International specification for developing and continuously improving preventive maintenance

S4000P-B6865-04000-00

Issue No. 1.0

Publisher:

Table of contents

The listed documents are included in Issue 1.0, dated 2014-05-23, of this publication.

Copyright and user agreement

1 Copyright

All correspondence and queries should be directed to:

ASD
10 Rue Montoyer
B-1000 Brussels
Belgium

2 Agreement for use of the specification S4000P™ suite of information

2.1 Definitions

S4000P™ suite of information means, but is not limited to:

- the "International specification for developing and continuously improving preventive maintenance" - ASD S4000P
- examples (eg, XML instances, PDF files, style sheets) and schemas
- any other software or information under the heading "**S4000P™ suite of information**" available for download from www.s4000p.org

Copyright Holder means AeroSpace and Defence Industries Association of Europe (ASD).

2.2 Notice to user

By using all or any portion of **S4000P™ suite of information** you accept the terms and conditions of this User Agreement.

This User Agreement is enforceable against you and any legal entity that has obtained **S4000P™** or any portion thereof and on whose behalf it is used.

2.3 License to use

As long as you comply with the terms of this User Agreement, the Copyright Holder grant to you a non-exclusive license to use **S4000P™ suite of information**.

2.4 Intellectual property rights

S4000P™ suite of information is the intellectual property of and is owned by the Copyright Holder. Except as expressly stated herein, this User Agreement does not grant you any intellectual property right in the **S4000P™ suite of information** and all rights not expressly granted are reserved by the Copyright Holder.

2.5 No modifications

You shall not modify, adapt or translate, in whole or in part, **S4000P™ suite of information**. You may however add business rules.

2.6 No warranty

S4000P™ suite of information is being delivered to you "as is". The Copyright Holder does not warrant the performance or result you may obtain by using **S4000P™ suite of information**. The Copyright Holders make no warranties, representations or indemnities, express or implied, whether by statute, common law, custom, usage or otherwise as to any matter including without limitation merchantability, integration, satisfactory quality, fitness for any particular purpose, or non-infringement of third parties rights.

2.7 Limitation of liability

In no event will the Copyright Holders be liable to you for any damages, claims or costs whatsoever or any consequential, indirect or incidental damages, or any lost profits or lost savings or for any claim by a third party, even if the Copyright Holder has been advised of the possibility of such damages, claims, costs, lost profits or lost savings.

2.8 Indemnity

You agree to defend, indemnify, and hold harmless the Copyright Holder and its parents and affiliates and all of their employees, agents, directors, officers, proprietors, partners, representatives, shareholders, servants, attorneys, predecessors, successors, assigns, and those who have worked on the preparation, publication or distribution of the **S4000P™ suite of information** from and against any and all claims, proceedings, damages, injuries, liabilities, losses, costs, and expenses (including reasonable attorneys' fees and litigation expenses), relating to or arising from your use of **S4000P™ suite of information** or any breach by you of this User Agreement.

2.9 Governing law and arbitration

This User Agreement will be governed by and construed in accordance with the laws of the Kingdom of Belgium.

In the event of any dispute, controversy or claim arising out of or in connection with this User Agreement, or the breach, termination or invalidity thereof, the parties agree to submit the matter to settlement proceedings under the ICC (International Chamber of Commerce) ADR Rules. If the dispute has not been settled pursuant to the said Rules within 45 days following the filing of a Request for ADR or within such other period as the parties may agree in writing, such dispute shall be finally settled under the Rules of Arbitration of the International Chamber of Commerce by three arbitrators appointed in accordance with the said Rules of Arbitration. All related proceedings should be at the place of the ICC in Paris, France.

The language to be used in the arbitral proceedings shall be English.

Chapter 1

Introduction to the specification

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 2	Development of preventive maintenance task requirements with intervals
Chap 2.2	System analysis
Chap 2.3	Structure analysis
Chap 2.4	Zonal analysis
Chap 2.5	Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources, traceability
Chap 3	In-service maintenance optimization (ISMO)

Chap No./Document No.	Title
Chap 3.2	ISMO preparation phase
Chap 3.3	ISMO analysis phase
Chap 3.4	ISMO follow-up phase
Chap 4	Interfaces of ASD S4000P
Chap 5	Terms, abbreviations and acronyms
S1000D	International specification for technical publications using a common source database
S3000L	International specification for Logistic Support Analysis - LSA
S5000F	International specification for operational and maintenance data feedback
SX000i	International guide for the use of the S-Series Integrated Logistics Support (ILS) specifications

1 Preface

1.1 History and feasibility

In 2004, the Customer Product Support Committee (CPSC) of AECMA (Association européenne des constructeurs de matériel aérospatial) decided to conduct a feasibility study for a new specification/handbook for "developing scheduled maintenance programs for military aircraft". A task was allocated to a group of maintenance specialists from different European aircraft/components manufacturers with direction to perform that feasibility study. The results of the feasibility study were approved by the CPSC of AECMA and the task for developing that specification/handbook was officially launched.

Since 2005 AECMA is named Aerospace and Defense Industries association of Europe (ASD) and CPSC is named Product Support Group (PSG).

A new specification ASD S4000M was developed taking into account existing and approved analysis procedures/specifications available. In addition the S4000M development team took into consideration the experience of analysts from European and world-wide industry in using different analysis methodologies specifically at military and civil aeronautics industries.

Due to an updated scope of ASD based on market needs, the specification ASD S4000M was neither published nor applied for Product analysis purposes.

The following aspects led to the development of a new specification ASD S4000P that fully replaces ASD S4000M:

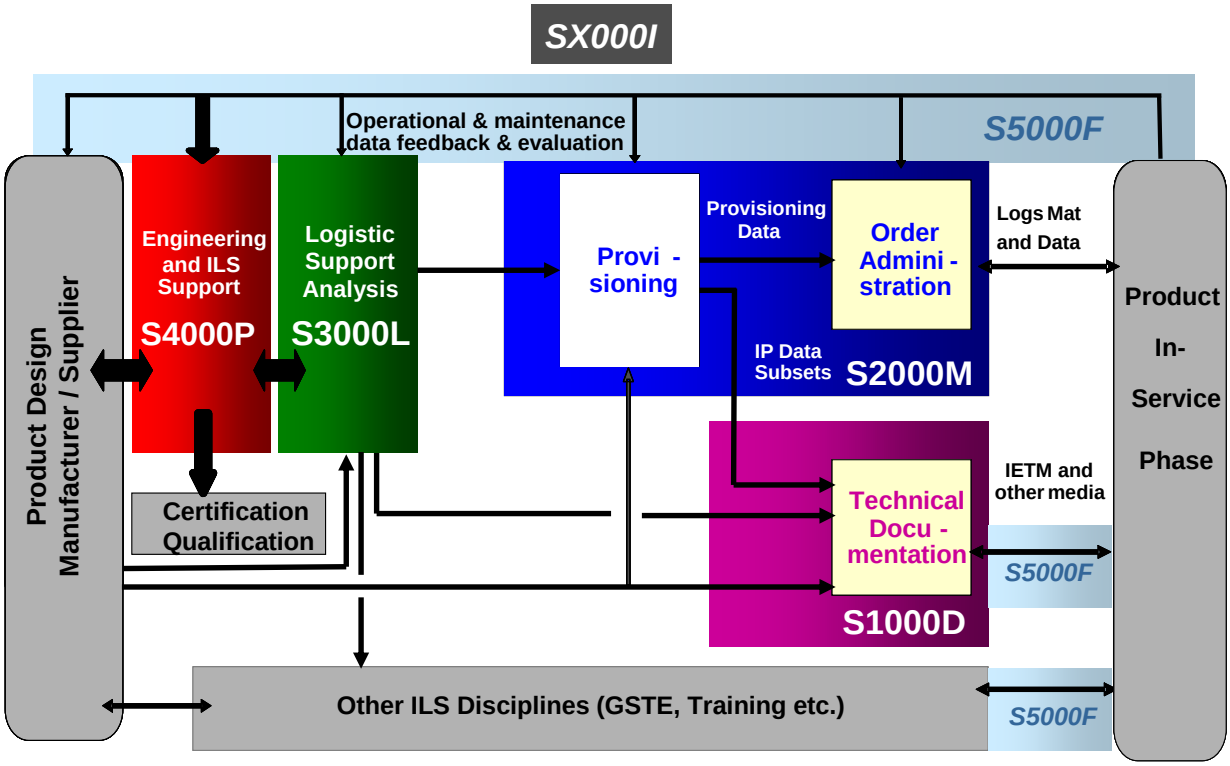
- Applicability of the described analysis methodologies on all Product types
- Implementation of innovations in Product system analysis, structure analysis and zonal analysis for developing Preventive Maintenance Task Requirements (PMTR) with scheduled intervals
- Harmonization, consolidation and traceability of analysis results from system-, structure- and zonal analysis and in between
- Extension of the applicability of the specification on the whole life cycle of a Product by introduction of an In-Service Maintenance Optimization (ISMO) process
- Description and clarification of interfaces between S4000P and other specifications of the S-Series of ILS specifications and further interfaces outside the S-Series

– Introduction of a chapter providing examples to support Product analysis (eg, for developing a Policy and Procedure Handbook (PPH))

1.2 S4000P ASD approval

The content of ASD S4000P Issue 1.0 has been prepared by experts from the European industry. After a final editorial check according to the S1000D rules, ASD has decided to publish S4000P Issue1.0.

S4000P is an integrated part of the S-Series of ILS specifications. Relevant interfaces to and from this specification are described in Chap 4.



ICN-B6865-S4000P0001-001-01

Fig 1 The S-Series of ILS specifications

In Fig 1 the main interrelations between the specifications S1000D, S2000M, S3000L, S4000P and S5000F are shown. SX000I is the specification explaining these interfaces and interrelations during a product life cycle. A future extension of the S-Series of ILS specifications is planned (eg, development and integration of a S6000T for Training).

1.3 S4000P future revisions

An international Steering Committee (SC) was already established for ASD S4000M in January 2013. This SC switched the responsibility from ASD S4000M to ASD S4000P in December 2013. The future development will be done together with experts from AIA and/or other national and international organizations.

The S4000P SC has the responsibility for the maintenance of this specification.

Note

The S4000P SC must not be mixed with the Steering Committee for developing and continuously improving preventive maintenance for a specific Product as described in Para 3.1.1.

This specification is available on the internet at the following web-site: www.s4000p.org

A comment/question form is available on this web-site.

In particular, the S4000P SC will be responsible for reviewing the following:

- Comments received from the aeronautical and non-aeronautical communities or any other body associated to ASD
- Modifications as a result of changes in other documents relevant for this specification
- Compatibility with other ASD specifications especially the S-Series of ILS specifications
- Other inputs (new or changed laws, regulations, experiences from Product in-service usages, etc)

Changes agreed by the S4000P SC will be published in future issues of this specification.

2 General

2.1 Scope

In line with the other ASD S-Series of ILS specifications, the terms "the Product" and "project" are introduced as follows:

- **Product** - Any technical platform, system, equipment, vehicle, facility, etc (air, sea, land, space, civil or military).

  Examples:

  Aerial ropeway systems, trains, ships, submarines, wind energy production plants, etc.

- **project** - The task spectrum to develop, maintain and dispose the Product

Besides the aspects covered by existing, valid analysis procedures/specifications, this specification takes into account the following requirements/aspects which are recommended to be described in a Product-specific PPH:

- Operation of the Product in both normal and adverse usage conditions
- Extension of applicability from aeronautic industry on other technical Product groups
- Introduction of "mission" next to "operation" as Functional Failure Effect (FFE) in system analysis
- Introduction of FFE related to environmental integrity or other aspects for example, collision with law in system analysis
- Standardization of the preventive maintenance task type selection
- Analysis of accidental damages on Product structure (for civil and military Product usage)
- Analysis of environmental deterioration impacts on Product structure (for civil and military Product usage)
- Introduction of the category "maintenance relevant structure" besides Structure Significant Items (SSI) and "other structure"
- Introduction of Significant Details (SD) to be defined on an SSI (if necessary)
- Modularity of the Zonal analysis methodology to allow the analysis of non-aeronautical technical Products
- Harmonization of PMTR with intervals in between the single analysis sources (System, Structure and Zonal Analysis) and with external sources for PMTR,
- Introduction of an In-Service Maintenance Optimization (ISMO) process with logics to be applied during the Product in-service phase,
- Interconnection of the initial analysis results from developing PMTR with intervals (refer to Chap 2) with the ISMO analysis (refer to Chap 3) for continuously improving maintenance,
- Description of S4000P interfaces within the S-Series of specifications. Refer to Chap 4.
- Description of S4000P interfaces to and from outside the S-Series of ILS specifications. Refer to Chap 4.
- Modifications in definitions and processes to meet individual Product types

2.2 Objective

The objective of this specification is to provide practice-based analytical methodologies for developing PMTR with intervals as the basis for elaboration of initial preventive maintenance programs for Products. In addition a process for continuously improving preventive maintenance during the Product in-service phase is provided. Refer to Chap 3 for ISMO.

Project regulatory requirements must be met (if any) and the specified processes/ methodologies must be acceptable to involved customers and manufacturers. It can be applied to any Product that needs to meet continued Product safety, law conformity, environmental integrity and mission/operational requirements at minimum cost and hence justify the costs of applying the methodology.

This specification concentrates on covering the peacetime scenario for in-service Product usage under specified usage conditions (eg, those defined in a Product use study). If an analysis is partially, or as a whole, based on design solutions that are not completely frozen, it should be recorded in the respective analysis for being updated at a later stage.

2.3 Preparation of a Product-specific PPH

It is important to be noted, that this specification must be tailored in a Policy and Procedures Handbook (PPH) to the specific requirements of the Product under analysis ensuring that all these requirements are met. All assumptions, guidelines and information applying to the Product analysis project as a whole, and not only to an individual S4000P analysis, are to be documented in an appropriate PPH, in business rules, in a User's Guideline or a similar document.

During development of the PPH, special attention must be paid to the following aspects:

- For international projects, having a split of Product design and development responsibilities, the responsibilities and work shares for the analysis of systems, structure and zones must clearly be defined
- The overview of responsibilities must cover the complete hard- and software of the Product under analysis
- Customers/users inputs or specifications are required to support analysts in making decisions for maintenance task applicability and effectiveness during the performance of analysis (intended or specified information regarding Product usage, different usage scenarios, etc)
- It is recommended to define the following information in an overview list of the Product with systems, structure and zones documented in the PPH:
    - Systems which have to be analyzed in the frame of S4000P system analysis only
    - Structure which has to be analyzed in the frame of S4000P structure analysis only
    - Systems which have to be analyzed for both S4000P system and structure analysis
    - Zones which have to be analyzed based on which S4000P zonal analysis module (eg, with all zonal analysis modules or with limited analysis modules)
    - Systems, structure or zones which are excluded from S4000P analysis including a justification for it

With the view on the whole Product life cycle two variants of a PPH are recommended for preparation:

- PPH for the development of PMTR with intervals (in parallel to the D&D process)
- PPH for In-Service Maintenance Optimization (ISMO-PPH)

Each PPH should contain all information and details required to perform the analysis according to this specification. This includes a detailed description of every usage scenario foreseen for the Product under analysis. Specific in case a customer usage exceeds or does not meet the design usage scenario, respective information should be highlighted in the PPH.

Prior to start the analytical activities the PPH should be prepared and harmonized in common with and signed by responsible authorities.

2.4 Maintenance program/OMP development

All PMTR with intervals resulting from S4000P system-, structure- and/or zonal analysis will initially be consolidated (refer to Chap 2.5) prior to be forwarded and entered into an applicable storage means for a further logistic support analysis (refer to S3000L).

Packaging of PMTR with intervals is a prerequisite for the later in-service phase performance of Product maintenance at the individual customer. The specification AIA / ASD S3000L describes rules and processes how to package PMTR with numerical interval values and task types developed on basis of S4000P (refer to Chap 10 in S3000L). Adjustment of selected maintenance task interval types and the numerical interval values can become necessary in order to produce the Product maintenance program / Operator Maintenance Plan (OMP).

Packaging rules and processes comprise:

- PMTR with intervals must be checked, if they are still conform with individual customer usage parameters. The assumption of Product usage parameters has been the basis for both the design and the analysis for developing PMTR. In case the customer deviates, the impact on PMTR with intervals has to be determined.
- Definition of maintenance task cluster(s) either calendar oriented (eg, yearly) or oriented on usage parameters, for example, every 1000 operating hours.

In addition AIA/ASD S3000L requires and describes the Maintenance Task Analysis (MTA) both for the single PMTR and for resulting task packages/clusters.

Accepted and released preventive maintenance task packages lead to the Product maintenance program / OMP that is to be provided as a Product technical publication. Refer to S1000D.

2.5 Maintenance program/OMP optimization during a Product in-service phase

The In-Service Maintenance Optimization (ISMO) process and logics (refer to Chap 3) define rules and methodologies how to correctly optimize the preventive Product maintenance during the in-service phase.

The accepted and authorized output of each ISMO analysis loop requires an updated packaging of the PMTR with intervals prior to produce the next generation of the Product maintenance program / OMP done by the responsible for the Product technical publication.

3 Project organization

3.1 General

To ensure the effective management and conduct of

- the development of PMTR in accordance with S4000P during the Product design and development phase

and/or

- the correct application of the ISMO methodology during the Product in-service phase

the project organization should consist of appropriate stakeholders as representatives of the Product.

Note

For S4000P analysis, the project organization has to be staffed by representatives from the following bodies/stakeholders:

- Operators

- Manufacturers (Product and equipment manufacturers)
- Regulatory authorities, if required

The final decision process including the specialist involvement will be decided by the Product manufacturer in accordance with the program objectives, contract and certification requirements. This means that it is up to the Product manufacturer to decide the organization required, support documentation and the involvement of operators, authorities, equipment manufacturers, etc, into the process. Details must be described in the PPH.

3.1.1 Program steering committee

A program Steering Committee (SC) should be established and should hold the responsibility for managing preventive maintenance development and improvement activities. The program SC should comprise members from representative stakeholders including, but not limited to, operator(s), the prime manufacturer, the main equipment manufacturers and regulatory authorities.

The program SC should be responsible for:

- overall governance and setting of both policy and initial goals for the preventive maintenance of a Product
- providing directions to working group activities
- liaising with manufacturers and operators, as required
- preparing the final recommendations
- ensuring that a Product specification for preventive maintenance development or for ISMO is fully applied on the complete Product (systems, structure and zones)
- coordinating inputs related to Product preventive maintenance
- …

Where applicable, the program SC should advise working groups to fully account for vendor requirements, accepting them only if they are both applicable and effective according to the criteria of S4000P.

3.1.2 Working groups

Specialist working groups should be formed as necessary to perform the analysis work. Members of these working groups should be suitably qualified and experienced specialists from the appropriate stakeholders (operators, manufacturers, suppliers and regulatory authorities).

In order to ensure the correct application of the specification, every personnel involved in the analysis work, must be trained before starting any analytical work.

In parallel, the program SC will explore all possible avenues in order to obtain the detailed technical information necessary to enable the working groups to

- determine applicable and effective PMTR with intervals
- highlight redesign requirements and/or recommendations on basis of analysis results
- evaluate the effectiveness and applicability of scheduled maintenance tasks with intervals from the Product technical publication in the frame of ISMO using in-service data / information

In all cases there should be an auditable documented trail to support the recommendations from the working groups to the SC. Once these recommendations have been approved by the SC all supporting evidence and analyses should, when required, be consolidated into a final report for submission to the involved regulatory authorities.

4 Analysis methods within the S4000P specification

S4000P provides analysis methods in the following chapters:

- Development of PMTR with intervals. Refer to Chap 2.

- Systems analysis. Refer to Chap 2.2.
- Structure analysis. Refer to Chap 2.3.
- Zonal analysis, including enhanced zonal analysis, L/HIRF analysis and other analysis modules. Refer to Chap 2.4.
- In-service maintenance optimization (ISMO). Refer to Chap 3.
- ISMO preparation phase. Refer to Chap 3.2.
- ISMO analysis phase. Refer to Chap 3.3.
- ISMO follow-up phase. Refer to Chap 3.4.

Each above mentioned chapter contains its own explanatory process with decision logic diagrams, as appropriate.

Single above mentioned S4000P chapter may be used independently from the other S4000P chapters.

All abbreviations, terms and acronyms used in the listed chapters of this S4000P specification are collected in Chap 5.

Chapter 2

Development of preventive maintenance task requirements with intervals

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
Chap 2.1	General
Chap 2.2	System analysis
Chap 2.3	Structure analysis
Chap 2.4	Zonal analysis
Chap 2.5	Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources, traceability

1 General

This chapter starts with an introduction (Chap 2.1) and continues with the description including the explanation of analysis methodologies for Product system analysis (Chap 2.2), for Product structure analysis (Chap 2.3) and for the analysis of product zones (Chap 2.4).

The consolidation/harmonization of all results from the single analysis sources above and the traceability of analysis sources per preventive maintenance task requirement (PMTR) with interval are described in Chap 2.5.

Chapter 2.1

General

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
Chap 1	Introduction to the specification
Chap 2.2	System analysis
Chap 2.3	Structure analysis
Chap 2.4	Zonal analysis
Chap 2.5	Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources, traceability
Chap 3	In-service maintenance optimization (ISMO)
S3000L	International specification for Logistics Support Analysis - LSA

1 Introduction

Each new Product or Product variant must have a set of preventive maintenance tasks with intervals developed prior to its introduction into service, in accordance with this analysis methodology.

This chapter is applicable for being applied during the Product design and development phase and in the frame of limited developments/modifications during the Product in-service phase.

1.1 Purpose

The purpose of this specification is to assist the prime manufacturer, Original Equipment Manufacturers (OEM) and involved regulatory authorities in developing initial Preventive Maintenance Task Requirements (PMTR) with interval types and interval values for new Products under development.

The analytical process determines applicable and effective PMTR with intervals to keep the inherent safety and reliability levels, the law conformity including environmental integrity of the Product from the beginning of the in-service phase.

In addition, further PMTR and intervals are to be selected to meet Product operational/mission availability and/or economical operator requirements (to achieve specified or predicted Product's Life Cycle Costs (LCC)).

Maintenance tasks with intervals resulting from this analytical methodology are the minimum PMTR, leading to the Operator Maintenance Plan (OMP). Refer to Chap 1 and Chap 2.4.

If preventive maintenance is either not applicable and/or effective for the Product design under analysis, re-design must be required or recommended, depending on the Functional Failure Effect Criticality (FFEC) of the Failure Cause (FC) under analysis.

Identified PMTR with intervals can be revised in light of actual experience that is accumulated throughout the Product use during the in-service phase. The relevant ISMO process is described in Chap 3.

1.2 Approach

The following essential points must be addressed in detail with regards to achieve efficient preventive maintenance of a Product:

- Objectives
- Content
- Method of development

1.2.1 Preventive maintenance objectives

The primary objectives related to efficient preventive Product maintenance are:

- to keep the inherent Product safety level, conformity with law (covering the environmental integrity), mission/operation accomplishment and reliability levels of the Product
- to maintain inherent Product safety, mission/operation accomplishment and reliability levels when deterioration has occurred
- to achieve these objectives at minimum costs
- to provide the information required for design changes/improvements and where necessary to exclude impact on law and minimise impact on the environmental integrity

Note

Preventive maintenance cannot correct deficiencies in the inherent safety and reliability levels of the Product. Should the inherent levels be found to be unsatisfactory, design change or modification will be necessary to obtain Product improvement.

1.2.2 Preventive maintenance content

The content of the preventive maintenance consists of a group of PMTR to be accomplished at specific interval types and numerical interval values. The guidance to determine and select these PMTR with intervals is defined in this specification. The subsequent development of a preventive maintenance program/Operator Maintenance Plan (OMP) for operators/customers includes a concept how to package the single PMTR with intervals and how to adapt selected intervals in an appropriate way. Refer to S3000L.

An efficient preventive maintenance program/OMP is one which schedules only the minimum PMTR with intervals necessary to meet the above mentioned objectives.

1.2.3 Method for preventive maintenance development

A Product's design and development evolves until its completion. Therefore, the planning for the scope, content and depth of the analytical process for developing PMTR with intervals must take this evolution into account.

To support the Product design responsible departments from a very early stage in an effective way, engineering support departments (reliability-, maintainability-, testability- and safety experts) must provide the results from their analytical work and from maintenance in-service experience from other Products.

This is because:

- Mandatory redesign requirements must be identified during the Product development phase as early as possible
- If PMTR are not applicable and/or effective, a feedback to the responsible engineering departments is essential latest before the Critical Design Review (CDR) takes place
- After a first analytical approach, identified PMTR with intervals must be checked in parallel to design-updates (if any). Completion work and/or updates of analysis results must ensure conformity with the latest (serial) Product design status.

The development of PMTR with intervals for a Product is based on three analytical methods provided within this specification:

- System analysis. Refer to Chap 2.2.
- Structure analysis. Refer to Chap 2.3.
- Zonal analysis. Refer to Chap 2.4.

Results from every method must be harmonized and consolidated on basis of Chap 2.5.

1.2.4 Selection of system and/or structure analysis methodology

The determination of Analysis Relevant Candidates (ARC) according to the system analysis (refer to Chap 2.2) must not be confused with the selection of Structure Significant Items (SSI) that is part of the structure analysis in Chap 2.3.

In order to avoid confusion and to ensure that all ARC or SSI of a Product are analyzed, an overview on analysis methodologies to be applied is recommended in the PPH. Refer to Chap 1.

Examples (from aviation technology):

- A landing gear system on a fixed wing aircraft must be analyzed both with the S4000P system analysis and with the S4000P structure analysis methodology.
- The main rotor assembly on a rotary wing aircraft (helicopters) must be analyzed both with the S4000P system analysis and with the S4000P structure analysis methodology.

Chapter 2.2

System analysis

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 1	Introduction to the specification
Chap 2.5	Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources, traceability
Chap 3	In-service maintenance optimization (ISMO)
Chap 5	Terms, abbreviations and acronyms
S1000D	International specification for technical publications using a common source database
DIN/EN Norm 31 051/(DIN/EN 13306)	Begriffe zur Instandhaltung/(Maintenance Terminology)
SAE ARP 5580	Engineering Society For Advancing Mobility Land Sea Air and Space International (SAE), Issue 2001

1 System analysis procedure

The determination of Preventive Maintenance Task Requirements (PMTR) with intervals for systems, including installed components and equipment must follow a clear process sequence using logic diagrams to support all analytical decisions.

The sequence of the chapters in this document represents the sequence of the work steps which are recommended to perform a Product system analysis.

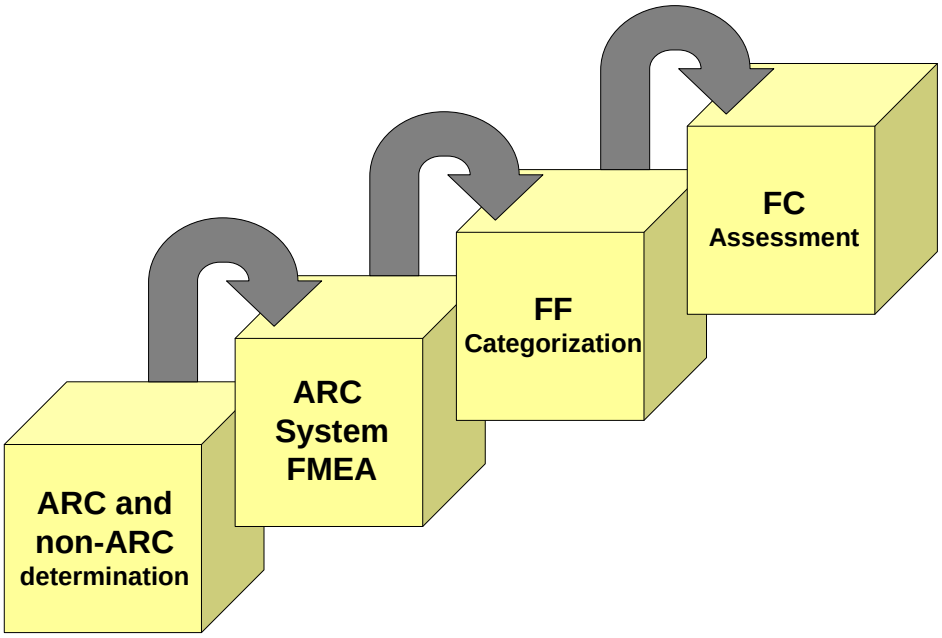
The determination of Analysis Relevant Candidates (ARC) in common with the identification of candidates not being relevant for analysis (non-ARC) is followed by a system Failure Mode and Effects Analysis (FMEA).

Principally, the FMEA evaluations are based on the Functions (F), Functional Failure Effects (FFE), and the respective Failure Causes (FC) identified for selected ARC.

Based on the FMEA results the criticality of each Functional Failure (FF) has to be categorized on basis of a given logic diagram. Another logic diagram is used to determine PMTR with intervals or to give redesign feedback to the responsible design department for each identified Failure Cause (FC).

To cover a crisis/war scenario of military Products and/or specific civil Product usage conditions, the determination of the ARC, the identification of non-ARC and the further analysis procedure must be adapted accordingly.

All used terms, abbreviations and acronyms are listed in Chap 5.



ICN-B6865-S4000P0002-001-01

Fig 1 System analysis process overview

2 ARC and non-ARC determination process

2.1 Scope of ARC and non-ARC determination

The main scope is to identify all Analysis Relevant Candidates (ARC) for the systems/components of the Product under analysis.

Additionally Product items not relevant for a further/deeper system analysis (categorized as non-ARC) are also identified prior to starting the system FMEA.

The determination of ARC and non-ARC clarifies the amount of candidates for analysis and supports the reduction of the system analysis effort.

Hereafter the chronological order of activities is described.

2.2 Establishment of a Product breakdown structure

Prior to determining ARC and non-ARC, the responsible Product design departments usually provide a Product design approach that is intended to fulfill the functional requirements specified for the Product under analysis.

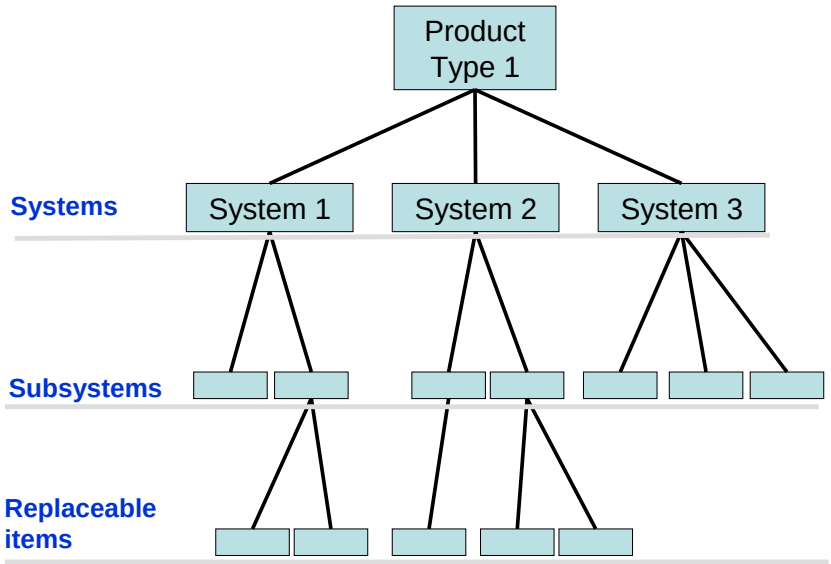
Specific in very early project phases, a suitable Product breakdown structure might not be available to immediately start the S4000P system analysis. In this "worst case" scenario an initial Product breakdown must be elaborated following the rules described in S1000D and taking into account the following aspects:

Two main types of Products must be taken into account when determining the Product breakdown structure:

- Product **Type 1**
- Product **Type 2**

2.2.1 Product Type 1

Product Type 1 as a unit comprises all technical systems installed within and/or directly on a common Product structure. The common Product structure can be subdivided into dedicated zonal areas. For Product Type 1 the analysis relevant usage data and assumptions are valid for the whole Product under analysis.



ICN-B6865-S4000P0003-001-01

Fig 2 Product Type 1 breakdown principle

Examples:

- Manned aircraft
- Train
- Ship

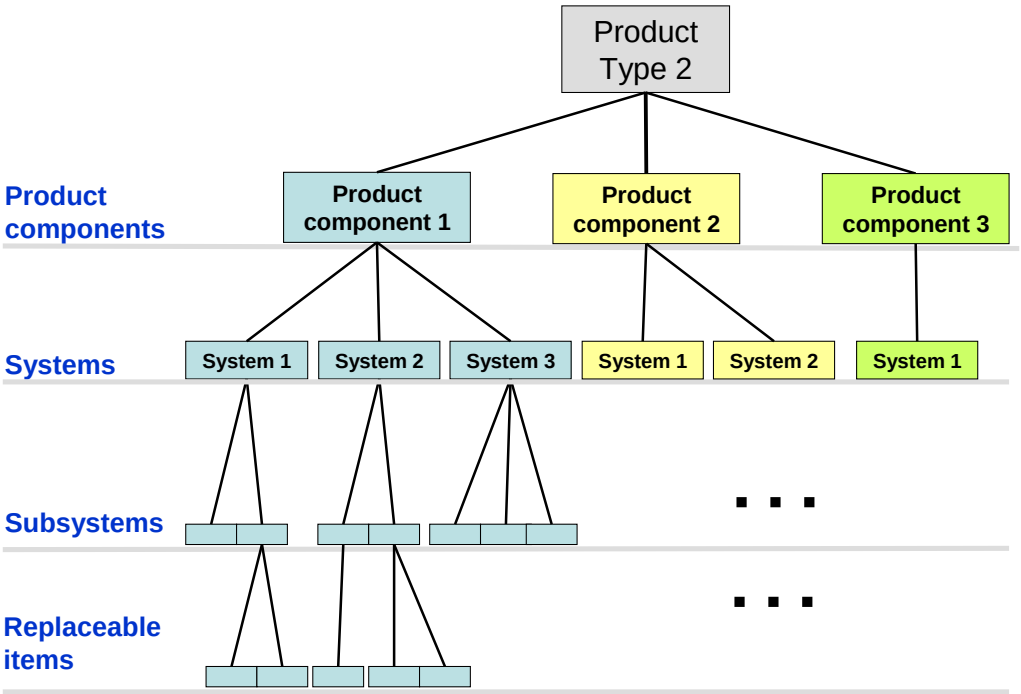
2.2.2 Product Type 2

Product Type 2 has a "higher Product complexity level" in comparison to Product Type 1. Product Type 2 must first be subdivided into its major Product components. Each component of this Product type must be subdivided into its technical systems, structure and zonal areas.

Analysis relevant data and assumptions are to be defined for each Product component. The data/assumptions may be significantly different between single Product components.

Note

It is recommended to prepare one PPH for the analysis of each Product component of Product Type 2.



ICN-B6865-S4000P0004-001-01

Fig 3 Product Type 2 breakdown principle

Example:

– Unmanned Air Vehicle (UAV) Systems that may comprise different types of ground stations/components next to the airborne components. A Product Type 2 is also known as a "System of systems".

The hardware and software of a Product has to be divided and arranged into major functional areas, systems and subsystems (refer to S1000D). All Product items/equipment must be covered within the Product breakdown structure.

The responsible analyst defines the highest manageable levels in the Product breakdown structure of the system under analysis ensuring that the analysis relevant breakdown is covered. The higher the selection of the manageable levels the less the number of Product candidates for ARC and non-ARC determination.

Note

Product structure (ie, S1000D System 51 thru System 57) that can contain items/subsystems being functionally relevant (eg, fuselage drains, door mechanisms) must be included in the ARC analysis process and must be coordinated with the Product structure analyses. In addition, for all safety/emergency systems or similar equipment, appropriate information transfer on an analyst/expert-level must be established.

2.3 Preparation of a list for ARC/non-ARC determination

On the basis of the Product breakdown structure, the manufacturer determines the list of items to which the ARC/non-ARC determination will be applied. If portions of the Product breakdown

structure can be excluded from ARC/non-ARC determination both the appropriate justification and the indication of those impacted portions of the Product breakdown structure must be documented.

2.4 Determination of ARC/non-ARC

The ARC/non-ARC determination comprises a set of decisions on functional failure effects in case the item function fails.

When answering these questions all ARC are identified.

The responsible analyst for the ARC/non-ARC determination has to apply the following questions to the list of items identified in the previous chapter:

- **Question 1**: Could a Functional Failure (FF) affect Product safety, including safety/emergency systems and/or emergency equipment?
- **Question 2**: Could a FF conflict with law and/or could the FF have a significant impact on environmental integrity (ecological damage)?

  Note

  It is recommended to agree the criteria of significance with involved authorities and to define it in the PPH.

- **Question 3**: Could a FF have an impact on mission/operational capability?
- **Question 4**: Could a FF of the selected item have significant economic impact?

  Note

  It is recommended to agree the criteria of significance with the customer/user and to define it in the PPH.

Question 1 and Question 2 are related to Product safety and Product conformity with law/environmental integrity. If one of these questions is answered "YES" the full S4000P system analysis must be conducted. Therefore "YES" on Question 1 and/or Question 2 defines the item under analysis as an ARC.

If both Question 1 and Question 2 are answered "NO" and one or both answers on Question 3 and Question 4 are answered "YES", the decision for a full S4000P system analysis must be evaluated.

Note 1

A full item analysis in line with S4000P system analysis is required in case of for example, contractual requirements (eg, Performance Based Logistics (PBL)). In this case the item under analysis becomes an ARC. Non selected items (non-ARC) will not be subject to further system analysis. PMTR with intervals can also be decided during the later in-service phase using the ISMO process. Refer to Chap 3.

If

- Question 1 thru Question 4 are answered "NO"

or

- Question 1 and Question 2 are answered "NO" and Question 3 and/or Question 4 are answered "YES" in accordance with Note 1 above,

than no further system analysis is required and the item is classified as a "non-ARC".

Note

System analysis for a selected ARC will not necessarily result in a PMTR with an interval.

Note

In complex technical Products comprising of several components which may be located and operated in different places (eg, Unmanned Air Vehicle (UAV) system components), Product components which have been identified as ARC may be handled/operated by different crews/personnel. Therefore FFE have to be analyzed and judged separately for the ARC of different Product components.

FF for, for example, on "Unmanned" Air Vehicles (UAV) cannot endanger human beings on board during flight for obvious reasons. However, human beings on the ground or in another manned aircraft flying in a common airspace can be endangered by a FF of a UAV.

UAV ground components directly linked to UAV guidance and control may be allocated to the same categories of criticality.

In addition, UAV ground components have to be analyzed for FF of items/equipment/subsystems which are ground safety relevant. FF may have FFE during ground component handling (disassembly, packaging, transporting, undo packaging, assembly, test) and/or during their operating/mission periods.

The results out of the ARC/non-ARC determination must then be recorded in the ARC/non-ARC list. An example of that list is shown in Fig 4.

		Product System Analysis ARC / non-ARC determination							
				DETERMINATION QUESTIONS					
S4000P CODE	**Design Identi-fication Drawing-No Part-No etc**	**S1000D SNS DMC S3000L LCN / PBI / etc …**	**ITEM NAME**	**Could a Functional Failure (FF) affect Product safety, including safety/ emergency systems and/or emergency equipment ?**	**Could a FF conflict with law and/or could the FF have a significant impact on environmental integrity (ecological damage) ?**	**Could a FF have an impact on mission/ operational capability ?**	**Could a FF of the selected item have significant economic impact ?**	**ARC ?**	**REMARKS**
A	**TBD**	**TBD**	**PRODUCT ITEM A**	Yes	Yes	Yes	Yes	**Yes**	
B	**TBD**	**TBD**	**SUBSYSTEM 1**	Yes	No	No	No	**Yes**	
C	**TBD**	**TBD**	**SUBSYSTEM 2**	No	Yes	No	No	**Yes**	
D	**TBD**	**TBD**	**SUBSYSTEM 3**	No	No	Yes	Yes	**To be evaluated**	**Decision depending on contract etc**
E	**TBD**	**TBD**	**SUBSYSTEM 4**	No	No	Yes	No	**To be evaluated**	**Decision depending on contract etc**
F	**TBD**	**TBD**	**SUBSYSTEM 5**	No	No	No	Yes	**To be evaluated**	**Decision depending on contract etc**
G	**TBD**	**TBD**	**SUBSYSTEM 6**	No	No	No	No	**No**	**Non-ARC; System Analysis stops**

ICN-B6865-S4000P0005-001-01

Fig 4 Example ARC/non-ARC list

2.5 Presentation and approval of ARC/non-ARC results

The results from the previous chapter have to be documented in the Product ARC/non-ARC list and presented to the project Steering Committee (SC), which must check and approve this list for subsequent allocation and distribution to responsible analysts.

2.6 Ongoing control of ARC/non-ARC determination

Each analyst has to:

- monitor the completeness of selected ARC throughout the application of S4000P analysis activities
- validate and control the correct selection of the highest manageable item level
- propose modifications with justifications (if required) of the ARC/non-ARC list to the project SC

The primary aim is to verify that no ARC has been overlooked, and that the right level for the analysis has been chosen, taking into account the current Product configuration and it is configuration variants (if any). For that purpose the manufacturer has to ensure that responsible analysts are integrated in established engineering change processes.

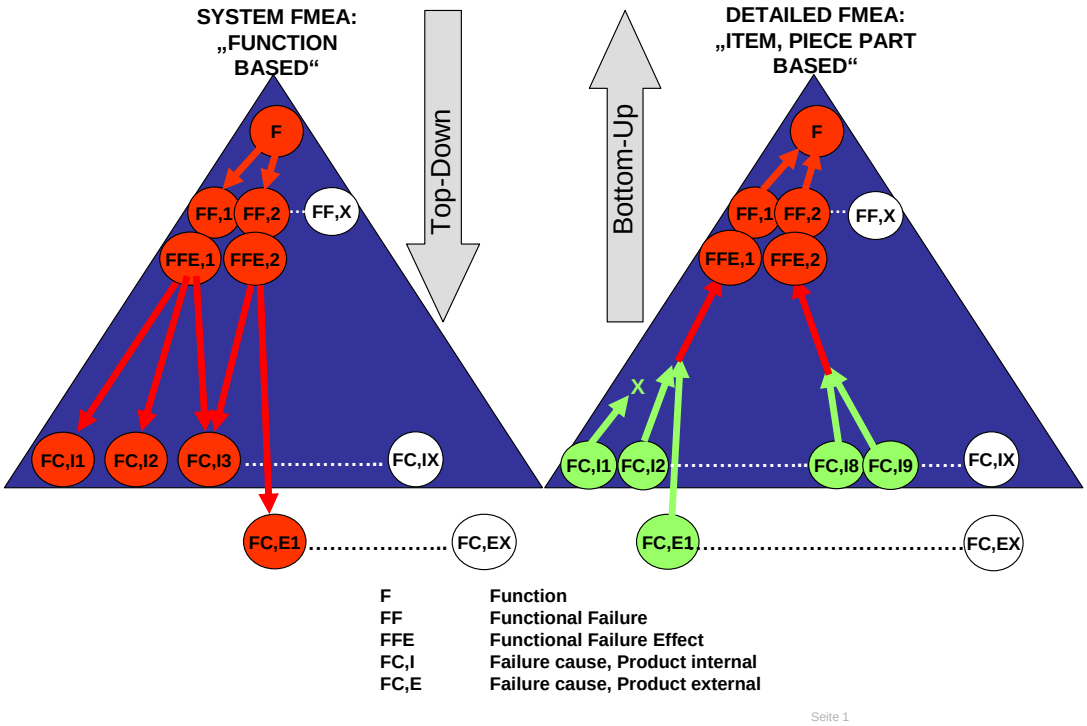
3 ARC System-FMEA

This is a "top-down" Failure Mode and Effects Analysis (FMEA) method in comparison to a "bottom-up" analysis method.

