may be generated as part of a market survey to detail what will be available, or expected to be provided, within a particular market area. If applicable, for example, for procurement of large systems or a plant, the report should be checked by the customer, having been provided to subcontractors and/or suppliers for information and agreement.

7.3 Supportability factors

7.3.1 Logistic support harmonization

Logistic support harmonization refers to the use of existing and planned supplier and customer logistic support resources, the re-use of existing hardware and software modules in the new items, and the development of common design and logistic support solutions for different elements of a new item. Appropriate harmonization may

- substantially reduce life cycle costing,
- minimize the need to introduce new logistic support resources,
- or minimize the need to modify existing arrangements.

A review of existing and planned supplier and customer logistic support resources should be performed. Existing customer resources may be identified from the customer profile and maintenance concepts. An example of a logistic harmonization analysis is shown in Table A.2.

Having identified existing and planned resources, logistic support constraints can then be identified and documented so that they are made available for consideration and influence during subsequent LSA and design activities.

7.3.2 Logistic support improvement (LSI)

Comparative analysis studies should be performed to identify past logistic support problems, good features and quantitative logistic support data on items or parts thereof that may have a relevance to the new item line.

The purpose of logistic support improvement (LSI) is to

- ensure improvement by building upon effective logistic support,
- correct inadequate logistic support performance found in previous items,
- capture quantitative logistic support data from past items with possible relevance to the new item,
- use this data to provide a baseline for assessing major logistic support demands of the new item,
- assess major logistic support demands for possible design solution for the new item.

The above factors all contribute to improving item availability, reducing logistic requirements and hence lowering LCC. An example of a logistic support improvement analysis is shown in Table A.3.

The information required for the studies may be derived from supplier records, customer defect reports, quality tracking systems, the customer profile constraints report or market research. If market research is required, then the aim should be to coordinate the additional data requirements with any market research conducted under the customer profile constraints and logistic support standardization studies.

7.3.3 Technological opportunities to improve logistic support

Innovative design features in the item or any accompanying logistic support equipment or features utilizing new technology applications can improve the item's design and logistic support, and thus reduce LCC. The inclusion of developing technologies can also avoid early obsolescence and extend the useful life of the item. However, the risk of using new technologies also has to be assessed since designs may not be mature and new functions and resources may be required to support the new technology. An example of a logistic technological opportunity analysis to improve or reduce logistic requirements is shown in Table A.4.

Studies should be performed to identify possible technological opportunities that may be beneficial in the item design concepts being considered to demonstrate the feasibility of supporting the new technology and associated logistic support technologies.

Such studies are not limited to the initial design phase, but can be applied during the life of the item to consider new advances in technology, obsolescence, and the stage when the item is beyond economic repair.

7.3.4 Supportability options

The purpose of this activity is to establish the major logistic support characteristics for the item for each design alternative and operational concept based on experience from previous items. The logistic support characteristics should be expressed in terms of AR&M characteristics, feasible logistic support concepts and associated major characteristics, for example, predicted number of failures or repairs, availability, spares used, test and support equipment and maintenance requirements with associated cost (if possible).

The maintenance concept describes the options as to how and where the item may be maintained at the various lines of repair or maintenance support echelons. The supply logistic support analysis considers the spares and material that should be provisioned and where they should be located.

The analysis should make use of the data collected on other relevant items and follow on from the analysis conducted under the LSI activity described in 7.3.2. An example of the logistic support characteristics, derived from the logistic support factors analysis is shown in Table A.5.

7.4 Supportability factors report

From both the above as well as the previous analyses described in this clause, the initial logistic support, environment, goals and requirements for the item are amended to reflect final logistic support parameters for inclusion in item specifications and any other controlling documentation. The initial requirements should generally focus on logistic design requirements. The supportability report is produced as an output of this activity and the LSA activities described in 7.2 and 7.3. It provides a method for advising the design team of lessons learned regarding the supportability of the existing items. This may be as a combined report or produced as separate or iterative reports depending on the size of the programme.

