SLOVENSKI STANDARD
oSIST prEN 9722:2022

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Aeronavtika - Arhitektura za integrirano upravljanje stanja sistema

Aerospace series - Architecture for integrated management of a system's health condition

Luft- und Raumfahrt - Zentralisierte Architektur für das Zustandssystemmanagement

Série aérospatiale - Architecture pour la gestion intégrée de l’état de santé d’un système

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49.020	Letala in vesoljska vozila na splošno	Aircraft and space vehicles in general

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Aerospace series - Architecture for integrated management of a system's health condition

Série aérospatiale - Architecture pour la gestion intégrée de l'état de santé d'un système

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This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee ASD-STAN.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (prEN 9722:2022) has been prepared by the Aerospace and Defence Industries Association of Europe — Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this document has received the approval of the National Associations and the Official Services of the member countries of ASD-STAN, prior to its presentation to CEN.

This document is currently submitted to the CEN Enquiry.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

Introduction

An *equipment health card* contains the mandatory deadlines for its maintenance, as well as the history of maintenance technical operations. This chiefly concerns the log book.

A *system health card* contains all the health cards for the equipment of which it is comprised. It shall be managed, on the one hand based on the information contained in each equipment health card, in order to monitor maintenance scheduling and troubleshooting, and on the other hand based on system configuration at a given time which results from the equipment exchanges caused, for example, by system maintenance.

The system health card for the fleet includes all the health cards for the fleet systems.

Data dematerialisation leads to transformation of the business and thus of its internal architecture and its external interactions, particularly through digital platforms. In addition, the numerous data sources and their real-time availability give more and more intrinsic value to each data item; their exploitation enables improved integrated management of the health condition of a system. This integrated management shall optimize the existing services (data processing or maintenance services management) or even create some new ones that will be proposed by the various stakeholders (actors) of the complete ecosystem.

This document provides recommendations about the centralization of the health data for a fleet of systems, such as an aircraft fleet for example, to ensure consistency between stakeholders (operators, repair facilities, designers, etc.) and the management of its health card.

These recommendations are based on a generic support organization proposal backed up by a product architecture for the system and its components.

The recommendations and diagrams in this document are functional and entail no constraints with respect to the organic architecture.

In this document, it is assumed that system health card access and management have a centralized address known to all, accessible to every rights holder, and within a time offered by dematerialisation of data. No assumption is made regarding the location of health card data, which can be decentralised in a cloud, for example. In this document, the health card is said to be centralized because the rights holders access it in the same way, at the same address.

Data protection is a major issue, but one that is not dealt with in this document, because it is a more general question which goes beyond the scope of health card management.

The document is structured in the following way:

General reminders on the health card are given in Clause 5. Clause 6 is the heart of this document and gives recommendations about system and product architectures. Clause 7 presents the use of the health card to make fleet maintenance projections. If the reader wishes to explore the subject in greater depth, Clause 8 gives the precautions to be taken when handling data. Finally, the prospects are proposed in Clause 9.

1 Scope

This recommendation is mainly aimed at all the trades which are actively involved in managing the health of a system.

Although it relies on examples of aeronautical systems, the expert group considers that these general recommendations are of interest for systems from other areas.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13306, *Maintenance — Maintenance terminology*

EN 9721, *Aerospace series — General recommendation for the BIT Architecture in an integrated system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 9721 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

4 Terminology and acronyms

The acronyms are explained in Table 1.

Table 1 — Acronyms

Acronym	Explanation
A/D	Airworthiness Directive
AOG	Aircraft On Ground
AOMP	Predictive Maintenance Operational Applications [*Applications Opérationnelles de Maintenance Prévisionnelle*]
ASL	Logistical Support Analysis [*Analyse du Soutien Logistique*]
BIT	Built-In Test
BNAE	*Bureau de Normalisation de l'Aéronautique et de l'Espace*
CAAC	Civil Aviation Administration of China
CAMM	Computer Aided Maintenance Management
CAMO	Continuing Airworthiness Management Organization
CBM	Condition Based Maintenance
CRM	Maintenance Report [*Compte Rendu de Maintenance*] (document containing information including failures seen by the pilot in-flight)
CRS	Certificate to Release to Service