Note

For a better understanding of "top-down" and "bottom-up" FMEA principles. Refer to Fig 5.

The specification SAE ARP 5580 subdivides FMEA into different types. Fig 5 shows the principle of a System FMEA (= top-down analysis) in comparison to a detailed (equipment) FMEA (= bottom-up analysis):



ICN-B6865-S4000P0006-001-01

Fig 5 Top-down and bottom-up FMEA principles

As shown in Fig 5, a system FMEA on the basis of a top-down analysis identifies the relevant Failure Causes (FC). Other FC without a direct impact on a FF are not selected. These direct FC can be either Product internal (as an inherent part of the Product hardware and software) or Product external (not a part of Product hardware and software).

Failure Mode and Effects Criticality Analysis (FMECA) is a detailed FMEA extended by an assessment of failure mode severity and probability of occurrence. FMECA applies the bottom-up analytical approach specific for safety relevant Product functions. Combinations of single FC (Fault Tree Analysis (FTA)) must also be analyzed using the FMECA and its "bottom-up" analytical methodology.

After ARC has been selected and prior to applying further S4000P system analysis activities, a System-FMEA must be prepared for each ARC listing:

- **Function (F)** — One or more Functions of the ARC under analysis
- **Functional Failure (FF)** — One or more Functional Failures identified for each ARC function
- **Functional Failure Effect (FFE)** — The potential "worst-case" end effect of each FF resulting on Product level
- **Failure Cause (FC)** — One or more Failure Causes allocated to each FF with its FFE

As a prerequisite for the ARC analysis, a brief system/subsystem/item description must be prepared or be available (eg, provided by engineering).

Additionally, any analysis relevant data and/or information (eg, S1000D system reference, Product fleet applicability, manufacturer's part number, reliability figures, design principle (redundancy, etc) must be added for the ARC under analysis.

Collected data should be documented in an appropriate form (preferably in an IT tool). This dataset is the prerequisite for the further Product system analysis and must be part of the total preventive analysis data set of a Product.

A detailed understanding of the ARC under analysis is essential to elaborate the ARC System FMEA that follows a top-down analysis approach.

The analyst must start with listing the ARC functions and not with analysis of single FC. The list of functions should be complete and not be restricted to the main functions only. There are almost secondary or minor functions that must be included in order to provide a complete view of the ARC functions.

3.1 ARC Functions

When defining an ARC function, the analyst must not only consider the function (as defined) but also the following:

- drawing the attention of the operators to abnormal conditions
- shutting down equipment in the event of functional failure
- eliminating or relieving abnormal conditions following a functional failure
- taking over from a failed function
- prevent dangerous occurrences from arising
- …

Functions of protective devices, emergency equipment and false operation (eg, untimely, unwanted exercising of the function) must be taken into account.

For example, system components with dual redundancy, such as concentric tubes, the function of both paths should be analyzed individually. The degradation and/or fault of one path may not be evident.

3.2 Functional failures

Each ARC Function may have one or more FF. In all cases the ARC fails to perform its intended function within specified limits.

For redundant systems/components, the loss of redundancy should be covered as a FF even if there is no direct impact on the normal operation of the Product.

Dormant FF of emergency equipment are safety relevant during normal Product operation/mission. For analysis purposes the prerequisites and/or circumstances must be explained.

Examples:

- Emergency release/cut function of a helicopter rescue hoist cable
- Engine emergency fuel shut-off valves
- Emergency power supply battery

3.3 ARC Functional failure effects

For each FF the "worst case" criticality of the functional failure effect on Product level must be evaluated. Functional Failure Effect (FFE) on the performance of the Product (end item) must be defined for both evident and hidden FF.

3.4 ARC Failure causes

FC lead to FF and must be defined in such a way that an effective assessment of applicable PMTR can be made during the FC assessment analysis (refer to Para 4.2). The FC should not just identify a component and how it fails (eg, mechanical or electrical fault, failing in open or closed position, open or short circuit, jammed linkage, contaminated orifice, broken housing).

More than one FC can contribute to a FF. Product internal FC as well as Product external FC can lead to such a combination.

Single FC might be involved in several FF with FFE.

Note

Items or parts, which are not a direct part of the system under analysis, may also be identified as a probable FC in the ARC under analysis.

The following items/interfaces can be the FC for a FF of the ARC under analysis. However these items/interfaces are not covered by the ASD system of this ARC:

- wires transferring electrical signals
- wires transferring electrical power
- tubes/pipes with/without pressurized fluids (eg, from hydraulic system)
- other Product subsystems or single items being connected to the system under analysis to ensure system functions
  To cover items/parts of other Product systems, the information about the related FC must be handed over and documented from the analyst of the ARC to the responsible analyst of the respective item/other system.

  The definition of applicable and effective PMTR for these FC must be decided by the analyst of the respective S1000D system/subsystem/sub-subsystem.

  Special attention must be paid to all probable FC of those other systems, which are linked to safety relevant FFE of the ARC under analysis.

  Correct information transfer has to be ensured specific in multinational development programs or in programs with a share of the design responsibility on different companies.

3.5 Documentation of ARC System-FMEA

A complete and correct ARC System-FMEA is the prerequisite in performing further system analysis steps.

The content of the ARC System-FMEA is recommended to be accepted by the responsible system design engineering and/or by safety departments.

For a traceable overview on all analysis results of the ARC System-FMEA, a tabular form is appropriate as it is shown in Fig 6.

ASD S4000P SYSTEM ANALYSIS					**ARC Logistic Control Number (LCN) or similar identification number**				
ARC FUNCTION AND FAILURE DATA SHEET / TABLE					ARC nomenclature				
Date		Name			TBD				
REF F	**FUNCTION (F)** **Function(s) of the ARC under analysis**	**REF FF**	**FUNCTIONAL FAILURE (FF)** **One or more Functional Failure(s) identified for each ARC function**	**REF FFE**	**FUNCTIONAL FAILURE EFFECT (FFE)** **The potential "worst-case" end effect of each single FF on Product level**	**REF FC**	**FAULURE CAUSE (FC)** **One or more Failure Cause(s) allocated to each FF with its FFE**	**REMARKS**	**UPDATE / INFORMATION / ETC**

ICN-B6865-S4000P0007-001-01

Fig 6 ARC System-FMEA table, example

Note

Where applicable, the SC must advise subordinate working groups to fully account for vendor requirements, accepting them only if they are both applicable and effective according to the criteria of S4000P.

Note

At this stage the PMTR with intervals must cover the latest/final configuration status of the Product. In case of modifications during the in-service/usage phase or in case of Product variants following other build standards, the initial PMTR with intervals must be reviewed.

Note

The S4000P analysis also covers fault tolerant systems. Such systems are defined as those being designed with redundant elements, which can fail without impact on safety or the mission/operating capability. In other words, redundant elements of the system can fail (fault), but the system itself has not failed. Individually, and in some combinations, these faults may not be annunciated to the operating crew/personnel, but by design the Product can be operated indefinitely, despite the faults, while still satisfying its functional requirements.

Consequently a manufacturer's fault-tolerant system design enhances the in-service system availability.

Note

The results from the ARC System FMEA are an important basis for the later in-service maintenance optimization (ISMO) during the Product in-service phase (refer to Chap 3). FC once identified on a theoretical basis for single ARC functional failures can be compared with real data from in-service experience (eg, missing failure causes can be added and analyzed later on). Relevant failure causes per each functional failure can be evaluated in terms of their probability of occurrence while real Product usage. Bringing them into a sequence from the failure cause with highest probability down to the failure cause with lowest probability, failure trouble shooting will be supported.

4 Application of system analysis logics

Based on the results of the ARC System FMEA (Para 3), the analyst now applies the analysis logics for each Functional Failure (FF) and on all corresponding Failure Causes (FC) in accordance with this specification:

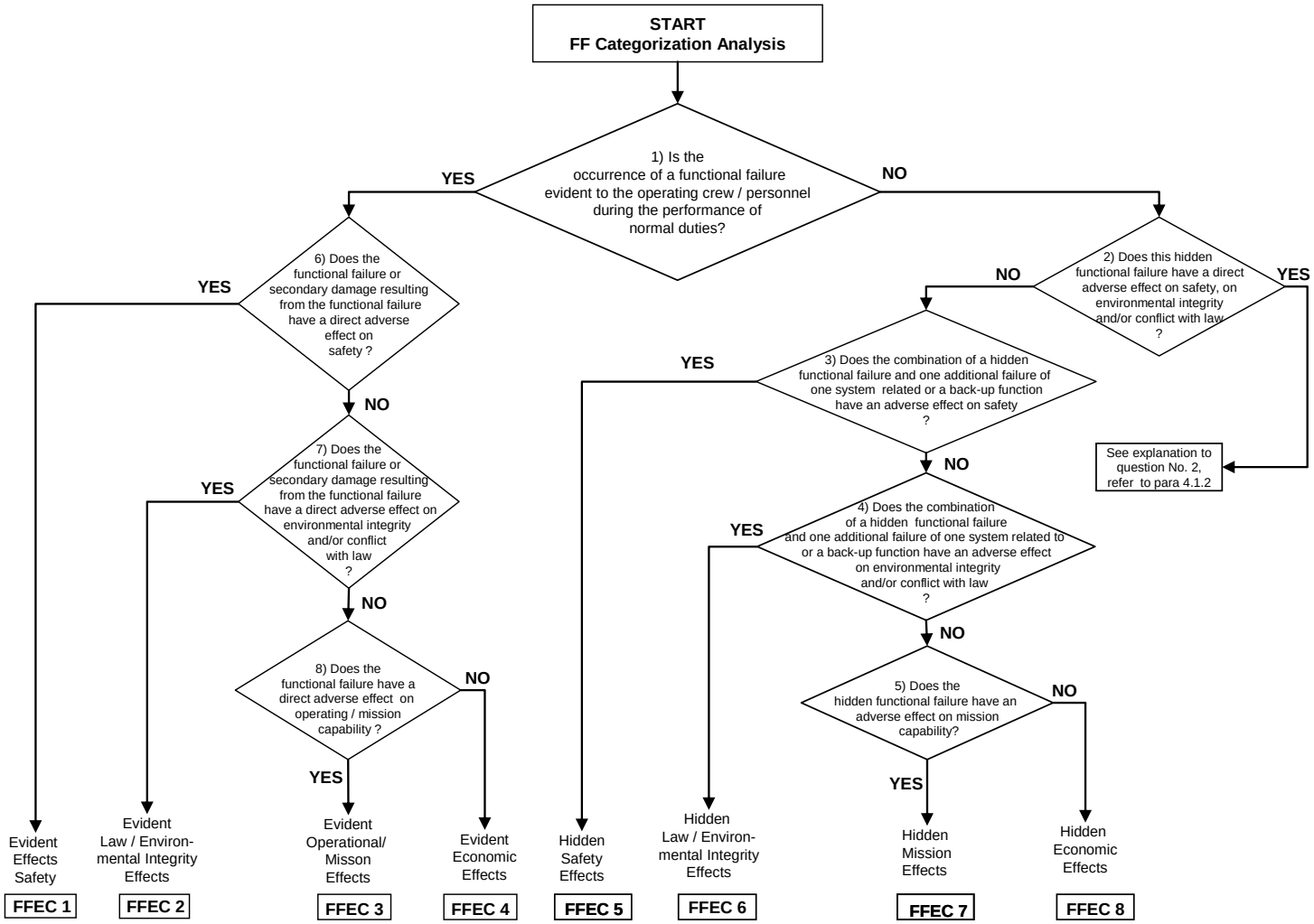
- **FF categorization logic** (Decisions 1 thru Decision 8) must be applied prior to the FC assessment logic. It requires the evaluation of the END EFFECT of each FF on Product level for determination of the Failure Effect Category (FEC) (eg, evident related to safety, mission, operation, law/environmental integrity, economy or hidden related to safety, law/environmental integrity, mission or economy).
- **FC assessment logic** (Decisions A thru Decision H). The logic starts with an approval, if preventive maintenance for the FC under analysis can be avoided by justification. Relevant criteria depend on the FFEC defined for that FC. If preventive maintenance is required, a selection of one or more applicable and effective PMTR follows.

  If more than one PMTR is identified, maintenance task type selection criteria will be provided by Table 2. If no PMTR is applicable and/or effective, redesign must be assessed by Table 3.

4.1 FF categorization logic

4.1.1 FF categorization logic diagram

The decision logic in Fig 7 is used for the analysis of FF in relation to system analysis. The logic flow is designed so that the analyst begins the analysis at the top of the diagram, and answers the "YES" or "NO" decisions which dictates the further direction of the analysis flow.



ICN-B6865-S4000P0008-001-01

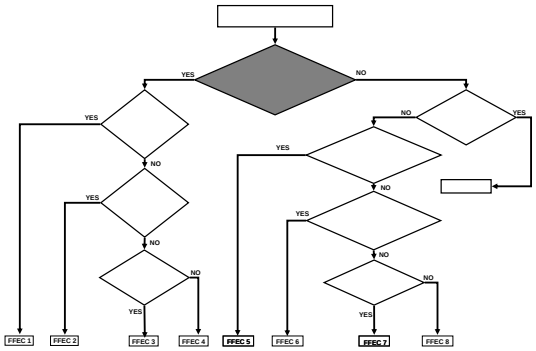
Fig 7 FF categorization logic diagram

4.1.2 FF categorization procedure

Each FF processed through the logic will be directed into one of the eight failure effect categories that is most analysis relevant.

The FF categorization is composed of following decisions with explanations hereafter.

Decision D1



ICN-B6865-S4000P0009-001-01

Fig 8 Decision D1

Is the occurrence of a FF evident to the operating crew/personnel during the performance of normal duties?

Decision D1 is related to each FF of the item under analysis. The intent is to segregate the evident and hidden FF.

The FF is classified as evident if the loss of function caused by its occurrence alone will eventually become apparent to the operating crew/personnel during normal duties during routine operation of the Product.

Where uncertainty exists with respect to the frequency of activation of certain systems of the Product, assumptions can be made in addition to the prerequisites given in the PPH. All assumptions must be recorded by the analyst.

Example (from aviation technology):

An Aircraft Flight Manual (AFM) is not available during the initial S4000P analysis in parallel to the Product design and development phase. Such an AFM will contain Flight crew "normal duties" and must be accomplished by the flight crew.

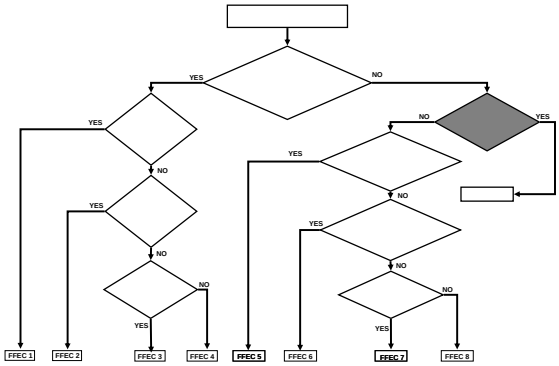
S4000P Working Groups (WG) can consider flight crew tasks as part of the operating crew/personnel's "normal duties" in advance. The respective functional failures covered by future Flight crew tasks are to be categorized as evident. Every S4000P analyst must document when such flight crew tasks are taken into account.

Once the AFM is available, all above mentioned assumptions made by the S4000P analysts must be verified to ensure that documented Flight crew tasks are included in the AFM. The FF categorization must be updated in case of a Flight crew task cannot be included into the AFM.

Answer: "YES" defines the FF is evident - continue to Decision D6.

Answer: "NO" defines the FF is hidden - continue to Decision D2.

Decision D2



ICN-B6865-S4000P0010-001-01

Fig 9 Decision D2

Does this hidden FF have a direct adverse effect on safety, on environmental integrity and/or conflict with law?

For additional design evaluation, this decision excludes single hidden FF that might have a potential impact on safety, on environmental integrity and/or conflict with law that should have been prevented already by initial design.

Note

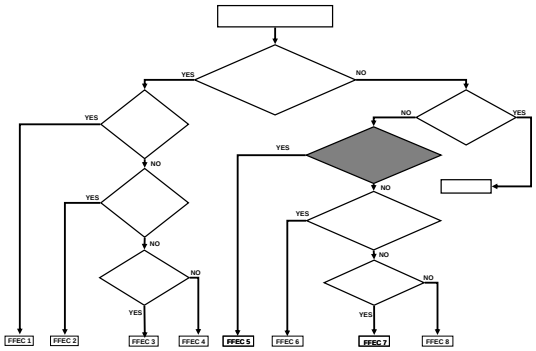
In general, this decision is applicable for none aircraft analysis, since aircraft certification rules excludes single hidden FF affecting safety, colliding with law and/or impacting environmental integrity.

Answer: "YES" determines a mandatory redesign for safety related functional failures.

For FF which can affect environmental integrity and/or conflict with law, redesign must be evaluated in detail according to applicable national/international laws and protocols.

Answer: "NO" indicates a fault tolerant system design (redundancy) and leads to Decision D3.

Decision D3



ICN-B6865-S4000P0011-001-01

Fig 10 Decision D3

Does the combination of a hidden FF and one additional failure of a system related or back-up function have an adverse effect on safety?

This decision is related of each hidden FF that has been identified in Decision D1.

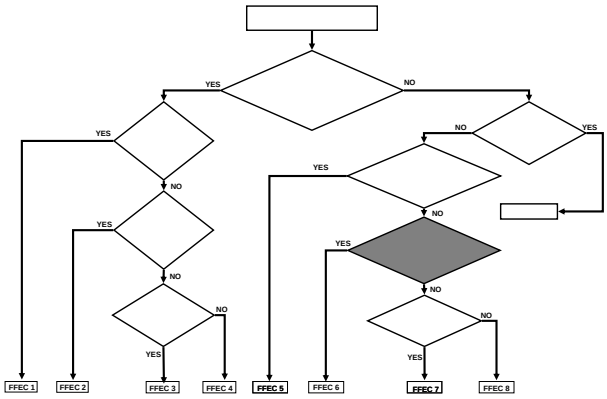
The decision takes into account failures in which the loss of the one hidden function (whose failure is unknown to the operating crew/personnel) does not of itself affect safety. However, in combination with an additional FF (system related or intended to serve as a back-up) has a direct or indirect adverse effect on safety.

For hidden functions of safety/emergency systems or equipment, the additional failure is the event for which this function of the system or equipment is designed (eg, failure of fire extinguisher in combination with the event "fire"). In these cases, a FFEC 5 (hidden safety effect) is to be selected.

Answer: "YES" defines that there is a hidden safety effect.

Answer: "NO" indicates that there is a hidden non-safety effect and Decision D4 must be answered.

Decision D4



ICN-B6865-S4000P0012-001-01

Fig 11 Decision D4

Does the combination of a hidden FF and one additional failure of a system related or a back-up function have an adverse effect on environmental integrity and/or conflict with law?

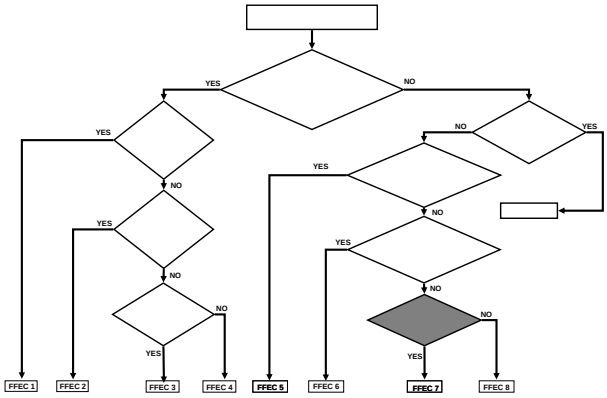
This decision considers the impact of hidden FF on environmental integrity and/or conflict with law.

Answer: "YES" defines that there is a hidden effect on environmental integrity and/or conflict with law.

Answer: "NO" implies that Decision D5 must be answered.

If this decision has been answered YES, the later FC assessment analysis must be conducted in relation to FFEC 6.

Decision D5



ICN-B6865-S4000P0013-001-01

Fig 12 Decision D5

Does the hidden FF have an adverse effect on mission capability?

This decision is related to each hidden FF not having an adverse effect on safety but can require use of abnormal mission procedures or limitation/cancellation of the mission.

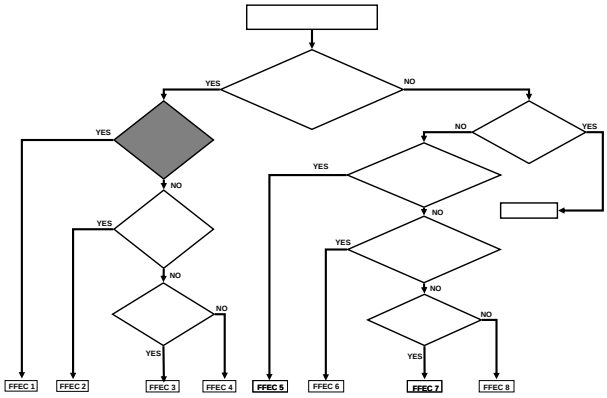
The assessment of whether or not a failure has an effect on mission capability can require consultation of documentation with mission procedures/manuals. FF affecting the performance of specific missions can also deteriorate operating capability.

Answer: "YES" defines that there is a hidden mission effect.

Answer: "NO" indicates that there is an economic effect.

Maintenance task requirements resulting from this assessment must be performed when the system under analysis is operated as described in the PPH. In case the PPH contains, for example, a second scenario that a system will not be used/activated for longer period the responsible analyst has to decide about PMTR with intervals covering that scenario.

Decision D6



ICN-B6865-S4000P0014-001-01

Fig 13 Decision D6

Does the FF or secondary damage resulting from the FF have a direct adverse effect on safety?

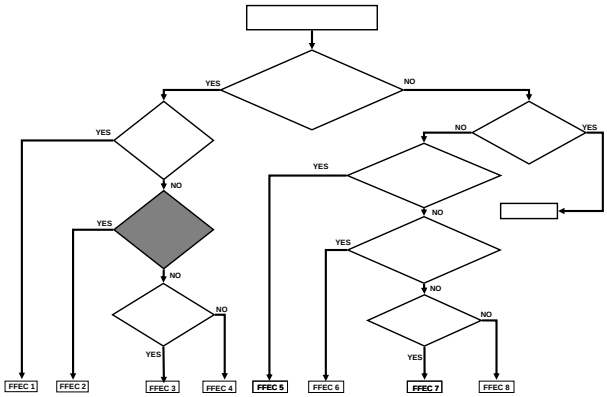
For a "YES" answer the FF must have a direct adverse effect on safety.

- Direct adverse effect on safety: To be direct the FF or resulting secondary damage must achieve its effect by itself, not in combination with other FF (no redundancy exists).
- Safety must be considered as adversely affected if the consequences of the failure condition can prevent the continued safe operation of the Product and/or might cause serious or fatal injury to human occupants/operator.

Answer: "YES" defines that this FF must be treated within the evident safety effect category and PMTR must be developed.

Answer: "NO" defines the evident FF is non-safety and Decision D7 must be answered.

Decision D7



ICN-B6865-S4000P0015-001-01

Fig 14 Decision D7

Does the FF or secondary damage resulting from the FF have a direct adverse effect on environmental integrity and/or conflict with law?

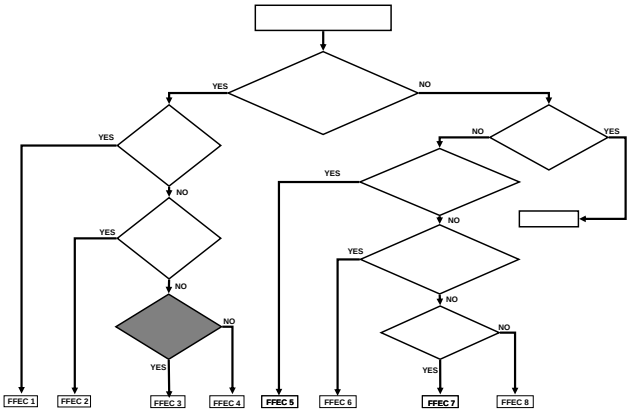
This decision has to take into account the influence of potential failures on law/environmental integrity.

Answer: "YES" defines an evident effect on environmental integrity and/or a conflict with law.

Answer: "NO" indicates that the effect is either operational/mission related or economic and Decision D8 must be answered.

If this decision has been answered "YES", the FC assessment analysis must to be conducted in the frame of FFEC 2.

Decision D8



ICN-B6865-S4000P0016-001-01

Fig 15 Decision D8

Does the FF have a direct adverse effect on operating/mission capability?

This decision is related to each evident FF not having a direct adverse effect on safety or law/environmental integrity. The answers can depend on the type of mission/operation.

Civil operations as well as the accomplishment of military missions can be considered.

The assessment of whether or not a FF has an effect on mission/operating capability can require consultation of documentation with mission/operational procedures/manuals and can require customer/operator involvement.

As the documents necessary to assess the effect on mission/operating capability are often not available during the initial S4000P analysis, all assumption for FF categorization analyses must be documented. Once the affected documents become available, all FF categorization analyses based on such assumptions must be verified.

Answer: "YES" answer is determined: There is an evident operational and/or mission effect.

Answer: "NO" answer indicates that there is an evident economic effect.

4.1.2.1 Functional failure effect categories in FF categorization analysis

Once the analyst has decided on the applicable FF categorization, the failures of the system under analysis are first separated into evident or hidden attributes.

With further assessment they are directed to the following eight Functional Failure Effect Categories (FFEC):

- **Evident safety (FFEC 1)**

  Evident FF with impact on safety

- **Evident law/environmental integrity (FFEC 2)**

  Evident FF with impact on environmental integrity and/or conflict with law

- **Evident operation/mission (FFEC 3)**

  Evident FF with impact on operation/mission

- **Evident economic (FFEC 4)**

  Evident FF with impact on economy

- **Hidden safety (FFEC 5)**

  Hidden FF with impact on safety

- **Hidden law/environmental integrity (FFEC 6)**

  Hidden FF with impact on environmental integrity and/or conflict with law

- **Hidden mission (FFEC 7)**

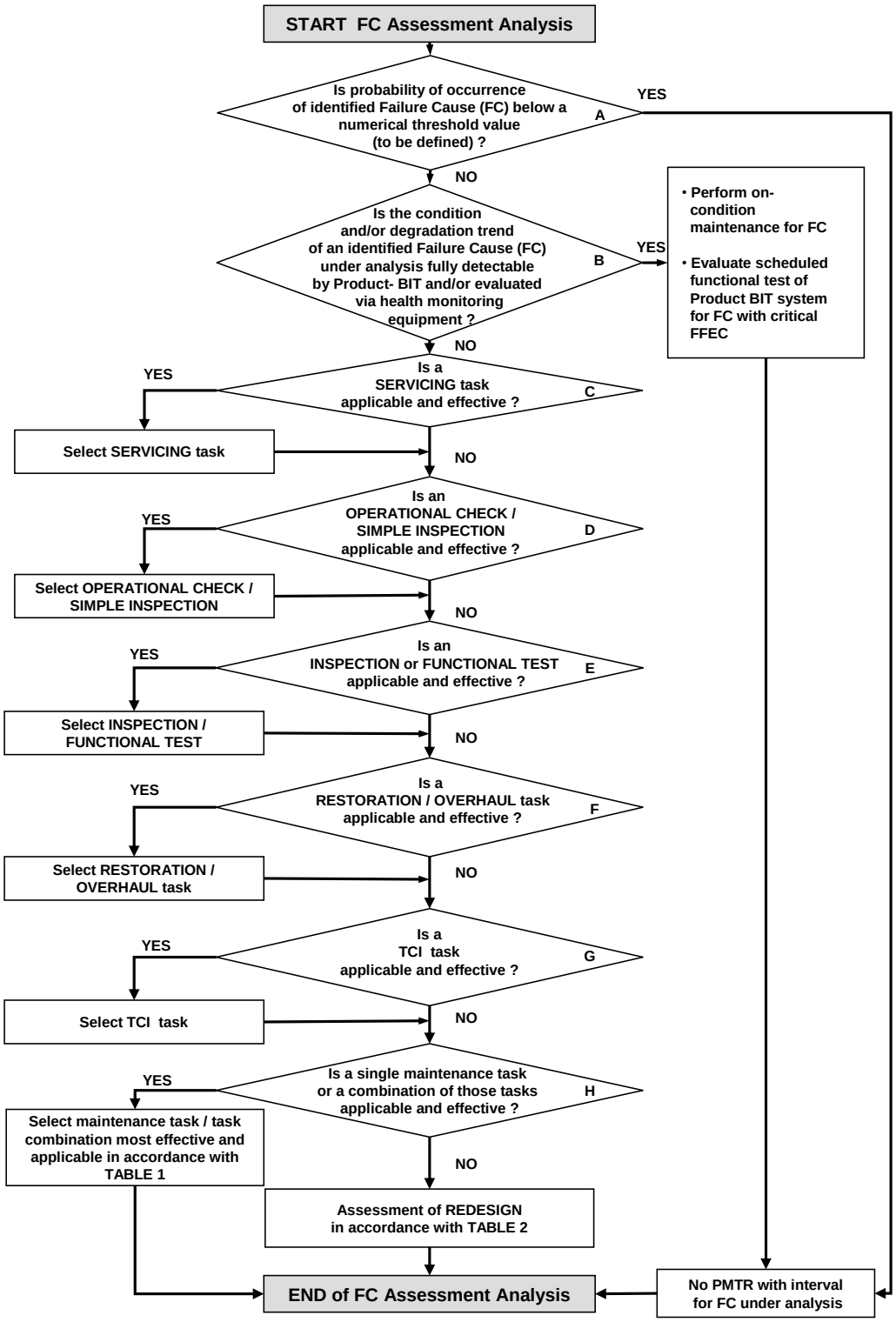
  Hidden FF with impact on mission capability

- **Hidden economic (FFEC 8)**

  Hidden FF with impact on economy

4.2 FC assessment analysis

4.2.1 FC assessment analysis logic diagram



ICN-C0419-S4000P0003-001-01

Fig 16 FC assessment analysis logic diagram

4.2.2 FC assessment analysis procedure

It is necessary to apply each FC to the unique FC assessment logic diagram. Refer to Fig 16.

Having passed through all decisions of the FC assessment logic, the selected FFEC have influence either on the maintenance task type selection or they lead to a redesign assessment.

Assumptions made during the analysis must be recorded for later traceability and validation. For example, if an analysis is (partially or as a whole) based on design solutions that are not completely frozen, this should clearly be recorded in the analysis sheets. All assumptions made in the course of the analysis must be checked and validated once the information required for this analysis work has become available.

Note

The FC assessment logic is based on the assumption of an increasing effort starting with servicing task types, followed by inspection/test task types and ending with restoration/Time Change Item (TCI) tasks.

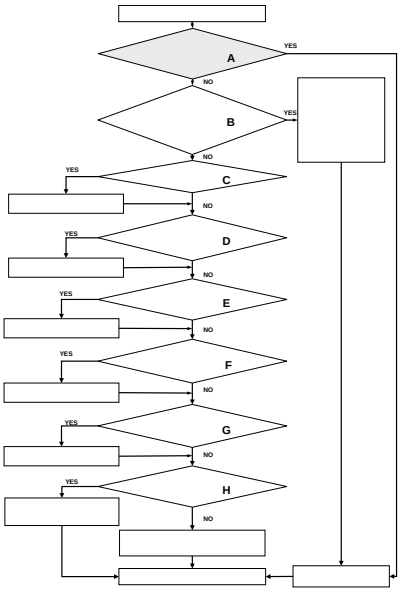
4.2.3 Explanation of FC assessment analysis decisions

Prior to the decisions about applicable and effective preventive maintenance task types, Decision A and Decision B clarify if a PMTR with interval is to be selected.

Having passed through the initial Decision A and Decision B in this analysis logic guide through the whole spectrum of possible PMTR. Refer to DIN/EN Norm 31 051/DIN/EN 13306.

In the following all Decisions and work steps of the FC assessment analysis decisions are explained. Background information is provided.

Decision A



ICN-B6865-S4000P0017-001-01

Fig 17 Decision A

Is probability of occurrence of identified Failure Cause (FC) below a numerical threshold value (to be defined)?

Numerical values for a probability threshold are recommended to be defined in a Product-specific PPH at least for FFEC allocated to the FC which are focused by responsible authorities.

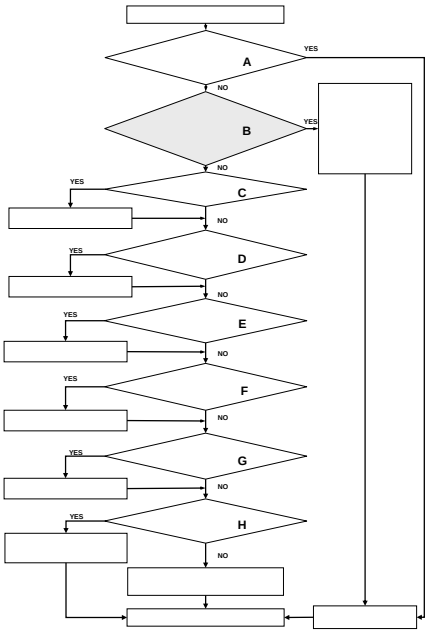
The definitions of threshold values are subject to project risk management.

Threshold values should be adapted to the criticality of FFEC. The lowest numerical value of a threshold is to be assigned to FFEC 1 and 5.

If a FC occurrence is determined to be below the predicted threshold (Answer "YES"), therefore no PMTR.

If the threshold relevant for the criticality of the FC under analysis is exceeded or if that thresholds are to be excluded for a certain Product (Answer "NO"), continue with Decision B.

Decision B



ICN-B6865-S4000P0018-001-01

Fig 18 Decision B

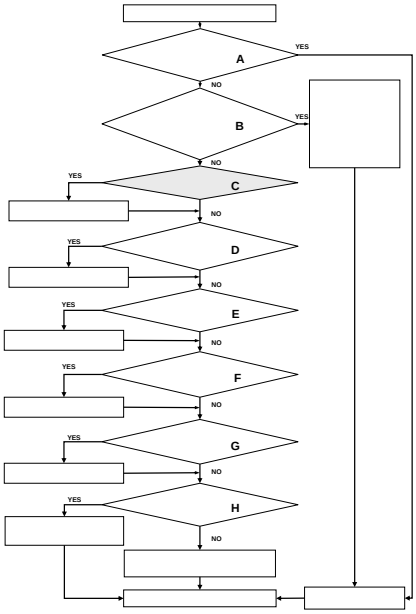
Is the condition and/or degradation trend of an identified Failure Cause (FC) under analysis fully detectable by Product- BIT and/or evaluated via health monitoring equipment?

If the Product-integrated BIT system and/or health monitoring equipment/system delivers sufficient and useable data for technical interpretation necessary to clearly evaluate the FC condition, the degradation status and/or the trend of the degradation of the item that causes the functional failure (FC) is known (Answer "YES"), therefore additional preventive maintenance is not required.

For a FC in combination with a critical FFEC (specific FFEC 1 and 5) evaluate preventive functional test tasks for the Product BIT and/or health monitoring system.

If a BIT/health monitoring system is not installed for the FC or does not deliver required condition-based information (Answer "NO"), continue with Decision C.

Decision C



ICN-B6865-S4000P0019-001-01

Fig 19 Decision C

Is a servicing task applicable and effective?

A servicing task must maintain inherent design capabilities to avoid the FC of the item under analysis. Servicing comprises, but is not limited to, the following maintenance task types:

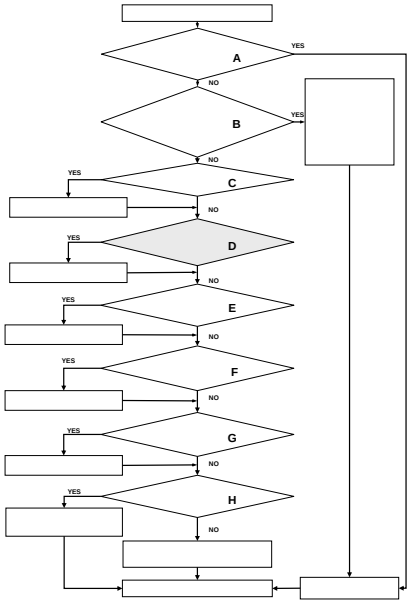
- Lubrication
- Adjustment,
- Cleaning/washing
- Replenishment

Applicability and effectiveness criteria for the selected maintenance task type or maintenance task type combination are listed in Table 4.

If the answer is "YES", select PMTR.

If the answer is "NO", continue with Decision D.

Decision D



ICN-B6865-S4000P0020-001-01

Fig 20 Decision D

Is an operational check/simple inspection applicable and effective?

The scope of this maintenance task is to verify functional operation of the FC.

Operational checks/simple inspections are maintenance task types to verify that an item is fulfilling its intended purpose. The check does not require quantitative tolerances. Both are failure finding maintenance task types.

In the frame of assessment of this decision the selected maintenance task types must be seen as independent from additional/external support equipment. The use of standard tools is allowed (eg, lamp, mirror).

Operational checks/simple inspections comprise the following maintenance task types:

- Operational test directly on the Product with or without BIT
- General Visual Inspection (GVI)
- Detailed Inspection (DET)

Applicability and effectiveness criteria for the selected maintenance task type or maintenance task type combination are listed in Table 4.

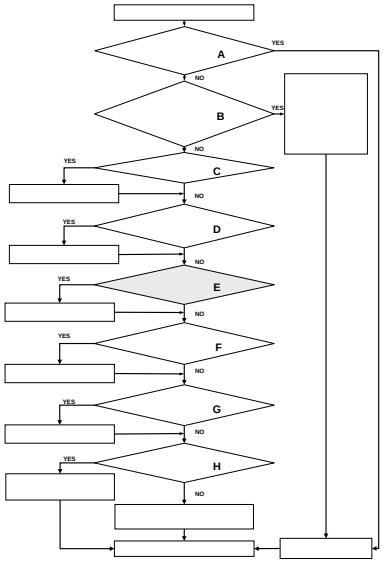
Note

A GVI resulting from the analysis can be transferred either into routine inspections or into the zonal inspection program as long as the FFEC for the FC is not allocated to FFEC 1, FFEC 2, FFEC 5 and FFEC 6.

If the answer is "YES", select PMTR.

If the answer is "NO", continue with Decision E.

Decision E



ICN-B6865-S4000P0021-001-01

Fig 21 Decision E

Is an inspection or functional test applicable and effective?

The scope of this maintenance task is to detect the degradation of function caused by the FC under analysis. When deciding an answer to this question the analyst must consider whether the effort and/or training to accomplish the selected maintenance task type causes a higher maintenance effort than the maintenance task type determined through Decision D.

A functional test is a quantitative test carried out directly on Product/system level or on the item/assembly level. The scope is to verify if one or more functions of an item/assembly perform within specified limits. As a consequence the following inspections/functional tests can require additional/external support equipment:

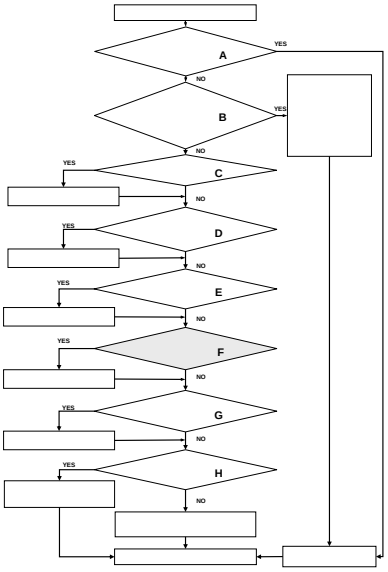
- Special Detailed Inspection (SDI)
- Non-Destructive Testing (NDT)
- Functional testing including evaluation of BIT/health monitoring data.

Applicability and effectiveness criteria for the selected maintenance task type or a maintenance task type combination are listed in Table 4.

If the answer is "YES", select PMTR.

If the answer is "NO", continue with Decision F.

Decision F



ICN-B6865-S4000P0022-001-01

Fig 22 Decision F

Is a restoration task applicable and effective?

The scope of this maintenance task is to avoid failures or reduce the failure rate related to the FC under analysis.

A restoration task is the work on or off the Product required so that its resistance to failure can be restored to an acceptable level. It is usually a sequence of various maintenance task types. However, the focused maintenance task types are:

- Part-replacement
- Overhaul (partial/complete)

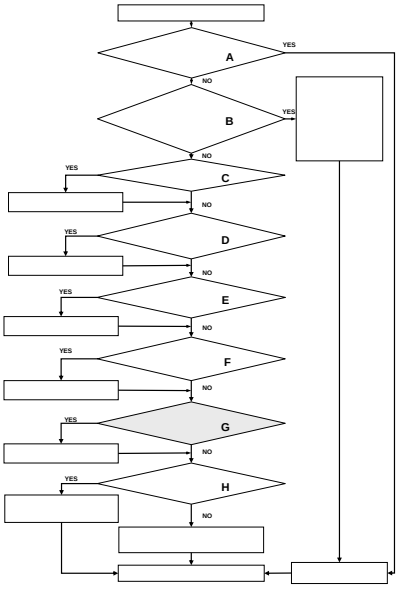
During the restoration process these maintenance task types are normally accompanied by servicing and test task types (eg, cleaning of single parts, adjustments, final acceptance test)

Applicability and effectiveness criteria for the selected maintenance task type or maintenance task type combination are listed in Table 4.

If the answer is "YES, select PMTR.

If the answer is "NO", continue with Decision G.

Decision G



ICN-B6865-S4000P0023-001-01

Fig 23 Decision G

Is a TCI task applicable and effective?

The scope of this maintenance task is to avoid failures or reduce the failure rate related to the FC under analysis.

The pre-requisites for a TCI task are:

- When a specified life limit is defined for the item and
- When a restoration task is not applicable and effective

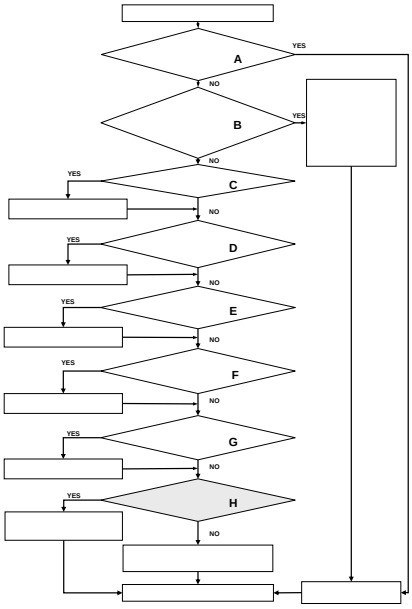
TCI tasks are normally applied to items such as cartridges, canisters, cylinders, engine components (eg, compressor/turbine disks), etc.

Applicability and effectiveness criteria for the selected maintenance task type or maintenance task type combination are listed in Table 4.

If the answer is "YES", select PMTR.

If the answer is "NO", continue with Decision H.

Decision H



ICN-B6865-S4000P0024-001-01

Fig 24 Decision H

Is a single maintenance task or a combination of those tasks applicable and effective?

If the answer is "YES", a review of all selected maintenance task types identified as applicable and effective is necessary. For this review the FFEC, resulting from the FF categorization analysis, must be taken into account. Refer to Table 2.

If the answer is "NO", redesign must be assessed in accordance with Table 3.

4.2.4 Maintenance task type selection criteria in FC assessment analysis

The applicable and effective maintenance task type or maintenance task type combination must be defined on the basis of the FFEC that results from the previous decisions in the FF categorization analysis in accordance with Table 2.