The supportability factors report includes details of logistic support problems and benefits resulting from the logistic standardization activity, the advanced technologies activity and the logistic improvements activity. The report is provided to the design team together with the requirement specifications as it defines limits on the design imposed by external logistic support constraints. It also identifies design ideas and directions that would benefit the supportability of the design. The supportability report should, when applicable, also be provided to subcontractors and suppliers.

An illustrative example of initial supportability and logistic support requirements emanating from the customer profile constraints and supportability factors series of activities is shown in Table A.6.

8 Identification of maintenance and logistic support activities

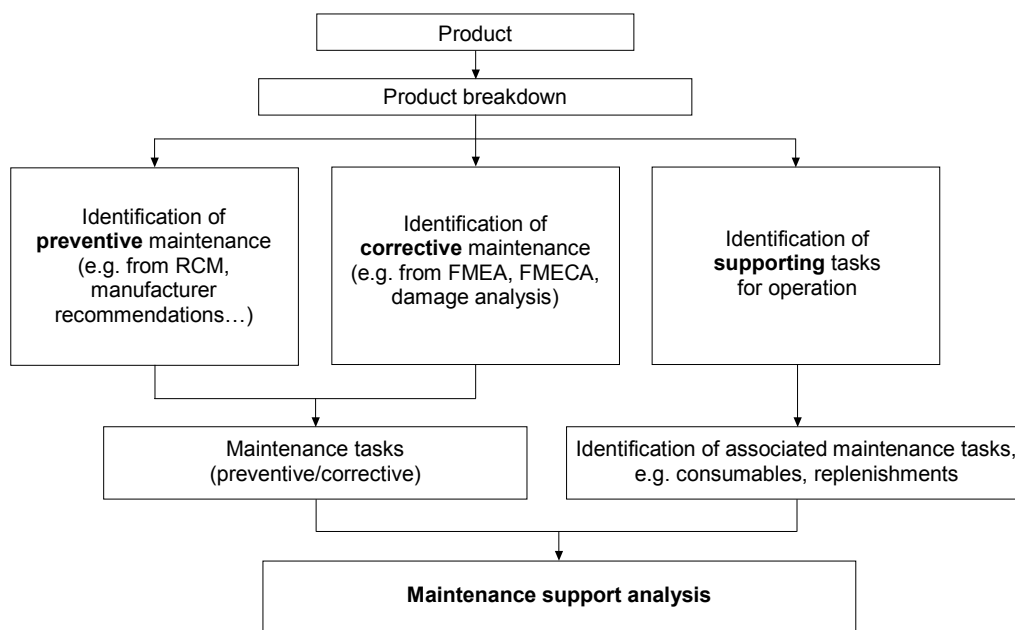
8.1 Purpose and process

The purpose of this activity is to ensure that all required repair, maintenance and operation supporting activities are identified and justified. Each event during operation of the item under analysis which needs an action in terms of maintenance and/or logistic support activities should be analysed and rectified by a corresponding action. In the same way, system design and logistic support alternatives are identified and analysed. The final result of the activity will be a system design with an optimized logistic support concept based on customer profile constraints. The system and logistic support concept is then further analysed to identify the detailed logistic support resources (Clause 8).

The process commences when the equipment breakdown and maintenance indenture levels have been proposed (software and hardware). The potential failure modes are identified from utilization of the data within functional analysis reports, fault tree analysis reports, FMEA and knowledge of in-field data for similar equipment. The required actions to address the failure is determined (none, preventive or corrective) and RCM may be used to identify these actions.

Reliability centred maintenance (RCM) is a method that can be used for establishing a scheduled preventive maintenance programme (see 8.2). Further information on RCM is given in IEC 60300-3-11.

LSA includes identification and analysis of logistic support solutions depending on the various events, which justify the required maintenance and logistic support activities. Figure 4 provides an overview identifying the events for any maintenance or logistic support activity.



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Figure 4 – Identification of maintenance and logistic support activities

The events which are identified by different technical/logistic analysis activities should be linked to a corresponding maintenance and logistic support activity, e.g.

- failures/damages are rectified by repair and/or replace procedures,
- unforeseen special events (e.g. overstraining of the item in use) require a subsequent inspection procedure,
- the achievement of time limits or other thresholds are triggers for scheduled maintenance activities,
- operational needs for activities (e.g. the replenishment of operating fluids).

It should be noted that the same design may have several logistic support alternatives but conversely different design options may have the same or other logistic support options or an element could be common to several logistic support options.

8.2 Identifying options

It should be noted that the identification of maintenance and logistic support activities by performing several technical/logistic analysis activities should be limited to a feasible extent. It is therefore recommended to analyse the maintenance and logistic support drivers considered complex, expensive, less reliable and/or safety critical components of the item.

Alternatives shall include both logistic support and design options. Design options may emerge from the design programme as a result of a pure design consideration (for example, for improved performance) or possibly from the results of earlier logistic studies (for example, unacceptable logistic implication on an earlier design). When considering the best design option, a full trade-off study shall be undertaken so that all factors, including logistic support options, are considered to establish the optimum solution.

As part of the design process, options are identified for trade-off. These are alternative means of meeting requirements and may have significant differences in terms of their logistic support requirements. To decide on the best approach, all technical and commercial issues should be assessed and hence ILS should contribute to the decision process. The design options are therefore subject to LSA (where the item is an LSA candidate) and recommendations are made as to their acceptability for logistic support.

The required operational and logistic functions should be considered by the designer and established at a reasonable level in order to commence trade-off studies. The depth of analysis should be limited to that sufficient to support the trade-off studies. Defining the functions in too much detail will result in the trade-off being unduly complex and costly with the conclusions being confusing and possibly misleading. At the system level, the primary functions may be limited to delivery, preparation for use, operate, maintain, store and dispose. If "operate" contains a sequence of events then these may be included. Similarly, with respect to "maintain" there could be regular maintenance work with scheduled and unscheduled elements which arises from it. For each of these functions the logistic aspects should be specified. For example, "prepare for use" may involve training, handbook instructions, personnel skill levels, specified time. The maintain and support functions may involve inspection, calibration, alignment, repair/replacement and/or replenishment of expendable items.

The level of analysis undertaken during the studies will depend upon the amount of detailed data available.

The preparation and evaluation of options covers the following sequence of events:

- identify the functional requirements relevant to the trade-off study;
- identify the logistic functions required to support each of these item functions;
- specify the criteria pertinent to these functions on which the trade-off study is to be ascertained;
- apply a weighting factor for each criterion, i.e. specify the level of importance;
- consider each trade-off option and apply a scoring methodology to determine the preferred option (see 8.4).

8.3 Factors influencing a trade-off study

The main key factors influencing a logistic trade-off study are as follows:

- method of operation including the operating environment and skills and capabilities of the users;
- reliability, maintainability and availability (which has a logistic impact);
- supportability;
- safety;
- costs (such as echelon of repair).

From these, the significant factors necessary to perform the maintenance actions, particularly logistic support resource requirements and cost drivers, are identified.

As an example, in the case of the G1 test cable in Table A.3, the trade-off study may be concerned with power or signal requirements (electric or light), but from a logistic viewpoint the trade-off study may address:

- a) partitioning of functions – functions should be adequately partitioned so that the location of a fault or potential fault can be readily identified (by test or inspection);
- b) use of BITE;
- c) failure mechanisms – frequency, significance;
- d) prevention – design robustness, inspections to examine wear, loose connections, etc., condition monitoring such as "noise" measurements;
- e) ease of maintenance such as:
 - cable length – consideration being given to resources and manufacturing costs, installation costs and major repair costs;

- localized repair – the inclusion of additional cable lengths to enable a specified number of localized repairs at the connector interfaces to be achieved. Failure of the interfacing items that result in disconnects and reconnects of the cable that can be the cause of cable failure also should be considered. From this data the resources and costs involved can be estimated;
- f) level of repair (using LORA) – A LORA is an analysis to select the most cost effective maintenance level for already identified maintenance task(s). In the above examples, options are either to replace the cable and refurbish for subsequent use or scrap. Alternatively, repair the cable *in situ*. There may be several levels of repair and several options to be considered to optimize the item down time, the various maintenance times, the personnel skill levels, the amount of training and the maintenance instruction manuals, to name but a few.