Table 2 Maintenance task type selection criteria

FFEC	Selection of maintenance task type or maintenance task type combination	Remark
1		
Evident - Safety	Select the applicable and effective maintenance task type or an appropriate combination of maintenance task types	Maintenance task interval to be defined for each maintenance task type
2		
Evident - Law/ Environmental integrity	Select the most effective maintenance task type or a maintenance task type combination	Harmonization of maintenance task intervals is recommended

FFEC	Selection of maintenance task type or maintenance task type combination	Remark
3		
Evident - Operation/Mission	Select a maximum of two applicable and effective maintenance task types	Maintenance task interval to be defined for each maintenance task type. Harmonization of maintenance task intervals is recommended
4		
Evident - Economic	Select the most applicable and effective maintenance task type	None
5		
Hidden - Safety	Select the applicable and effective maintenance task type or an appropriate combination of maintenance task types	Maintenance task interval to be defined for each maintenance task type. Harmonization of maintenance task intervals is recommended
6		
Hidden - Law/ Environmental integrity	Select the most effective maintenance task type or a maintenance task type combination	Harmonization of maintenance task intervals is recommended
7		
Hidden - Mission	Select a maximum of two applicable and effective maintenance task types	Maintenance task interval to be defined for each maintenance task type. Harmonization of maintenance task intervals is recommended
8		
Hidden - Economic	Select the most applicable and effective maintenance task type	None

Note

A servicing task for a FC must be selected in all cases if considered applicable and effective.

4.2.5 Redesign requirement assessment

When no preventive maintenance task type is applicable and effective, a redesign requirement must be assessed in accordance with Table 3.

Table 3 Redesign requirement assessment

FFEC	Redesign requirement	Remark
1		
Evident - Safety	Redesign is mandatory	FF cannot be avoided by preventive maintenance
2		
Evident - Law/ Environmental integrity	Redesign must be evaluated	National/International laws and protocols must be taken into account

FFEC	Redesign requirement	Remark
3		
Evident - Operation/Mission	Redesign must be evaluated	Customer requirements/contract must be taken into account
4		
Evident - Economic	No redesign requirement necessary	Cost benefit analysis maybe appropriate
5		
Hidden - Safety	Redesign is mandatory	FF cannot be avoided by preventive maintenance
6		
Hidden - Law/ Environmental integrity	Redesign must be evaluated	National/International laws and protocols must be taken into account
7		
Hidden - Mission	Redesign must be evaluated	Customer requirements/contract must be taken into account
8		
Hidden - Economic	No redesign requirement necessary	Cost benefit analysis maybe appropriate

4.2.6 Maintenance task type selection criteria

Table 4 gives the criteria for the selection of applicable and effective preventive maintenance task types with respect to the FFEC category.

Table 4 Maintenance task type selection criteria

Maintenance task type	Applicability	Safety effect	Law / Environmental integrity effect	Operational /mission effect	Economic effect
		FFEC 1 & 5	FFEC 2 & 6	FFEC 3 & 7	FFEC 4 & 8
Servicing	The maintenance task restores the item to a specific standard / status to enable its intended use	The maintenance task must reduce the risk that a FC could lead to a safety relevant FF	The maintenance task must reduce the risk that a FC could lead to a FF that might cause a conflict with law / might have a negative impact on environmental integrity	The maintenance task must reduce the risk that a FC could lead to a FF that might reduce the operational availability / impact the mission performance	The maintenance task must be cost effective.
Operational test or simple inspection	Identification if the FC has occurred	The maintenance task must ensure availability of the function to assure safety	The maintenance task must ensure availability of the function to assure that there is no conflict with law / environmental integrity	The maintenance task must ensure availability of the function to ensure operational availability / mission performance	The maintenance task must be cost effective
Inspection or functional test	Reduced resistance to failure must be detectable on the FC and there must be a reasonable consistent interval between the potential to failure and actual failure (P to F interval)	The maintenance task must be able to measure an items functional performance level against a specific value to ensure availability of the function assuring safety	The maintenance task must ensure availability of the function to reduce the risk of a fault resulting in a conflict with law and/or in a negative impact on environmental integrity	The maintenance task must ensure availability of the function to reduce the risk of a fault resulting in a reduction of operational availability / mission performance	The maintenance task must be cost effective
Restoration	The FC must show functional degradation characteristics at an identifiable age, and a large proportion of units must survive to that age. It must be possible to restore the item to a specific standard of failure resistance	The maintenance task must prevent or reduce the probability of a functional failure to assure safety	The maintenance task must prevent or reduce the probability of a functional failure that results in a conflict with law and/or in a negative impact upon environmental integrity	The maintenance task must prevent or reduce the probability of a functional failure to an acceptable level to enable operational availability / mission performance	Not applicable
TCI	The FC must show functional degradation characteristics at an identifiable age and a large proportion of units must survive to that age	The TCI task must reduce the risk that a FC could lead to a safety relevant FF	The TCI task must prevent or reduce the probability of a functional failure that results in a conflict with law and/or in a negative impact upon environmental integrity	The TCI task must prevent or reduce the probability of a functional failure to an acceptable level to enable operational availability / mission performance	An economic life limit must be cost effective

5 Interval determination for system preventive maintenance task requirements

5.1 General

As part of the S4000P system analysis logics, the analyst must determine the interval of each PMTR ensuring that it satisfies both the applicability and effectiveness criteria.

For each maintenance task requirement the analyst must select one or more combinations of

- a most appropriate maintenance interval type (eg, calendar or usage based)

and

- an appropriate numerical interval size

based on available data and/or engineering judgment. Where specific data on failure rates and characteristics are not available, then the intervals for preventive system PMTR must be based engineering/safety analysis and/or on experience with similar systems.

For newly developed Products there is insufficient information available to determine optimum intervals until the equipment has passed a time period in it is in-service phase. If conservative intervals have been selected for the initial PMTR, a later ISMO analysis is a most effective and highly recommended method. Refer to Chap 3.

If the effort to perform a PMTR is low, this should not lead to selecting a high maintenance task frequency (= low interval size). This is because of the risk of maintenance induced errors increasing with the probability of a negative impact on safety and/or reliability.

Note

The interval determination in the frame of this analysis methodology should be based on the technical evaluation done by the responsible analyst. Predicted interval packages should not be the driving figures for interval determination.

5.2 Recommendations

When determining the most appropriate interval type and numerical interval size for a PMTR, the analyst must take account of all available relevant data, and consider at least the following:

- Product manufacturer's data including test results and technical analyses
- customer specific usage scenario (one or more)
- other customer requirements
- vendor/equipment manufacturer recommendations/requirements
- certification authorities and/or law based requirements
- experience gained from identical or comparable Products
- best engineering judgments
-

Note

The original maintenance task intervals must be defined on the basis of the harmonized usage scenario for a standard Product utilization. In the case of different usage scenarios deviating from the standard usage scenario with other mission/operating environments and/or climatic conditions deterioration characteristics and external impacts on the Product under analysis, they must be reassessed. The respective information must be documented in the PPH (refer to Chap 1). Consequently the maintenance task interval must be adjusted accordingly. The reasons and the justification for these changes or adjustments of maintenance task intervals must be noted in the analysis report.

- When available, reliability data in combination with the "statistic fault distribution" within a defined time period of the item under analysis must be taken into account as well as probable degradation. The appropriate maintenance task interval selection must prevent an increase of the probability of functional failures.
- The maintenance task interval should be less than the shortest likely interval between the point at which a potential failure becomes detectable and the point at which it degrades into a functional failure (if failure data is available, this interval can be referred to as the P to F interval).

- The shortest time between the discovery of a potential FC and the occurrence of the FF should be long enough for an appropriate action to be taken to avoid, eliminate or minimize the consequences of the FF.

5.3 Interval types and numerical values for preventive system maintenance task requirements

The determination of interval types and the numerical values for a system maintenance task requirement consists of two aspects:

- The identification of the appropriate interval type (eg, operating hours, cycles or calendar time). In some cases more than one of these parameters can be valid for a particular system maintenance task requirement.
- The allocation of the associated numerical value per interval type

The selection of an interval type for a system maintenance task requirement depends on one or more technical parameters that trigger the deterioration process of an individual FC.

Typical interval types are:

- calendar time
- flight hours
- Product operating hours
- Product operating cycles
- operating hours/cycles of single Product equipment
- special usage related events (eg, role change, pods removal)
- etc

The responsible analyst must decide, if an interval type can be selected as the primary interval type. Additionally analysts may recommend, for example, two interval types with different numerical values in parallel, explaining that the system maintenance task requirement is driven by that interval type with a numerical value that comes first.

For some maintenance task requirements, it can be appropriate for the analyst to consider specifying an initial interval (threshold) that is different from the repeat interval.

6 Certification maintenance requirements (if applicable)

In addition to those PMTR with intervals established through the S4000P analysis methodology, PMTR can arise within a certification process

Example: Aircraft certification process.

A Certification Maintenance Requirement (CMR) is a PMTR, established during the design certification of the Product. CMR usually results from a formal, numerical analysis conducted to show compliance with potential catastrophic and hazardous FFE. A CMR is intended to detect and/or eliminate safety significant latent FC that would, in combination with one or more other specific Product-internal FC or Product-external FC (eg, events), result in a hazardous or catastrophic FFE. In addition, all FFE with an impact on environmental integrity and/or FFE that conflicts with law are assumed to be CMR.

Note

CMR are derived from a fundamentally different analytical process than the PMTR with intervals that result from preventive maintenance analysis.

The harmonization between maintenance task requirements on the basis of S4000P methodology and CMR is described in Chap 2.5.

7 Trend-leader selection

PMTR for items defined in the S4000P system analysis procedure can be selected for a trend-leader concept.

A trend-leader selection is a process to evaluate and determine a sample of items under analysis for inspection or testing at defined intervals for any unexpected degradation and/or external impact (normal or specific environment, accident). The identified PMTR with intervals will be limited on these trend-leaders only.

The selected places of item installation, the number of trend-leader items per individual Product and/or the number of selected Product serial numbers must statistically be representative for the technical status of the Product fleet.

The selection-strategy of trend leaders increases the technical knowledge on the Product and reduces the total maintenance effort of the complete Product fleet.

Trend leader selection and sampling are again a part of the ISMO analytical process to be established during a Product in-service phase. Refer to Chap 3.

Chapter 2.3

Structure analysis

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 1	Introduction to the specification
Chap 2.2	System analysis
Chap 2.4	Zonal analysis
Chap 2.5	Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources
Chap 3	In-service maintenance optimization (ISMO)
Chap 5	Terms, abbreviations and acronyms
S1000D	International specification for technical publications using a common source database
S3000L	International procedure specification for Logistic Support Analysis - LSA

1 Product structure

A Product structure consists of all load carrying and/or load bearing members (eg, body of a submarine, engine/motor mountings, wings on an aircraft, aircraft landing gear, (flight) control surfaces and related points of attachment, ship hull).

The actuating portions of Product items such as wheel axle of a land vehicle, aircraft landing gear or aircraft wing flaps (flight control), etc, will be treated as Product systems and Analysis Relevant Candidates (ARC) must be analyzed as described in Chap 2.2. Attachments of system actuators to the Product structure including hinges must be analyzed as Product structure according to this chapter.

Note

Refer to Chap 1 and Chap 2.2 for more information and clarification regarding the selection of ARC and/or Structure Significant Item (SSI).

Product structure can be subdivided according to the consequences of their loss of function as follows:

- Necessary for continued Product safety during the in-service phase
- Necessary to avoid conflicts with law (including ensuring environmental integrity)
- With significant impact on Product maintenance and/or Product availability
- Without significant impact during the Product in-service phase

Consequently Product structure can be allocated to the following categories:

- **Structure Significant Item (SSI)** with or without **Significant Details (SD)**, when loss of item function can impact Product safety and/or can lead to a conflict with law (including environmental integrity).
- **Maintenance relevant structure**, when loss of item function can cause high maintenance effort and/or can have significantly impact on the Product availability.
- **Non-critical structure**, when loss of item function has no significant impact on in-service Product usage.

2 Damage and failure sources on Product structure

The assessment of Product structure for the selection of preventive maintenance task requirements (PMTR) must consider the following damage and failure sources:

2.1 Accidental damage

Accidental Damage (AD) is the physical alteration of an item, normally caused

- by impact that occurs as random or single unscheduled events during the in-service Product usage
  - AD examples from aircraft technology:

    Lightning strike, severe hail, weapons release, cargo air delivery, role changes, air to air refueling, debris, spillage.
- by the result of human error during Product manufacturing, assembly, operation or maintenance
- by impacts based on, for example, deliberate deterioration, sabotage acts (eg, during Product deployments) or battle damages. These impacts, although not strictly accidental, can also be considered within this damage category because the resulting effects on the SSI/SD are comparable to the previous listed damage causes.
- by less obvious AD arising from operator-, passenger- or maintainer activities or from overheating. These AD types can manifest them self as distorted, torn, punctured or otherwise distressed structure, delamination or disbonding.

Potential sources of AD are to be considered for all material variants of the Product structure (metallic, non-metallic or a combination of both).

2.2 Environmental deterioration

Environmental Deterioration (ED) is the gradual physical degradation of structural material properties as a result of their interaction with the climate or the localized environmental conditions.

ED can be caused by:

- chemical interaction
- erosion
- fluid or gas absorption
- thermal cycling
- electromagnetic radiation
- etc

ED can manifest itself on or inside the Product structure as:

- corrosion
- stress corrosion
- cracking
- loss of surface finish
- softening of composite material matrices (including adhesives used in laminated composites)
- delamination
- degradation of static fatigue
- impact on strength properties
- etc

A local interface of different material types including material combinations of metallic and non-metallic structure components can cause electrochemical processes degrading the involved structure materials. All identified ED impacts must be analyzed for each selected SSI/SD.

2.3 Fatigue failure

Fatigue Failure (FF) is based on a process of progressive, permanent structural change occurring inside a structure material. A fatigue failure usually begins and grows on a microscopic scale until it manifests itself as visible material cracking.

The crack propagation mainly depends on:

- material properties and its geometry,
- the level, amplitude and frequency of fluctuating stresses

and

- the number of load cycles applied

Fatigue Failures culminate in material cracks that reduce the residual strength of the structure item and cause fractures if the residual strength of the structure material falls below the applied load.

3 Objectives of preventive structural maintenance

During the Product in-service phase structural failures and/or structural damages of the Product structure under analysis must be identified as soon as possible prior a potential loss of the structural function can lead to critical or non-tolerable consequences.

Primary objectives of the preventive structural maintenance of a Product are to

- maintain the inherent Product safety level
- avoid a potential conflict with law (including environmental integrity) throughout the operational or usage life of the Product
- ensure and/or optimize the Product availability for missions/operations
- optimize the Product Life Cycle Cost (LCC) in an economical manner without neglecting the previous listed objectives

PMTR with intervals for Structure Significant Items (SSI)/Significant Details (SD) selected on basis of this analysis methodology must be harmonized with:

- Product type certification requirements

  Note

  Regulatory authorities can require/predict safety limitations, replacement times for structural safe-life parts/items to ensure continued Product safety. These PMTR with intervals, known as Time Change Items (TCI), must be harmonized with PMTR with interval developed on basis of this analytical process.

- additional PMTR (if existing) raised by the a Maintenance Review Board (MRB) or a comparable organization/team

The analytical process for this Product structure analysis must take into account:

- Structural design philosophy and characteristics
- Fatigue evaluations (depending on safe life or damage tolerance design principle)
- In-service experience from (similar) structural items on other Products (if existing)
- Structure fatigue test results and experience
- Item susceptibility to failures and damages (AD, ED and FF)
- PMTR from Corrosion Prevention and Control Program (CPCP) for metallic parts/items, based on in-service experience of operators
- Consequences of structural deterioration to continuing safe Product operation including:
  - The effect on the Product, for example loss of function or reduction of residual strength
  - Multiple sites or multiple element fatigue damage

- The effect on Product usage or response characteristics caused by the interaction of structural damage or failure with associated Product systems
- Loss of structural items during mission or operation

– Applicability and effectiveness of all available maintenance task types to detect, to delay, to prevent from or to stop structural deterioration
– Inspection interval thresholds and repeat intervals
– Sampling and/or fleet leader program or other methods

To achieve an optimized preventive structural Product maintenance, applicable and effective inspections/tests must meet the detection requirements from each of the AD, ED, CPCP and Fatigue Failure assessments. All available technical means for inspection and test on market must be taken into account.

Due to the fact that new structure materials and material combinations are already selected by Product designers and additional ones will be developed for future Product structures, this specification must also cover all kind of material combinations (eg, metallic material component combined with non-metallic material elements). In most cases the single structure materials of such material combinations remain inseparable from each other after the production process.

This structure analysis methodology leads to harmonized PMTR with original interval types and numerical interval values. The determination of preventive maintenance tasks with intervals for a the Product maintenance program/Operator Maintenance Plan (OMP), follows the process and rules described in Chap 10 of the specification S3000L and original PMTR intervals can be adapted for task packaging purpose.

To optimize preventive maintenance tasks for Product structure documented in a maintenance program/OMP, the ISMO process is to be applied during the Product in-service phase. Refer to Chap 3.

4 Structure analysis procedure

This para contains logics, guidelines and explanations for developing applicable and effective PMTR with intervals for the structure of a Product (eg, air vehicle; ship; train, tank).

This basic information set must be supplemented and extended with every information necessary to support the analytical work necessary to prepare the Product-specific PPH. Refer to Chap 1.

If additional information is necessary to cover other structural impacts, for example, from crisis or war scenario of military Products and/or specific usage conditions, it is recommended to define and explain it the PPH.

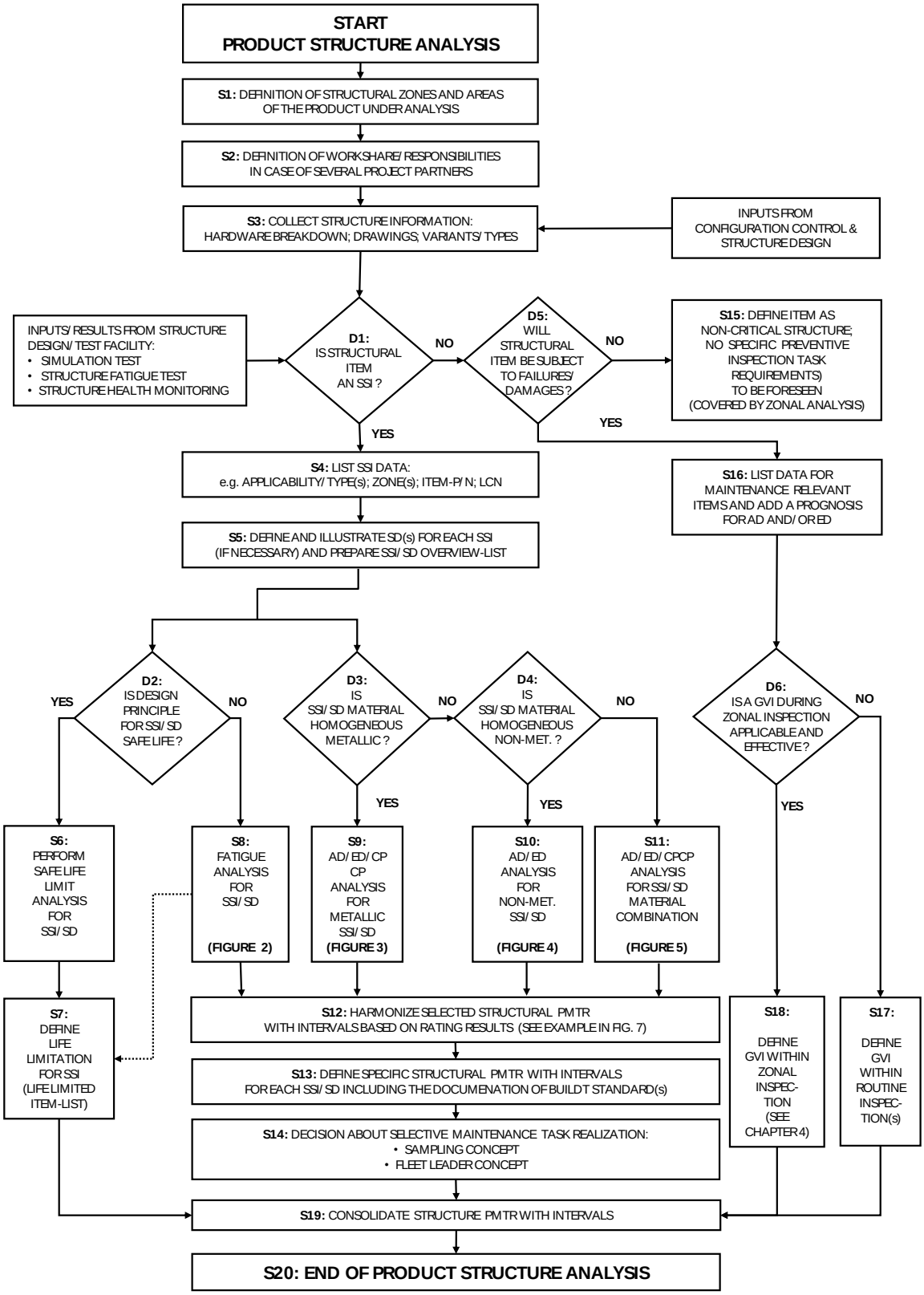
It is recommended to get the PPH accepted by all involved stake holders prior to start the analytical work.

4.1 Structure analysis logics

The procedure for developing and harmonizing structural PMTR with intervals for a Product structure must follow the main structure analysis logic diagram according to Fig 1.

The work steps S8, S9, S10 and S11 in the main logic diagram comprise a set of Decisions (D) and work Steps (S) necessary to analyze each SSI or each SD on single SSI.

More detailed logics (Fig 2 thru Fig 5) are integrated in the descriptions of selected work Steps (S) of the main logic diagram.



ICN-C0419-S4000P0001-001-01

Fig 1 Product structure analysis - Main logic diagram

Hereafter the process steps (Step S1, Step S2, Step S3, etc) and decisions (Decision D1, Decision D2, Decision°D3, etc) of the main logic diagram are described and explained. For some process steps of the main logic diagram (eg, for Step S8), detailed sub-logics are described and explained in addition:

Step S1:

The definition of both zones and areas for the Product structure under analysis is a prerequisite for Product overview and for documentation of analysis results. If several Partner Companies (PC) are involved in a Product design and development, each PC is analysis responsible for his structure design work share.

Step S2:

In case of a Product structure development being split over several PC it has to be ensured, that SSI/SD as well as maintenance-relevant structure are defined for the complete Product structure. Potential responsibility interface problems are to be solved and solutions must be defined in the PPH. From each PC one or more responsible analysts must be nominated.

Step S3:

As an initial activity, each analyst has to collect basic information about the structural items of the Product structure allocated to his work share responsibility: Such as structural items drawing tree, structure part numbers, specification data, design status of the single structural items and information about Product variants and design deviations (if already known at the date of the performance of the analytical work).

Decision D1:

An SSI is defined in Para 1 and in Chap 5.

As a prerequisite for this structure analysis, the built standard of each SSI for all Product structure variants (if existing) must clearly be defined by design responsible departments (eg, by drawing number, part number, modification status). This is a prerequisite for correct maintenance task type selection and for scheduled interval rating.

Depending on the SSI design data and parameters, the SSI location on the Product and the expected failures/damages:

– the complete SSI can be subject to inspection/test task requirements and/or to CPCP task requirements depending on the material type

or

– only one or more SD on an SSI can be subject to one or more inspection/test task requirements and to CPCP task requirements (depending on the material type)

Only those structural items must be selected for a further detailed structure analysis on basis of interval rating systems, which fulfill the SSI criteria. Each SSI decision is based on inputs from the design responsible department (results from calculations, simulations, fatigue test results), safety hazard analysis, experience with other Products (eg, data evaluation from health monitoring) and/or on requirements from responsible authorities.

If the structure item is judged to be an SSI (Answer YES), continue with Step S4.

If not (Answer NO), continue with Decision D5.

Step S4:

Document all selected SSI with drawing- and item data in an SSI overview list. The responsible analyst must evaluate the position of installation of each SSI on a Product and must create an overview sketch for later analysis.

Step S5:

According to Chap 5, a Significant Detail (SD) is defined as a limited area of an SSI or a local spot on the SSI. In general, the SD has not an own part number, drawing number but the identification data from the SSI. Therefore every SD and its geometrical dimensions must be defined and documented, for example, on the drawing of the SSI under analysis.

The SD definition on an SSI is based on, for example:

- results from Product and/or item fatigue tests
- simulation results from manufacturers'

or

- operators' experience with similar structural items based on comparable usage conditions

Depending on the SSI location on the overall Product, different failure causes, impacts by the environment and/or by damages can influence the selection of SD on an SSI.

Each SD on an SSI must be selected on basis of:

- highest fatigue-related criticality (eg, those areas, where initial cracks are to be expected first)
- highest probability for damages and/or deterioration impacts

An applicable and effective inspection/test method must be selected for each SD. The determination of the location and the geometrical size of the SD is a prerequisite to define PMTR with intervals for each SD. Both location and surroundings of each SD have individual influence on the PMTR selection.

The numerical size of the interval and the interval type must be determined on basis of traceable interval rating systems. Different SD on one SSI can therefore lead to completely different PMTR with different intervals in addition. For each SSI/SD Decision D2 and Decision D3 have subsequently to be answered in parallel.

Decision D2:

A input from the design responsible department is necessary to decide about the design principle "safe life" or "damage tolerant" for each SSI/SD. The result must be added in the SSI/SD overview list (refer to Step S4).

If the SSI/SD design principle is "safe life" (Answer YES), continue with Step S6.

If not (Answer NO), continue with Step S8.

Step S6:

For SSI/SD with a "safe life" design principle, the design responsible department must deliver information/data about the respective SSI. Depending of the specified Product life cycle the individual SSI life limit:

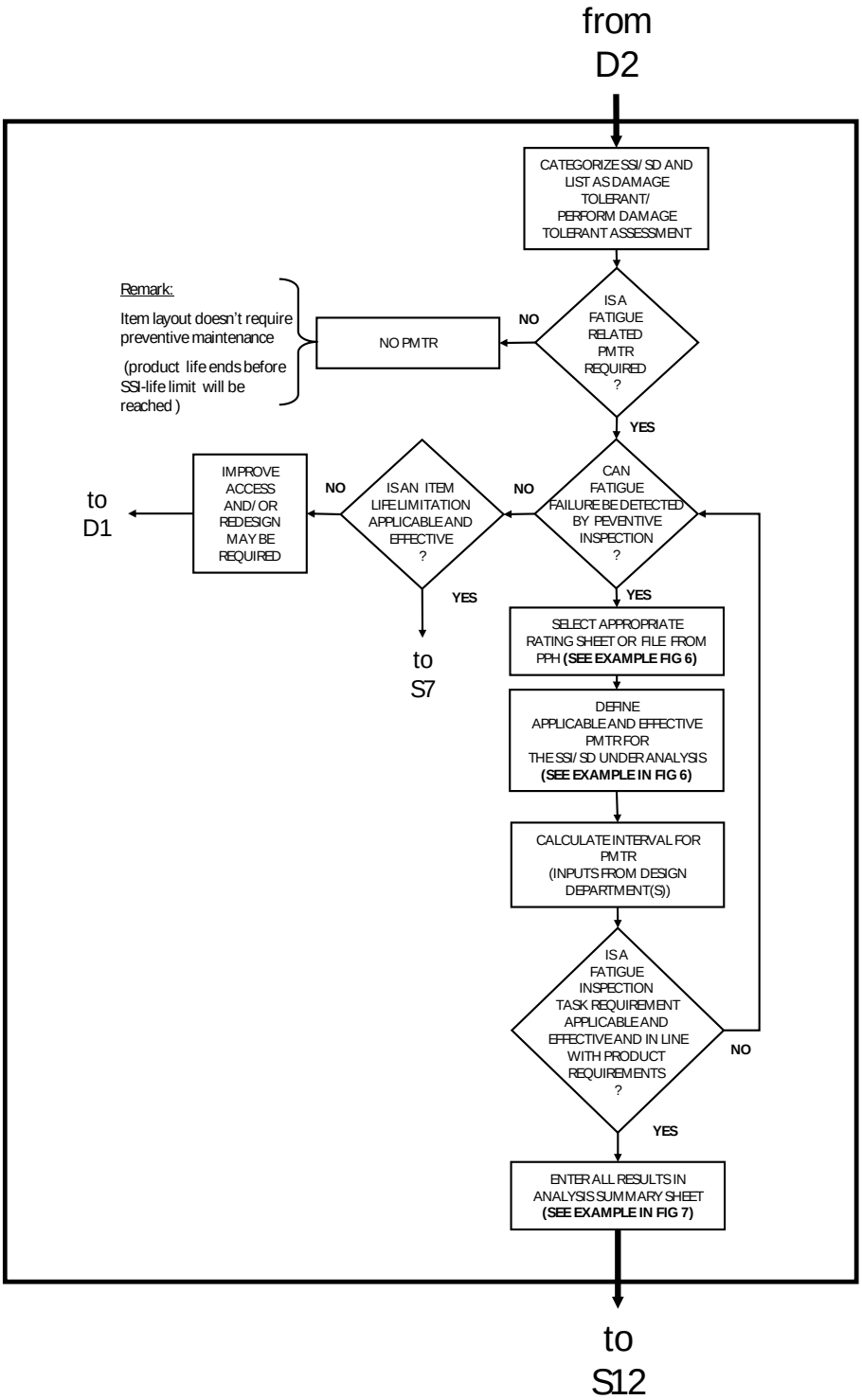
- ends within the Product life cycle and this type of SSI must be replaced and discarded before reaching its predicted life limit at a predefined interval
- is equal with or even exceeds the Product life cycle and this type of SSI must not be replacement and discarded in a scheduled manner. In case of a future expansion of the Product life cycle, these SSI have to be analyzed again.

Step S7:

All life-limited SSI have to be listed in the Product life-limited item list to be ready for a presentation to responsible authorities.

Step S8:

In Fig 2 further analysis steps and decisions for Fatigue analysis are described:



ICN-C0419-S4000P0002-001-01

Fig 2 Product structure analysis - Fatigue analysis for SSI/SD

For metallic SSI with a "damage tolerant" design principle, the applicable and effective inspection/test must be defined by the analyst taking into account maintainability experience.

A PMTR selection sheet or file according to the PPH must be filled. Refer to example in Fig 6.

The responsible structure design department determines the preventive inspection interval for a timely detection of a fatigue failure. These depend on manufacturers' calculation and/or simulation data. If a PMTR is not applicable and/or effective, the improvement of the SSI/SD accessibility, a scheduled replacement of the SSI or item-redesign must be taken into consideration.

The fatigue related inspections are influenced by:

- manufacturers' damage tolerance evaluations

and/or

- results from fatigue data simulation at the manufacturer
- manufacturers' hardware tests including destructive test results (if any)
- significant changes of usage parameters at the operator documented in an approved analysis procedure (PPH)

Inspections related to detect Fatigue Failure in non-metallic SSI is assumed not to be required if SSI design is based on a "no-damage growth" design philosophy substantiated by test results. Where no in-service experience exists with similar structure material, structural PMTR must be based on manufacturers' recommendations only.

Decision D3/Decision D4:

The type of material of the SSI/SD under analysis leads to subsequent decision sheets/files and logics. Next to homogeneous metallic SSI or homogeneous non-metallic SSI, new SSI material combinations must be analyzed separately.

If the SSI/SD material is homogeneous metallic (Answer on D3 is YES), continue with Step S9.

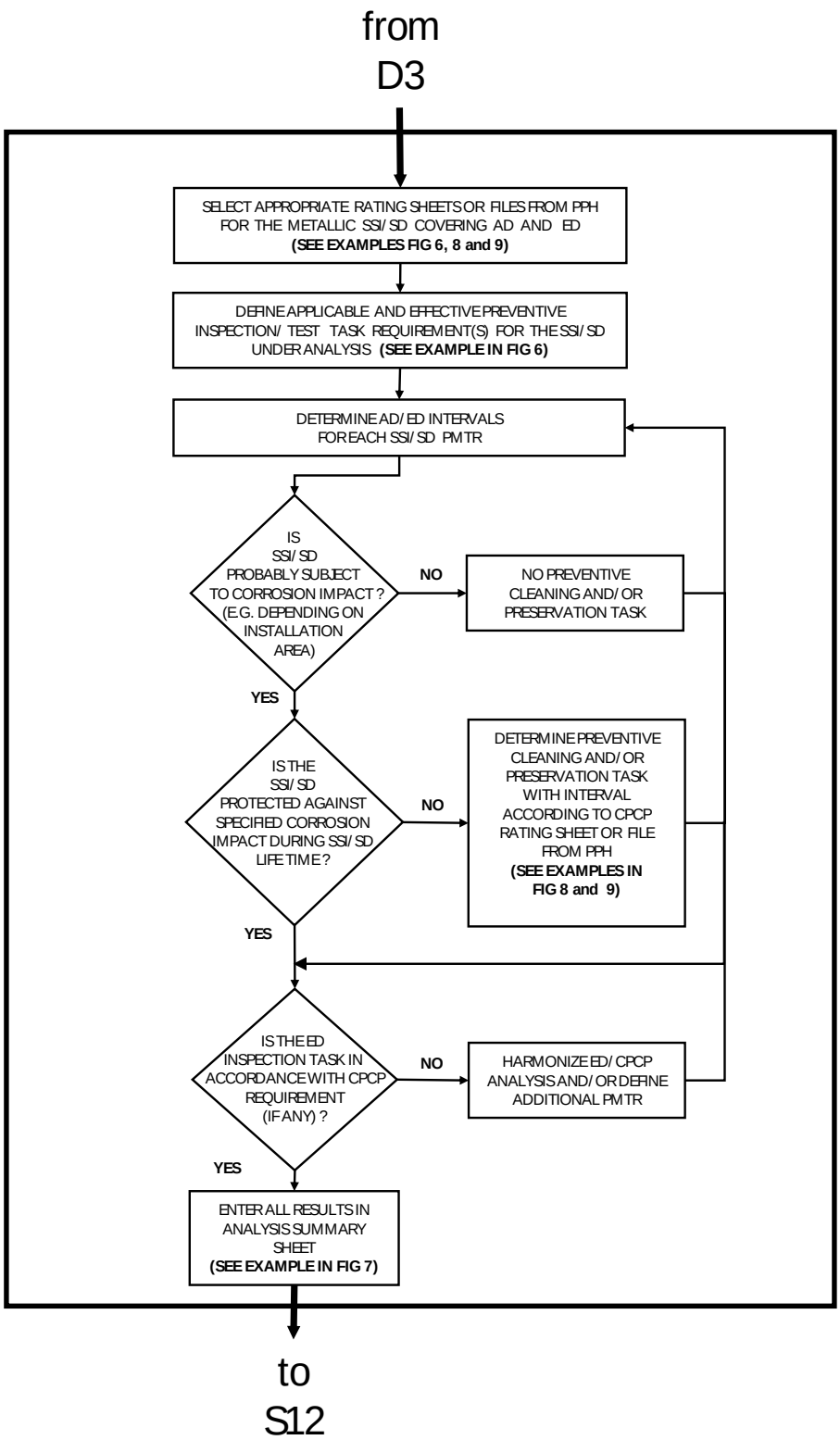
If the SSI/SD material is not homogeneous metallic (Answer on D3 is NO), continue with Decision D4.

If the SSI/SD material is homogeneous non-metallic (Answer on D3 is NO and on D4 is YES), continue with Step S10.

If the SSI/SD material is neither homogeneous metallic nor homogeneous non-metallic (Answer on both D3 and D4 is NO), continue with Step S11.

Step S9:

The "homogeneous metallic SSI/SD analysis" is described in the following Fig 3:



ICN-C0419-S4000P0003-001-01

Fig 3 Product structure analysis - AD/ED/CPCP Analysis for metallic SSI/SD

Fig 3 above shows the single analytical steps and decisions how to determine and combine scheduled inspections/tests based on AD/ED analysis and PMTR from Corrosion Prevention

and Control Program (CPCP). PMTR based on CPCP can include Temporary Protection Systems (TPS), if applicable.

AD, along with stress corrosion and some other forms of corrosion, can occur at any time during a Product's service/usage life; as these are random in nature. Because of this fact, inspection/test requirements pertaining to these conditions must apply to each Product throughout its operational life. However, most forms of corrosion depend on the parameters time or usage and are more likely to occur as the Product ages. Where this is concerned operator and manufacturer experience on similar structures can be called upon, which can then be used to establish appropriate PMTR (including PMTR based on CPCP) for the control of ED.

As far as environmental conditions would deviate from specified conditions for the Product, exceeding corrosion can occur on metallic Product structure. To prevent the Product from starting corrosion and/or from exceeding corrosion, the CPCP contains PMTR for metallic SSI/SD. The scope is to identify and control starting corrosion processes on Product structure as early as possible.

Depending on the Product structure materials and the specified operational environments, a CPCP can be established to maintain the resistance of the metallic Product structure to corrosion as a result of systematic structural deterioration through chemical and/or environmental interactions. The CPCP is an integral part of this analysis step for metallic SSI/SD. Therefore preventive servicing task requirements (eg, cleaning, preservation) can be selected additionally to avoid or to delay a predicted corrosion process which can have a negative influence on the SSI fatigue. Scheduled intervals for servicing task requirements are a result of the CPCP-rating sheet/file that deals with main impact parameters on probable corrosion processes.

Corrosion prevention:

Preventive maintenance task types for corrosion prevention are:

- Cleaning of SSI/SD from substances, which can otherwise support or accelerate corrosion processes
- Preservation of SSI/SD with one or more applicable consumables, which temporarily protect the SSI/SD surface from starting or ongoing corrosion processes (TPS). These consumables must not negatively impact any of the Product's
    - materials
    - paints
    - equipment
    - functions
    - the performance of other PMTR with intervals
    - …
- Preventive replacement of a corrosion protection paint (if existing) including the cover paint to protect the metallic SSI/SD surfaces in the best way
- Reduction of moisture or humidity on the relevant SSI/SD or even on the complete Product (drying equipment)

All PMTR have to be selected on basis of the task selection sheet/file for SSI/SD. Refer to example for inspection task type selection in Fig 6.

In the frame of CPCP, a servicing task combination, for example, washing and preservation in addition to inspection tasks must be taken into account. Preventive servicing tasks can be applied also on the surrounding structure of the SSI/SD or in the complete zone of the SSI/SD. The treatment of the whole area/zone might be more effective in comparison to a limited spot-/local treatment. Details about the treatment process must be decided by the analyst in cooperation with design departments.

Temporary Protection System (TPS) requirements of Product structure are recommended for the whole Product fleet, which operates under the same or under comparable environmental conditions.

The determination of intervals for PMTR based on CPCP is affected by:

- Estimated or known effectiveness from comparable SSI/SD material surfaces already operated with or without corrosion protection.
- Applicability of washing- and/or preservation task requirement for the selected SSI/SD.
- Effectiveness of washing and/or preservation task requirement for the selected SSI/SD.
- Changes of corrosion impact parameters on SSI/SD due to different Product usage or operation parameters and the basic corrosion protection does not withstand the new environmental scenario.

When a PMTR with interval will neither be applicable nor effective, a SSI/SD redesign must be taken into account (eg, modification of the SSI/SD surface by material coating).

Corrosion control:

The CPCP program is also expected to allow control of the corrosion status on the metallic Product structure up to the acceptable corrosion level or better. PMTR can be based on the ED analysis, assuming a Product operated in a specified and typical environment. If corrosion is found to exceed the specified corrosion level at any inspection, the PMTR based on CPCP for the affected area must be reviewed by the operator or manufacturer with the objective to face the real parameters impacting the corrosion process.

To control the acceptable corrosion level of metallic material, PMTR related to ED are usually applicable at an interval threshold that is established, for example, during the Product type certification process. The definition of those interval thresholds can be based on manufacturers' and/or operators' in-service experience with similar Product structure, taking into consideration differences in relevant design features such as choice of material, assembly process, corrosion protection systems. Refer to Para 6 and Para 7.

The analyst determines inspection repeat intervals on basis of separate rating sheets/files for AD and ED. Applicable rating sheets/files are to be provided in a PPH as the basis for efficient analytical work.

For the individual SSI metallic material, the Product usage and operational scenario, the most important AD and ED impact parameters causing material damages as well as the forecast of the future deterioration process must be taken into account and documented in interval rating sheets/files. Refer to rating examples for metallic material in Fig 8 and Fig 9.

The intervals for repetition of identified PMTR must also be defined in accordance with rating sheets or files. Refer to examples in Fig 6.

Note

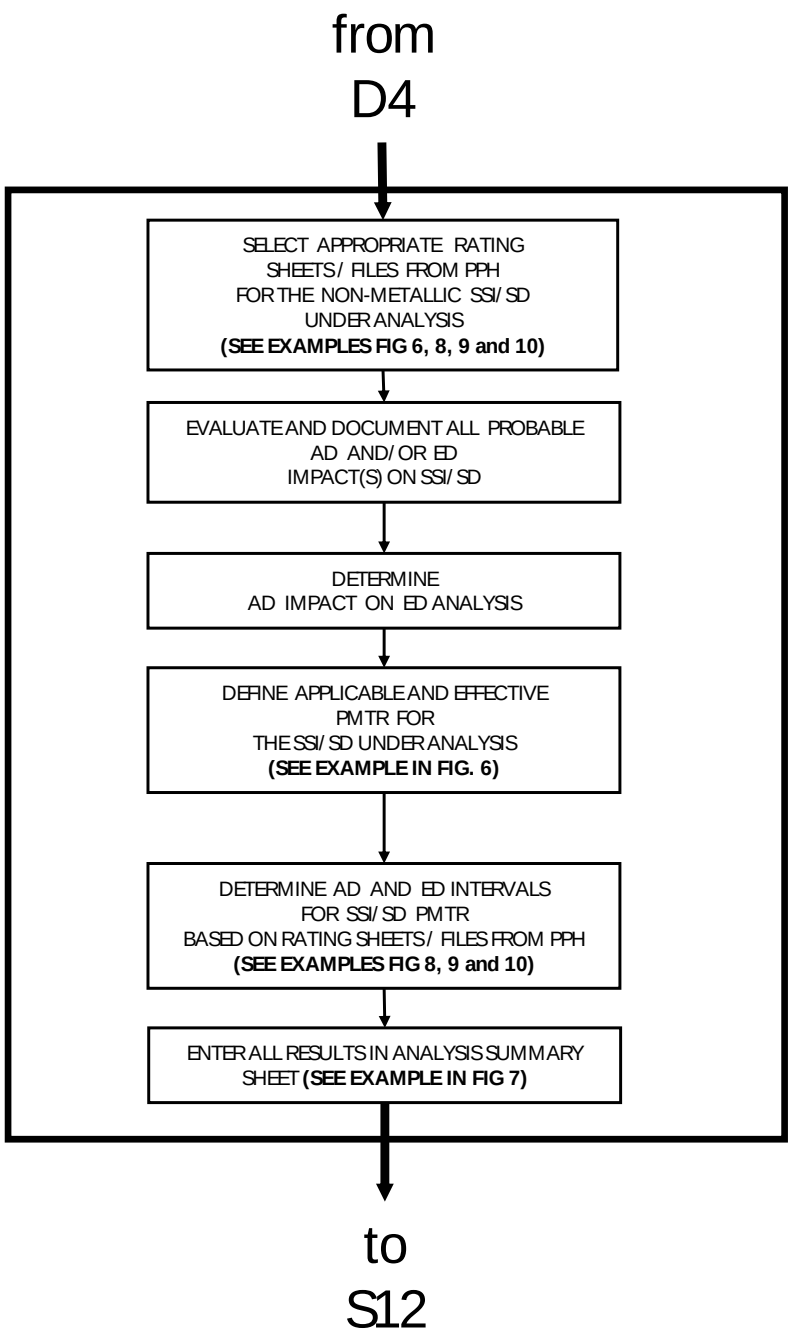
A Product structure age exploration program can verify the Product structure's resistance to corrosion deterioration prior to define PMTR interval thresholds for CPCP. The age exploration program can be established and submitted to the program SC for approval and inclusion in the preventive structural maintenance concept.

Note

Susceptibility to a long-term deterioration of Product structure is assessed with regard to the operating environment. Areas such as major attachments, joints of non-metallic parts with metallic parts and areas of high stress levels are likely candidates for PMTR. This also includes direct interfaces between metallic material and non-metallic materials. These interfaces must be analyzed for potential electrochemical and/or wear damage and/or deterioration.

Step S10:

The homogeneous non-metallic SSI/SD analysis is described in the following Fig 4:



ICN-C0419-S4000P0004-001-01

Fig 4 Product structure analysis - AD/ED Analysis for non-metallic SSI/SD

Non-metallic structure materials are also susceptible to damages and/or deterioration (eg, delamination, dissolution). When a Product structure is classified as an SSI comprising one or more SD, preventive inspections and/or test tasks are required to verify adequate structural strength throughout the operational or usage life of the Product.

Following the sequence of the work steps shown in Fig 4 the applicable and effective SSI/SD inspection/test task requirements have to be selected prior to the determination of a PMTR interval. A PMTR selection sheet/file must be available in the PPH for the responsible analysts. Refer to example for inspection task selection in Fig 6.

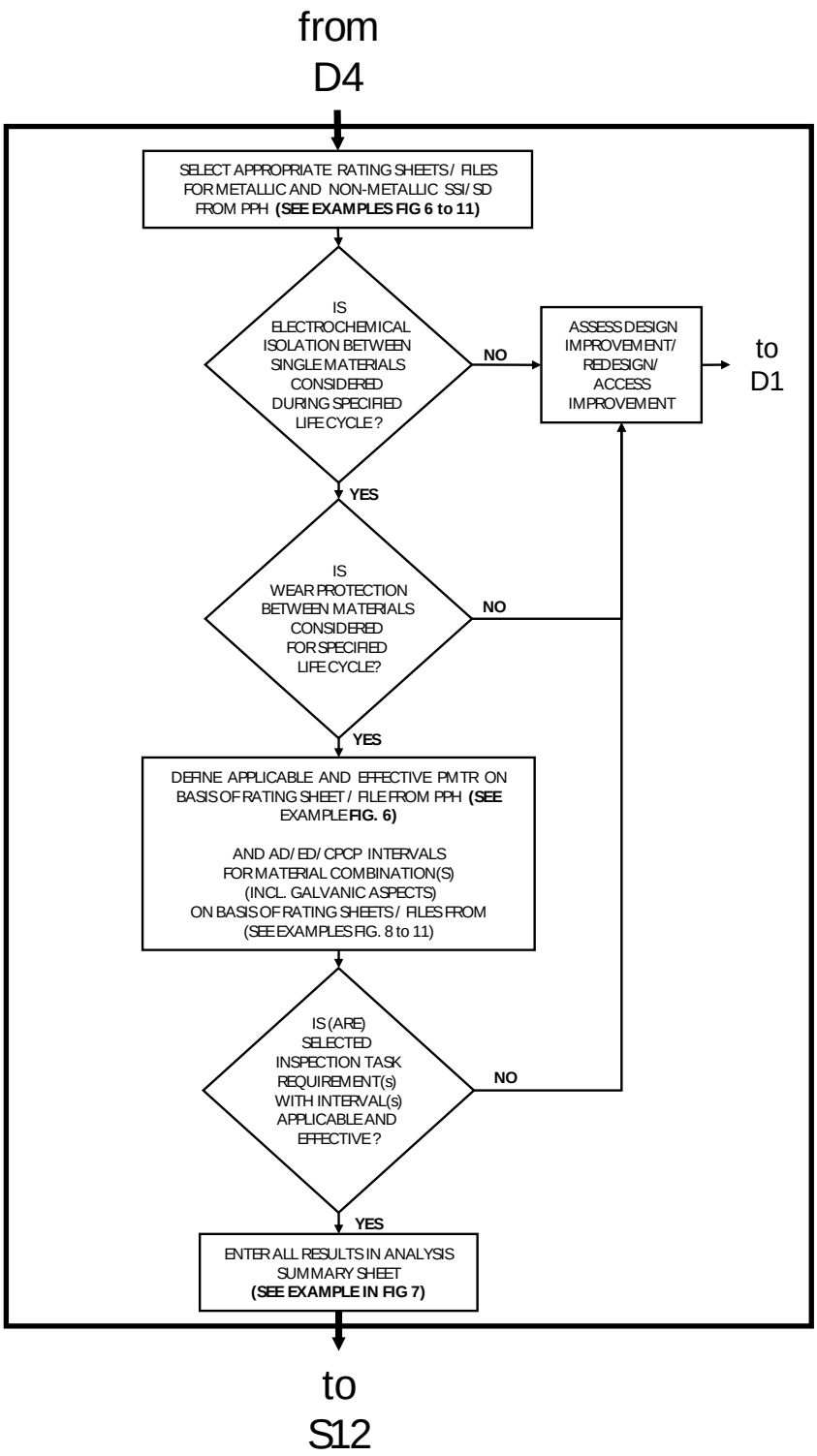
Having defined the task type of the PMTR, the analyst determines intervals for PMTR for each SSI/SD on basis of rating sheets/files. Focused on the SSI/SD structure material, AD and ED rating sheets/files must be filled and the different interval results must be harmonized by the responsible analyst. For the individual SSI material, a guess of future AD and ED impact parameters, the Product usage/operational scenario as well as the forecast of the future deterioration process must be taken into account and documented in the rating sheets/files (refer to Fig 10 and Fig 11). A CPCP analysis is not applicable for non-metallic SSI/SD.

Note

An age exploration program can support the verification of the rate of structural deterioration of non-metallic SSI. Results can support the improvement on the PMTR interval rating for non-metallic SSI.

Step S11:

The SSI/SD material-combination analysis is described in following Fig 5:



ICN-C0419-S4000P0005-001-01

Fig 5 Product structure analysis - Analysis of SSI/SD material combinations

Material combinations of SSI/SD are not limited on a local interface between two or more different materials which can be separated from each other. The material combinations mentioned in this Product structure analysis cannot be separated from each other during the Product life cycle.

Example: A non-metallic structure material that is reinforced with metallic layers and/or wires permanently fixed inside a common resin matrix.

After checking necessary technical preventions implemented by design (eg, electro-chemical isolation between different material types, protection against water ingress) this analysis methodology proceeds with the analysis of both the metallic components and the non-metallic components of the material combination.

Depending on the design of the material combination, the location of the single material components towards each other, the SSI/SD geometry and the installation on the complete Product, the AD and ED interval rating sheets lead to different severity of AD/AD impacts in comparison to a homogeneous material component rating.

Usually those SSI material layers located close to the item surface have a more severe impact from ED. AD impacts on the single SSI/SD material components depend on the design of the SSI/SD and on the overall location and installation of the SSI/SD on the Product.

The analysis steps described in the PPH rating sheets for the single material components "metallic" and "non-metallic" are also applicable for this SSI/SD analysis of a material combination.

Step S12:

All analysis steps from Step S8 thru Step S11 determine PMTR with intervals for the selected SSI/SD. Depending on the location of those SSI/SD on the Product relatively to each other it must be checked, if PMTR with intervals can be combined or harmonized from the technical point of view in order to reduce the total maintenance effort in a future Product in-service phase.

As a consequence of such a interval harmonization process, the maintenance effort increases for the single PMTR with the higher numerical interval value. But this effect is compensated in a positive manner, if the total maintenance effort for both PMTR with a common interval can be reduced significantly.

Example: Two SD on an SSI are located very close to each other on a Product. According to structure analysis results they have to be inspected with a detailed inspection at different intervals. For each detailed inspection high accessibility effort is necessary (Product disassembly/assembly). The combination of both detailed inspections at a common lowest interval is most effective.

Step S13:

After a first harmonization of PMTR with intervals for SSI/SD on the rating sheets/files, all analysis results have to be documented including a reference on the valid built standard of each SSI (drawing number, part number, etc). This is to follow-up decisions for future configuration changes after having finished the initial structure analysis.

Step S14:

Products in a Product fleet with the highest rate of usage/operation cycles in combination with usage stress parameters on upper level are most susceptible to initial fatigue failures and cracking.

Differences of Product usage parameters at an operator enable the selection of the sampling methodology to perform preventive inspection/test tasks only on selected Products of the Product fleet.

Example: Aircraft with highest number of hard landings become preferred candidates for inspections/tests on structural items of the landing gear structure.

Inspection/test of structural items on pre-selected Products provide the highest probability for a detection of failures and/or damages in due time. Sampling and/or a fleet leader strategy must be defined on basis of appropriate statistical data, including:

- the number of Products inspected with a built standard representative for the SSI/SD
- the inspection/test methods and PMTR repeat intervals
- in-service/usage experience and data
- the operational surroundings and conditions in which the Product will be operated in the coming life cycle period (eg, preferable in cold weather, sea-water, desert conditions)

A list of SSI with SD (if required), which are suitable for a fatigue related sampling with justifications about fleet leader inspections/tests must be established and submitted to the program Steering Committee (SC) for approval. That information supports the development of a later scheduled maintenance program/OMP for the Product. Refer to Chap 10 in S3000L).

Every reduction of the preventive maintenance effort for the Product fleet by introduction of a sampling and/or fleet leader concept must be agreed by Product responsible authorities (if existing) and/or by the responsible management of the Product manufacturer.

The sampling/fleet leader concept is again subject to the ISMO analysis during in-service phase (refer to Chap 3). During the Product in-service phase, one or more analysis loops of the ISMO process is recommended to be performed in order to update the OMP of a Product. For both the development of the initial OMP and for the OMP updates by ISMO during the in-service phase, responsible regulatory authorities must be involved.

Decision D5:

Next to the SSI/SD remaining structural items are defined as "non-SSI".

Non-SSI according to this specification consists of two item categories:

- Maintenance relevant Product structure
- Non-critical Product structure

Maintenance relevant Product structure:
Potential failures or damages on/to non-SSI are not as critical as failures or damages on SSI/SD Failures or damages on maintenance relevant structure can lead to a significant reduction of Product availability for mission/operation and/or can cause high repair costs.

Within zonal boundaries (to be defined in a Product zonal plan), maintenance relevant structures can be located both externally and internally in the Product structure. Zonal areas which do not require specific accessibility effort (means: no disassembly work etc) will either be inspected during routine inspections on basis of a high task frequency (eg, daily-, preflight-, turnaround-, transit-, post flight inspections on an aircraft) or by zonal inspections with a lower task frequency.

For maintenance relevant structure the most effective inspection/test method is not limited to a General Visual Inspection (GVI). Failures or damages on maintenance relevant structure must be detected by an appropriate inspection/test method with applicable intervals during the Product life cycle. The scope is a timely detection of failures, damages on the selected structural item or the item deterioration status.

For maintenance relevant structures, two types PMTR with intervals must be preferred:

- Inspection during routine inspections (eg, in the frame of routine inspections)
- Inspection during a preventive maintenance task package (eg, every 6 month)

The decision about the interval can be based on individual operators' and manufacturers' experience with similar Product structure. For structure containing new materials and/or Product design concepts, selected intervals can be based on an assessment of manufacturers' material test results (if available), experiences and/or recommendations from material suppliers.

Non-critical Product structure

Non-critical structures are neither SSI/SD nor maintenance relevant structures. The inspection of non-critical structures must be covered by a GVI performed during zonal inspections.

Note

The SSI selection must not be confused with the ARC selection that is part of the system analysis explained in Chap 2.2. Both the ARC and the SSI selection can become relevant on selected Products (eg, main rotor assembly and tail rotor assembly of helicopters). Clarification in common with an overview on the selected types of analysis candidates must be given in a Product-specific PPH. Refer to Chap 1 and Chap 2.2.

Structure items categorized as non-critical structure don't require specific PMTR with intervals. That Product structure is covered by a GVI performed during zonal inspections. If experience shows that damages and/or environmental impacts lead to time-consuming and/or cost-intensive repair or modification, non-SSI can be switched to maintenance relevant structure in the frame of the ISMO process. Refer to Chap 3.

If the structural item is judged to become maintenance relevant during the Product in-service phase (Answer YES), continue with Step S16.

If not (Answer NO), continue with Step S15.

Step S15:

As described before, non-critical structure does not lead to a specific PMTR with interval. Potential failures or damages are covered by the GVI and its interval defined in the standard zonal analysis (refer to Chap 2.4). Non-critical structure must be identified in the structural item list for future control and overview purposes. On basis of the structural item list, it can be verified, if correct criticalities of all structural items have been categorized.

Step S16:

The analyst collects information, data and drawings about selected maintenance relevant items and evaluates the item susceptibility to AD and/or ED. The maintenance relevant item list can be used by the Product design departments, for example, to develop standard structure repair procedures.

Decision D6:

The GVI on the maintenance relevant structural item must identify potential damages which are visible and accessible. Maintenance personnel have a direct access to the identified structural item without disassembly effort and without the use of support equipment/tools.

If the GVI is judged to be frequent enough during the standard Zonal inspection (Answer YES), continue with Step S17.

If not (Answer NO), continue with Step S18.

Step S17:

Depending of the estimated failure or damage cause, the analyst defines a preventive GVI task requirement, for example during Product routine inspections. Routine inspection intervals are lower in comparison to zonal inspection intervals.

Step S18:

A low probability of failure, damage events or a slow deterioration process on maintenance relevant structure can be covered by the GVI performed during the zonal inspection. A GVI must detect all obvious and visible failures, damages, loose items and/or foreign objects inside the zone under inspection. The selection of the numerical value of the interval for the GVI in the

zone results from the zonal interval rating. Refer to standard zonal analysis described in Chap 2.4.

Step S19:

Consolidate all PMTR with intervals identified during Product structure analysis. Take into account the different analysis relevant work shares of the Product structure (if any).

To allow a better traceability of the analytical work and to optimize the correlation of analysis results, it is recommended to describe selected PMTR in a more detailed way on the analysis summary sheets (however a description on technical publication level is not required).

Step S20:

End of the S4000P Product structure analysis for a defined Product configuration/state of construction.

If the Product design changes on the Product structure, the manufacturer must establish an approval process, if the structure analysis process must be started again for the impacted structure. If necessary, the S4000P analysis results must be updated accordingly.

5 Rating systems for structural significant items/significant details

Depending on the material type of an SSI/SD, rating systems have to be applied to ensure:

- a traceable selection of the most applicable and effective maintenance task types

and

- the traceability of the numerical interval values that have been determined in the frame of this analytical method

The development of the rating system must comprise:

- manufacturers' best engineering judgments
- "state-of-the-art" technology knowledge
- considerations of all existing Product analysis requirements
- requirements from or conditions predicted by authorities
- operator experiences

Available inspection/test methods are based on the "state-of-the-art" set of maintenance task types available when the analysis work takes place. It is essential, that for maintenance task type selection, a harmonized selection logic is provided in the PPH. The PPH must consequently be used by all analysts. Refer to Fig 6.

In case new maintenance task types being developed and available in the future, the optimization of preventive maintenance (ISMO) will consider new technologies during the Product in-service phase. Updated maintenance task selection logic must be documented in the ISMO-PPH. Refer to Chap 3.

Several interval rating examples are attached to this structure analysis (refer to Fig 7 thru Fig 11). However interval rating sheets/files must be individually developed for each Product under analysis and can’t be transferred from one Product to the other Product without a detailed evaluation.

Each likely source of damage and the susceptibility of the SSI/SD to that damage must be rated. The combination of the rating results covers all deterioration impacts on the SSI/SD under analysis. Additionally the differences between metallic, non-metallic materials and material combinations for each SSI/SD to be taken into account.

The purpose of developing structural PMTR with intervals is to provide timely detection of potential impacts by AD, ED, and FF. The interval rating systems used for both AD and ED must be in a suitable format that will enable easy comparative assessments for SSI/SD.

For metallic SSI/SD, the AD/ED analysis must comprise a rating table for corrosion protection (refer to Fig 9). This table must include both the manufacturers' experience and the operators' feedback relating on different environmental conditions under which the Product will be operated.

After having finished the interval ratings for all SSI/SD in the same inspection area (with common accessibility) it is recommended to harmonize the resulting intervals.

Damage size, accessibility together with the different inspection methods are important factors to define an interval rating system for FF. For the final FF interval determination the crack growth curve must be calculated by the responsible structure design department.

5.1 Rating fatigue failure

The rating system must lead to inspection/test task requirements with intervals. The applicable preventive inspection task requirements must be determined on basis of the inspection task selection logic. Refer to Fig 6.

The inspection intervals of each selected PMTR must provide a high probability of detecting fatigue failure in the fleet before such failure reduces any Product's residual strength below allowable levels. To achieve this, the rating system must consider the following:

- Detection standards for applicable inspection/test methods

  Note

  Estimated detectable crack lengths can be used for the fatigue failure detection evaluations required as part of Product type certification.

- Applicable inspection/test levels and methods (eg, visual, NDT), directions (eg, external, internal) and repeat intervals

Responsible departments for structure fatigue must receive Product-specific information about selected SSI/SD to calculate the appropriate PMTR intervals.

5.2 Rating accidental damage

The rating systems for AD must include evaluations of:

- the susceptibility of the SSI/SD to minor accidental damage
- the residual strength of the SSI/SD after accidental damage has occurred
- the timely detection of damage

Susceptibility to minor accidental damage

Susceptibility to minor AD must be based on the frequency of exposure and the location of damage from one or more sources.

Typical examples include, but are not limited to:

- manual handling on or close to the Product
- human error resulting from errors during manufacture, maintenance, and/or operation
- foreign objects or debris
- inclement weather - including lightning strike, hail, etc
- cargo handling or air delivery
- mission role change (military)
- air-to-air refueling (military)

Residual strength after damage occurrence

Residual strength after damage occurrence must be based on the probable size of damage in relation to the critical damage size for the SSI/SD.

Timely detection of damage

Timely detection of damage must be based on the expected rate of growth and visibility of the SSI/SD for inspection. Account must also be taken of the damage growth associated with non-chemical interaction with an environment, such as disbonding or delamination growth associated with for example freeze or thaw cycle.

5.3 Rating environmental deterioration of metallic structure

All parts of metallic structure are susceptible to ED, particularly when they are exposed to abrasive or corrosive agents that cause a localized loss of material. If not discovered at a very early stage, this process reduces the load carrying capability of the affected structure, lowering the structure fatigue strength.

Usually its occurrence is proportional to calendar time, increasing with the age of the structure. Each metallic SSI/SD must be rated for ED as follows:

- type of corrosion
- surface protection
- exposure to corrosion

The ratings for ED are based on an items susceptibility to damage induced by the environment along with the potential effectiveness and durability of surface protection systems.

Specific examples of ED exposure are:

- Exposure to a deteriorating environment (eg, for aircraft: pressure cabin condensation, galley spillage, toilet spillage, cleaning fluids, missile exhaust, chaff-flare operation)
- Galvanic corrosion. A contact between dissimilar materials with potential for galvanic activity.
- Breakdown of surface protection systems (eg, deterioration of paint, primer, bonding, sealant, corrosion inhibiting compounds and cladding systems with the resulting corrosion of metallic materials or fluid incursion into permeable non-metallic materials)

Attention must be given to the Products anticipated operating environment and the likelihood of damage from contact between dissimilar metals. Generally areas exposed to moisture, dirt and heat are the most susceptible to corrosion and must be properly maintained.

A timely detection is determined by sensitivity to relative size of damage and visibility of the SSI/SD for inspection.

5.4 Rating environmental deterioration of non-metallic structure

Environmental deterioration associated with composites includes delamination, disbonding, blistering and the appearance of internal voids. Rating systems must permit evaluation of the susceptibility to, and timely detection of any structural deterioration of the material in common with an assessment of the efficiency of the protective system, the material composition and exposure to the environment.

Typical factors that affect composite materials are:

- moisture or humidity
- heat or high temperature
- ultraviolet light

Specific ED examples representative of some common composite materials are shown below:

- Aramid Fiber Reinforced Plastic (AFRP, also known as Kevlar), for example, is sensitive to Ultra-Violet (UV) light, moisture and other fluids, when directly exposed
- Glass Fiber Reinforced Plastic (GFRP), for example can undergo long term degradation when directly exposed to UV light, but is judged to have a low sensitivity to the environment
- Carbon Fiber Reinforced Plastic (CFRP) is judged to have a low sensitivity to the environment

5.5 Rating of metallic and non-metallic structure material combinations

The single rating sheets/files for metallic and non-metallic material are also applicable for material combinations of metallic and non-metallic materials. However, depending on the type of material combination, the location of installation on the Product and the resulting exposure to accidents and/or deterioration rating values of a material combination differ from a homogeneous material type rating. Rating systems for material combinations are based on the manufacturers' experience and/or on operators' feedback.

6 Definition of interval thresholds

For definition of an initial interval threshold for a PMTR on SSI/SD, the source of damage or the failure cause must be taken into account:

- **AD** - An inspection threshold is not applicable for interval rating in the frame of accidental damage analysis.
- **ED** - The initial inspection thresholds for all levels of inspection are based on existing relevant in-service experience, manufacturers' recommendations, and/or a conservative age exploration process.
- **Fatigue Failure** - Inspections directly related to fatigue failure detection will occur after an interval threshold. This interval threshold must be defined by the manufacturer and approved by the appropriate regulatory authority. Thresholds are normally established as part of the damage tolerance certification requirements. These are subject to change as service experience, additional testing, or analysis work is obtained. Next to the inspection threshold, repeat intervals have to be defined. Both threshold and repeat interval definition have to be defined by the responsible Product structure design department.

7 Definition of repeat inspection intervals

After the initial PMTR has been conducted, the repeat interval gives the period until the next inspection becomes due:

- **AD** - The repeat intervals of the inspection must be based on operators' and manufacturers' experience with similar Product structures.
- **ED** - The repeat intervals for detection, prevention and control of ED (eg, corrosion, stress corrosion, delamination) must be based on existing in-service experience and/or manufacturers' recommendations.
- **Fatigue Failure** - The repeat intervals for fatigue related inspections is/are based on the damage tolerance evaluations and/or fatigue test results of the design departments. These are used to demonstrate that applicable and effective inspections/tests provide sufficient probability of detecting fatigue failures for each SSI/SD.

8 Documentation of preventive maintenance tasks with intervals during Product in-service phase

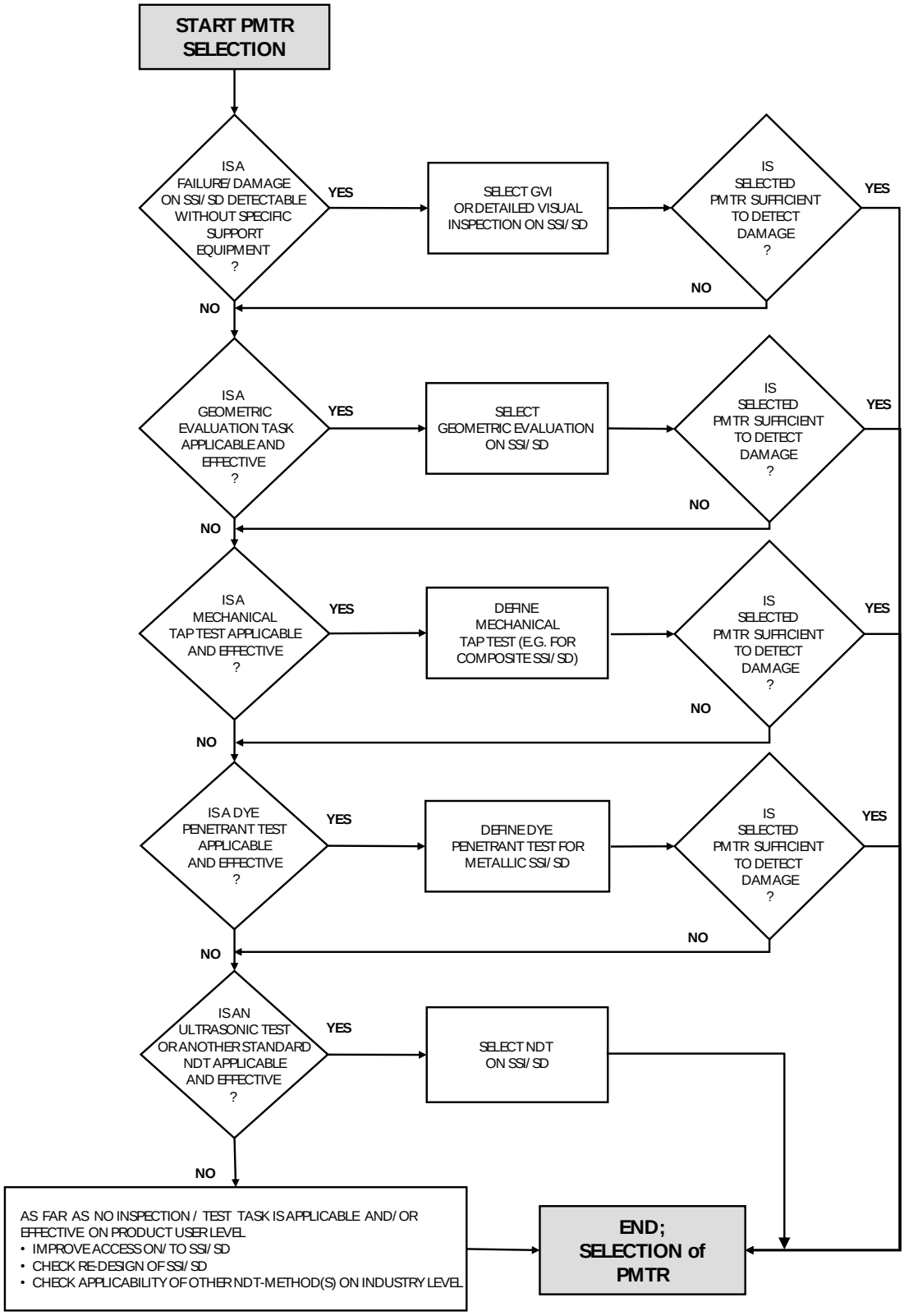
PMTR resulting from this analytical methodology have to be authorized and can be documented in an appropriate database (refer to S3000L) to become part of the technical documentation of the Product (refer to S1000D). These PMTR with intervals have to be performed from the beginning of the Product in-service phase on. PMTR with intervals, developed prior the Product in-service phase, must be optimized using the ISMO process during the Product in-service phase (refer to Chap. 3).

The Product manufacturer and operators must implement a satisfactory system for the effective collection and dissemination of in-service data and experience from the preventive structural maintenance.

This process can be supplemented by a system, which is required by existing regulations for reporting occurrences, failures, malfunctions or defects (eg, service difficulty reports, fault reports, maintenance work orders). Based on collected and evaluated information, the content of an OMP can be checked and optimized.

Depending on the experience, valid preventive maintenance tasks and/or their interval types and or the numerical interval values can be:

- changed or modified
- replaced
- supplemented or extended by a new maintenance task requirement with interval
- limited on dedicated inspection spots or Significant Details (SD)
- deleted



ICN-C0419-S4000P0006-001-01

Fig 6 Inspection task type selection on operator maintenance level (can be adapted for the structure under analysis

Structure analysis summary sheet			
Product name	LCN	SSI/SD Description	Item part number

DRAWING NUMBER		DRAWING TITLE	
MATERIAL			
PROTECTION			

SSI/SD SELECTION EXPLANATION	SSI/SD DESIGN CONCEPT
	FATIGUE SAFE LIFE (Y/N): FATIGUE LIFE LIMIT: DAMAGE TOLERANT (Y/N):
DIAGRAM/ DRAWING/ SKETCH	
COMMENTS	

INSPECTION REQUIREMENTS/INTERVALS				
	THRESHOLD	REPEAT	METHOD	REMARKS
AD ANALYSIS				
ED ANALYSIS				
Fatigue Failure ANALYSIS				
CPCP ANALYSIS				
PREPARED BY:		..../..../.....	AUTHORISED BY:	..../..../.....

ICN-C0419-S4000P0007-001-01

Fig 7 Structure analysis rating sheet (to be defined and filled with rating data specific for a Product under analysis), example

ACCIDENTAL DAMAGE (AD) ANALYSIS SHEET PART 1
(FOR METALLIC AND NON - METALLIC SSI/SD)

PRODUCT NAME	LCN	SSI/SD DESCRIPTION	ITEM PART NUMBER

SOURCE OF DAMAGE:

	YES	NO
GROUND HANDLING		
CARGO HANDLING		
MANUFACTURING DEFICIENCIES (1) (2)		
MAINTENANCE ACTIVITY		
RUNWAY DEBRIS		
SPILLAGE		
WATER ENTRAPMENT		
CARGO AIR DELIVERY		
PRODUCT ROLE CHANGE		
REFUELLING (E.G. AIR TO AIR)		
OTHERS		
		NONE

→ NO PREVENTIVE INSPECTION REQUIRED

CONSEQUENCE OF DAMAGE:

FATIGUE INFORMATION:

SUBSTANTIATION METHOD:

SAFE LIFE DESIGN PRINCIPLE

BASICSAFE LIFE LIMIT

ARE ABOVE WRITTEN DAMAGE(S) TAKEN INTO ACCOUNT FOR SAFE LIFE LIMIT CALCULATION ?

YES → APPLY BASIC SAFE LIFE LIMIT

NO → RE-CALCULATE SAFE LIFE LIMIT

DAMAGE TOLERANT DESIGN PRINCIPLE

DAMAGE TOLERANT PMTR INTERVAL

NEW / ADDITIONAL DAMAGE TOLERANT IMPACT(S) ?

NO → APPLY BASIC INTERVAL

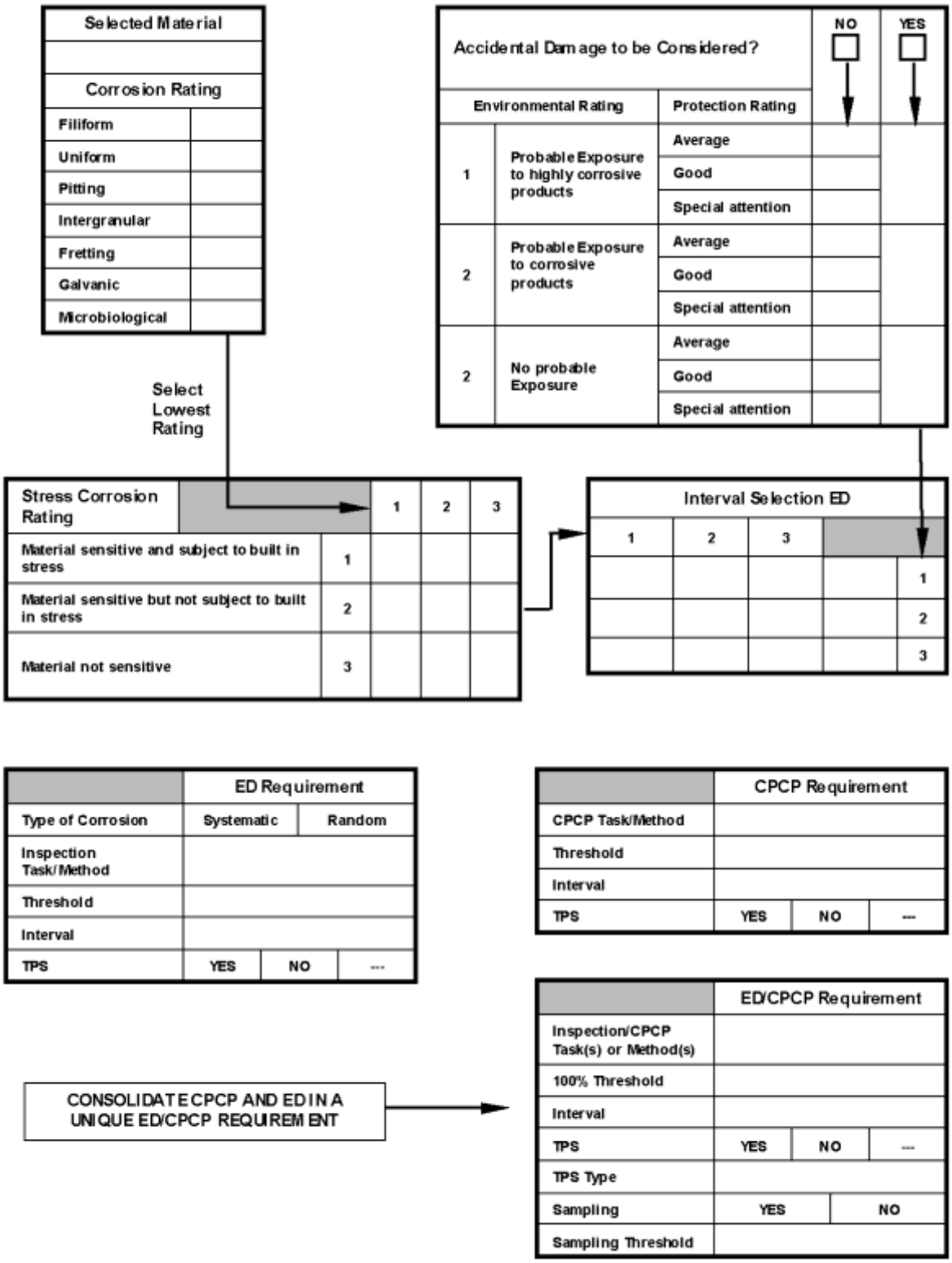
YES → DEFINE NEW INTERVAL

REMARKS:

1. SSI's/SD's SHALL NOT BE CONSIDERED SUSCEPTIBLE TO MANUFACTURING DEFICIENCIES IF THIS POTENTIAL SOURCE OF ACCIDENTAL DAMAGE HAS BEEN TAKEN INTO ACCOUNT IN THE DESIGN SUBSTANTIATION OF THE SSI/SD.
2. MANUFACTURING DEFICIE NCIES SHALL BE CONSIDERED AS A POTENTIAL ACCIDENTAL DAMAGE SOURCE IF THE SSI/SD IS MADE OF A MATERIAL WHICH IS NEW TO THE INDUSTRY OR IF ITS MANUFACTURING PROCESS IS PARTICULARLY COMPLEX OR NEW TO THE INDUSTRY.

ICN-C0419-S4000P0008-001-01

Fig 8 AD analysis sheet Part 1, example



ICN-C0419-S4000P0009-001-01

Fig 9 Combined interval rating sheet for metallic SSI/SD covering both AD Part 2 and ED, example

ACCIDENTAL DAMAGE (AD)
ANALYSIS SHEET (PART 2) FOR COMPOSITE SSI/SD

PRODUCT NAME	LCN	SSI/SD DESCRIPTION	ITEM PART NUMBER

SAFE LIFE DESIGN CONCEPT

DETERMINE FACTOR V FROM

		LIKELIHOOD OF DAMAGE		
		PROBABLE	**POSSIBLE**	**UNLIKELY**
VISIBILITY BASED ON ACCESSIBILITY/ INSPECTION METHOD EFFECTIVENESS	POOR	**e.g. 4**	**e.g. 3**	**e.g. 2**
	ADEQUATE	**e.g. 3**	**e.g. 2**	**e.g. 1**
	GOOD	**e.g. 2**	**e.g. 1**	**e.g. 1**

DETERMINE FACTOR H FROM

		SENSITIVITY TO DAMAGE
SAFE LIFE (SL) (to be defined; e.g. in CYCLES)	SL ≤ TBD	**high (e.g. 3)**
	TBD < SL ≤ TBD	**medium (e.g. 2)**
	SL > TBD	**low (e.g. 1)**

INTERVAL= SAFE LIFE VALUE/(VxH)	
MAXIMUM INSPECTION INTERVAL: **X** (TBD; e.g. CYCLES)	
INSPECTION METHOD:	(TASK SELECTION ACCORDING TO ANNEX A)

REMARKS:

ICN-C0419-S4000P0010-001-01

Fig 10 AD analysis sheet, Part 2 for composite SSI/SD, example

Environmental deterioration (ED) analysis sheet for composite SSI/SD

Product name	LCN	SSI/SD description	Item part number

MATRIX A - ENVIRONMENTAL SUSCEPTIBILITY OF COMPOSITE MATERIALS

MATERIAL TYPE / ENVIRONMENTAL IMPACTS	CARBON / EPOXY	GLASS / EPOXY	KEVLAR / EPOXY	CARBON / EPOXY WITH FOAM FILLING	GLASS / EPOXY WITH FOAM FILLING	KEVLAR / EPOXY WITH FOAM FILLING	CARBON / EPOXY WITH HONEYCOMB FILLING	KEVLAR / EPOXY WITH HONEYCOMB FILLING
ULTRAVIOLET LIGHT								
HUMIDITY								
AGGRESSIVE FLUIDS								
COMBINED EFFECT OF HUMIDITY + HIGH TEMPERATURE								
CHAFF-FLARE								
MISSILE LAUNCH (EXHAUST GASES)								
SELECT LOWEST RATE	Eg 2	NOTE:	WHEN DIFFERENT FIBERS (CARBON, GLASS, KEVLAR) ARE USED WITHIN THE SAME MATERIAL, THE LOWEST SUSCEPTIBILITY RATING MUST BE SELECTED.					

MATRIX B - MATERIAL PROTECTION RATING

PROBABLE EXPOSURE TO	PROTECTION			WITH AD IMPACT
	PAINT	PRIMER	NONE	
U.V. LIGHT				
HUMIDITY				
HUMIDITY + HIGH TEMPERATURE				
AGGRESSIVE FLUIDS				
SELECT	LOWEST RATE			e.g. 3

MATRIX C – 1st RATE COMBINATION

	1	2	3	4
1				
2				
3				
4				
COMBINED RATE 'C'				2

MATRIX D

LIKELIHOOD OF DAMAGE	RATE
NEGLIGIBLE	
LOW	
MODERATE	
HIGH	
SELECTED RATE	e.g. 2

MATRIX E – 2nd RATE COMBINATION

	1	2	3	4
1				
2				
3				
4				
COMBINED RATE 'E'				2

COMBINED RATE 'E'	1	2	3	4
INSPECTION INTERVAL	INTERVAL A	INTERVAL B	INTERVAL C	INTERVAL D

INSPECTION REQUIREMENT: THRESHOLD = ...

REPEAT = ...

INSPECTION METHOD: .....

Remarks:

ICN-C0419-S4000P0011-001-01

Fig 11 ED analysis sheet for composite SSI/SD, example

Chapter 2.4

Zonal analysis

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 2.2	System analysis
Chap 2.3	Structure analysis
Chap 2.5	Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources, traceability
Chap 3	In-service maintenance optimization (ISMO)
Chap 5	Terms, abbreviations and acronyms
S1000D	International specification for technical publications using a common source database
S3000L	International procedure specification for Logistic Support Analysis - LSA

1 Product zones

For analysis purpose, a Product geometry must be subdivided into 2- and/or 3-dimensional areas, named as Product zones in this document. Each Product zone borders either towards one or more other Product zones or is limited only by its own zonal dimensions.

A Product zone is defined on basis of accessibility from a Product user and/or from Product maintenance personnel to the zone:

- Product zones with a limited accessibility from outside the Product

and/or

- Product zones with a limited accessibility from inside the Product
- Product zones with unlimited accessibility

The selection and definition of Product zones must be defined in a "Product zonal plan". This document must cover 100% of the physical Product dimensions. To each Product zone a zonal numbering is to be allocated. Overlapping areas between single Product zones must be avoided.

If a Product is composed of several main Product components (eg, main system components for Unmanned Air Vehicle (UAV) systems like air vehicle and ground stations) a "component zonal plan" for each Product component must be prepared. The components are physically separated from each other with own physical dimensions, with different impact parameters during in-service phase, with different usage parameters, etc.

2 Objectives of zonal analysis

Both the ASD S4000P system analysis (refer to Chap 2.2) and the ASD S4000P structure analysis (refer to Chap 2.3) concentrate on failure/damage causes and their consequences/functional effects on functional levels of a Product system or of Product structure. For these failure/damage causes applicable and effective preventive maintenance task requirements (PMTR) with intervals must be defined or item redesign must be required/evaluated.

Besides of the above mentioned analysis methodologies, the ASD S4000P zonal analysis is to be applied on a Product zone with all items from Product systems being installed inside the zonal Product structure.

It takes into account at least the following aspects for developing applicable and effective PMTR with intervals:

- zonal damage susceptibility
- density / complexity of equipment/item installation in the zone under analysis
- access frequency of maintenance personnel to the zone under analysis
- criticality of interfaces between equipment/items of different systems and functions inside a zone under analysis
- Product-external impacts on Product zones and the equipment/items installed inside

PMTR with intervals for Product zones must be developed from application of the zonal analysis procedure according to this specification.

This zonal analysis logic has a modular structure by intention. At least one or more Zonal Analysis Modules (ZAM) allow a modular composition of the zonal analysis methodology necessary for different Product types and Product technologies:

- ZAM 1 - Standard zonal analysis
- ZAM 2 - Enhanced zonal analysis
- ZAM 3 - Lightning/High Intensity Radiated Field (L/HIRF) analysis
- ZAM X - one or more additional modules necessary for a specific Product type

Applicable ZAM must be invented and/or composed individually for a Product under analysis.

The module ZAM 1 must be selected for every Product zonal analysis. It is limited to the selection of the maintenance task type General Visual Inspection (GVI) and evaluates the relevant standard impact parameters for an individual Product zone. The numerical interval value of the PMTR for a zone is defined on basis of a specific rating sheet/table.

Note

Many support items such as plumbing, ducting, structure attachment items, wiring, etc, cannot be evaluated as potential FC with possible contribution to Functional Failures (FF) during system analysis (refer to Chap 2.2). In all Product zones, visible failures or damages, items without a correct attachment, foreign objects and visible degradation can occur during Product in-service usage. For these cases the preventive zonal GVI is an appropriate failure/damage detection method.

ZAM 2, ZAM 3 and ZAM X (if applicable for the Product under analysis) give additionally appropriate attention to every Product zone in terms of:

- probable sources of ignition (eg, caused by damages on electrical wiring installations) in ZAM 2
- combustible material and/or accumulation of explosive vapor in ZAM 2
- Lightning (L) impacts in ZAM 3
- impacts from High Intensity Radiated Fields (HIRF) in ZAM 3
- other Product-specific impact sources (if applicable) in ZAM X

ZAM 2 focuses on potential zonal hazards and can be applied on many Product types.

ZAM 3 (L/HIRF analysis) has no or only a limited applicability on Product types (eg, not for submarines or satellite analysis).

ZAM X can be defined and composed with ZAM 1, ZAM 2 and/or ZAM 3 for every individual Product type.

Note

ZAM 2 and ZAM 3 have initially been developed by industry for aircraft zonal analysis.

The zonal analysis logics in ZAM 2, ZAM 3 and (if required) in ZAM X are to be linked to results from system analysis (refer to Chap 2.2) and to structure analysis (refer to Chap 2.3). This is to enable a traceable selection of applicable and effective PMTR with intervals next to GVI requirements (if necessary).

In the final work steps of the zonal analysis main logic (refer to Fig 1) all identified PMTR with intervals must be harmonized on basis of the following rules:

- If PMTR with intervals can't be integrated into zonal GVI intervals (as so-called "stand-alone maintenance tasks"), these PMTR must be harmonized with PMTR from Product system analysis and/or from Product structure analysis. For "stand-alone" PMTR with intervals, the relevant Failure Causes (FC) and the allocated criticality category must be transferred into the analysis sheets/files of the respective S4000P analysis. For system analysis, refer to Chap 2.2 and/or for structure analysis, refer to Chap 2.3.
- Each preventive GVI with interval on an equipment/item identified from a system analysis (refer to Chap 2.2) and/or from a structure analysis (refer to Chap 2.3) and/or from ZAM 2, ZAM 3 and/or ZAM X, that has no "stand-alone" PMTR, can be harmonized with the interval of the GVI for the zone, where that equipment/item is installed.

The accessibility of maintenance personnel to a Product zone or to a limited area of a Product zone is taken into account in this zonal analysis procedure. If limitations or exclusions of access are identified during this zonal analysis, feedback to the responsible design departments and/or Product management must be provided. Depending on their feedback/their decisions, the selection of PMTR with intervals must be assessed again.