8.4 Establishing the criteria to conduct a trade-off study

For conducting trade-offs the criteria by which the trade-off is to be judged should be established. These criteria should be tailored to identify the most pertinent discriminators for a particular trade-off. Examples of key criteria are

- performance,
- physical parameters,
- reliability and maintainability (R&M),
- ability to manufacture,
- ability to maintain,
- maintenance and logistic support costs and other relevant life cycle costs,
- safety and risks,
- environmental impact.

The level of importance of these criteria should also be established and a scoring methodology determined in order to select the preferred solution. For example, performance, R&M and LCC may be assessed to be of equal importance with the remaining criteria of an equal and lesser importance.

For example, the trade-off could be to compare two options for testing: a manual point-to-point testing method and a fully automated test system. The trade-off study may consider the following aspects of each option:

- development costs;
- ability to manufacture;
- production costs;
- operation and logistic support costs;
- training requirements;
- the need for maintenance support equipment;
- spares and repairs for the logistic support equipment;
- the level of built-in test;
- skill level required for test;
- test time and associated costs;
- accuracy of test and error correction costs;
- skill level required to maintain the logistic support equipment;
- number of personnel required for test and maintenance;
- safety and risks.

8.5 Conducting a trade-off study

During the concept phase, trade-off studies are usually conducted at a high level when the minimum of data is available and these can have the greatest impact, in terms of performance, logistic support and LCC. In successive phases of development and manufacture, further trade-off studies are conducted, for example, level of repair analysis (LORA), usually on selected areas of the item, but in greater detail so that the optimum solution is selected.

As the development of an item progresses, the trade-off study becomes more detailed. One useful technique to be considered is the FMEA/FMECA technique (described further in IEC 60812) which identifies possible faults and their significance and the associated RCM analysis. It should be noted that this technique can be applied at the LRI or "black box" level as opposed to the component level. This powerful tool identifies potential design improvement areas (to eliminate significant performance and safety related failures) and enables testability, fault diagnosis and maintenance tasks to be formulated. In the early stages, the failures that will generate expensive maintenance tasks can be identified and steps taken to reduce these costs by

- eradicating the problem and/or minimizing the significance of the problem through re-design or by changing the item's operation,
- adopting a preventive maintenance approach, for example, active condition monitoring so that a potential failure is detected and corrected before it arises,
- simplifying the maintenance task so that costs can be minimized.

Logistic support options and trade-offs usually commence by considering the various maintenance alternatives for each design option, repair level and location, for example:

- item replacement at customer's premises/discard on failure;
- skill levels and equipment required;
- timescales.

When considering logistic support equipment, further maintenance options shall also be addressed. The number of alternatives to be examined can become quite large, but by concentrating upon the identified functional requirements and recognizing that many of the alternatives are repeated within the trade-off options, it is possible to reduce the quantity to a manageable number.

An example of a trade-off analysis is shown in Annex B.

8.6 Trade-off study reports

Various reports are produced from these LSA activities which can be formal reports produced by the LSA team or inputs to the overall option assessment process within a design team. The aim is to ensure that the life cycle cost implications of a design decision are identified early enough to influence the selection of an alternative design. These reports can either address the design as a whole or be limited to specific areas of logistic support. Typical reports include:

- design trade-off studies – these identify the main logistic support costs associated with different item design options as part of the main development process;
- level of repair analysis (LORA) – the LORA is a specific trade-off study that is used to identify the optimum maintenance level or location for a repair to be undertaken. It may be used for design optimization or as part of a logistic support system assessment;
- logistic support alternatives/trade-off studies – these evaluate alternative logistic support concepts as part of the development of the logistic support system. They are usually used internally within the logistic support department as an aid to planning the logistic support to be provided for a new item;

- achievement of performance versus logistic support costs – identification of areas where minor changes of performance, including availability, would result in a significant reduction in LCC.

The reports are seen by the design team who consider the factors raised in the selection of the final design. This may not always result in the optimum logistic support solution when performance is critical and any decision to enhance performance at the expense of supportability should be documented. Further trade-off studies may be required to resolve areas of conflict.

9 Investigation of maintenance activities and determination of LSA activities

9.1 General

After the customer profile constraints and supportability factors have been outlined (see Clause 7) and design and maintenance support options have been evaluated (see Clause 8), the next step is to determine the detailed logistic support requirements for the selected design and associated logistic support concept. The objectives of the LSA activities in this clause are as follows:

- identify the maintenance support requirements, and the detailed logistic support resources for the item based on the design configuration, the designated level of reliability when used as intended and associated logistic support concept;
- identify what logistic support will be required by the customer from the supplier during operation (for example, helpline);
- set up and implement a feedback loop and infrastructure to identify the customer's problems as an input to future item development.

There are a number of LSA activities for achieving these objectives. The applicability of these activities will depend on the type of item and the stage of development and may be iterative to enable the full determination of logistic support resource requirements.

The main LSA activities are as follows:

- maintenance support task (MST) – this involves the detailed analysis of the operation and maintenance activities to identify the logistic resource requirements;
- existing logistic support impact – this task assesses the impact the item will have on existing logistic support organizations and resources. The maintenance activities (Clause 8) may identify a need to increase or decrease the extent of the existing logistic support organization. The impact if these changes is assessed within this activity;
- post-manufacture and installation logistic support – this task identifies and plans for logistic support following the end of the manufacture and installation phase;
- supportability assessment this is the evaluation and verification of the effectiveness of the proposed logistic support. The assessment activity may involve the use of supportability assessment models to assess maintainability and estimate achieved supportability. The activities will also include the development of action plans to correct any deficiencies in supportability characteristics (see Clause 10).

9.2 Maintenance support task (MST)

9.2.1 General

The maintenance support task (MST) is used to detail the operation and maintenance tasks required for the item. Its purpose, using a step-by-step review of each maintenance task, is to identify the manpower, skills, tools, test equipment, resource or spares necessary to carry out the activities. The maintenance support task process is shown in Figure 5.

The data produced should be documented in an LSA database to provide a central store of information. This store is used to develop the various item logistic support outputs. For ease

of production of technical documentation and training, where possible, the activity descriptions should be in a format to allow them to be used directly in the development of these outputs.

9.2.2 Maintenance support task process

The MST identifies the detailed maintenance tasks (support resources, tools, etc.) necessary to undertake the repair/replacement action and recommends optimum solutions. This optimization may necessitate design changes and maintenance indenture level changes to progressively establish the final solution.