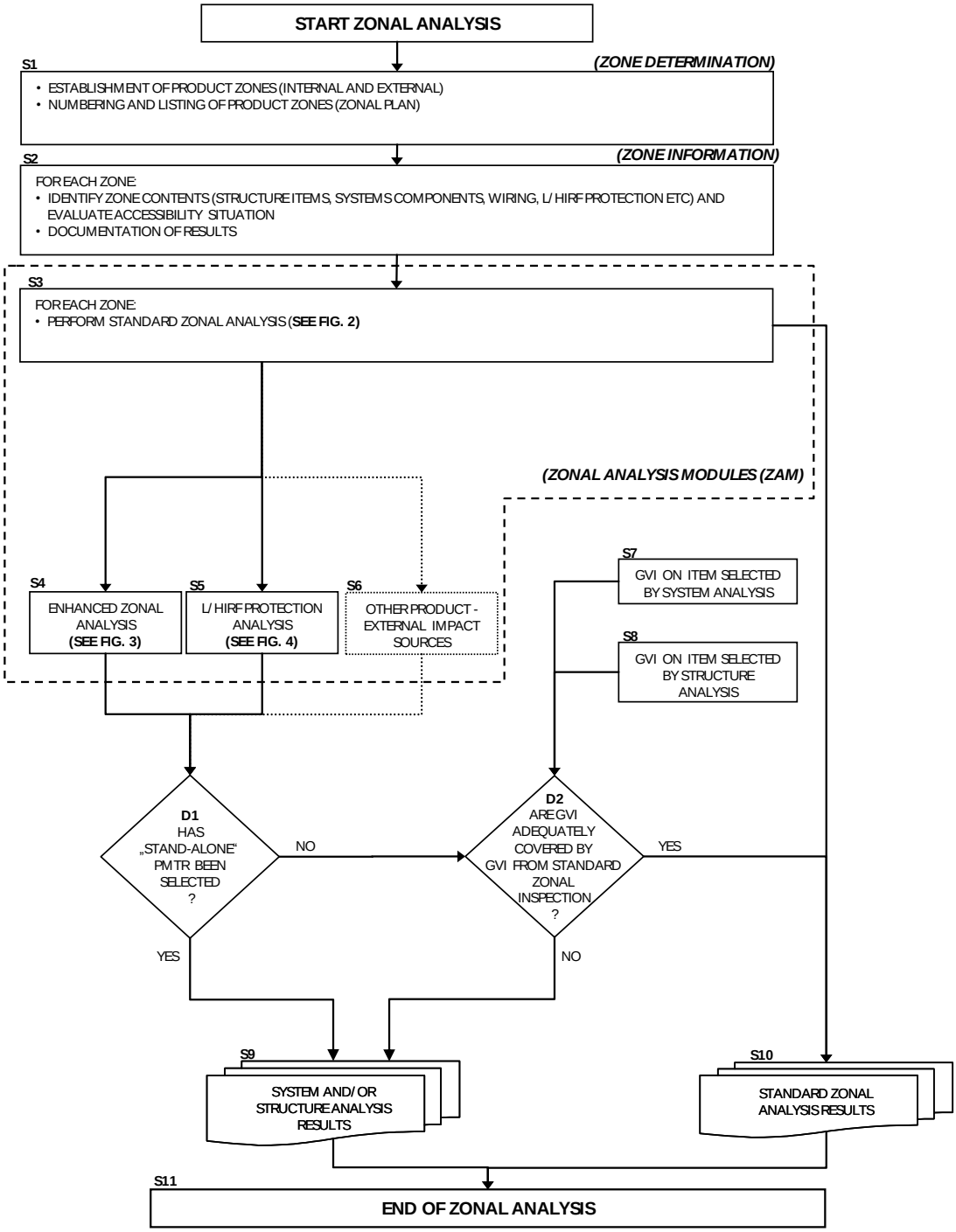
A zonal analysis on basis of this analysis methodology lead to harmonized PMTR with original interval types an numerical interval values. To determine preventive maintenance tasks with intervals for a Product maintenance program/OMP, follow process and rules given in Chap 10 in S3000L. For task packaging purpose, original PMTR intervals can be adapted.

The ISMO process (refer to Chap 3) is applicable and effective during the Product in-service phase, to optimize preventive maintenance tasks for Product zones documented in a maintenance program/OMP.

3 Zonal analysis procedure

This procedure is illustrated on flow charts in Fig 1, Fig 2, Fig 3 and Fig 4.

The procedure overview for zonal analysis is shown in the following main structure analysis logic diagram:



ICN-C0419-S4000P0012-001-01

Fig 1 Zonal analysis - Main logic

The process **Steps S** (Step S1, Step S2, Step S3, etc) and the **Decisions D** (Decision D1 and Decision D2) according to this zonal analysis procedure are explained hereafter.

Step S1:

Latest when the zonal analysis is decided to be started, the Product must be divided into Product zones with precise geometric dimensions and boarders towards each other. An official document (eg, called Product zonal plan) including a zone numbering for internal and/or

external Product zones must be issued and kept up to date. For the definition of Product zones, the accessibility of the zones during a later Product in-service phase must be taken into account. The Product with its complete geometric dimensions must be covered and all geometric deviations in the Product fleet (if any), Product variants etc must be covered by the Product zonal plan.

Step S2:

If the Product zonal analysis can be limited to selected Product zones, this information must be documented and justified in the Policy and Procedure Handbook (PPH). Selected and suppressed zones must be defined and justified on a list/in a data file ready for being presented to responsible regulatory authorities (if any).

For each analysis-relevant zone, prepare one or more work sheets/files collecting zonal relevant data and information such as:

- zone location and accessibility on the Product
- approximate zonal dimensions
- numbers and types of technical systems and components installed permanently and/or temporary
- typical power levels in wiring bundles and wiring/cable types
- information specific to L/HIRF protection items
- vibration, shock levels
- impact parameters on Environmental Deterioration (ED) and/or Accidental Damage (AD)

In addition, assess the presence of combustible material, either through contamination (eg, dust) or occurring by design (eg, potential accumulation of fuel vapor).

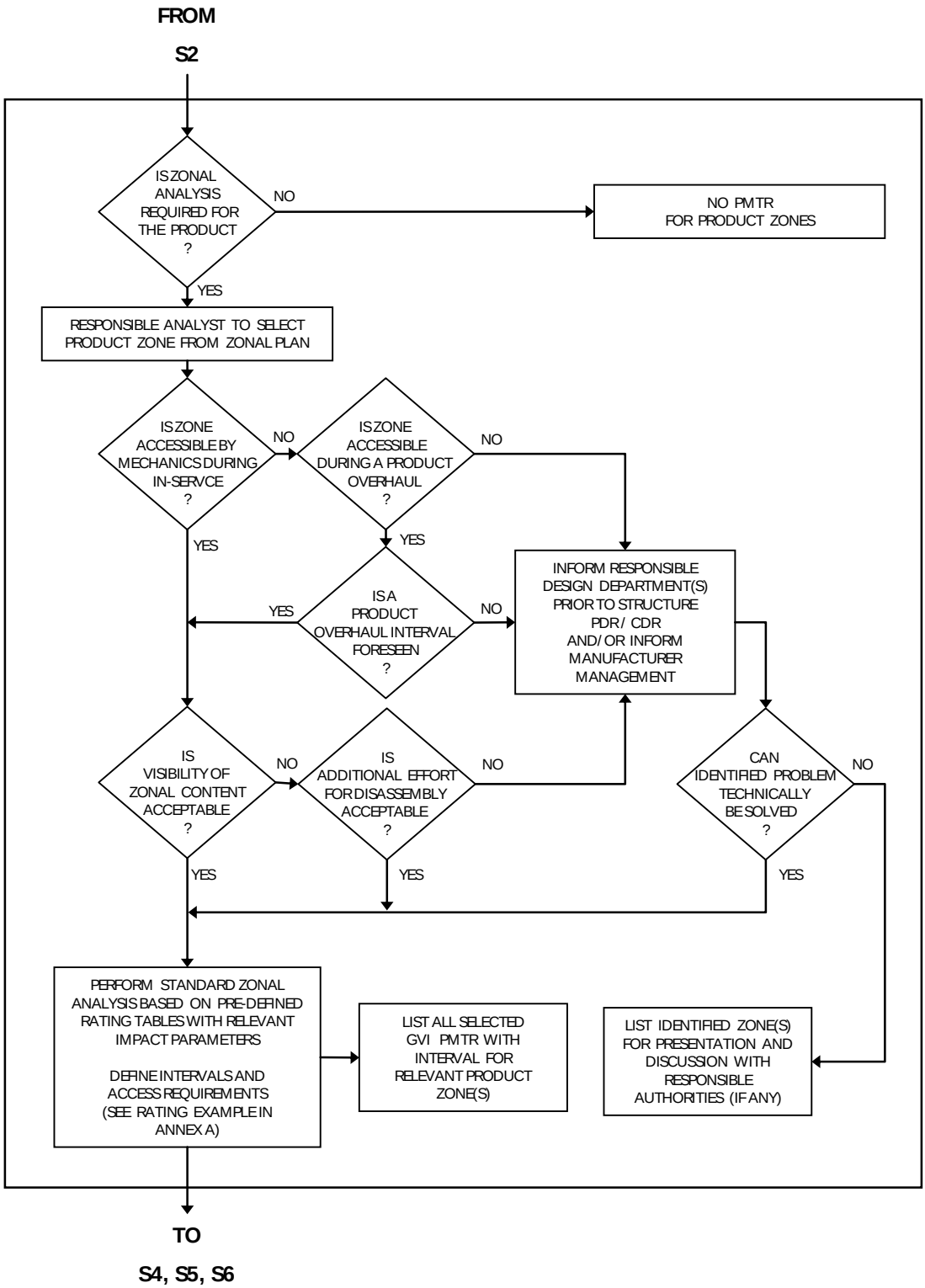
Identify zones that have comparable and/or identical impacts from ED, AD and a comparable zonal density. These zones can be addressed in one common rating sheet in the standard zonal analysis (ZAM 1).

Every enhanced zonal analysis (ZAM 2), L/HIRF analysis (ZAM 3) and/or other analysis modules (ZAM X, if decided for a specific Product type in a PPH) must be performed for each individual zone.

The analyst must take into account all configurations of each Product zone under analysis on the zonal work sheets/files.

Equipment/items installed in a zone must be listed, whether they are options or modifications and whether they are permanently installed on the Product or with temporary installation only.

Step S3:



ICN-C0419-S4000P0013-001-01

Fig 2 Flow chart standard zonal analysis

The standard zonal analysis (ZAM 1) according to Fig 2 in general defines the preventive maintenance task type GVI with intervals for the Product zones.

The zonal GVI with interval for an individual Product zone can be defined on basis of the stabile status of design, if personnel access to the zone is not limited or impossible and the visibility on equipment/items installed in the zone sufficient for inspection purpose.

The following cases do not allow the definition of a zonal GVI with interval for selected zones during an ongoing zonal analysis:

- An identified problem (eg, accessibility, new positioning of equipment inside a zone) must be solved first. A close contact between analyst and the responsible design department and/or management of the manufacturer is required. The analysis of the relevant zones must be postponed.
- A zonal GVI is not applicable for a zone under analysis because eg, accessibility will not be possible after Product assembly and the design can't be changed anymore. These zones (if any) must be documented with information and/or justifications.

All numerical values of intervals for GVI determined on basis of ZAM 1 must be derived from rating sheets/tables available in the PPH (refer to Fig 3 and Fig 4). These rating tables cover the likelihood of accidental damage parameters including specific damage causes (eg, as a consequence of military weapon activation and the effect of hot gas emissions after missile launch, gunfire vibrations, ejection of chaff and flares) and of environmental deterioration parameters.

The selection of intervals takes into account:

- the definition of repetitive numerical interval values starting from the beginning of the in-service phase on

and/or

- the definition of initial interval thresholds with subsequent repeat intervals
- the implementation of change steps for numerical interval values during the Product in-service phase (eg, start GVI with small intervals at the begin of the life cycle, followed by extended intervals during the Product midlife phase and followed by small intervals at the end of the Product life cycle)

The following parameters are taken into account to determine numerical interval values and interval types for a zonal GVI:

- hardware susceptibility to damage
- density of equipment/items installed inside the zone under analysis
- the amount of preventive and non-preventive activities and access frequency to the zone (operator, maintenance- and other personnel)
- amount of equipment newly designed/developed/produced (ie, less in-service experience exist)
- operators and manufacturers' experience with similar Products, systems and structures

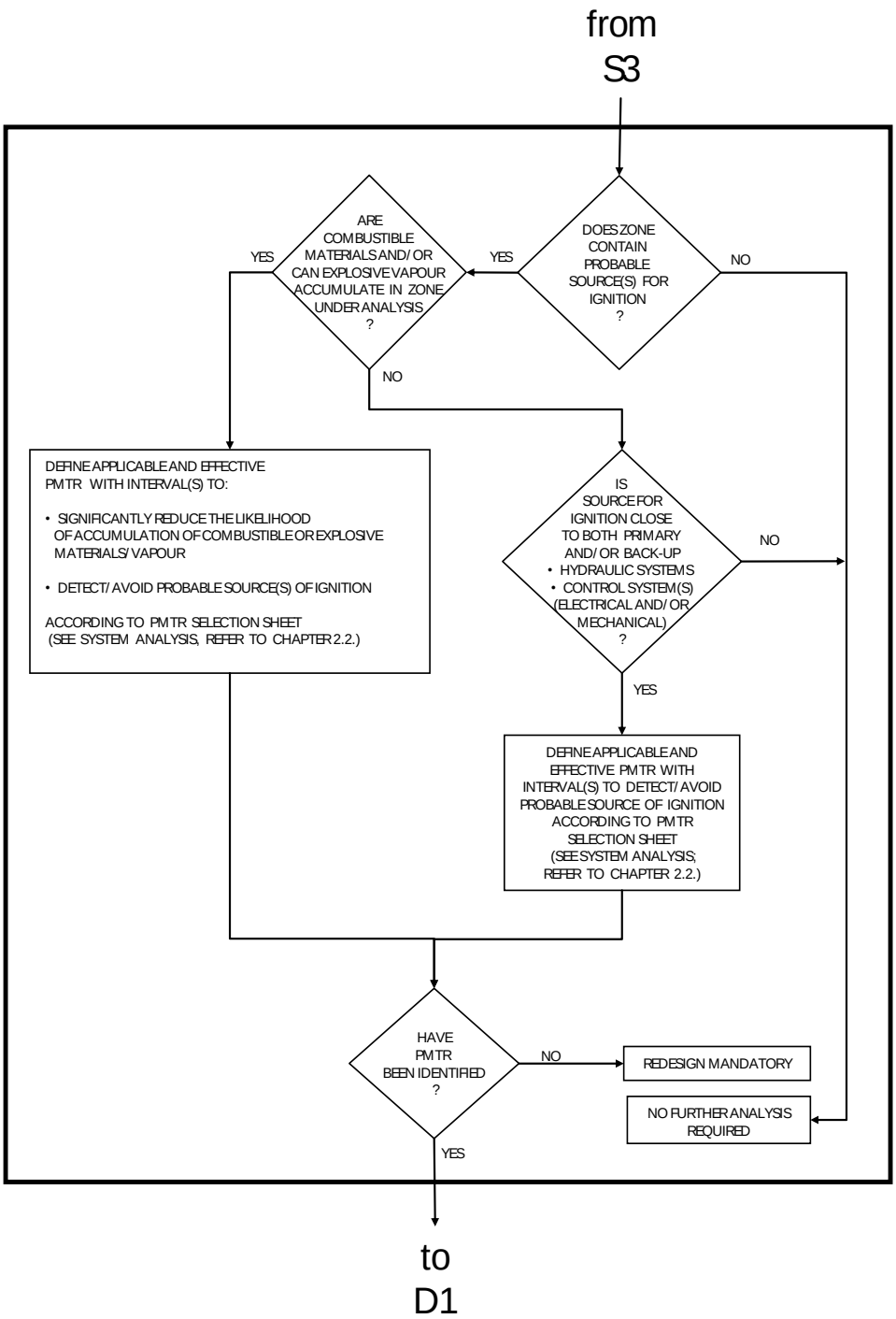
If possible, intervals must correspond to those intervals selected for targeted overall preventive Product maintenance (eg, according to a Product specification).

ZAM 1 according to Step S3 is followed by one or more additional ZAM explained in further analysis steps. Refer to Step S4, Step S5, Step S6.

Step S4:

By the enhanced zonal analysis (ZAM 2) all Product zones with equipment, wiring, tubes, etc, installed, must be analyzed, if they contain one or more sources of ignition (eg, sparks caused by a damaged electrical isolation of a power cable, hot spots on tubes/ducts/outlets) and/or if they contain combustible material / explosive vapor.

For Product zones, perform the work steps and answer the decisions according to Fig 3.



ICN-C0419-S4000P0014-001-01

Fig 3 Flow chart enhanced zonal analysis

ZAM 2 is linked to the standard maintenance task type selection sheet used in the S4000P system analysis (refer to Chap 2.2), that enables to identify applicable and effective PMTR with interval also besides GVI.

All selected PMTR with interval must ensure that appropriate attention is paid to possible sources of ignition, which can lead to fire and/or explosion in the zone under analysis.

Applicable and effective PMTR with interval must also be selected to minimize any contamination by or an accumulation of combustible materials inside a Product zone. In particular, the size and layout of the zone, its accessibility and the density of installed equipment have influence on the selection of the most effective PMTR.

Example:

> A deteriorated or damaged electrical isolation of an electric power cable, in combination with explosive fuel vapor surrounding that cable, is a probable critical scenario for a functional failure. A selection of a preventive high voltage test for the cable (to detect faulty/damaged spots on the cable isolation) and, in addition- a preventive servicing task of the fuel vapor ventilation system (eg, clean the air ventilation holes) can be an applicable and effective combination of PMTR.

Sources of ignition in close proximity (ie, within 2 inches or 50 mm) to both primary and back up hydraulic, mechanical or electrical controls are subject to the analysis in ZAM 2. For those - potentially critical- failure cause interfaces, one or more PMTR with intervals must be selected.

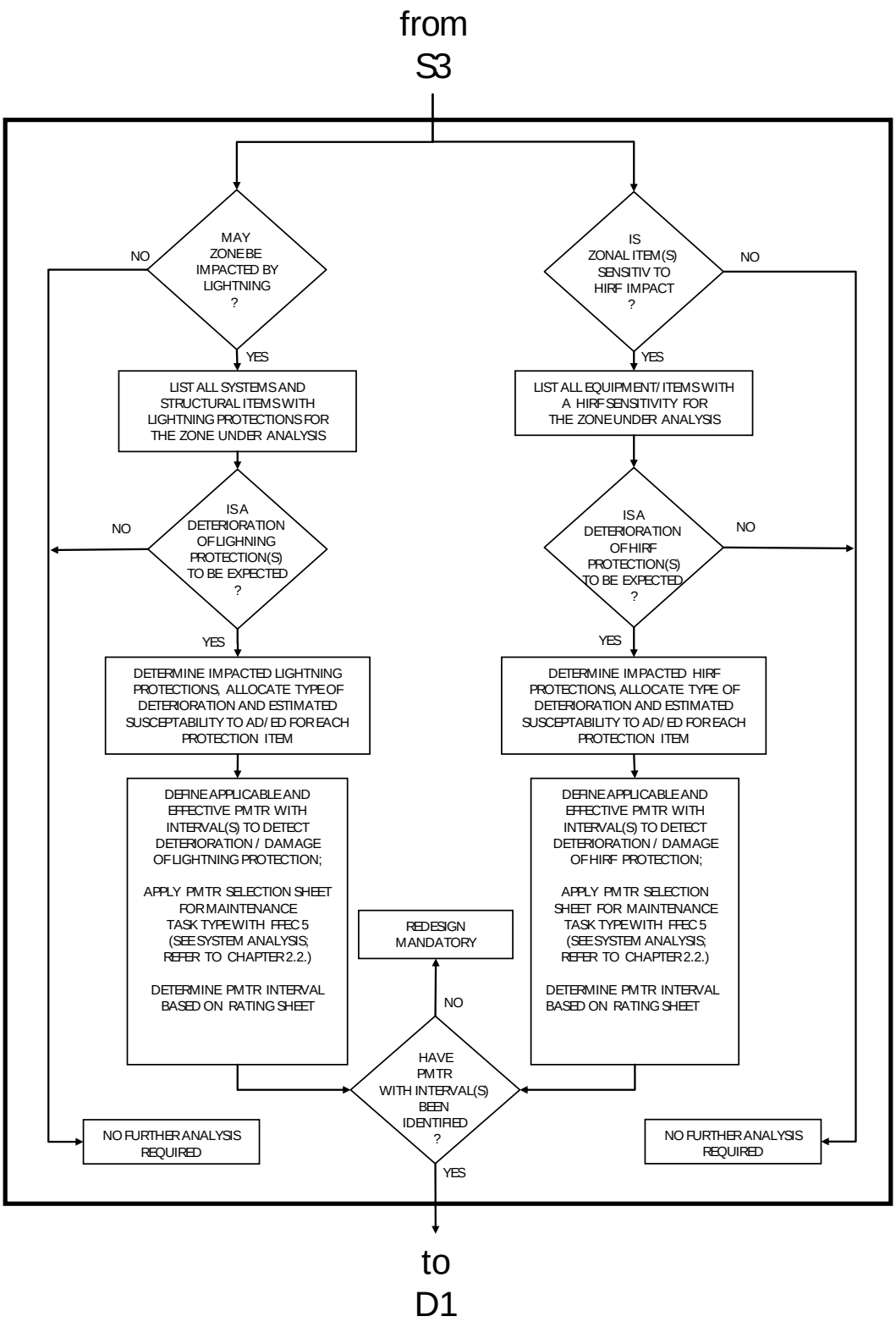
Examples for PMTR selection are provided in the system analysis (refer to Chap 2.2) and structure analysis (refer to Chap 2.3). The determination of intervals (numerical value and type) for PMTR follows analysis methodologies and rules to be precised in Product-specific interval rating sheets/files of the PPH.

When, during this enhanced zonal analysis, no applicable PMTR with interval can be identified for the identified critical interfaces, the Product redesign becomes mandatory.

Accidental Damage (AD), Environmental Deterioration (ED) and specific damage sources (eg, as a consequence from the use of a weapon in a military Product usage scenario) must also be considered in this enhanced zonal analysis (ZAM 2).

Step S5:

Fig 4 shows the process work steps and decisions necessary to perform the L/HIRF analysis (ZAM 3) for a Product zone.



ICN-C0419-S4000P0015-001-01

Fig 4 Flow chart L/HIRF analysis

The L/HIRF analysis (ZAM 3) is an integrated part of this Product zonal analysis procedure.

L/HIRF preventive maintenance for a Product relies on adequate protection provided by both LRU internal and LRU external L/HIRF protection components:

- Internal Line Replaceable Unit (LRU) L/HIRF protection components are those L/HIRF protection features, incorporated inside an LRU. Protection devices such as filter pin connectors, discrete filter capacitors and transient protection devices that are installed within LRUs on one or more of the LRU interface circuits. For LRUs whose failure can have an adverse effect on safety, the Product manufacturer will work with the LRU manufacturers to confirm that the LRU manufacturers' maintenance philosophy will ensure the continued effectiveness of L/HIRF protective features. This can include specific procedures or other data acceptable to regulatory authorities to conclude that the L/HIRF protection devices continue to perform their intended functions throughout the in-service phase. These L/HIRF protection components are not subject to this S4000P analysis methodology.
- LRU external L/HIRF protection components installed on the Product (ie, any protection not installed within an LRU), who's failure can have an adverse effect on Product safety, must be analyzed by this ZAM 3. Normally this includes items such as shielded wires, back shells; metallic meshes raceways, bonding jumpers, connectors, composite fairings with conductive mesh, the inherent conductivity of the Product structure and Product specific devices, (eg, RF gaskets).

PMTR for the LRU external L/HIRF protection systems on the Product are to be developed to support the Product type certification and to develop the Preventive Maintenance Review Board (PMRB) report. These L/HIRF protection systems have to be identified for analytical development of PMTR with intervals. The intent is to reduce the possibility that a single Product-external failure cause (eg, a lightning strike) in combination with the occurrence of a technical failure cause (eg, ED or AD) across redundant channels of L/HIRF protection, can impact Product safety during the Product in-service phase. Each L/HIRF protection system item is evaluated in terms of its susceptibility to degradation from ED and/or AD impacts.

The analytical work required in ZAM 3 is based on the following data/inputs:

- A description of the L/HIRF protection systems and a list of L/HIRF protection components by zone whose failure can have an adverse effect on safety. Protection within a given zone must include both electrical and non-electrical protection components. Create a matrix that lists the location of each component within the zone. Examples of electrical components include:

  - wire shielding
  - pigtail terminations
  - back shells
  - bonding straps

  Examples of non-electrical components include:

  - metallic meshes
  - raceways
  - conductive gaskets
  - conductive coatings
  - structure and substructure

- Data about the component characteristics and applicable performance data (if available) for each protection component within a zone. Protection component characteristics are properties that are relied upon to provide L/HIRF protection, such as resistance to corrosion, effects of environment and robustness of design. Examples of such kind of data/predictions are:

  - development data
  - qualification test data

- in-service predictions for Product environment , like effects of environmental parameters surrounding the Product, corrosive effects, condensation, temperature, vibration on a protection item with respect to degradation effects
- in-service predictions for Product susceptibility to damage, like the probability of damage during maintenance activities or the likelihood of damage during operations/missions/deployments (eg, areas where connectors can be stepped on by personnel, effects of de-icing fluid on a connector during winter operations)

The detailed and self-explanatory L/HIRF analysis process logic in ZAM 3 is shown in Fig 4. Using a logic-based analytical process, taking into account probable consequences of the protection system failures/damages, the analyst determines the types of PMTR that is/are both applicable and effective in combination with their intervals.

Both the Lightning (L) and the HIRF impacts must be analyzed in parallel.

For equipment that is installed in a zone which is sensitive to one or to both of these impacts, applicable and effective PMTR with intervals must be determined on the basis of the standard PMTR selection sheet also used during the S4000P system analysis. Refer to Chap 2.2.

The numerical value of the PMTR interval must be defined either on basis of the interval rating sheets/files provided in the PPH or according to the PPH/guidelines based on Chap 2.2. L/HIRF protections require an analysis for functional failure effects (FFE) caused by ED and AD to determine the likelihood of component degradation based on the environment in which the component is installed.

The selection of a single PMTR or of a combination of PMTR (if more PMTR are applicable and effective) depend on the criticality category of the potential Functional Failure Effect Code (FFEC) that is FFEC 5 for L/HIRF related PMTR.

If no PMTR with interval can be identified as applicable and/or effective for the equipment/item under analysis, a redesign is a mandatory requirement in combination with FFEC 5.

Resulting PMTR with intervals must be harmonized with other PMTR and intervals identified in other ZAM and/or from system- and/or structure analysis.

Step S6:

The zonal analysis modules X (ZAM X) in this Product zonal analysis can be composed as flexible options to cover individual Product types.

The definition of additional ZAM X depends on the individual Product type and its operator-specific in-service usage scenario. Depending on manufacturers' investigations, experience with (comparable) Products and their in-service behavior, authorities' requirements, etc, a Product zonal analysis procedure must be extended by additional ZAM X. The document must precise these ZAM X with relevant impact sources/parameters.

Examples for additional ZAM X for specific Product types:

- Submarines: Analysis of zones for potential impacts caused by underwater shockwaves
- Spacecraft/satellites: Analysis of zones for potential impacts from radiation outside of the terrestric atmosphere and/or for collision of a satellite zones with particles in the earth orbit
- Aircraft: Analysis of zones due to impacts from volcanic particles on air/air pollution in the surroundings of big cities/nuclear, chemical and/or biological particles/substances on air (eg, military mission scenario)

Decision D1:

The standard zonal analysis ZAM 1 is limited to selection of the maintenance task type GVI. This inspection method is not only focused on one or more equipment/items installed in a Product zone. A zonal GVI is valid and to be performed for the zone under analysis as a whole.

But the numerical interval value and the interval type for a zone is individual and depends on the rating of the respective zone. Refer to Step 3.

The Enhanced Zonal Analysis (ZAM 2) identifies "stand-alone" PMTR with intervals like:

- "Stand-alone" GVI for specific equipment/items in a limited area within the zone (the numerical interval value can deviate from the zonal GVI interval)
- Detailed visual inspections for specific equipment/items in a limited area or on specific equipment/items installed in a zone
- Functional check/test on specific equipment/items installed in a zone
- Restoration or cleaning task requirements on specific equipment/items installed in a zone

The L/HIRF analysis (ZAM 3) defines "stand-alone" PMTR with intervals like

- "Stand-alone" GVI for specific L/HIRF protections in a limited area within the zone (the numerical interval value can deviate from the zonal GVI interval)
- Detailed visual inspections for specific L/HIRF protections in a limited area or on specific equipment/items installed in a zone
- Functional check/test on L/HIRF protections installed in a zone

Note

Identified PMTR from Enhanced Zonal Analysis and/or L/HIRF analysis must become "stand-alone" PMTR because potential FFE are either safety-critical or can collide with law and/or environmental integrity.

The analysis in ZAM X can also define "stand-alone" PMTR with intervals for specific equipment/items within the zone.

If a identified PMTR is selected as a "stand alone" task (Answer YES), continue with Step S9.

If not (Answer NO), continue with Decision D2.

Step S7:

All preventive GVI requirements with intervals determined by the system analysis and categorized with FFEC 1, 2, 5 or 6 must remain as "stand-alone" GVI requirements with own intervals.

For remaining preventive GVI requirements from system analysis categorized with FFEC 3, 4, 7 or 8, Decision D2 becomes relevant.

Step S8:

All preventive GVI selected for SSI/SD determined by the structure analysis must remain as "stand-alone" PMTR allocated to a FFE criticality category as follows:

- FFEC 1 (safety impact) or FFEC 2 (conflict with law/environmental integrity) for evident functional failures of the Product structure
- FFEC 5 (safety impact) or FFEC 6 (conflict with law/environmental integrity) for hidden functional failures of the Product structure

Preventive GVI on structural items categorized as non-SSI must be allocated to one of the following FFE criticality categories:

- FFEC 3 (mission/operation impact) or FFEC 4 (economy impact) for evident functional failures of the Product structure
- FFEC 7 (mission/operation impact) or FFEC 8 (economy impact) for hidden functional failures of the Product structure

For all GVI requirements categorized with FFEC 3, 4, 7 or 8, Decision D2 becomes relevant.

If an analyst is in doubt to categorize correctly, always the "worst case" FFEC must be selected. That means the FFEC with the lower numerical value (eg, FFEC 1 must be selected prior to FFEC 2, FFEC 3 must be selected prior to FFEC 4).

Decision D2:

For this decision only those preventive GVI with interval are relevant, without categorization as a "stand-alone" PMTR.

The interval of each preventive GVI requirement on equipment/item must be compared with the numerical interval value for the zonal GVI in the respective zone.

The preventive GVI requirement for the equipment/item is covered by the zonal GVI (Answer YES), if:

- the numerical value of the interval of the zonal GVI is smaller than the GVI interval for the equipment/item
- the numerical value of the interval of the zonal GVI is larger than the GVI interval for the equipment/item, but the numerical value of the interval of the zonal GVI can be reduced down to the GVI interval for the equipment/item

Note

A general prerequisite for the integration of an equipment/item GVI into a zonal GVI is accessibility to and visibility of the identified equipment/item in the installed position.

If a GVI on equipment/item cannot be integrated into a zonal GVI (Answer: NO), a "stand-alone" equipment/item GVI with interval must be defined and listed in the PMTR summary of the system analysis or of the structure analysis.

A preventive GVI in combination with FFEC 1, 2, 5 and 6 must lead to answer NO. These GVI must remain as "stand-alone" PMTR. Only preventive GVI requirements with intervals categorized as FFEC 3, 4, 7 or 8, can lead to answer YES in this decision.

If a GVI is adequately covered by standard Zonal inspection (Answer YES), continue with Step S10.

If not (Answer NO), continue with Step S9.

Step S9:

In this analysis step the identified PMTR with intervals must be transferred either to the results from the relevant Product system analysis (refer to Chap 2.2) or to the results from Product structure analysis (refer to Chap 2.3).

This information transfer must at least comprise the identified failure causes and/or damage causes, the FFEC criticality categorizations per PMTR and a consolidated PMTR interval on the level of Product zonal analysis for:

- all "stand-alone" GVI with intervals resulting from ZAM 2 (enhanced zonal analysis), ZAM 3 (L/HIRF analysis) and/or from ZAM X

and

- all PMTR with intervals next to the maintenance task type GVI (eg, preventive detailed inspection, functional test, NDT)

All PMTR with intervals must uniquely be identified in the data documentation/data base to allow traceability during future OMP reviews and/or changes. This is to prevent the later inadvertent deletion or escalation of "stand-alone" PMTR with intervals without proper consideration of risks.

Step S10:

This zonal analysis step integrates preventive GVI without "stand-alone" requirement from

- system analysis (refer to Chap 2.2)

and/or from

- structure analysis (refer to Chap 2.3)

into the standard zonal inspections.

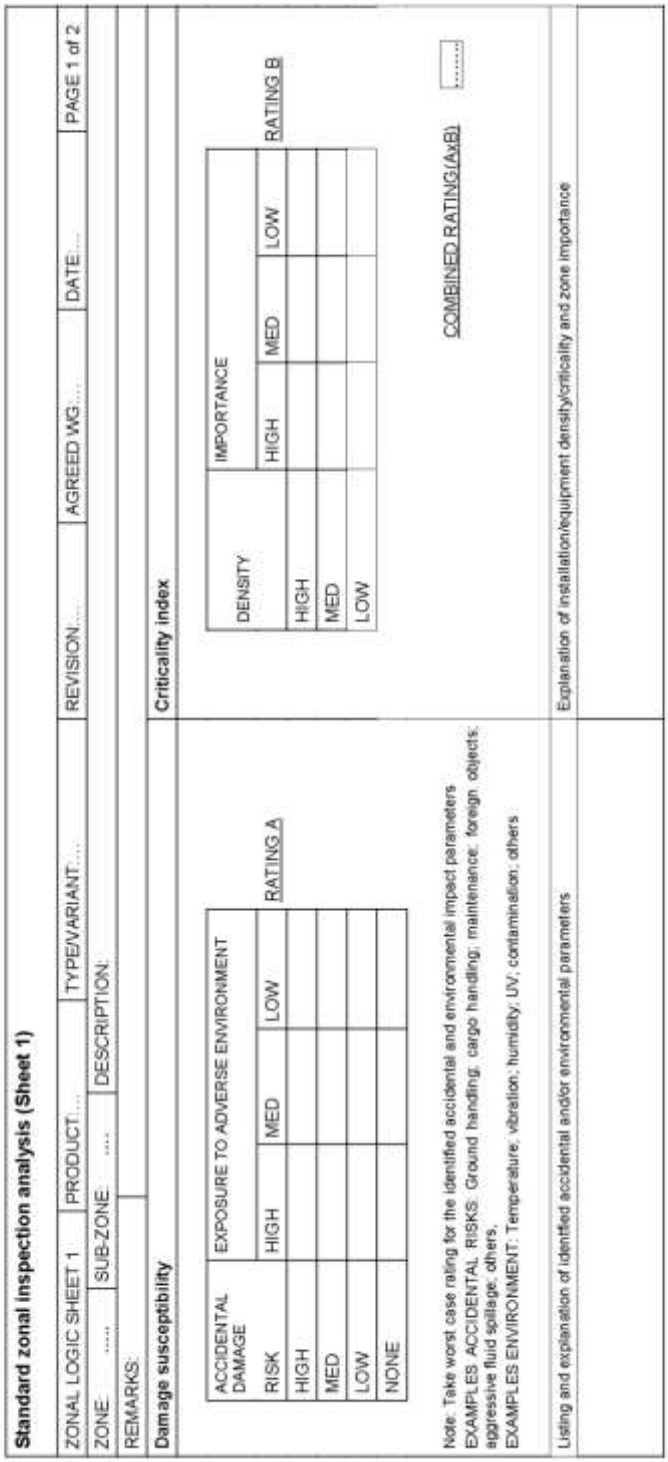
The GVI requirements are covered by the zonal GVI with interval in that zone, where the equipment/item under analysis is installed in. (ZAM 1, standard zonal analysis, Step S3)

If an adaption of the interval for the zonal GVI has been decided in order to allow integration of one or more identified system or structure GVI with intervals, background information and/or justifications must be documented in the standard zonal analysis (ZAM 1).

Step S11:

End of S4000P Product zonal analysis for a defined Product configuration / state of construction.

If the Product design changes on Product zones, the manufacturer must establish an approval process, if the zonal analysis process must be started again for the impacted zones. If necessary, the S4000P analysis results must be updated accordingly.



Standard zonal inspection analysis (Sheet 1)

ZONAL LOGIC SHEET 1	PRODUCT:...	TYPE/VARIANT:...	REVISION:...	AGREED WG:...	DATE:...	PAGE 1 of 2
ZONE:	SUB-ZONE:	DESCRIPTION:				
REMARKS:						

Damage susceptibility

ACCIDENTAL DAMAGE RISK	EXPOSURE TO ADVERSE ENVIRONMENT			RATING A
	HIGH	MED	LOW	
HIGH				
MED				
LOW				
NONE				

Note: Take worst case rating for the identified accidental and environmental impact parameters
EXAMPLES ACCIDENTAL RISKS: Ground handling; cargo handling; maintenance; foreign objects; aggressive fluid spillage; others.
EXAMPLES ENVIRONMENT: Temperature; vibration; humidity; UV; contamination; others

Listing and explanation of identified accidental and/or environmental parameters

Criticality index

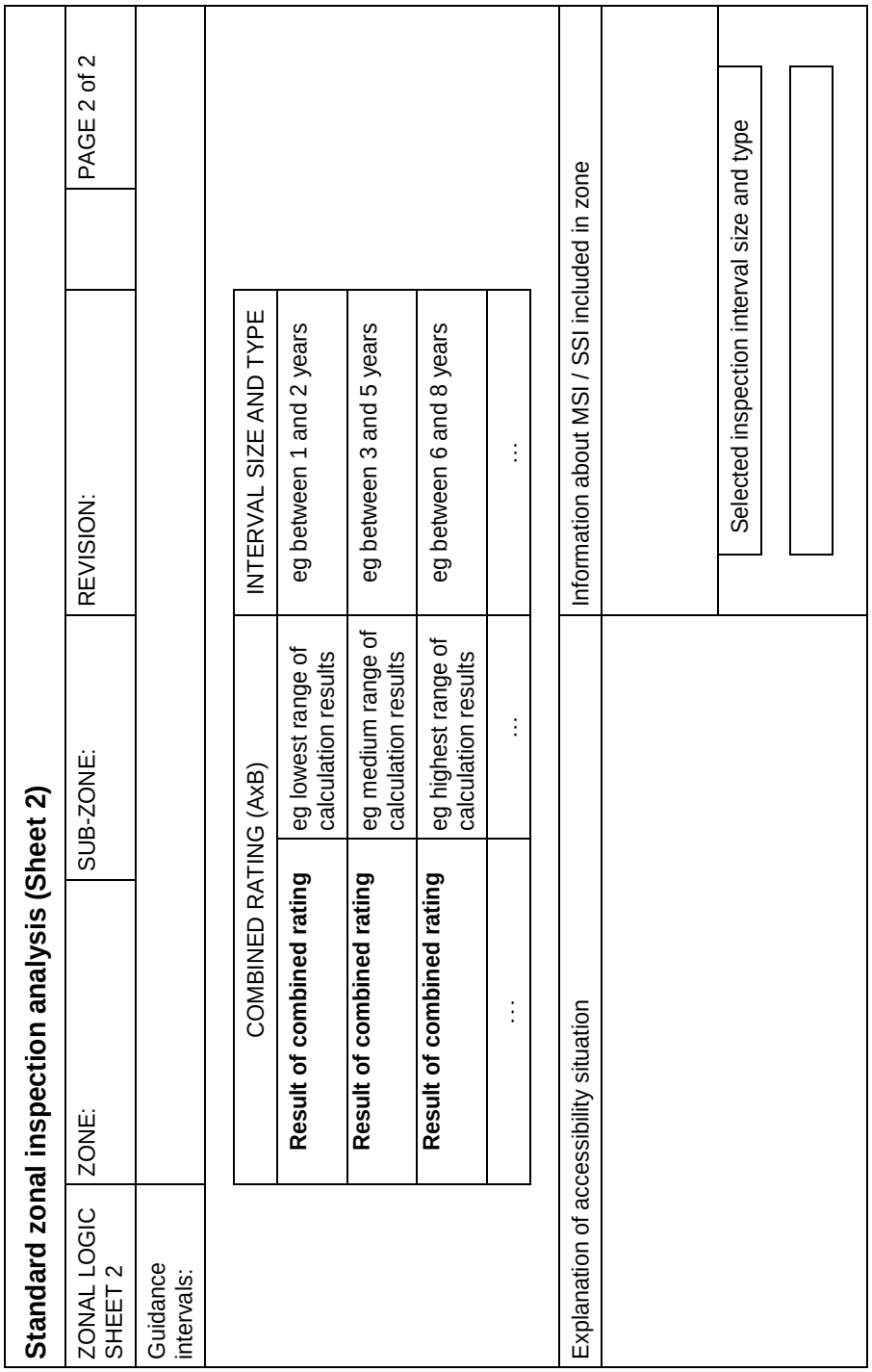
DENSITY	IMPORTANCE			RATING B
	HIGH	MED	LOW	
HIGH				
MED				
LOW				

COMBINED RATING(AxB) .....

Explanation of installation/equipment density/criticality and zone importance

ICN-C0419-S4000P0016-001-01

Fig 5 Interval rating sheet for standard zonal inspection, example (Sheet 1 of 2)



Standard zonal inspection analysis (Sheet 2)				
ZONAL LOGIC SHEET 2	ZONE:	SUB-ZONE:	REVISION:	PAGE 2 of 2
Guidance intervals:				

COMBINED RATING (AxB)		INTERVAL SIZE AND TYPE
Result of combined rating	eg lowest range of calculation results	eg between 1 and 2 years
Result of combined rating	eg medium range of calculation results	eg between 3 and 5 years
Result of combined rating	eg highest range of calculation results	eg between 6 and 8 years
...	...	...

Explanation of accessibility situation	Information about MSI / SSI included in zone
	Selected inspection interval size and type

ICN-C0419-S4000P0017-001-01

Fig 6 Interval rating sheet for standard zonal inspection, example (Sheet 2 of 2)

End of data module

Chapter 2.5

Consolidation of analysis results, harmonization with other preventive maintenance task requirement sources, traceability

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 2.2	System analysis
Chap 2.3	Structure analysis
Chap 2.4	Zonal analysis
Chap 3	In-service maintenance optimization (ISMO)
S3000L	International procedure specification for Logistic Support Analysis - LSA

1 Overview

The S4000P analysis methodologies

- System analysis (refer to Chap 2.2)
- Structure analysis (refer to Chap 2.3)
- Zonal analysis (refer to Chap 2.4)

cover a complete Product analysis for preventive maintenance task requirements (PMTR) with intervals.

Each of the analytical methodologies deliver PMTR with intervals, which must either already be consolidated within these single analysis methodology and/or consolidated among the methodologies. The following chapters give an overview on necessary consolidation and harmonization activities prior to forward the analysis results to the Logistic Support Analysis (LSA) (refer to S3000L) and further logistic analysis activities.

The wording "task requirements" in PMTR is selected by intention for this S4000P specification because later Logistic Support Analysis (LSA) activities may lead to adaptations specifically allocated to the intervals of single maintenance task requirements. The final PMTR with intervals will be defined in the Product technical publication. Therefore the maintenance task interval type and/or numerical interval size in the valid Product documentation must not be identical with the basic interval that has originally been identified on basis of S4000P.