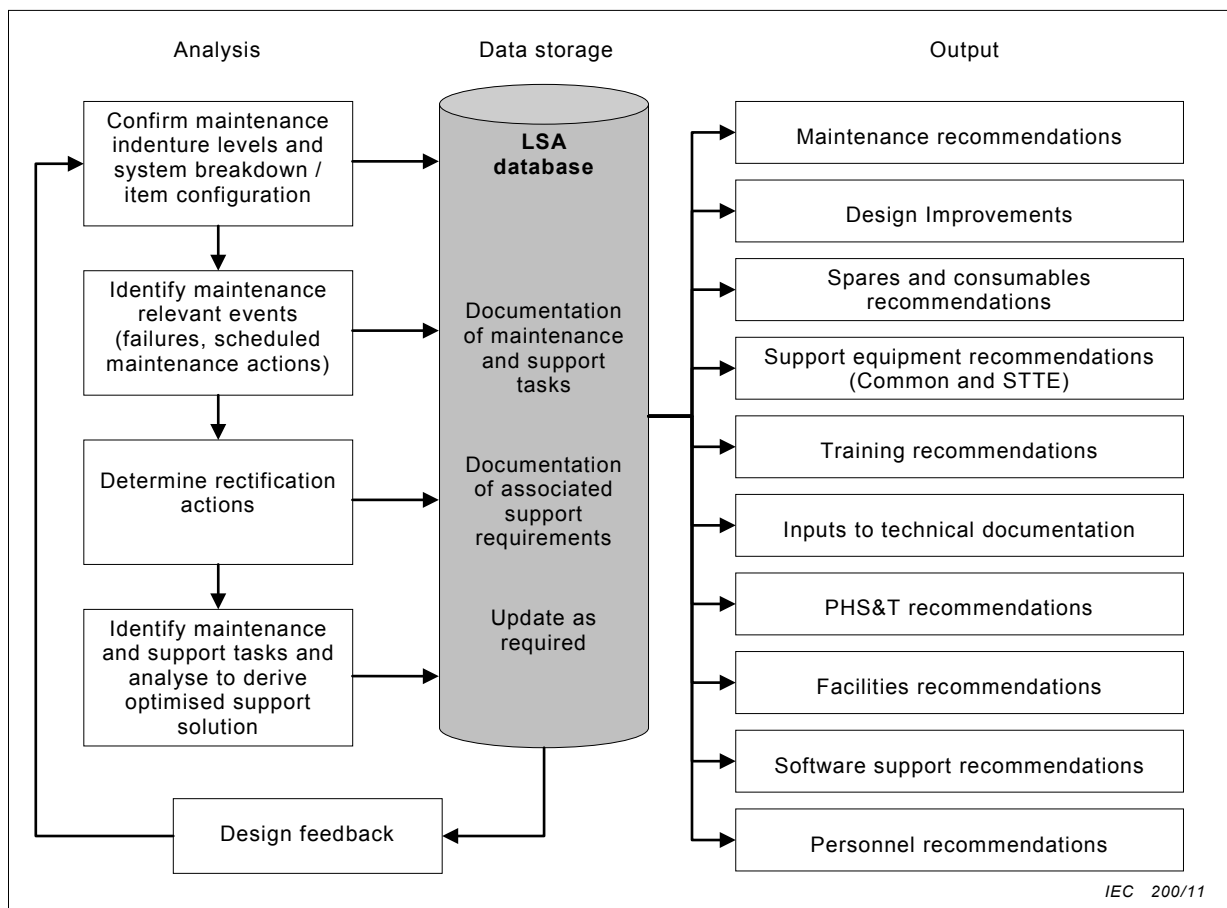


Figure 5 – Maintenance support task

9.2.3 LSA database

The LSA database provides the forum to record the functional analysis, item listing, FMEA and results of the MST (maintenance support task requirements). The analysis is checked for consistency and completeness and is updated as required during the item development.

9.2.4 Outputs

9.2.4.1 General

The LSA database provides information for developing the item logistic support outputs and information where design improvements may be required. These outputs are defined in more detail in Clauses 10 and 11.

9.2.4.2 Maintenance recommendations

The maintenance requirements identify the corrective and preventive maintenance tasks. The tasks are collected into a maintenance plan, which is described in 11.3.2.

9.2.4.3 Design improvements

As a result of the task analysis, those areas that fail to meet the logistic support requirement will be identified which will highlight potential problem areas to management that may require future item development or contingency plans.

9.2.4.4 Spares and consumables recommendations

The step-by-step task analysis identifies both the spares recommendations and the appropriate level or location where the repair will be undertaken. It is essential that the maintenance support task is used for the development of the spares requirements. This ensures the items provided for repairing the system are correct and the other elements of logistic support (for example, training, support equipment) are also applicable for the repair operations to be performed.

9.2.4.5 Support equipment recommendations

The maintenance support task identifies the need for special and/or common support equipment. In this area it should be noted that a harmonization of identified support equipment is recommended to avoid the provision of different tools for similar logistic support activities which can use a single support equipment to perform the task.

9.2.4.6 Training recommendations

This maintenance support task identifies the training requirements for operation and maintenance of the item. The use of the task analysis as the basis of the training programme will reduce training times and ensures that a common format and description is used for all the individual maintenance operations which make up the overall repair actions.

9.2.4.7 Inputs to technical documentation

Much of the technical documentation can be produced based on information in the LSA database. Descriptions of the item required for user manuals will exist in technical and R&M reports and activity analyses are the basis of maintenance instructions. The technical documentation may be provided in an electronic format; for example, spare parts catalogue and maintenance manual.

9.2.4.8 Packaging, handling, storage and transportation (PHS&T) recommendations

The requirements for PHS&T, both for the delivery of the main item and the provision of spares should be examined to identify any constraints or potential problems that could be reduced during the early design phases. Where the item is not developed for a specific user the requirements for PHS&T will still apply as reduction in problems will result in cheaper distribution and improved customer acceptance. The PHS&T requirements will be identified as part of the design and LSA analysis activities. These will identify any limitations in terms of weight, volume, fragility, storage, labelling or special requirements.

9.2.4.9 Facilities recommendations

The requirements for facilities to carry out maintenance, training, supply, storage and software support should be identified and documented. These include size and types of buildings, environmental requirements, and services needed. It should be noted that facilities are of special criticality for a whole project. The long planning periods and the high investments normally demand consideration of required facilities at a very early project phase.

9.2.4.10 Software support recommendations

Software support applies both to item internal software (such as diagnostic or remote sensing etc) and to software which is part of the main function of an item. The recommendations for performing maintenance (modification and replacement) of software and training related to the software should be identified and documented. These include size and types of software, loading concept, configuration control and the development support environment.

9.2.4.11 Personnel recommendations

The requirements for manpower to carry out operation and maintenance should be identified and documented. These include numbers, locations and skills needed.

9.3 Potential impact on existing logistic support for new items

9.3.1 General

This activity assesses the effect on the existing logistic support system by the introduction of new items into use. Whenever existing logistic support resources and facilities need to be shared by the old and the new items, the transition period should be planned. Also, this activity can provide an early indication of the logistic support problems likely to be encountered when the new item is in use. Although this activity is primarily intended to assess the impact on the customer's logistic support system, there are aspects of this activity which can apply to the producer of the new item whenever an old and new item are considered to be supported simultaneously.

9.3.2 Activity description

The evaluation of the impact on existing operation and logistic support systems should address the availability and ability of existing systems to support the new item. This evaluation should include existing maintenance, repair, training and supply facilities as well as personnel. Where the resources and facilities are shared, the assessment should identify any assumptions made with regard to their shared use during the time period involved.

The existing manpower resources should be analysed and compared with the planned requirements to identify the need for additional staff or training. The effect of any lack of adequate skilled manpower for supporting the new item should be identified and used to determine the actions required to correct any deficiencies. Possible actions to resolve the identified problems/shortfalls include the recruitment of skilled staff or increased training to supplement areas where skills are weak.

The output of this activity will also identify areas where existing logistic support resources, facilities and infrastructure is inadequate compared to the planned requirement.

Whilst the primary purpose of this activity is to identify potential problems/shortfalls in the item logistic support organization, it can also be used to identify potential markets for the provision of additional logistic support services. This may include maintenance and supply support for a specified period of time until the required logistic support resources can be generated. There is also the possibility of design modifications by the producer to improve reliability, reduce skill requirements or reduce the time to repair.

The use of this data will allow the manufacturer to satisfy the expectations of the user and to ensure that any logistic support contracts adequately allow for the logistic support of the new system.