2 Consolidation and harmonization within the S4000P analysis methodologies according to Chap 2

At the end of a system analysis (Chap 2.2) every analyst has to consolidate all selected PMTR for a system with intervals. This first consolidation is documented in the respective system analysis reports.

The analytical effort is influenced by the number of Failure Causes (FC) which have to be analyzed for applicable and effective PMTR. For some FC more than one PMTR with interval may be identified. FC that are unable to be preventively maintained become candidates for a re-design assessment.

The consolidation of analysis results leading to PMTR with intervals differs between the structure analysis (Chap 2.3) and the system analysis (Chap 2.2).

The zonal analysis (Chap 2.4) can lead to two maintenance task types as analysis results:

1 General Visual Inspection (GVI) requirements with intervals for every Product zone as a result from the standard zonal analysis

2 PMTR with intervals besides GVI selected from the complete maintenance task spectrum during enhanced zonal analysis, L/HIRF analysis or during other Product-specific zonal analysis modules

Maintenance task type 1 is consolidated in the final steps and decisions of the zonal analysis.

Maintenance task type 2 requires a harmonization of selected maintenance task/interval requirements additionally defined on basis of the zonal analysis with every impacted system- or structure analysis to which the determined item under analysis belongs according to the Product breakdown structure (eg, bonding strap between two structural parts).

3 Consolidation and harmonization with other sources of preventive maintenance tasks

Results from the S4000P preventive maintenance analysis must be harmonized with the results, for example, of a functional hazard analysis (FHA), a Product/system safety hazard analysis (SSHA), a Fault Tree Analysis (FTA) or other appropriate analysis documents (if available).

When identifying other safety-relevant Product-external FC or identifying additional combinations of critical FC on basis of S4000P analysis methodologies not yet covered by the above mentioned analysis results, a harmonization with these existing safety analytical results is mandatory.

Both the maintenance task interval and the allocation of the criticality level of a PMTR developed from S4000P analysis may be overruled when other safety- and/or law-based maintenance task sources are taken into account.

Example:

Harmonization process between S4000P maintenance task requirements and Candidate Certification Maintenance Requirement (CCMR) for aeronautical Products.

The process for coordinating S4000P derived maintenance tasks with CCMR involves a Certification Committee (CC). The certification committee can influence the analytical decisions based on S4000P analytical results as shown in the flowchart below (Fig 1). This process will be an acceptable means to permit the use of an S4000P maintenance task in lieu of a CCMR, as determined by an appropriate certification committee.

1 CC identifies the CCMR from the System Safety Assessment (SSA).

2 Certification committee determines if one or more S4000P defined maintenance tasks exist, which are categorized to impact safety and/or environmental integrity and/or collide with law and which will detect and/or eliminate the latent failure identified in the SSA.

3 If one or more S4000P maintenance tasks do not exist, the certification committee will ask the SC/WG if a re-assessment of the S4000P system analysis is possible to include a maintenance task, based on additional information provided by the SSA report.

4 If the re-assessment was performed and one or more S4000P maintenance tasks were generated, it must be clarified if the maintenance tasks meet the interval and scope of the CCMR? If the scope does not meet the intent of the CCMR, go directly to box 7. If YES: Go to box 6.

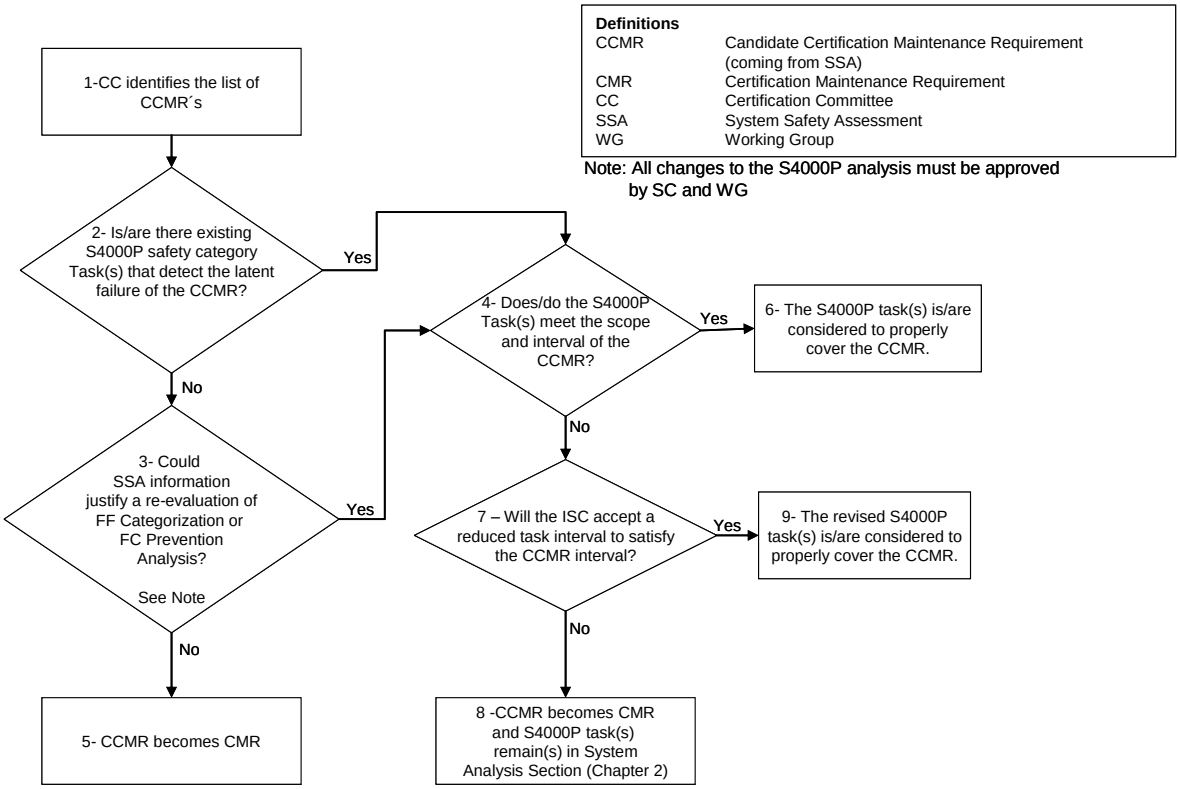
5 If the re-assessment was not performed or if the re-assessment did not generate one or more S4000P maintenance tasks, then the CCMR becomes a CMR.

6 The S4000P maintenance task is considered to properly cover the CCMR.

7 The SC/WG can accept a certification committee proposed reduction in the S4000P maintenance task intervals, in lieu of a CMR. SC/WG should consider advantages and disadvantages of either. No change to scope should be acceptable.

8 If the SC/WG does not accept the certification committee proposed change, then a CMR is established. The CMR and S4000P maintenance tasks remain independent.

9 If the SC/WG accepts the certification committee proposed maintenance task, the revised S4000P maintenance tasks are considered to properly cover the CCMR.



ICN-B6865-S4000P0039-001-01

Fig 1 CMR and S4000P analysis results coordination

4 Traceability of background data between maintenance task/interval requirements and the authorized final tasks/intervals

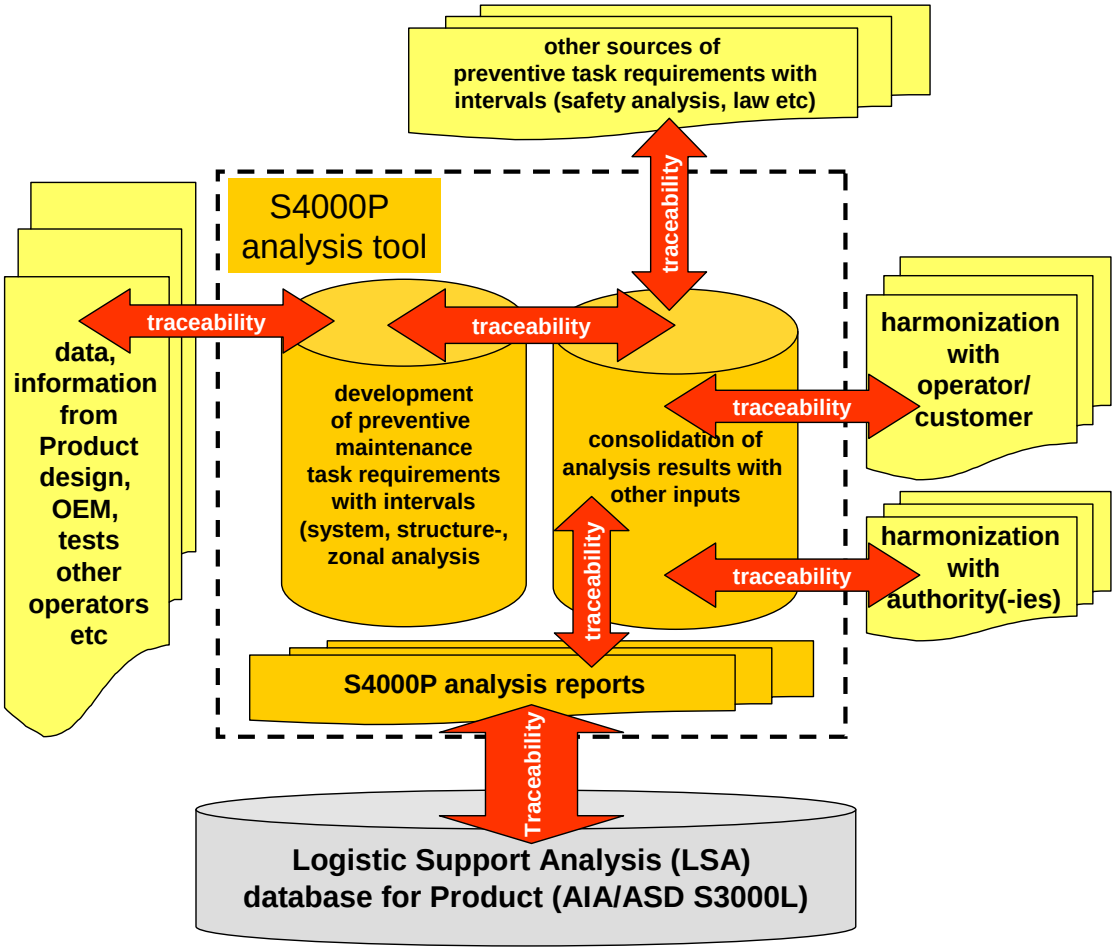
Consolidated PMTR with intervals result from the S4000P analysis. Further adaptations of PMTR intervals are required in order to package the single PMTR into maintenance task clusters for a later effective Product maintenance performance.

The scope is to elaborate and provide an Operator Maintenance Plan (OMP) to operators/customers in accordance with. Refer to S3000L.

To optimize the Product maintenance during Product in-service phase an ISMO process (Chap 3) is essential. Cross-reference data/information must allow traceability from each preventive maintenance task written in the OMP back to the original PMTR with interval and its analytic background information.

This traceability includes all information with reference to the reasons for deviations/adaptations (if any).

Fig 2 gives an overview on important interfaces to be traced for each PMTR with interval.



ICN-B6865-S4000P0040-001-01

Fig 2 Interfaces of PMTR with intervals

Chapter 3

In-service maintenance optimization (ISMO)

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
Chap 3.1	General
Chap 3.2	ISMO preparation phase
Chap 3.3	ISMO analysis phase
Chap 3.4	ISMO follow-up phase

1 General

This chapter starts with an introduction (Chap 3.1) and continues with description and explanation of the In-Service Maintenance Optimization (ISMO) preparation phase (Chap 3.2), followed by the ISMO analysis phase (Chap 3.3) and ends with the ISMO follow-up phase (Chap 3.4).

Chapter 3.1

General

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 1	Introduction to the specification
Chap 2	Development of preventive maintenance task requirements with intervals
S3000L	International specification for Logistics Support Analysis - LSA
S5000F	International specification for operational and maintenance data feedback
JAP(D) 100C-22	MILITARY AVIATION ENGINEERING - Guide To Developing And Sustaining Preventive Maintenance Programmes (UK MoD)
MSG-3	Operator/Manufacturer Scheduled Maintenance Development
MIL-STD-1843 - RCM	Reliability-centered maintenance for aircraft, engines and equipment

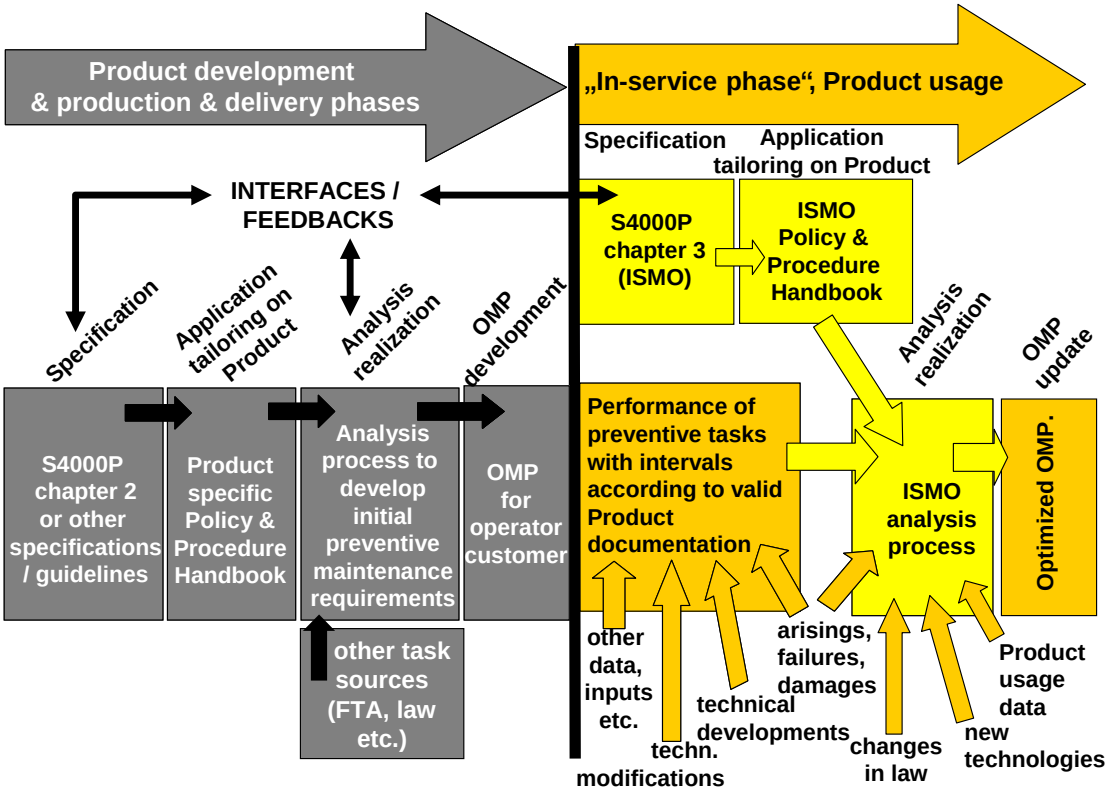
1 Introduction

The Product In-Service Maintenance Optimization (ISMO), described in this document, must be realized during the Product in-service phase in order to improve an existing preventive maintenance program in the Product "as built and as maintained" configuration.

With an effective set of preventive maintenance tasks and intervals documented in an operator/customer-specific Operator Maintenance Plan (OMP), unscheduled maintenance is also impacted in a positive manner. The ISMO process optimizes the whole Product maintenance because preventive/scheduled and unscheduled maintenance depend on each other.

Similar to the steps to develop an OMP, an ISMO Policy and Procedure Handbook (ISMO PPH) must be written for the individual Product that is subject to optimization.

To cover Product-specific needs, each ISMO process must be developed in such a PPH/guideline similar to the initial preventive maintenance task analysis according to Chap 2 or other applicable specification.



ICN-B6865-S4000P0025-001-01

Fig 1 Development and continuously improvement of preventive maintenance according to S4000P

As shown in Fig 1, several information sources (technical inputs, data, experience, changes of (usage) parameters, new technologies, test results, etc.) can appear during the Product in-service phase. These sources are based on experience from Product usage. They are necessary to check, whether former analyst assumptions, that led to maintenance tasks or intervals in an OMP, can be confirmed or not later on. The ISMO analytical process works like a "test-bench" for each single preventive maintenance task with interval and comprises questions and answers supported by reliable in-service experience.

This ISMO process is composed of process logics with sequential work steps and decisions leading to detailed recommendations on preventive maintenance tasks and/or intervals. In

addition to the logics, explanations and examples are provided for a better understanding of all steps and decisions. ISMO has initially been developed by European industry and successfully been applied on military aircraft (fighter and mission/transport aircraft). On the basis of gained experience and "lessons-learnt" from several ISMO applications, a generic process variant was introduced into this specification. The ISMO process is applicable on all complex technical Products.

ISMO is to be applied on Products in-service. It is recommended that a first ISMO process-run should be established after enough in-service experience has accumulated. The more in-service experience available, the higher the probability is to achieve a better ISMO result. In-service data and experience from both Product usage and Product maintenance have to be used.

In-service data is not a "must prerequisite" for starting an ISMO process in general. The ISMO process logics also work with small or missing in-service data/inputs.

The ISMO process can be applied on Products with different histories and backgrounds related to design and development and preventive maintenance program/OMP developments.

The following different scenarios possibly led to preventive maintenance tasks and intervals in an OMP:

- Support engineering or engineering departments have performed a preventive maintenance task analysis in line with an analysis guideline/PPH on basis Chap 2. Results have been kept up to date (Fig 1).
- Support engineering or engineering departments have performed a preventive maintenance task analysis in line with an analysis guideline/PPH on basis of another specification / procedure handbook (eg, ATA MSG-3, MIL-STD-1843 - RCM). Results have been kept up to date.
- Support engineering or engineering departments have performed a preventive maintenance task analysis in line with an accepted analysis guideline/PPH but these data are not available, not valid anymore, not up to date and/or do not allow any traceability, etc.
- Support engineering was not (enough) involved during Product development or did not perform any preventive maintenance task analysis. All preventive maintenance tasks and intervals have, for example, exclusively been determined by engineering on basis of other Best Engineering Judgement (BEJ).
- A combination of the previous described scenarios resulted in a set of preventive maintenance tasks and intervals that has no or not enough traceability of maintenance task/interval backgrounds.

Many Products are operated by operators/customers worldwide. These Products have to be maintained during their on-going in-service phases. In all cases valid and updated documentations are the baseline for each ISMO application. These OMP documentations may contain deviations from one operator/customer to another.

A preventive maintenance task with intervals written in an OMP is based on at least one of the following sources:

- Requirements from authorities including law-based requirements, certification maintenance requirements (CMR), etc
- Predictions by equipment manufacturers interconnected with warranty-background
- Preventive Maintenance Task Requirements (PMTR) with intervals resulting from analysis activities of a Product responsible manufacturer
- Best Engineering Judgement (BEJ), for example, by provided by Product engineering departments

If the responsible Product manufacturer decides an analytical process for developing PMTR with intervals, one of the following specifications/guidelines should be the basis for the Product-specific ISMO PPH:

- S4000P, Chap 2 (preferred selection)
- MSG-3
- JAP(D) 100C-22
- Others

On basis of such a Product ISMO PPH/analysis guideline, PMTR out of the following maintenance tasks types can be defined:

- Servicing (eg, wash, clean, lubricate, preserve)
- Inspection/functional test/check
- Replacement (Time Change Items (TCI)) or overhaul

The responsible analyst defines the maintenance task type (eg, detailed inspection) and an appropriate interval type (eg, 200 start cycles) plus a numerical interval value for each maintenance task requirement.

For this purpose the analyst uses all available development data, prototype test results/experience (if available) and other technical information, etc.

PMTR with intervals have to identify and/or to eliminate failure causes (FC) leading to potential Product Functional Failure Effects (FFE).

Potential FFE on Product level are:

1 Safety can be impaired if:

There is an impact on continued Product operational safety including the involvement of human beings during maintenance activities on, inside or close to the Product.

2 Environmental integrity/law conformity can be impaired if:

There is an impact on environmental integrity including law conformity during Product mission/operation.

3 Mission/operational availability can be impaired if:

There is an impact on the specified Product mission or operational availability.

4 Economy/costs can be impaired if:

There is an impact on Product economy and resulting Life Cycle Costs (LCC).

If PMTR with intervals are linked to FFE allocated to Item 1 and Item 2, continued Product safety, environmental integrity and/or law conformity can be impacted. Authorities, responsible for Product certification, will review these PMTR by preference. Involved authorities preferably approve these PMTR.

An operator/customer focuses on PMTR with intervals allocated to Item 3 and Item 4. Operators/customers require or appreciate a reduction of FC, which increase mission/operational availability and/or reduce Life Cycle Costs. The achievement of a high mission/operational availability and/or an upper LCC limit can be fixed by, for example, a Performance Based Logistic (PBL) contract between individual customers/operators and Product manufactures. In such cases the manufacturer will insist on the performance of identified PMTR with intervals having mission/operational and/or cost impacts. Without existing PBL/contractual constraints, every Product operator/customer is allowed to adjust PMTR with intervals of these Functional Failure Effect Categories (FFEC) within his own responsibility.

Having gained approval by the responsible officials/authorities and after potentially being supplemented with further preventive maintenance tasks with intervals (eg, maintenance tasks/intervals from safety analysis, legal requirements, manufacturer and design requirements), all PMTR with intervals are packaged into interval clusters in an OMP.

The packaging activities require adaptations of numerical interval values. All adaptations must be traceable and the adaptation rules must be defined in the ISMO PPH.

In selected cases, intervals have to be re-calculated from one interval type into another interval type on the basis of the individual customer/operator Product usage scenario.

The OMP becomes valid for the customer/operator starting with the Product in-service phase.

It is known that during a Product in-service phase further preventive maintenance tasks with intervals will be added in an OMP. For all FFEC, maintenance task numerical interval values are allowed to be reduced within a limited frame by customers/operators (eg, reduction from 14 months to 12 months).

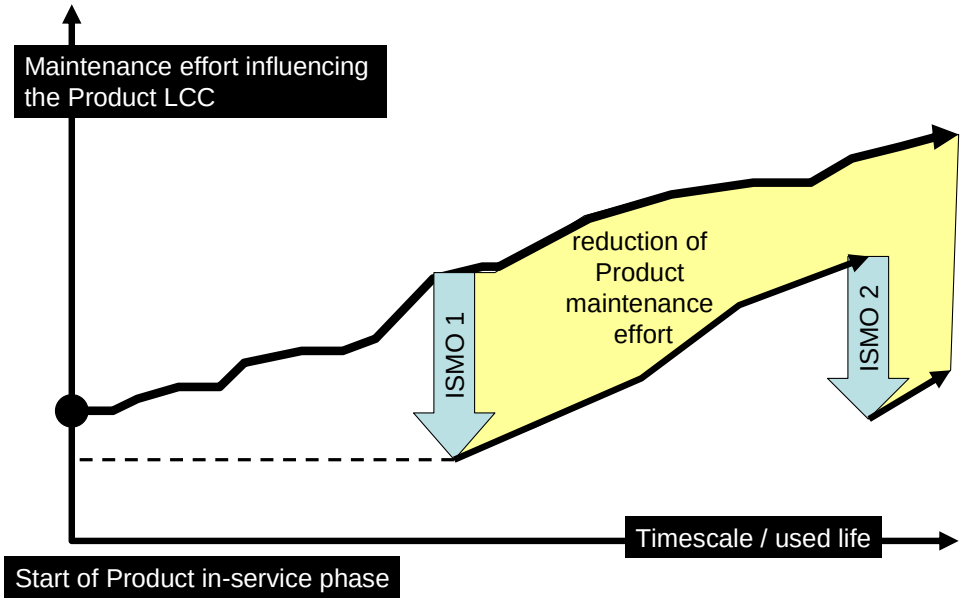
In most cases, the effort for maintenance increases during a Product in-service phase. This is a loading factor on the Product LCC.

This structured ISMO analytical process identifies various recommendations on each preventive maintenance task with interval (eg, maintenance task deletion, interval extension, maintenance task replacement) with justification for each recommendation given. The ISMO process structure itself guarantees that the approach of different analysts is harmonized between them without any process differences.

Industry experience is that ISMO leads to a significant lowering of in-service maintenance effort without an increase of certification-relevant risks and without a reduction of Product availability.

By taking into account new analysis methodologies, new maintenance technologies, in-service experience, etc, ISMO contributes to lowering the certification-relevant risks and to improving the Product availability for mission/operation.

The following figure shows the optimization principle of ISMO for a Product during its in-service phase. The example in Fig 2 shows two ISMO analytical-loops after starting the Product in-service phase.



ICN-B6865-S4000P0026-001-01

Fig 2 ISMO loops during the Product in-service phase

The ISMO process must not be performed as a "spot-light" activity done only once during the Product in-service phase. A continuous application process is recommended.

Experience shows, that the setup of an initial ISMO 1 analysis loop after the start of an in-service phase consumes the major preparation- and analytical effort. These basic investigations are the prerequisite for the later ISMO analysis of individual maintenance tasks with intervals.

Due to conservative maintenance task and interval definitions at the early period of Product usage an ISMO 1 loop provides a high potential of optimization. The previous maintenance effort can significantly be lowered after finishing ISMO 1.

A second ISMO analysis as shown in Fig 2 and consequent ISMO analyses can refer to the fundamental ISMO 1 preparation work. Therefore subsequent ISMO analyses are more effective. The ISMO process contributes to the Product integrity management of a Product fleet.

The main scopes of the ISMO processes are:

- Reduction of risks that might lead to certification-relevant consequences (including Product safety)
- Ensuring that environmental integrity and the conformity with national laws are adhered to
- Increase Product availability
- Reduction of Product LCC
- Applicability on all Products independent from their development history
- Applicability on all Products independent from in-service data/experience background
- Applicability on all Products independent from the organisational situation (eg, no contact to Product manufacturer, low manufacturer inputs or other Product user data available on demand or not)
- Applicability on all types of ASD Products (airborne, on/under ground, on/under sea, outer space)
- Integration of former analytical data (eg, from an initial analysis, if available)
- Integration of in-service data using inputs from S5000F and other in-service information/knowledge available
- Traceability between existing analytical background data (if available) and the valid preventive maintenance program/OMP of a Product
- Creation of a data base prior and during the ISMO analytical process for optimizing preventive maintenance tasks with intervals which will be used throughout the remaining Product in-service life for further ISMO analysis loops
- Approval and/or compensation of missing FFEC per preventive maintenance task with interval
- Evaluation of potential changes in a Product usage scenario compared to the former assumptions during design and development, to check the impacts on preventive maintenance tasks and intervals for those changes
- Evaluation of new knowledge in preventive maintenance task analysis methodology including a check of consequences on preventive maintenance for the Product under analysis
- Investigation on the completeness of the preventive maintenance task analysis on Product configurations and Product variants, if any
- Coverage of different usage scenarios in national and multinational Product development
- Coverage of customer-/operator- specific preventive Product maintenance programs/OMP with different usage scenarios and/or environmental conditions
- Taking into account Product design changes, configuration differences (eg, individual repairs for customer/operator)
- Provide clear and traceable output of all recommendations with justifications during ISMO analysis ready for approval and acceptance
- Provide data for a further data transfer to the S3000L database

2 ISMO process overview

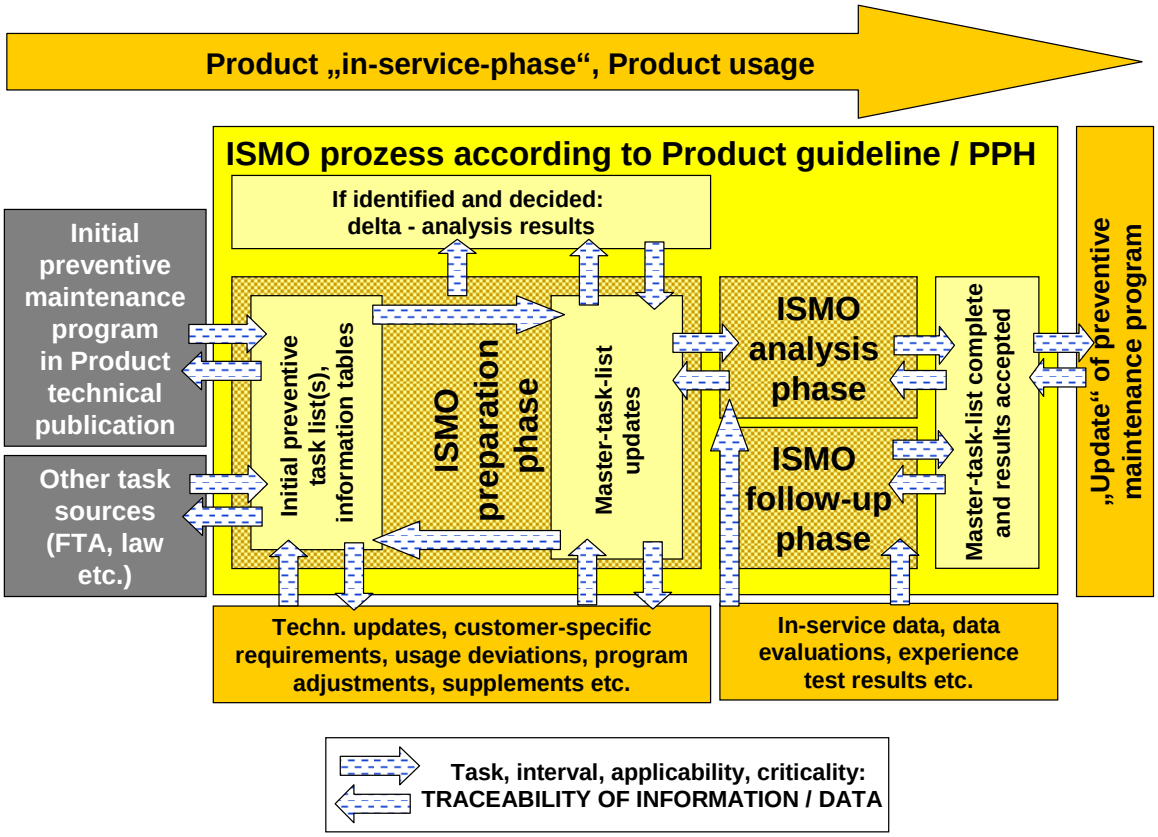
The ISMO process consists of the following three main phases:

- Phase 1 - ISMO preparation phase
- Phase 2 - ISMO analysis phase
- Phase 3 - ISMO follow-up phase

The ISMO process starts with the ISMO analysis preparation Phase 1 and is followed by the ISMO analysis Phase 2.

At the end of the ISMO preparation phase, the set of valid preventive maintenance tasks with intervals must be complete and sufficient background information for each single preventive maintenance task must be collected. The data and information of the updated "Master-Task-List" (MTL) are important prerequisites for every analyst to be able to perform the subsequent work during the ISMO analysis phase.

The ISMO follow-up Phase 3 is not directly dependent on the period of performance of the ISMO analysis phase. The ISMO follow-up phase can run in parallel to the ISMO analysis phase or can be performed at a later stage. The ISMO follow-up phase can be used to permanently monitor the in-service data for unscheduled anomalies on items where preventive maintenance is not yet identified.



ICN-B6865-S4000P0027-001-01

Fig 3 Overview on ISMO process

As an essential part of the ISMO process, a verification of every maintenance task FFEC will be performed. In the case of any discrepancy between the maintenance task FFEC and the Product design safety case, actions shall be undertaken by the Product-responsible industry.

When a FFEC is missing or not known, an applicable maintenance task criticality must be defined at least during the ISMO analytical process.

To achieve the main scopes of the ISMO process listed in Chap 1, the ISMO analysis must be carried out in the specific sequence which is shown in Fig 3.

Chapter 3.2

ISMO preparation phase

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 2	Development of preventive maintenance task requirements with intervals
MSG-3	Operator/Manufacturer Scheduled Maintenance Development
S1000D	International specification for technical publications using a common source database

1 Introduction

Within the ISMO preparation phase the process examines if the analytical basis for the valid preventive maintenance tasks with intervals exists and if the procedural aspect of that analytical basis can be judged as technically "up to date" or not.

Any deficits identified in the analytical basis lead to the determination of subsequent analysis activities where needed.

Where parts of the analytical basis do not exist or cannot be verified, subsequent analysis activities must be examined. This can be compensated by utilizing extensive operating experience with this Product. In this context, it must be considered, that FC with potentially

safety-relevant FFEC should be determined using the analytical approach. In these cases, it is not appropriate to wait for the FFE to occur in operation.

Once all preventive maintenance tasks and their intervals have been identified and collected, the next steps are as follows:

1 Preparation of "Scheduled task lists". The Master Task List (MTL) shall comprise all preventive maintenance tasks with intervals and additional data from customer/user.

2 Review validity of the individual maintenance tasks with respect to the configuration of the Product fleets

3 Examining the applicability of every individual maintenance task for all Product serial numbers of the Product fleets

Finally, the initial Product usage scenario that was the basis for the Product design and development is to be compared with:

- the individual customer/user Product usage scenarios
- potential changes in the individual customer/user Product usage scenario throughout the on-going in-service phase

The ISMO analysis preparation phase develops and creates all data and parameters necessary for the analysts to conduct the later ISMO analysis phase according to this document.

The ISMO analysis preparation phase comprises the following aspects:

- Comparison of analysis process and analysis methodology originally used for the Product (if applicable) with currently known preventive maintenance task analysis standards in industry (eg, S4000P, MSG-3).
- Evaluation of an additional analysis effort for functional systems, structure and/or zones of the Product.
- Check if revised or new documents, legal requirements, etc, are relevant for analysis.
- Collection of cross-reference data that allows traceability between individual Preventive Maintenance Tasks Requirements (PMTR) with intervals defined in the valid technical documentation and analyses roots (if any) or other maintenance task/interval sources.
- Merging of all cross-reference lists/data into a MTL that allows a complete overview on all PMTR and the preventive maintenance tasks and intervals on basis of the Product documentation allocated to items/equipment of the Product systems, structure and zones.
- Determination of analyst work sharing for the ISMO analysis phase taking into account specifically the individual maintenance task with interval, the FFEC of that maintenance task and the design responsibility for the item under analysis.
- Establishment of working groups, meeting structures, definition and implementation of reporting structure, if necessary.
- Coordination and organisational tasks defining communication, responsibilities, etc, between Product manufacturer, equipment manufacturer, every responsible regulatory authority, etc.
- …

2 Process logic of ISMO preparation phase

The diagrams show the individual process **Steps** (S) and the **Decisions** (D) numbered consecutively.

In the logic, the steps and decisions are numbered continuously and explained in the following chapter.

The process steps are given an alphanumeric code **VYZZ** where:

- "**V**" - gives the preparation phase

– "**Y**" - gives the Step S or Decision D
– "**ZZ**" - is a number, ascending from 01 to 99

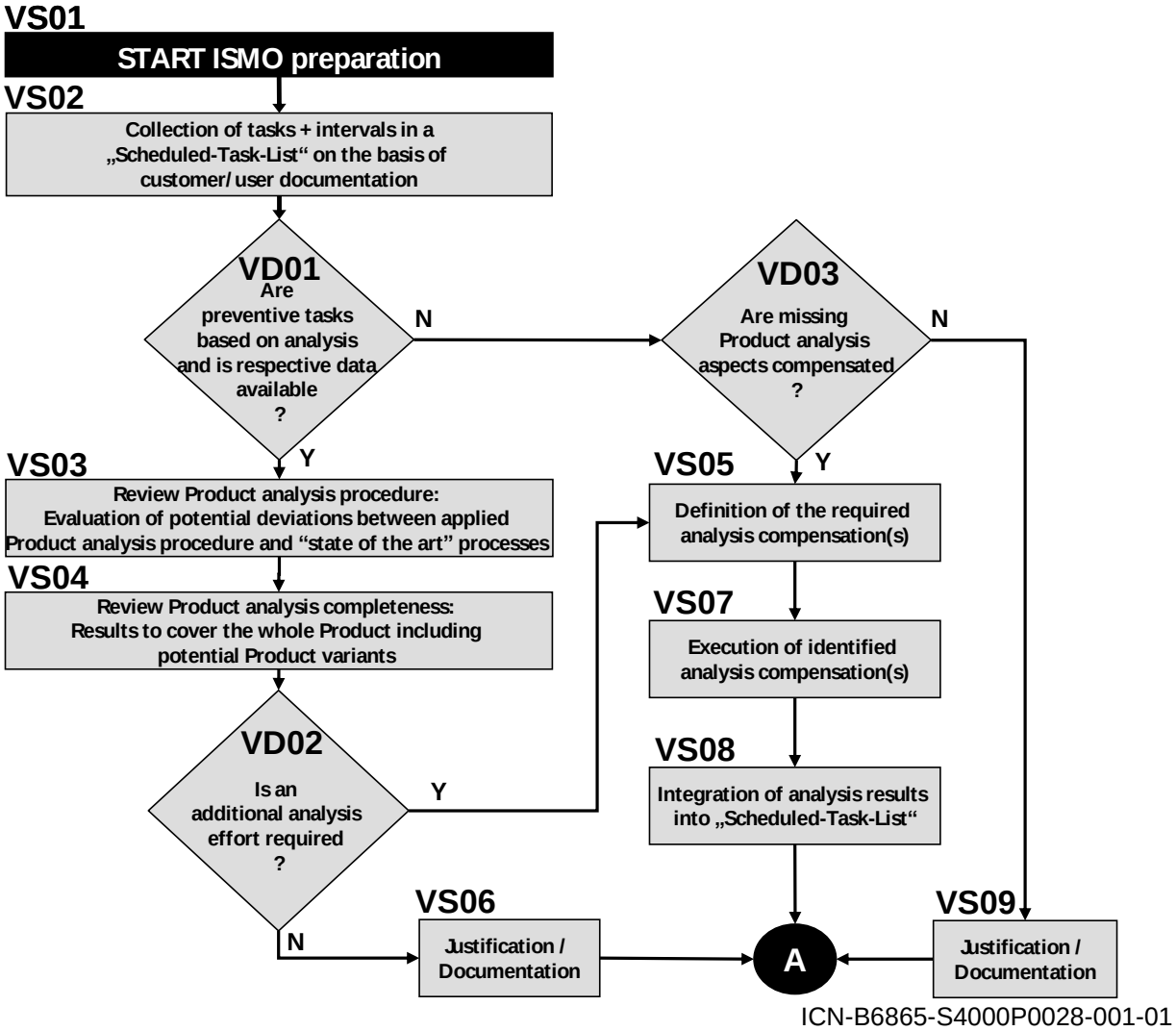
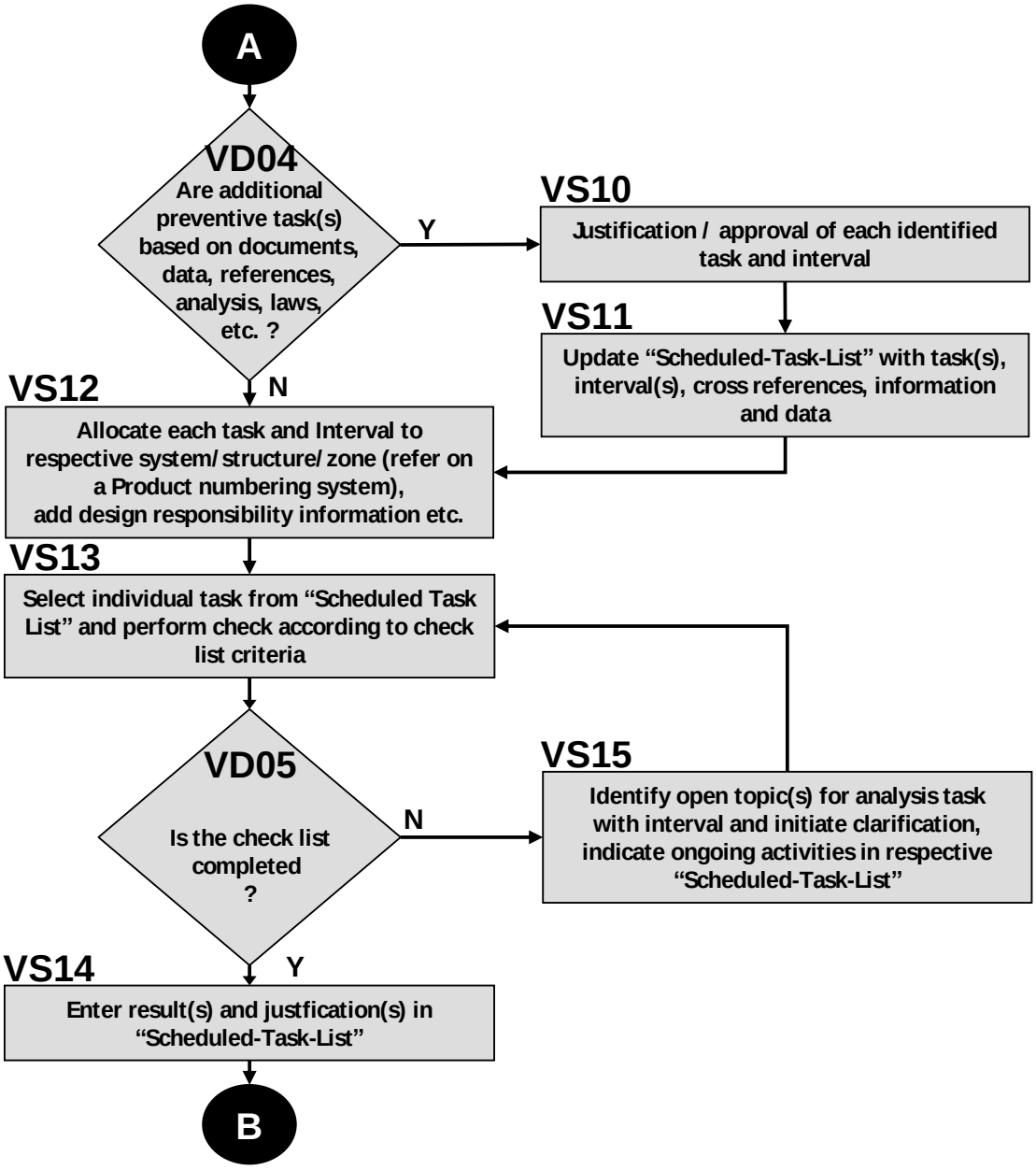
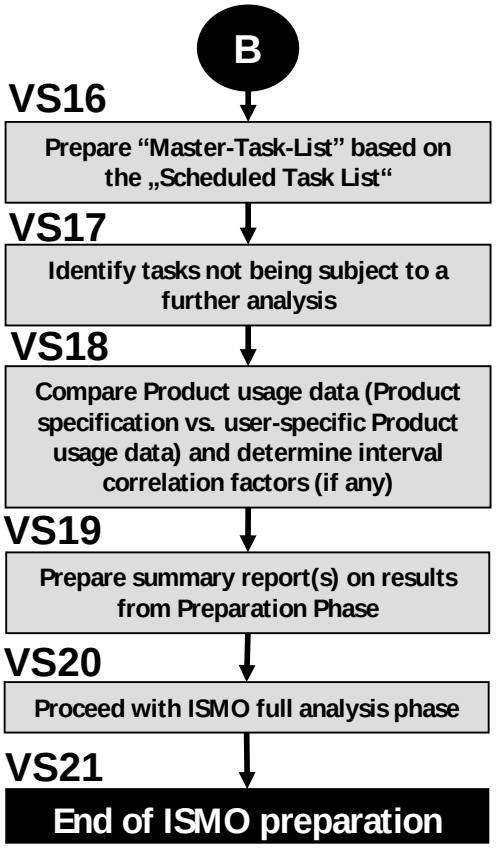


Fig 1 ISMO analysis preparation phase (Sheet 1 of 3)



ICN-B6865-S4000P0029-001-01

Fig 2 ISMO analysis preparation phase (Sheet 2 of 3)



ICN-B6865-S4000P0030-001-01

Fig 3 ISMO analysis preparation phase (Sheet 3 of 3)

3 Description of process logic of ISMO preparation phase

The individual process **Steps** (S) and **Decision** (D) of the analysis preparation phase (V) are described below.