9.4 Post-production support (PPS)

9.4.1 General

This activity is intended to assess the activities which should be completed to ensure that the item is supportable for its expected service life, after the production line closes and therefore is a subset of the in-service logistic support activity. It is as applicable to the manufacturer, who has to plan his warranty policies and marketing of logistic support, as it is to the end-user who requires assurance that his item will be supported for its expected life. Except for basic component manufacturers, every production and assembly process is dependent on continued supply of components and assemblies and is therefore subject to PPS problems. In some cases, the item is a common part for several products and as a consequence PPS planning should address aspects across these products, such as configuration control, spare parts, supply chain, requirement prediction etc.

9.4.2 Activity description

The identification of a strategy for long-term logistic support should form part of the basic marketing development. Even if the item is only intended to have a short lifespan, the generation of a management strategy for identifying post-production problems early enough to take remedial action will allow a controlled phase-out of an item whilst still providing economic logistic support. Obsolescence management is an important consideration for long-term logistic support. This is detailed in IEC 62402.

The possibility of upgrading the design as an integral part of the repair process should also be considered as a means of maintaining the logistic support environment and reducing the impact of obsolescence.

The main steps to be undertaken to resolve PPS problems are as follows:

- assess the useful life of the new item – the expected life of the item may be limited by design limitations, obsolescence due to improved performance or technology or simply customer preference;
- identify potential resource problems – this can be achieved by examination of the provisioning parts list, the use of market surveys or the use of vendor questionnaires to identify potential problems. The common problems for PPS include:
 - the original manufacturer is no longer in business or no longer makes the item required;
 - support and test items are no longer available or used elsewhere;
 - the rights to data and software were not obtained and should be considered;
 - high-cost spares were procured in low quantities;
 - there are differences in management priorities;
 - uncontrolled modifications and life extensions exist;
 - the customer is unable to repair the item due to lack of resources;
- develop alternatives to resolve or address problems. These may need to be a once and for all spares buy, the establishment of a special repair facility or the procurement of design rights and production technical data to allow in-house production;
- develop and document a PPS management strategy in a PPS plan. This ensures that the problem is identified and brought to management attention, together with proposals for resolving problems or reducing the risk.

9.4.3 Post-production support (PPS) plan

A PPS plan provides the mechanism for identifying and managing post-production support problems when the production ends and there is still the likelihood of spare parts being required. The following are possible areas on which a PPS plan should focus:

- post-production maintenance organization and responsibilities;
- assessment of the impact of technological changes and possible obsolescence;
- alternative strategies to accommodate the loss of production sources;
- possibility of extending the item life and implications on the logistic support available;
- currency of technical data base, for example, production drawings;
- provision for retention of factory test items, special tools and dies;
- the effectiveness of updating the LSA database in line with design changes.

10 Verification of logistic supportability

10.1 General

This activity confirms the effectiveness of the logistic support arrangements, identifying any shortfalls, the reasons for the shortfalls and the actions to correct deficiencies.

Although this is primarily aimed at validation and acceptance of the final logistic support arrangements, its use earlier in the programme allows early identification of problems and facilitates cost effective correction. The test and evaluation activity can be divided into two main areas: "logistic support acceptance strategy" and "monitoring of field data".

10.2 Logistic support acceptance strategy

The cost of performing a logistic support assessment can be significant and an effective strategy will ensure that the supportability, AR&M parameters, and the logistic support resources can be demonstrated in an economic manner. The simplest, minimum cost, solution is to use field data from general item acceptance trials to provide confidence in the achievement of the theoretical predictions of supportability and AR&M requirements based on the defined logistic support plan and resources provided, for example, spares, test equipment.

Logistic support assessment is applicable to both the customer and the item manufacturer. Lack of an effective test and acceptance strategy will result in inadequate proving and hence possible increased customer complaints due to problems encountered through poor logistic support.

The procedure for developing and applying an effective test and evaluation (T&E) strategy is shown in Figure 6.

The first step is to identify those parameters that will be demonstrated. These may be the high-risk areas, cost or performance drivers or marketing demonstrations. The existence of verifiable theoretical analysis and field data on existing or similar items should be used to provide the necessary level of confidence which may avoid the need for expensive trials. Maximum use should be made of data from previous studies and this activity should not be scheduled until such data is available.