Note

Important note for performance of the ISMO analysis preparation phase.

In answering decision questions, the following principle applies:

– A conservative decision is to be taken in the event of lacking information or data, ambiguity or doubt.

  This means that in these cases the decision should be made in favour of greater preparation work (eg, decision in favour of conducting further analysis).

VS01:

The ISMO analysis preparation phase is a logic module that must be processed independently and before the start of the next ISMO analysis phases.

Specifically the ISMO analysis phase strongly depends on that pre-work to be done and finished in this ISMO analysis preparation phase.

The ISMO analysis preparation phase is intended to ensure that all maintenance tasks with intervals required for the operating safety, availability and economy of technically complex Products (eg, aircraft) are complete.

VS02:

All preventive maintenance tasks with their valid intervals which are predicted by the Product documentation must be listed in a "Scheduled task list" per customer/user. The use of an applicable IT-tool/IT software is recommended.

The individual maintenance tasks with intervals are to be allocated to the functional subsystems of the Product in line with reference to S1000D.

VD01:

This question clarifies the analytical background for the existing preventive maintenance tasks and intervals.

New or updated analysis specifications like S4000P or MSG-3 (published and mainly applied on civil aircrafts) cover up-to-date analytical aspects.

Necessary analysis compensations have to be determined and respective analysis processes have to be described for the Product under analysis.

If an analytical basis exists (Answer "YES"), for example, on the basis of a S4000P or MSG-3 analysis, continue with VS03 and VS04.

If no analytical basis exists (Answer "NO"), continue with VD03.

VS03:

The "analysis process review" examines which analysis process was defined and applied to the Product during its design and development phase. Newer issues of existing analysis standards or newly developed analysis methods can show considerable improvements over older methods used years ago, particularly with respect to certification relevant aspects.

VS04:

This process step reviews the completeness of analysis activities to develop PMTR for a Product, taking into account all Product configuration variants. All Product subsystems with equipment, Structure Significant Items (SSI) and the Product zones must either be covered by analysis or must be justified as non-analysis relevant. Such analysis exceptions can be Analysis Relevant Candidates (ARC) where a set of preventive maintenance tasks and intervals is predicted by OEM, authorities, etc.

Any analysis deficits must be identified and documented.

VD02:

After performing work steps VS03 and VS04 supplementary analysis activities can be decided.

If supplementary analyses are necessary (Answer "YES"), continue with VS05.

If not (Answer "NO"), continue with VS06.

VD03:

If, for example, no analytical justification for preventive maintenance tasks with intervals exists, it must be determined and decided whether a complete or a reduced analysis to develop these PMTR with intervals is necessary (eg, according to Chap 2). If a complete analysis is required, all systems, SSI and the zones of the Product are analysed comparable to the initial analysis during a design and development phase.

A reduced analysis, in contrast to a new analysis, must cover at least all FC with a FFEC related to safety-relevant FF. This procedure covers the minimum certification-relevant FFEC.

PMTR and/or design recommendations to the design departments will be defined.

An analysis handbook/guideline/PPH for the complete or reduced analysis must be prepared by industry and approved by the responsible authorities prior to starting the analytical work.

Insofar additional analysis effort is identified (Answer "YES"), continue with VS05 and VS06.

If additional analytical effort is not required (Answer "NO"), continue with VS09.

VS05:

If a supplementary analysis requirement is identified, the approach and scope are to be determined and documented.

VS06:

If an analytical basis exists and is judged to be complete in line with new methodologies of preventive maintenance task analysis, no supplementary analysed maintenance tasks are necessary. The review result/decision is to be substantiated and justified in a written format.

VS07:

Perform identified analysis activities decided according to VS05.

VS08:

After performing the compensating analysis activities, the Scheduled task list for the Product is to be reviewed as to:

- Whether the PMTR determined by analysis are already listed. If the maintenance task already exists, the previous categorisation of the maintenance task is to be compared with the analysis result in respect to the potential FFE and corrected where necessary. The higher critical FFEC is to be selected by the analyst when in doubt. If a maintenance task is not in the list, the list is to be expanded to include this maintenance task along with the interval and the FFEC identified in the analytical work.
- Whether the intervals determined by analysis agree with the intervals of the existing maintenance tasks in the Scheduled task list. If not, the differences are to be identified and noted in the list.

VS09:

As no analytical basis exists and no complete or reduced analysis is required, the examination result/decision is to be substantiated and justified in a written format.

VD04:

It must be determined whether further PMTR with intervals are valid, which are not included in the Scheduled task lists according to step VS08. Further relevant preventive maintenance tasks with intervals can be based, for example, on the operating experience of customers/users of similar/comparable Products. Changes in legal bases (eg, new environmental or occupational safety regulations) can lead to new additional PMTR which must be added to the Scheduled task lists.

If further PMTR with intervals become relevant or will become relevant for the Product (Answer "YES"), continue with VS10.

If not (Answer "NO"), continue with VS12.

VS10:

Identified PMTR with intervals are to be added to the respective Product breakdown element (S1000D) of the Scheduled task list. The sources or the origin of those PMTR with intervals are to be determined and documented in the Scheduled task list.

VS11:

The PMTR with intervals identified in the previous step VS10 must to be entered into the Scheduled task list for the affected Product system, for the SSI or for the Product zone including all background data/information.

Due to potential differences concerning legislation from one customer/user to another, it is assumed that deviations of identified maintenance tasks with intervals might appear between the Scheduled task lists of different customers/users.

VS12:

The collected maintenance tasks and intervals in the Scheduled task list of a customer/user should now contain all PMTR and all preventive maintenance tasks with their interval from valid Product documentation for being analysed in the subsequent ISMO analysis phase.

The list clarifies which Product system/subsystem/equipment/item and which configuration the individual maintenance task with interval is valid for.

Additionally, information about the design responsibility is allocated to each maintenance task with interval in accordance to the System Breakdown Code (SBC) in the Scheduled task list of the customer/user.

VS13:

Single preventive maintenance tasks with intervals listed in the Scheduled task list might not be ready for being analysed in the ISMO analysis phase.

Therefore a set of questions must be answered for each maintenance task with interval in order to clarify the analysis readiness. The following table contains questions which are recommended to be answered. They must be adapted for a Product in an ISMO guideline/PPH:

Table 2 Maintenance task check table

No.	Question	Remark
Q1	Is a preventive maintenance task with interval still applicable for the Product fleets operated by the customer/user or is this maintenance task limited, for example, on single Product serial numbers only?	Check of the maintenance task validity and applicability in terms of the valid configuration- and build standard. If an individual maintenance task does not apply to the configuration of the Product fleet, for example, because the configuration has subsequently been modified, this must be noted in the Scheduled task list. This individual maintenance task is to be marked accordingly for the further maintenance task analysis.
Q2	Is the preventive maintenance task listed a single maintenance task ready for later analysis or is it part of, for example, a maintenance task combination or a maintenance task mixture?	For example, wash and lubricate at a certain interval is a maintenance task mixture that is to be separated into a wash-task and a lubricate-task

No.	Question	Remark
Q3	Does a maintenance task package (eg, a Zonal Inspection) contain safety-relevant subtasks or have such maintenance tasks been transferred into that maintenance task package?	Maintenance task packages that comprise a set of various individual maintenance tasks, are to be separated according to the following basic rule: Every safety-relevant individual maintenance task within a maintenance task package is to be taken out of that package and included in the Scheduled task list as a "standalone" maintenance task with its own interval under the corresponding functional system or SSI and with a FFEC "safety-relevant".
Q4	Has the maintenance task no regular interval?	Such maintenance tasks are no subject to the ISMO analysis phase (eg, maintenance task becomes relevant only after an entry of a certain event)
Q5	Is the maintenance task interval for the preventive maintenance task without limitations or thresholds?	It is known that selected preventive maintenance tasks have been introduced, for example, by engineering departments specific to gain experience during the initial Product in-service phase only (limitation). Structural items might be inspected after a certain interval threshold for the first time (threshold) Knowledge about those topics support the later ISMO analysis phase
Q6	Has the maintenance task with interval been determined on the basis of Safety/Fault-Tree Analysis (FTA) or has the maintenance task been dictated by law etc?	Information supports the correct categorization of the maintenance task criticality based on the single failure mode severity codes.

The questions in the above table might not be answered immediately for each preventive maintenance task listed in a Scheduled task list.

Open questions or unclear aspects must be highlighted and, for example, answered at a later stage of the ISMO process.

Question Q1 thru Question Q4 must be answered prior to the maintenance task/interval analysis in the subsequent ISMO analysis phase

Question Q5 and Question Q6 can be answered if information /facts are available.

If a task is not a maintenance task (eg, organisational task), the ISMO analysis stops.

VD05:

If, at least Question Q1 thru Question Q4 according to VS13 have been checked and answered, the individual maintenance task with interval is ready for being analyzed by the following ISMO analysis phase.

In this case (Answer "YES"), continue with VS14.

If not (Answer "NO"), continue with VS15.

VS14:

The results of all investigations done in VD05 must be documented in the Scheduled task list.

VS15:

In the case of necessary ongoing clarifications related to Question Q1 thru Question Q4 in VD05 the maintenance task is not ready for being analyzed in the ISMO analysis phase and must be postponed. This status must be tracked in the Scheduled task list.

VS16:

When the responsible analysts indicate that the Scheduled task list is completed, this list becomes the draft MTL. This MTL is the result out of the ISMO preparation phase with a total overview on all valid preventive maintenance tasks with intervals and background data.

Known FFEC, design responsibilities and other analysis relevant data can be defined in the draft MTL.

VS17:

All preventive maintenance tasks with or without regular intervals which do not fulfill the criteria for being analyzed during ISMO analysis phase must be clearly highlighted in the MTL.

Those maintenance tasks are later candidates for deletion or documentation in separate documentation. Thus the ISMO preparation phase reduces the effort for ISMO analysis in advance.

VS18:

The determination of PMTR with intervals for the "initial maintenance program/OMP" is based on the original Product use study giving information about the planned usage scenario. This scenario was specified for the product development with its subsystems, equipment components, structure items and zones.

The actual customer usage of the Product in its subsequent in-service phase can deviate from the original development assumptions. Differences are to be determined and documented in this working step. On this basis, decisions are to be made in respect of the retention or change of intervals and interval relations (that is, based on arithmetic conversion) for the use-dependent, safety-relevant individual maintenance tasks in the maintenance task analysis.

VS19:

To document all decisions and results achieved during the ISMO analysis preparation a common report must be prepared to be available on demand by authorities/customers.

VS20:

Start of ISMO analysis phase.

In the ISMO analytical phase, all preventive maintenance tasks with intervals on basis of the valid Product documentation are subjected to a detailed analysis.

VS21:

The ISMO analytical preparation phase has been conducted.

If PMTR with intervals are identified and are not listed in the draft MTL at the end of this ISMO preparation phase, those maintenance tasks must be entered in VD04 of this logic with subsequent steps and decisions.

If the analysis methodology for developing PMTR changes, for example, due to specification updates, a part of this process shown in the logic decisions VD01 to VD03 with the related works steps VS03 to VS09 must be reviewed.

End of data module

Chapter 3.3

ISMO analysis phase

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 3.2	ISMO preparation phase
DIN Norm 31 051/(DIN/EN 13306)	Begriffe zur Instandhaltung/(Maintenance Terminology)

1 Introduction

The ISMO analysis phase contains a detailed analysis for individual preventive maintenance tasks with intervals on the basis of a valid Product documentation. These maintenance tasks with intervals must be identified in the draft MTL during the ISMO preparation phase.

The methodology of this ISMO analytical logic supports the detailed analysis of every preventive maintenance task. This methodology covers the detailed analysis of:

- certification-relevant servicing tasks
- certification-relevant inspections and functional test

- certification-relevant preventive replacements (Time Change Items (TCI)) or overhauls
- Inspections on SSI or on every SD on SSI

The ISMO analysis phase must follow a uniform, comprehensible decision logic which in particular introduces or validates the following aspects for each individual maintenance task:

- Criticality categorization (FFE) of the FC to which a preventive maintenance task (including BEJ task) is related.
- Remove safety-relevant individual General Visual Inspections (GVI) on items/equipment from zonal inspections. "Standalone" preventive maintenance tasks with intervals must be created.
- Detailed analysis of the different types of preventive maintenance tasks including SSI and zonal inspections.
- Determination of any interval threshold per preventive maintenance task that the Product documentation does not take into account.
- Harmonization of interval types in accordance with international specifications. Refer to DIN Norm 31 051/(DIN/EN 13306).
- Integration of in-service experience from Product maintenance to-date including the effectiveness of the individual preventive maintenance tasks.
- Integration of the fleet-leader concept for preventive maintenance tasks with intervals.
- Integration of sampling principles for preventive maintenance tasks with intervals.

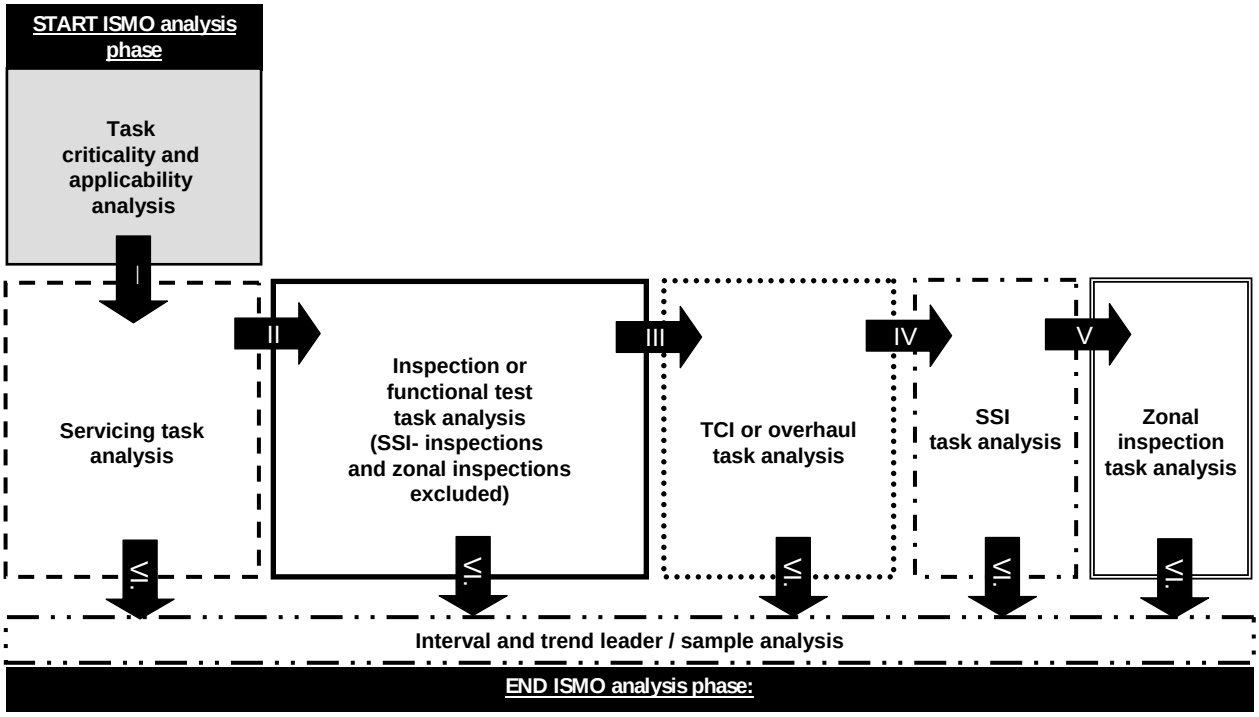
The approval of the process logic by responsible authorities is decisive for the subsequent acceptance and implementation of the analysis results.

Approval by the responsible authorities is to be sought before the start of the actual analysis work.

2 Process logic overview ISMO analysis phase

During the ISMO analysis phase every preventive maintenance task with interval must be checked by a set of questions accompanied by activities that are required from the responsible analyst.

The analysis logic of this ISMO analysis phase is composed of modules which are linked with each other as follows:



ICN-B6865-S4000P0031-001-01

Fig 1 Overview/links of analysis modules for the ISMO analysis phase

The modules cover the analysis of all maintenance task types. Depending on the maintenance task type, questions must be answered in respect to servicing tasks, inspections/functional tests, TCI/scheduled overhaul, SSI or for zonal inspections.

With respect to the resulting analysis effort, it must be noted that within the individual query blocks, the analysis can terminate after one of the first questions.

A final analytical step, "trend leader and sampling" is only performed when a preventive maintenance task with interval cannot be deleted based on the queries in the previous analysis modules.

Each analysis module comprises detailed questions, evaluations and/or investigations which have to be determined in a Product specific analysis guideline or PPH.

For more detailed information about the content of the analysis modules, refer to Para 3.

Note

It is recommended to implement the detailed analysis logic including the description of the individual analysis steps, decisions and recommendations in an electronic analysis tool to be used by all analysts. Such a tool would support the analysts, reduce inconsistent data entries and would lower the analytical effort.

3 Process logic of ISMO analysis phase

The logic diagrams show the individual process **Steps** (S), the **Decisions** (D) and the **Recommendations** (R), numbered consecutively.

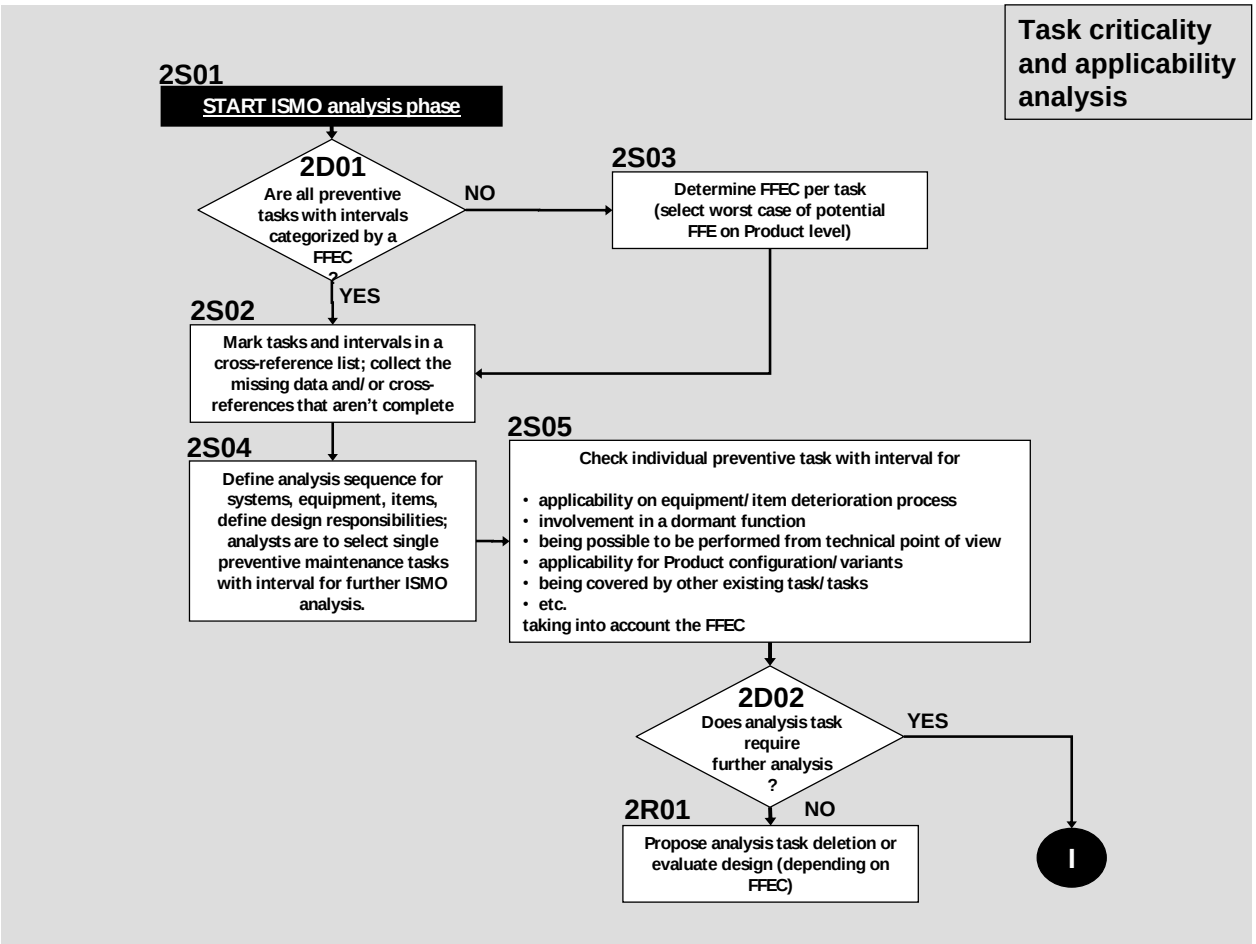
In the logic diagrams, the steps and decisions are numbered continuously and detailed in Para 4.

The process steps are given an alphanumeric code **2YZZ** where:

– "**2**" - gives the ISMO analysis phase

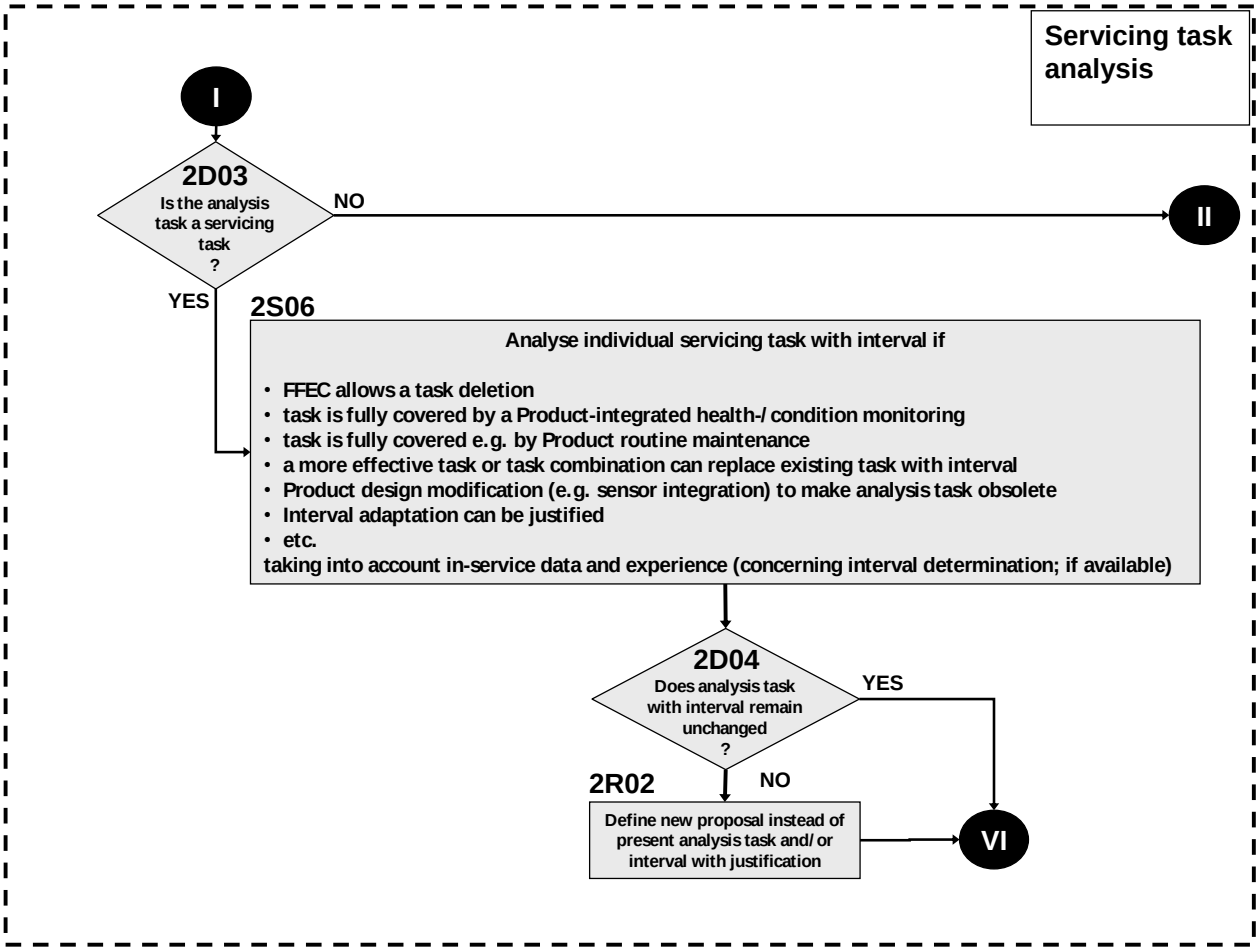
– "**Y**" - gives the Step S, Decision D or Recommendation R
– "**ZZ**" - is a number, ascending from 01 to 99

The following analysis logic is a generic version of a detailed analysis logic that must be elaborated and defined in a Product specific guideline or PPH.



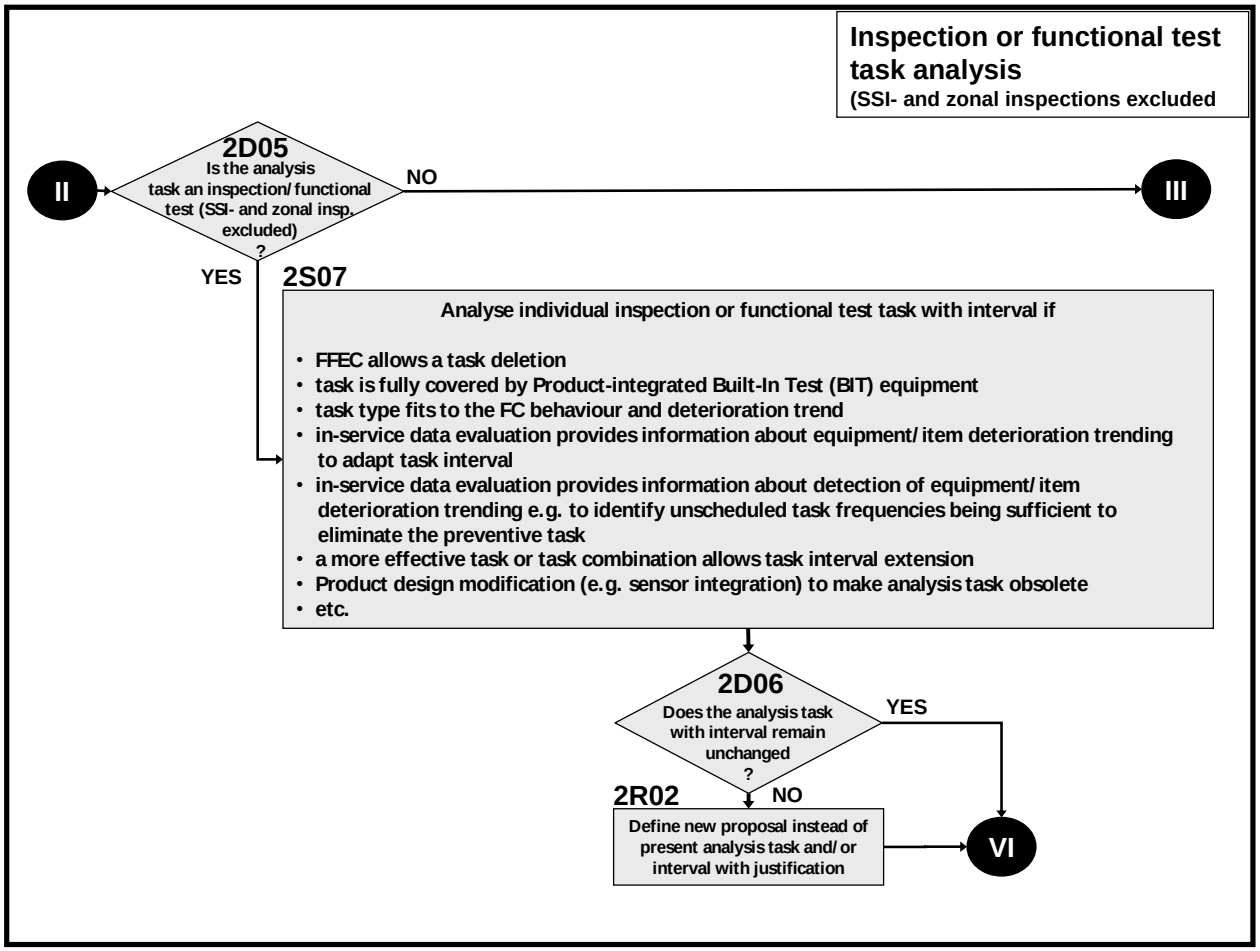
ICN-B6865-S4000P0032-001-01

Fig 2 ISMO maintenance task criticality and applicability analysis



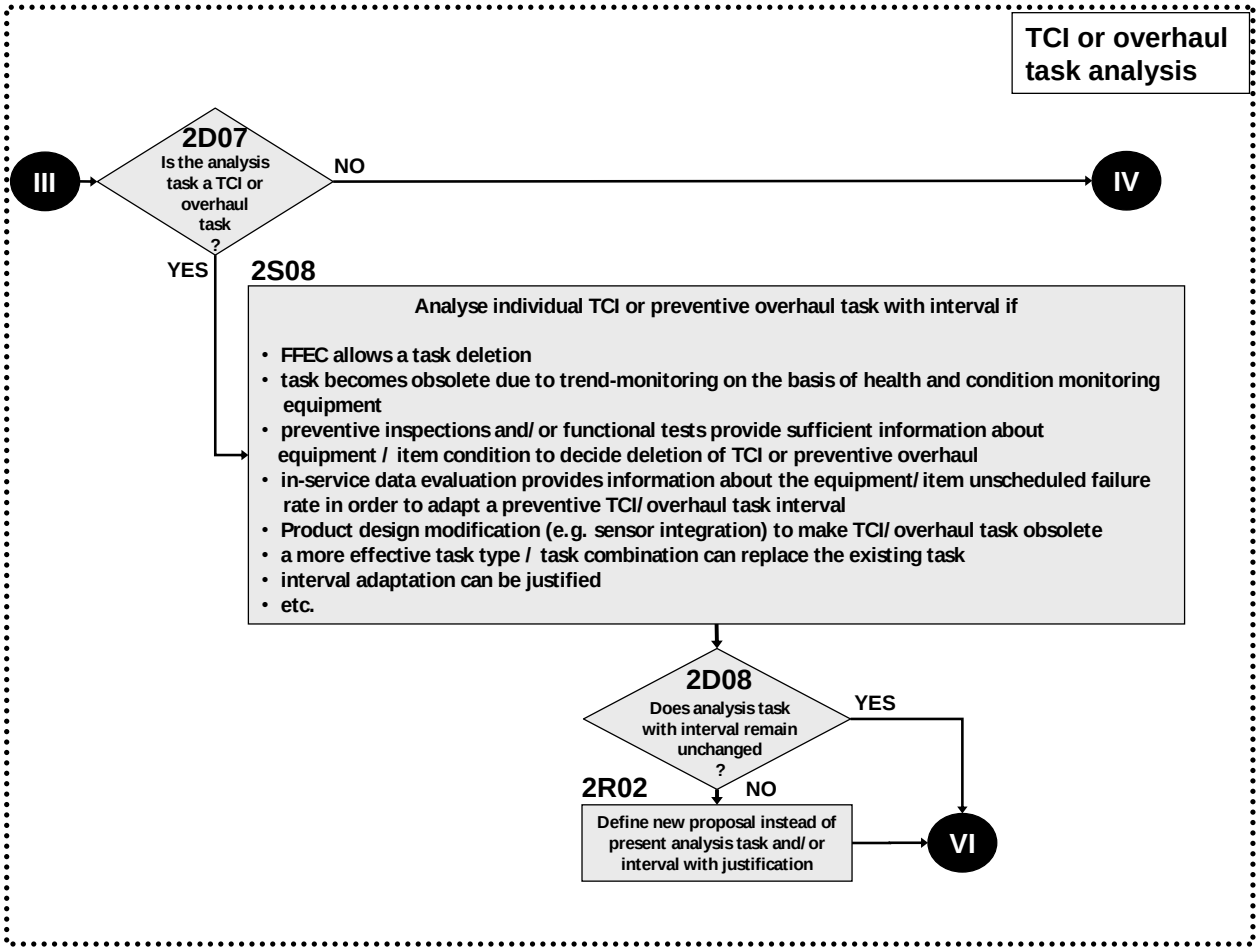
ICN-B6865-S4000P0033-001-01

Fig 3 ISMO servicing task analysis



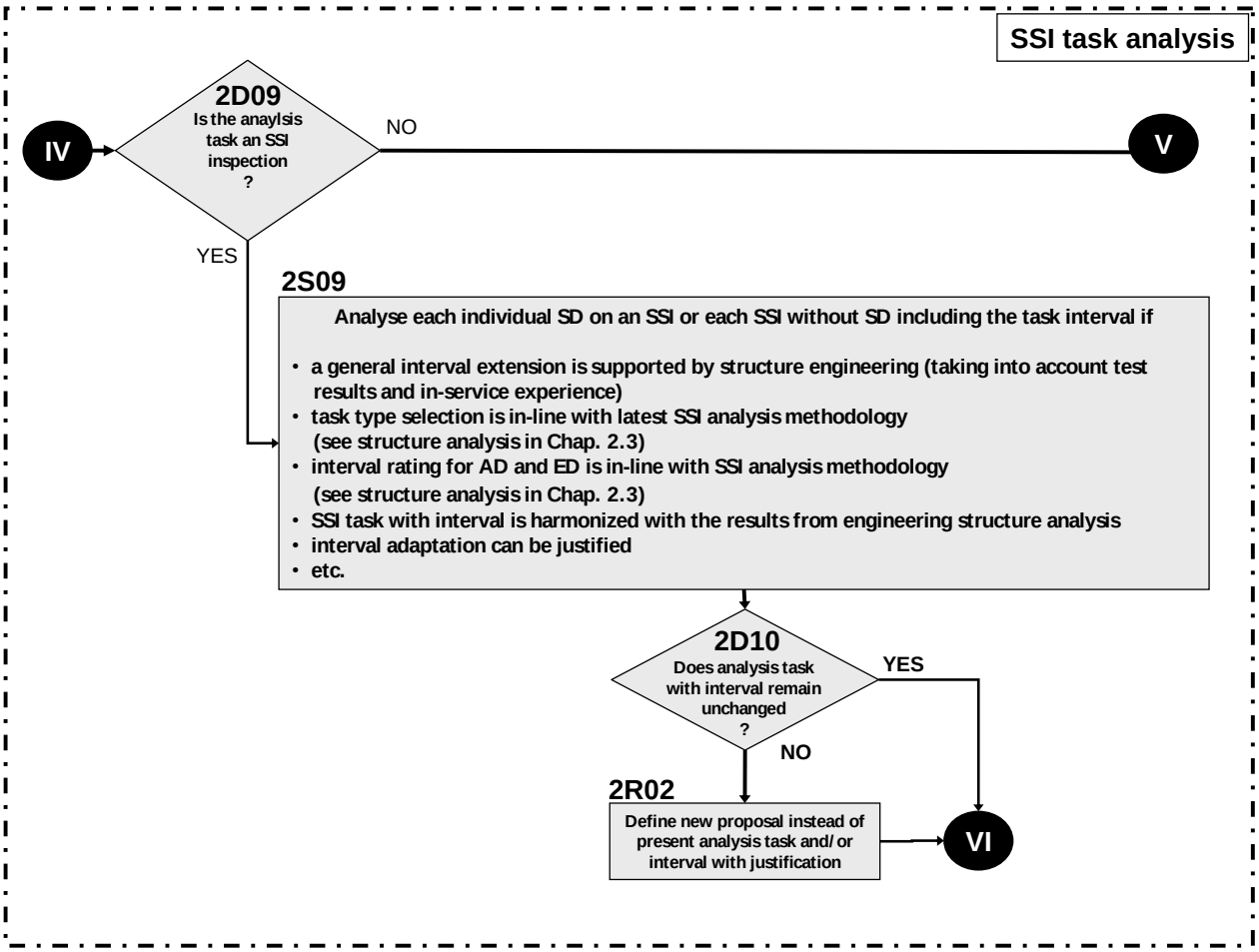
ICN-B6865-S4000P0034-001-01

Fig 4 ISMO inspection or functional test task analysis (SSI-inspections and zonal inspections excluded)



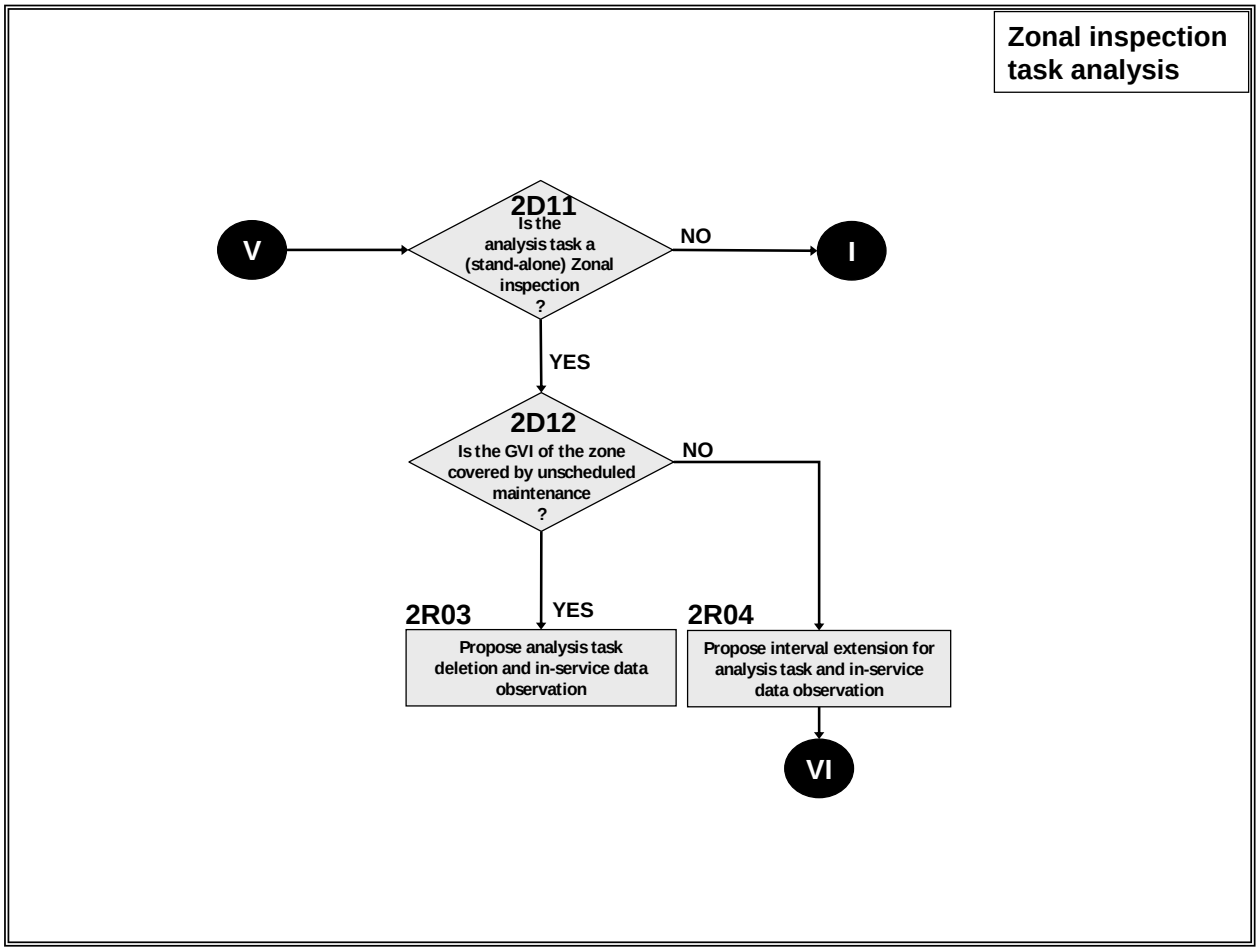
ICN-B6865-S4000P0035-001-01

Fig 5 ISMO Time change item or overhaul task analysis



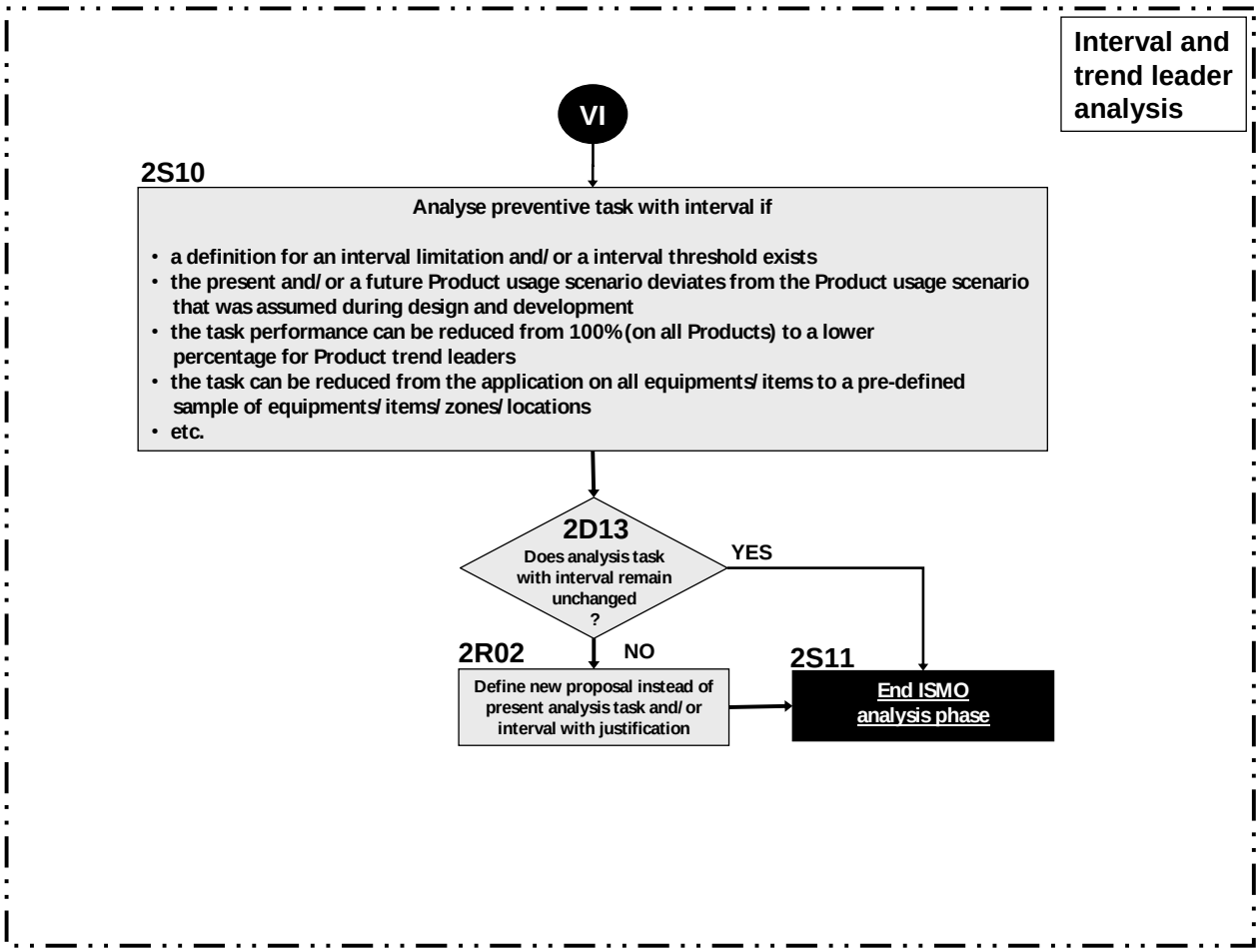
ICN-B6865-S4000P0036-001-01

Fig 6 ISMO SSI task analysis



ICN-B6865-S4000P0037-001-01

Fig 7 ISMO zonal inspection task analysis



ICN-B6865-S4000P0038-001-01

Fig 8 ISMO interval and trend leader analysis

4 Description of the generic process logic for ISMO analysis phase

This para describes the working Steps (S), the Decisions (D) and the Recommendations (R) of the generic logic to be used during the ISMO analysis phase. Initially, all sequential working steps and decisions are described.

With the view on a Product specific analysis guideline or PPH, the working steps 2S05, 2S06, 2S07, 2S08, 2S09, 2S10 must be detailed in a decision logic that leads to precise recommendations and combinations of, as follows:

- Delete maintenance task with interval
- Propose new or additional maintenance task with interval
- Keep maintenance task type and reduce interval
- Keep maintenance task interval as an upper limit
- Extend maintenance task interval
- Reduce maintenance task interval permanently
- Reduce maintenance task interval temporarily
- Design change proposed
- Detailed analysis is mandatory
- Define upper interval limit
- Define interval threshold

- Define product sample for maintenance task with interval
- Define reduction of maintenance task application on equipment/ items
- etc

The generic analysis logic on the following pages comprises 2R01, 2R02, 2R03 and 2R04 as general recommendations. In a Product specific analysis guideline or PPH these must be precise as listed above.

2S01:

The ISMO preparation phase (Chap 3.2) is the prerequisite for starting this ISMO analysis phase.

A suitable ISMO analysis team requires not only professional knowledge regarding maintenance, but also particular specialized knowledge of both the technology of the Product under analysis and the field of support engineering/ILS.

A software tool for supporting the analysts is recommended, that guides each analyst through the query logic provided and explained in the Product-specific analysis guideline or PPH. Questions and decisions with reasoning/information as well as recommendations are to be documented in this tool.

2D01:

For a system under analysis all preventive maintenance tasks with intervals, listed in the MTL must comprise all analysis relevant data (FFEC, background information and traceability of maintenance task roots).

This is the prerequisite for starting the ISMO analysis phase for single preventive maintenance tasks.

The Answer is "YES" if:

- analysis relevant information per system is completed

or

- the SSI task criticality is categorized

or

- the Zonal inspection task criticality is categorized

In these cases (Answer is "YES"), continue with 2S02.

In other cases (Answer is "NO"), continue with 2S03.

2S02:

Indicate Systems, SSI and Zones completed with analysis-relevant background data ready for being analyzed in ISMO analysis phase

2S03:

Where information for ISMO analysis phase (specific criticality categorization) is missing, the lack of data has to be compensated. If in any doubt, the responsible analyst must select a "certification-relevant" FFEC for the maintenance task.

2S04:

The analysis must be done at a functional subsystem or item level to detect any optimization potential in the set of preventive maintenance tasks per subsystem or item.

Proceeding in this way, for example, multiple functional tests or inspections at different intervals can be deleted.

To start the analysis on functional subsystems, different selection criteria must be taken into consideration:

- Analysis relevant data and information (incl. in-service data) is available
- A subsystem/equipment or item that significantly contributes to mission availability / Life Cycle Cost (LCC) must be analyzed with the highest priority (use data from logistic support analysis databases, operating data (if available) or alternatively an analysts' estimation about the maintenance effort per individual maintenance task)
- etc

Select an individual maintenance task from the common MTL and proceed with further analysis steps.

2S05:

Independent from the maintenance task type, the individual maintenance task must withstand general questions related to:

- deterioration process of one or more relevant FC
- involvement of FC in a dormant or emergency function
- positive prerequisites for maintenance task realization
- applicability for all or for limited Product configuration/variants
- etc

The FFEC allocated to a maintenance task supports decisions if the maintenance task can be deleted or not.

2D02:

The output from 2S05 must either be a confirmation of the present maintenance task type (Answer is "YES", continue with 2D03), or a recommendation that the maintenance task type is not applicable (Answer is "NO", continue with 2R02).

2D03:

This question asks for a preventive maintenance task type "servicing".

Preventive servicing tasks are, for example:

- Cleaning
- Replenishment or supplement consumables
- Preservation
- Lubrication, greasing
- Adjustment, calibration

If the maintenance task in this question is answered "YES", continue with 2S06.

If answered "NO", continue with 2D05.

2S06:

For the maintenance task type servicing, specific technical prerequisites must exist.

Alternative solutions to compensate a maintenance task depends on its type and the failure cause/causes related.

The individual maintenance task must take into account the following:

- FFEC
- health-/condition monitoring installed in the Product (if any)

- routine maintenance task exist in parallel
- alternative maintenance task/tasks with interval/intervals exist
- potential design modifications/adaptations implemented
- experience from the in-service phase
- etc

Depending on the FC and the related maintenance task criticality a recommendation (refer to the beginning of this chapter) must be developed and justified.

2D04:

If the maintenance task with interval remains unchanged (Answer "YES"), continue with 2S10.

If the analysis leads to a new proposal (Answer "NO"), continue with 2R02.

2D05:

As the analyzed maintenance task is not a servicing task, this question asks for a preventive inspection or functional test.

Preventive inspections/functional tests comprise:

- General visual inspection (GVI)
- Detailed visual inspection
- Measurement
- Material testing (destructive or non-destructive)
- Condition/functional test (with or without testing device/equipment)

If the analyzed maintenance task can be assigned to one of these maintenance task types above (Answer "YES"), continue with 2S07.

If answered "NO", continue with 2D07.

2S07:

For the inspection or functional test specified technical prerequisites must exist.

Alternative solutions to compensate such maintenance tasks depend on the maintenance task type and the failure cause/causes behind the maintenance task.

The individual maintenance task must take into account the following:

- FFEC
- Built-In Test (BIT) equipment health-/condition monitoring installed in the Product (if any)
- can the FC be attributed to deterioration or its fault trending (including in-service data output)
- alternative maintenance task/tasks with interval/intervals already exist
- effective design modifications/adaptations
- etc

Depending on the FC and the related FFEC a recommendation must be developed and justified (refer to the beginning of this chapter)

2D06:

If the maintenance task with interval remains unchanged (Answer "YES") continue with 2S10.

If the analysis leads to a new proposal concerning maintenance task and/or the interval (Answer "NO"), continue with 2R02.

2D07:

As this analyzed maintenance task is neither a servicing task nor an inspection/functional test (except for SSI inspection and zonal inspection), it must be determined whether this is one of the following preventive maintenance tasks types:

- Equipment/item/part replacement (TCI)
- Overhaul of the item/part/module/equipment

If the maintenance task type belongs to one of these maintenance task types (Answer: "YES"), continue with 2S08.

If answer is "NO", continue with 2D09.

2S08:

For a preventive replacement task (Time Change Items (TCI)) or overhaul task, specific technical prerequisites must exist.

Alternative solutions to compensate such maintenance tasks depend on the maintenance task type and the FC related to the maintenance task.

The individual maintenance task must take into account to the following:

- FFEC
- condition monitoring based on health-/condition monitoring installed in Product (if any)
- other maintenance task-based sources allowing condition monitoring
- is the preventive maintenance task effective, based on evaluating unscheduled failures/faults
- does a more effective preventive maintenance task type or task combination with interval/intervals exist
- is there potential effective design modifications/adaptations
- etc

Depending on the FC and the related maintenance task criticality a recommendation must be developed and justified (refer to the beginning of this chapter)

2D08:

If the maintenance task with interval remains unchanged (Answer "YES") continue with 2S10.

If the analysis leads to a new proposal concerning maintenance task and/or the interval (Answer "NO"), continue with 2R02

2D09:

The analyzed maintenance task is not a servicing task and no inspection/functional test (except SSI inspection or zonal inspection) and no TCI or overhaul task has been identified.

This question asks for a SSI inspection.

If "YES", continue with 2S09.

If "NO", continue with 2D11.

2S09:

For the maintenance task type SSI inspection a specific analysis process is required.

The individual SSI task with interval must be checked to ensure that:

- a general interval extension is supported by responsible design departments

or

– a maintenance task type selection is in line with valid SSI analysis methodology

or

– a maintenance task interval is correctly rated in line with SSI analysis methodology and harmonized with other maintenance task/interval sources (eg, design department, safety analysis, authority)

or

– an interval adaptation can be justified

or

– etc

Depending on the analysis result a recommendation must be developed and justified (refer to the beginning of this chapter).

2D10:

If the maintenance task with interval remains unchanged (Answer "YES") continue with 2S10.

If the analysis leads to a new proposal concerning maintenance task and/or the interval (Answer "NO"), continue with 2R02

2D11:

As the maintenance task is neither a servicing task, nor an inspection/functional test (except SSI inspection and zonal inspection), a preventive replacement/overhaul, or an SSI inspection, the maintenance task must be a zonal inspection as it is the only remaining maintenance task type.

Stand-alone zonal inspections without critical sub-tasks shall be categorized as "non-certification-relevant" GVI. Subtasks with a higher criticality must have been extracted from Zonal analysis during the ISMO preparation phase prior to starting the ISMO analysis phase.

If answer is "YES", continue with 2D12.

If answer is "NO", go back to 2D03 for renewed querying of the maintenance task type.

2D12:

If operating crew/maintenance personnel have access to a zone frequently, the preventive GVI of the zone can be omitted (eg, due to fault frequency and failure elimination or other maintenance tasks within this zone).

Note

The criterion for a minimum unscheduled access frequency to a zone shall be determined jointly with the responsible authorities/manufacturers.

The prerequisites for deleting a preventive zonal inspection are:

1 The responsible maintenance personnel are well trained and instructed to perform a GVI in this zone after every unscheduled access.

2 No additional dismantling/removal is required in the zone under analysis.

If answer is "YES", continue with 2R03.

If answer is "NO", continue with 2R04.

2S10:

This analysis step must prove that the maintenance task can be limited on certain time periods only (eg, an upper interval limit, or a threshold).

In addition, it must be clarified if the maintenance task with interval can be limited on a Product sample or on a sample of equipment/items/zones/locations etc.

Depending on the analysis result a recommendation must be developed and justified (refer to the beginning of this chapter).

2D13:

If the maintenance task with interval remains unchanged (Answer is "YES") continue with 2S11.

If the analysis leads to a new proposal concerning maintenance task and/or the interval (Answer is "NO"), continue with 2R02

2S11:

End of ISMO analysis phase.

The results must be documented and a final report with all analysis results and substantiation has to be submitted to customers, users and authorities.

Following final authorization and approval by the responsible authorities, the report is to be submitted to the ILS units responsible specifically for updating the technical documentation.

2R01:
Propose analysis task deletion or evaluate design (depending on FFEC).

2R02:
Define new proposal instead of present analysis task and/or interval with justification.

2R03:
Propose analysis task deletion and in-service data observation.

2R04:
Propose interval extension for analysis task and in-service data observation.

Chapter 3.4

ISMO follow-up phase

Table of contents

Page

List of tables

List of figures

References

Table 1 References

Chap No./Document No.	Title
Chap 2	Development of preventive maintenance task requirements with intervals

1 Introduction

There are various reasons for deviations between initial assumptions during the development of Preventive Maintenance Task Requirements (PMTR) with intervals and the subsequent elaboration of a Product maintenance program/OMP and maintenance experience accumulated during the usage of a Product.

Therefore it is essential to identify accumulations of unscheduled failure and/or damage messages which have not been taken into account in the initial approach while determining and improving preventive maintenance tasks and intervals in maintenance programs OMP for a Product.

As far as such arisings have been identified as safety-critical or as far as they might have conflicted with law/environmental integrity, applicable decisions have already been initiated during the running Product in-service phase using regulatory mechanisms established per Nation/customer etc. In between Product users the exchange of Product-important information is established and coordinated as well.

Impacts on mission availability and/or in unscheduled maintenance activities with high cost impact for a user/customer improvement mechanisms depend on the individual use and maintenance of a product by a customer/user.

This ISMO follow-up phase takes into account these aspects using process and logics according to this document.

For this purpose new preventive maintenance tasks with intervals might be determined which have not been part of the respective maintenance program/OMP of the customer/user.

The application of the ISMO follow-up phase ensures that newly identified maintenance tasks with intervals are in line with the remaining maintenance tasks of the single item/equipment maintenance concepts. In addition full traceability of all maintenance task-related decisions is required which can be used during the remaining Product in-service phases. This ensures in-service experience-oriented and an on-going development of the maintenance programs/OMP of different customers, if any.

If PMTR with intervals cannot reduce unscheduled arisings, the evaluation of design improvements will be recommended. To support such decisions, in-service data will be collected, filtered, evaluated and calculated as inputs for support cost-trade-offs.

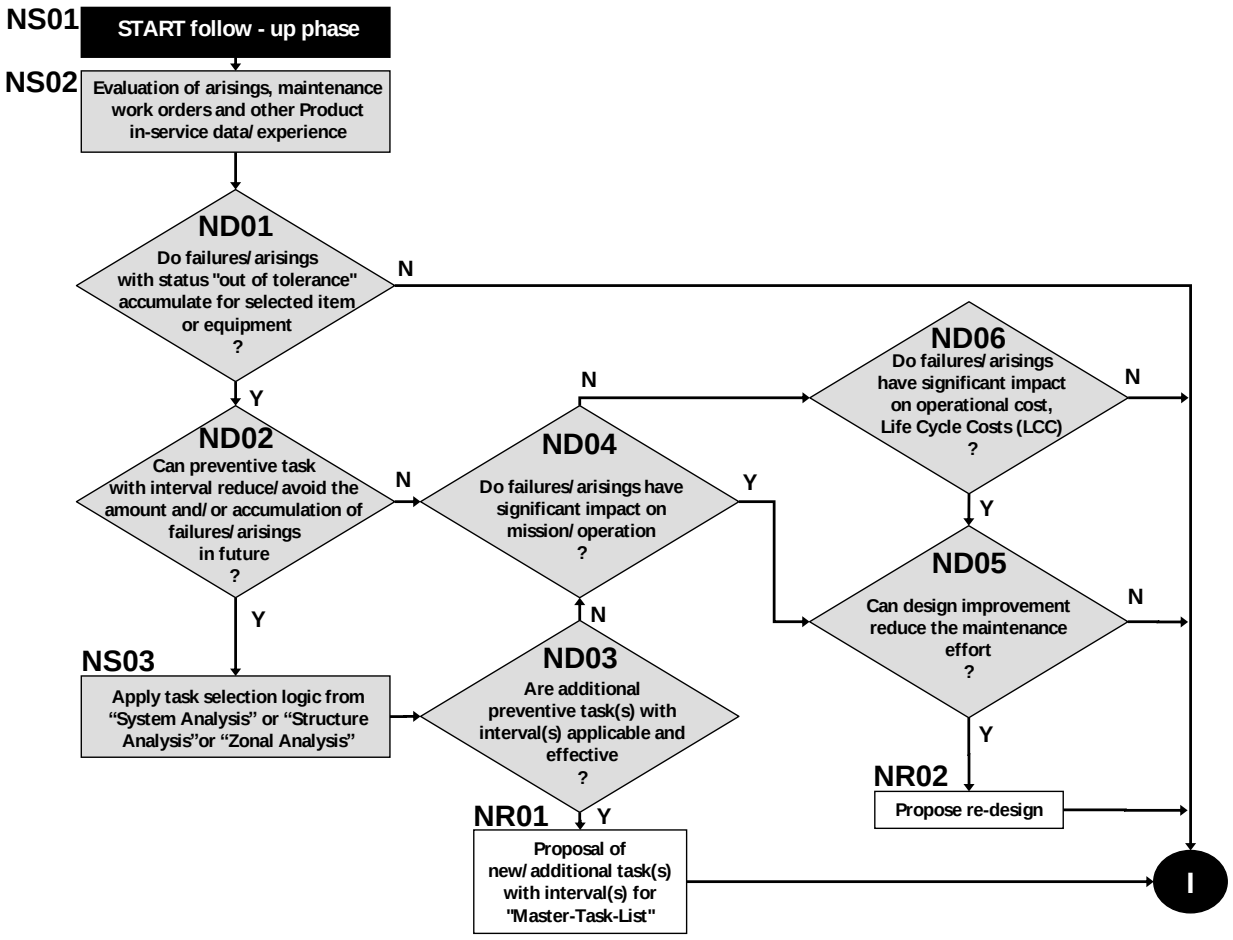
2 Process logic of ISMO follow-up phase

The logic diagrams show the individual process **Steps** (S), the **Decisions** (D) and the **Recommendations** (R), numbered consecutively.

In the logic diagrams, the steps and decisions are numbered continuously and detailed in Para 3.

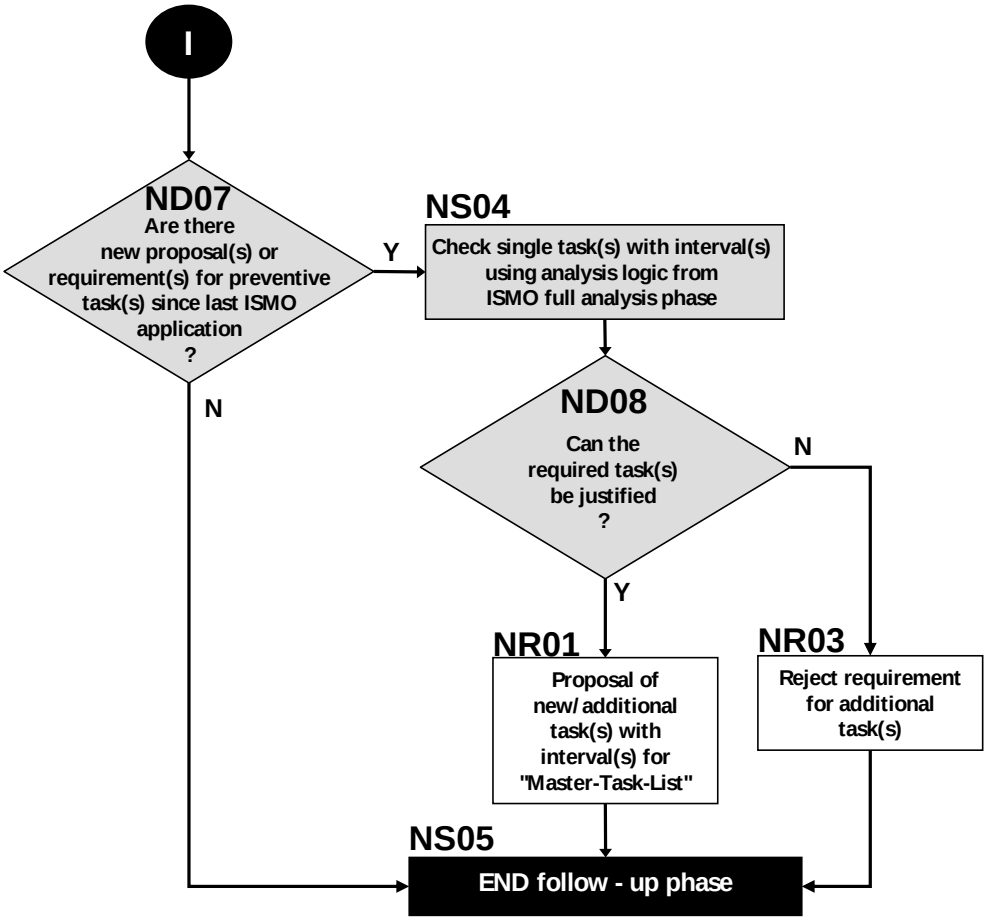
The process steps are given an alphanumeric code **NYZZ** where:

- "**N**" - gives the ISMO follow-up phase
- "**Y**" - gives the Step S, Decision D or Recommendation R
- "**ZZ**" - is a number, ascending from 01 to 99



ICN-B6865-S4000P0041-001-01

Fig 1 ISMO follow-up phase (Sheet 1 of 2)



ICN-B6865-S4000P0042-001-01

Fig 2 ISMO follow-up phase (Sheet 2 of 2)

3 Description of process and decision steps of ISMO follow-up phase

This para describes the working **Steps** (S), the **Decisions** (D) and the **Recommendations** (R) of the generic logic to be used during the ISMO analysis phase

Note

Important note for performance of the ISMO follow-up phase.

In answering decision questions, the following principle applies:

– A conservative decision is to be taken in the event of lacking information or data, ambiguity or doubt.

NS01:

The ISMO follow-up phase can be started in parallel to the ISMO analysis phase or later. After having finished the ISMO phase, no preventive maintenance task with interval should remain within the Product maintenance program/OMP that is not applicable, not effective or without any technical justification.

NS02:

During the ISMO analysis phase, the in-service data evaluation is focused on items, equipment and zones for which preventive maintenance tasks with intervals have already been

determined. The result of the evaluation assists each analyst to answer questions and to justify the answers in the single analysis logics.

The ISMO follow-up phase searches for of numerous arisings and unscheduled maintenance on items and equipment, where preventive maintenance was not established in the past.

ND01:

This question clarifies if there are failures/arisings and resulting unscheduled maintenance activities documented for selected items/equipment which significantly exceeds the assumptions made during the design and development phase.

If such cases have been identified (Answer "YES"), continue with ND02.

If not (Answer "NO"), continue with ND07.

ND02:

Prior to applying the complete maintenance task selection and interval determination process, the analyst is asked whether preventive maintenance might be applicable and effective for the identified FC. That probability should be at least higher than 50%.

If the probability is judged to be high enough to justify a further analysis effort (Answer "YES"), continue with NS03.

If not (Answer "NO"), continue with ND04.

NS03:

Depending on the item/equipment that has been identified for a detailed analysis, the analyst shall define which analysis methodology is required. For this purpose Chap 2 is applicable.

To determine an effective maintenance task with interval for a mission and/or economical relevant failure cause without any contractual restrictions between manufacturer and Product user, decisions can be done by the customer/user (based on in-service experience and/or future Product usage plans).

ND03:

Having applied the agreed analysis process for maintenance task and interval determination either one or more preventive maintenance tasks with intervals have been identified or no maintenance tasks with interval were found.

If maintenance tasks with intervals have been defined (Answer "YES"), continue with NR01.

If not (Answer "NO"), continue with ND04.

ND04:

If preventive maintenance tasks with intervals are not applicable and/or effective a technical improvement or a change of the present design status shall be evaluated. Reductions in mission/operational availability are assumed to be more important for a product compared to economic aspects only.

If mission/operational availability is impacted (Answer "YES"), continue with ND05.

If not (Answer "NO"), continue with ND06.

ND05:

The answer to this question is decided with the best engineering judgement of the analyst. It is no guarantee that the decision will be confirmed by any design departments of the manufacturer and equipment manufacturers, etc.

If design improvement can reduce the unscheduled maintenance effort (Answer "YES"), continue with ND05.

If it cannot reduce the unscheduled maintenance effort (Answer "NO"), continue with ND06.

ND06:

Unscheduled maintenance activities which lead to high costs during a Product in-service phase shall be reduced to a minimum. A reduction of operational costs automatically influences the product LCC in a positive manner.

If operational costs can be reduced significantly (Answer "YES"), continue with ND05.

If not (Answer "NO"), continue with ND07.

ND07:

In parallel to an on-going ISMO analysis performed according to this document, requests for preventive maintenance tasks with intervals might additionally be raised by users/customers.

All requests shall be answered using the questions in line with this ISMO process.

If new requirements exist (Answer "YES"), continue with NS04.

If not (Answer "NO"), close the ISMO follow-up phase with NS05.

NS04:

Enter the logic of the ISMO analysis phase with each required single maintenance task and its interval. Answer the logic questions and take into account in-service experience/data as much as possible.

ND08:

After having passed the ISMO analysis phase for each individual maintenance task with interval, a decision can be made if a required maintenance task can be justified and if the proposed interval is correct or must be adapted.

All approved maintenance tasks with intervals (Answer "YES"), continue with NR01.

In case of maintenance tasks and intervals cannot be justified (Answer "NO"), continue with NR03.

NS05:

The ISMO follow-up process is closed within the ISMO analytical process.

Explanation of results from ISMO follow-up phase:

NR01:

Proposal of new/additional maintenance tasks with intervals which have not been predicted by the customer/user technical publication before.

NR02:

An investigation must be proposed and initiated as to whether a design improvement could reduce the documented accumulation of arisings/unscheduled maintenance,

NR03:

If maintenance tasks and intervals cannot be justified prepare a rejection statement with a suitable justification to the originator of each request.

Chapter 4

Interfaces of S4000P

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
Chap 4.1	General
Chap 4.2	S4000P interfaces outside the S-series of ILS Specifications
Chap 4.3	Interface S4000P - S1000D
Chap 4.4	Interface S4000P - S3000L
Chap 4.5	Interface S4000P - S5000F
Chap 4.6	Interface S4000P - SX000I

1 General

This chapter is foreseen to provide, in a future issue, an introduction (Chap 4.1) and will continue with S4000P interfaces outside the S-Series of ILS Specifications (Chap 4.2).

The S4000P-relevant descriptions of interfaces within the S-series of ILS specifications will be described in Chap 4.3, Chap 4.4, Chap 4.5 and Chap 4.6.

Chapter 5

Terms, abbreviations and acronyms

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
Chap 5.1	Terms, abbreviations and acronyms - Glossary of terms
Chap 5.2	Terms, abbreviations and acronyms - Abbreviations and acronyms

1 General

This chapter provides a glossary of terms (Chap 5.1) and a list of acronyms and abbreviations (Chap 5.2).

Chapter 5.1

Terms, abbreviations and acronyms - Glossary of terms

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
None	

Glossary of terms

Accidental Damage (AD)	A physical deterioration of an item caused by contact or impact with an object or influence which is not a part of the Product, or by human error during manufacturing, operation of the Product, or maintenance practices.
Analysis Relevant Candidate (ARC)	An item in the Product breakdown structure identified by the manufacturer on highest manageable level in the frame of system analysis, whose functional failure: – could affect safety – is undetectable during missions/operations – could have significant mission/operational impact – could collide with law and/or have significant impact on environmental integrity (ecological damage) – could have significant economic impact
conditional probability of failure	The probability that a failure will occur in a specific period provided that the item concerned has survived to the beginning of that period.
contingency period	A phase to continue to operate the Aircraft in safe conditions while operating conditions may not allow accomplishing every maintenance task as detailed in the standard maintenance program/OMP. During this period only minimum maintenance tasks required for safety and operation will be performed.

acceptable corrosion level	A corrosion damage that does not require structural reinforcement or replacement or corrosion occurring between successive inspections exceeds allowable limit but is local and can be attributed to an event not typical of operator usage of other Products in the same Product fleet. Example from the aeronautic industry: Corrosion Level 1.
Corrosion Prevention and Control Program (CPCP)	A program of maintenance tasks implemented at a threshold designed to control a Product structure to Corrosion Level 1 or better. This program contains both preventive servicing and inspection tasks.
crisis time	A sequence of interactions between the governments of two or more sovereign states in severe conflict, short of actual war, but involving the perception of a dangerously high probability of war. In this crucial, unstable situation action might be taken associated with or performed by armed services (military).
damage tolerant	A qualification standard for Product structure. An item is judged to be damage tolerant if it can sustain damage and the remaining structure can withstand reasonable loads without structural failure or excessive structural deformation until the damage is detected.
delamination/disbond	A structural separation or cracking that occurs at or in the bond plane of a structural element, within a structural assembly, caused by in service accidental damage, environmental effects and/or cyclic loading.
deployment	The distribution of a military unit, weapon systems, resources or similar systematically or strategically to perform operations temporarily dislocated from the normally assigned duty area.
direct adverse effect on (operating) safety	Direct – To be direct, the functional failure or resulting secondary damage must achieve its effect by itself, not in combination with other functional failures (no redundancy exists). Adverse effect on safety – Safety shall be considered as adversely affected if the consequences of the functional failure must cause serious or fatal injury to human beings. Operating – The time interval (period) during which the Product is activated or in a usage condition and human beings are .
economic effects	The failure effects, which do not prevent Product operation, but are economically undesirable due to added labor and material cost for Product or shop repair.
Electrical Wiring Interconnection System (EWIS)	An electrical connection between two or more points including the associated terminal devices (eg, connectors, terminal blocks, splices) and the necessary means for its installation and identification.
environment	The effects of the atmosphere, corrosive materials, condensation, temperature, and vibration on the protection, with respect to Product degradation.

Environmental Deterioration (ED)	The physical deterioration of an item's strength or resistance to failure, as a result of chemical interaction with its climate or environment.
exploration operation safety	A systematic evaluation of an item based on analysis of collected information from in-service experience. It verifies the item's resistance to a deterioration process with respect to increasing age.
failure cause	The reason why the functional failure occurs.
failure condition	The effect on the Product and its occupants, both direct and consequential, caused or contributed to by one or more failures, considering relevant adverse operational or environmental conditions.
Fatigue Failure (FF)	The initiation of a crack or cracks due to cyclic loading and subsequent propagation.
fatigue related sampling inspection	The inspections on specific Product selected from those which have the highest operating age/usage in order to identify the first evidence of deterioration in their condition caused by fatigue damage.
fault	An identifiable condition in which one element of a redundant system has failed (no longer available) without impact on the required function output of the Product system (ARC). At the system level, a fault is not considered a functional failure.
fault-tolerant system	A system that is designed with redundant elements that can fail without impact on safety or operating capability.
function	The normal characteristic actions and/or performance of an item.
functional test	A quantitative test to determine if one or more functions of an item or a system perform within specified limits. The maintenance task must be able to detect degradation (wear, leakage, etc) and not just the complete failure.
functional failure	The item/system fails to perform its intended function within specified limits.
functional failure effect	The end effect of a functional failure on the Product level.
functional failure effect collides with law	The functional failure causes the Product - temporary and/or permanently - not to be in line with released law regulations. Refer to "functional failure effect".
functional failure effect impacts ecological integrity	The functional failure causes a reversible or irreversible pollution/poisoning of the environment with temporary and/or permanent consequences for the ecosystem. Refer to "functional failure effect".
hard time	The removal from service of an item at a specified life limit – no repair task effective/applicable.

hidden function	Active – A function which is normally active and whose cessation will not be evident to the operating crew/personnel during performance of normal duties. Inactive – A function which is normally inactive and whose readiness to perform, prior to it being needed, will not be evident to the operating crew/personnel during performance of normal duties.
inherent level of reliability and safety	The level which is built into the unit and, therefore, inherent in its design. This is the highest level of reliability and safety that can be expected from a unit, system, or Product if it receives effective maintenance to achieve higher levels of reliability generally requires modification or redesign.
inspection - DETailed (DET)	An intensive examination of a specific item, installation or assembly to detect damage, failure or irregularity. Available lighting is normally supplemented with a direct source of good lighting at an intensity deemed appropriate. Inspection aids (mirrors, magnifying lenses, etc) may be necessary. Surface cleaning and elaborate access procedures may be required.
Inspection - General Visual Inspection (GVI)	A visual examination of an interior or exterior area, installation or assembly to detect obvious damage, failure or irregularity. This level of inspection is made from within touching distance unless otherwise specified. A mirror may be necessary to enhance visual access to all exposed surfaces in the inspection area. This level of inspection is made under normally available lighting conditions such as daylight, hangar lighting, flashlight or droplight and may require removal or opening of access panels or doors. Stands, ladders or platforms may be required to gain proximity to the area being checked.
inspection - Special Detailed Inspection (SDI)	An intensive examination of a specific item, installation, or assembly to detect damage, failure or irregularity. The examination is likely to make extensive use of specialized Inspection Techniques and/or equipment. Intricate cleaning and substantial access or disassembly procedure may be required.
inspection - routine	A dedicated package of inspection tasks which have to be performed, for example, before, between and after the use/operation/mission of a Product. Example from aeronautical industry: Before flight, after flight or turn round inspection, etc.
inspection - simple	An inspection that can be performed by a human being without the use of any further technical support means (support and test equipment). General Visual Inspections (GVI), DETailed inspections (DET) and Routine inspections belong to simple inspections.
inspection - zonal	A collective term comprising selected general visual inspections and visual checks that are applied to each zone, defined by access and area, to check system installations and structure for security and general condition.

interval (initial - repeat)	Initial interval (threshold) – An interval between the start of Product service-life and the first maintenance task accomplishment. Repeat interval – An interval (after the initial interval) between successive accomplishments of a specific maintenance task.
item	Any level of hardware assembly (system, subsystem, part, module, component, unit, tool, accessory, etc).
Item - Structure Significant Item (SSI)	A structural item or assembly, which contributes significantly to carrying flight, ground, pressure or control loads, and whose failure could affect the structural integrity necessary for the operating safety of the Product and/or could impact human safety and/or could impact law and/or environmental integrity.
limitations	A section of the Instructions for Continued Operation Safety that contains each mandatory replacement time, structural inspection interval, and related structural inspection task. This section may also be used to define a threshold for the fatigue related inspections and the need to control corrosion to Level 1 or better. The information contained in the section with Item Life Limitations may be changed to reflect service and/or test experience or new analysis methods.
maintenance relevant structure	A structure that can occur both externally and internally and will either be inspected during relatively frequent routine inspections or prior to the less frequent zonal inspections.
maintenance task	An action or set of actions required achieving a desired outcome, which restores an item to or maintains an item in serviceable condition, including inspection and determination of condition.
maintenance task applicability	A set of conditions that leads to the identification of a maintenance task type when a specific set of characteristics of the failure cause being analyzed would be discovered and/or corrected as a result of the maintenance task being accomplished.
maintenance task effectiveness	A specific set of conditions that lead to the selection of a task already identified to be applicable. Avoids, eliminates, or reduces the negative consequences of the failure to an extent that justifies doing the task at the selected interval.
maintenance task type	A maintenance task type is a PMTR out of the main preventive maintenance task categories servicing, inspection/functional test and TCI/overhaul, eg a lubrication task as part of the maintenance task category servicing;

missions (military or civil)	The specific Product operations performed in the frame of Product usage. Examples from aeronautic industry: – Medical transport or evacuation flights (eg, MEDEVAC) – External cargo/load transport on helicopters – Firefighting flights – Air-to-air refueling – Boarder control flights – Approach and landing on unpaved runways – Autonomous approach – Formation flight – Low/high level flight
mission capability	The Product shall be capable to carry out the pre-planned mission. That includes the functionality of the mission equipment. The mission capability is more focused on the military use of a Product. Refer to "operational capability".
multiple element fatigue damage	A simultaneous cracking of multiple load path discrete elements working at similar stress levels.
multiple site fatigue damage	The presence of a number of adjacent, small cracks that might coalesce to form a single long crack.
non-ARC	An item from Product breakdown structure, which are not relevant to perform deeper S4000P system analysis effort after having finished the ARC and non-ARC selection.
non-critical structure	A structure that does not require specific preventive maintenance tasks.
non-metallic	Any structural material made from fibrous or laminated components bonded together by a medium. Materials such as graphite epoxy, boron epoxy, fiberglass, Kevlar epoxy, acrylics and the like are non-metallic. Non-metallic includes adhesives used to join other metallic or non-metallic structural materials.
normal duties	Those duties associated with the operation of the Product, on a daily basis (or every time when the Product is used), to include the following: – Procedures and checks performed during Product operation in accordance with the Product maintenance and operating publications. – Recognition of abnormalities or failures by the operating crew/personnel through the use of normal physical senses (noise, vibration, temperature, visual observation of damage or failure, changes in physical input force requirements, etc). Refer to "operating crew/personnel".
operational capability	The Product shall be capable to carry out the pre-planned operation. The operational capability is more focused on the civil use of a Product. Refer to "mission capability".
operating crew/personnel	The trained and qualified personnel who are on duty to operate the Product. Maintenance crew is not part of operating crew. Refer to "normal duties".

operational check	An operational check is a maintenance task to determine that an item is fulfilling its intended purpose. Does not require quantitative tolerances. This is a failure finding maintenance task.
operational effects	A failure effects which interfere with the completion of the Product operation. These failures might cause delays, cancellations, ground or flight interruptions, high drag coefficients, altitude restrictions, military mission derogation, etc.
other structure	Refer to "uncritical structure".
Partner Company (PC)	A company, which is responsible to design structure parts, equipment or systems of the technical Product in line with an agreed Product work share.
potential failure	A defined identifiable condition that indicates that a degradation process is taking place that will lead to a functional failure.
preventive maintenance task	A maintenance activity to timely identify and/or eliminate a potential Failure Cause (FC) or consequence of a damage prior leading to a functional failure (FF) of the affected item or zone. The scope is to avoid the occurrence of a functional failure effect (FFE) for the Product related to the following FFE categories: – safety – conflict with law / environmental integrity – mission/operational availability – economy Preventive maintenance includes scheduled activities with numerical interval values and interval types and activities following special events (eg, after an unscheduled lightning strike on an aircraft). For these events scheduled intervals or interval thresholds cannot be defined. Typical interval types are, for example, based on calendar time (days, months, years, etc) and usage oriented parameters like operating cycles or operating hours. Therefore scheduled maintenance is a subset of preventive maintenance.
Preventive Maintenance Review Board (PMRB)	A board of maintenance experts taking part in regular meetings to discuss both procedural steps and analysis results.
prime manufacturer	A manufacturer responsible for the complete Product.
Product	Any technical platform, system, equipment, vehicle, facility, etc (air, sea, land, space; civil or military).
Product breakdown structure	The Product breakdown structure provides an exhaustive, hierarchical tree structure of items that make up the Product, arranged in whole-part relationship.
protective device	Any device or system that has a function to avoid, eliminate or reduce the consequences of an event or the failure of some other function.
P to F interval	An interval between the point at which a potential failure becomes detectable and the point at which it degrades into a functional failure.
redundant functional elements	Two or more independent physical elements of a system/item providing the same function.
residual strength	The strength of a damaged structure.

restoration	The work on or off the Product required so that its resistance to failure can be restored to an acceptable level.
routine inspection	A line maintenance activity on Product. Example from aeronautics industry: daily-, preflight-, turnaround-/transit-, post flight-inspections.
safe life structure	A structure, which is not practical to design or qualify as damage tolerant. Its availability is protected by hard time limits, which remove items from service before fatigue cracking is expected.
safety effect	An effect on safety implies that the consequences of failure are extremely serious or possible catastrophic and could cause: – injury to human beings – the loss of the Product itself or related Products – extensive damage to equipment
safety/emergency systems or equipment	A device or system that: – enhances the evacuation of the Product in an emergency or if it does not function when required – results in a failure condition that might have an adverse effect on safety
scheduled maintenance task	Refer to "preventive maintenance task".
Significant Detail (SD)	A limited area of an SSI or a local spot being also part of the whole SSI.
servicing	Any act of lubricating or other servicing tasks like washing, replenishment of consumables, etc, for the purpose of maintaining inherent design capabilities.
stand-alone maintenance task	A maintenance task selected either in the enhanced zonal analysis and/or in the L/HIRF protection analysis in the frame of the zonal analysis process. Each stand-alone maintenance task with interval shall prevent from probable safety-relevant failure effects. Due to this maintenance task background any merging with other maintenance tasks, like with a GVI of a zone, is not allowed. For traceability-reasons all Stand-alone maintenance tasks must be separately listed in a Product maintenance program/OMP to be carried out in the Product in-service phase.
structural assembly	Several structural items, which together provide a basic structural function.
structural function	The mode of action of Product structure. It includes acceptance and transfer of specified loads in items (details, elements, assemblies) and provides consistently adequate Product response and operation characteristics.
Structural Significant Item (SSI)	A structural item or assembly, which contributes significantly to carrying loads (eg, flight, ground, pressure or control loads on an aircraft), and whose failure could affect the structural integrity necessary for the operating safety of the Product and/or could impact human safety and/or could collide with law including environmental integrity

susceptibility to damage	The likelihood of damage during maintenance or damage during operations.
threshold	Refer to "interval - initial".
threshold period	A period during which no occurrences of the failure can reasonably be expected to occur after the item enters into service.
Time Change Item (TCI)	A equipment/item on the Product which must be replaced prior to a predefined replacement interval gets exceeded.
Temporary Protection System (TPS)	A single servicing task or a servicing task packages, which are suitable to protect metallic SSI/SD from a negative corrosion impact during a certain period of time. After a deadline has passed the temporary protection task has to be performed again or the environmental impact on the Product changes.
uncritical structure	A Product structure which is judged neither to be a structure significant item (SSI) nor a maintenance relevant structure.
visual check	A visual check is an observation to determine that an item is fulfilling its intended purpose. Does not require quantitative tolerances. This is a failure and/or damage finding maintenance task.
Zonal Analysis Module (ZAM)	A part of the Product zonal analysis that covers either general analysis aspects (standard zonal analysis) or Product-specific analysis aspects. ZAM must be defined in a PPH individually for a Product.

Chapter 5.2

Terms, abbreviations and acronyms - Abbreviations and acronyms

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
None	

1 Abbreviations and acronyms

1.1 General

When there is doubt that an abbreviation or acronym will be understood or whenever there is ample space to write in full, the term must be written out rather than abbreviated. Abbreviations and acronyms listed reflect their use in S4000P and not in other documents.

1.2 Word combination - Acronym

Abbreviations for word combinations, acronyms, must be used as such and not separated for use singly, unless authorized singly.

Single abbreviations can be combined when necessary if there is no abbreviation listed for the combination.

1.3 Tense and number

The same abbreviation must be used for all tenses, possessive cases, singular and plural forms of a given word.

1.4 Abbreviation and acronym list

AD	Accidental Damage
AECMA	Association européenne des constructeurs de matériel aérospatial
AIA	Aerospace Industries Association

ARC	Analysis Relevant Candidate
ASD	Aerospace and Defense Industries association of Europe
ATA	Air Transport Association (of America)
A4A	Airlines for America
BIT	Built-In Test
CC	Certification Committee
CCMR	Candidate Certification Maintenance Requirement
CDR	Critical Design Review
CMR	Certification Maintenance Requirement
CPCP	Corrosion Prevention and Control Program
CPSC	Customer Product Support Committee (within AECMA. From 2011: PSG - Product Support Group)
DET	DETailed inspection
D&D	Design and Development
ED	Environmental Deterioration
EWIS	Electrical Wiring Interconnection System
EZAP	Enhanced Zonal Analysis Procedure
FC	Failure Cause
FF	Functional Failure
FFE	Functional Failure Effect
FFEC	Functional Failure Effect Code
FMEA	Failure Mode and Effects Analysis
FTA	Fault Tree Analysis
GVI	General Visual Inspection
ISMO	In-Service Maintenance Optimization
LCC	Life Cycle Costs
LCN	Logistic Control Number
L/HIRF	Lightning/High Intensity Radiated Field
LIL	Lifed Item List
MSG-3	Maintenance Steering Group 3
MTL	Master Task List
NDT	Non Destructive Test(ing)
OEM	Original Equipment Manufacturer
OH	Operating Hours

OMP	Operator Maintenance Plan
PBL	Performance Based Logistics
PC	Partner Company
PMRBR	Preventive Maintenance Review Board Record
PMTR	Preventive Maintenance Task Requirement
PPH	Policy and Procedure Handbook (product-specific)
PSG	Product Support Group (within ASD)
SBC	System Breakdown Code
SC	Steering Committee
SD	Significant Detail
SDI	Special Detailed Inspection
SHA	System Hazard Analysis
SSA	System Safety Assessment
SSI	Structural Significant Item
TCI	Time Change Item - listed in Life Item List (LIL)
TPS	Temporary Protection System
ZAM	Zonal Analysis Module
ZHA	Zonal Hazard Analysis

Chapter 6.0

Examples

Table of contents

Page

List of tables

References

Table 1 References

Chap No./Document No.	Title
None	

1 General

This chapter is foreseen to provide, in a future issue, examples of S4000P analysis application, examples of a PPH content, etc, in order to support a Product manufacturer to initiate analysis projects.