Acronym	Explanation
DB	Database
DMC	Direct Maintenance Cost
DOM	Director of Maintenance
DRL	Data Readiness Level
FIDES	Guide to reliability calculations
FMS	Fleet Management System
GSE	Ground Support Equipment
HAZOP	HAZard and OPerability analysis
HUMS	Health and Usage Monitoring System
IATA	International Air Transport Association
IoT	Internet of Things
IVHM	Integrated Vehicle Health Management
IVVQ	Integration, Verification, Validation and Qualification
KPI	Key Performance Indicator
LIS	Logistics information system
MATMOM	Implementation and Maintenance Equipment [*Matériel de Mise en Œuvre et de Maintenance*]
MCO	Maintenance in Operational Conditions
MEL	Minimum Equipment List
MFOP	Maintenance Free Operating Period
MIMS	Maintenance Information Management System
MMS	Maintenance Management System
MRO	Maintenance Repair and Overhaul
MS	Support Equipment [*Matériel de Soutien*]
NSI	Industrial Support Level [*Niveau de Soutien Industriel*]
NSO	Operational Support Level [*Niveau de Soutien Opérationnel*]
NTI	Maintenance Level [*Niveau Technique d'Intervention*]
OAM	Original Aircraft Manufacturer
OEM	Original Equipment Manufacturer
OODA	Observe, Orient, Decide, Act
ORA	Operational Risk Assessment Operational Readiness Assessment
OSA	Open System Architecture
PEDS	Prognostic Enhancements to Diagnostic Systems

Acronym	Explanation
PHM	Prognostic Health Management
PMA	Part Manufacturer Approval (non-OEM parts but approved by the certification authorities)
RCM	Reliability Centred Maintenance
RUL	Remaining Useful Life
SB	Service Bulletin
SCADA	Supervisory Control and Data Acquisition
SIMAD	Integrated structure for maintenance in operational condition of Defence Ministry aeronautical equipment
SIMP	Intelligent Predictive Maintenance System [*Système Intelligent de Maintenance Prévisionnelle*]
SSES	Health Monitoring System [*Système de Surveillance de l'Etat de Santé*]
TRL	Technology Readiness Level
WO	Work Order

Explanation are given on reccuring terms in Table 2.

Table 2 — Terminology

Terminology	Explanation
Aircraft	In this document, the term "aircraft" is used to illustrate a system.
Operator	The organization comprising the users and administrators.
Industrial contractor	Refers to an industrial stakeholder which, depending on the context, performs either maintenance services, or produces systems (aircraft for example) and equipment.
Corrective maintenance	Technical operations designed to return a faulty system to service.
Preventive maintenance	Technical operations designed to prevent failures.
Predictive maintenance	Preventive maintenance based on a prognosis of the level of damage (see 5.2.4).
Scheduled maintenance	Preventive maintenance based on calendar events, or a schedule (also called systematic maintenance).
On-condition maintenance	Preventive maintenance based on a level of damage, may be a counter or the result of operating tests (also called condition-based maintenance).
Owner	Owner of the aircraft fleet.
Maintenance service	Refers to the service activity.
Additional works	Maintenance work not stated in the initial work order and which was added further to the results of inspections and observations made during the work requested in this work order.

Terminology	Explanation
Aircraft	In this document, the term “aircraft” is used to illustrate a system.
User	A person in charge of fleet operation.

5 Information on which this document is based

5.1 Overview of maintenance

5.1.1 Content of the health card

The health card contains the following information (at least):

a) for each aircraft (or more generally system):

 1) the aircraft breakdown structure (applied configuration): list of aircraft parts with their serial numbers,

 2) record of overall events (hard landing for example);

b) for each item (aircraft structure, equipment or component):

 1) the condition of the service life counters,

 2) record of hardware and software configurations,

 3) installation record (on which aircraft the item was installed),

 4) the record of technical events such as troubleshooting or fault records from the HUMS,

 5) maintenance record (the mandatory deadlines can be deduced from this record, along with the condition of the counters and the manufacturer’s maintenance obligations).

5.1.2 Health card value chain

5.1.2.1 Introduction

Numerous parties are involved in managing the health card, whether for its use or its value enhancement.

5.1.2.2 The uses of the health card

The uses U of the health card are given below:

— U1: The health card offers the traceability underpinning the aircraft’s airworthiness (CAMO).

— U2: The heath card provides information specific to a system (designated by its serial number) and needed for scheduling its maintenance.

— U3: The health card provides data for lessons learned for the stakeholders (users, designer, etc.).

Uses U1 and U3 can be seen in the architecture presented in Annex A - View of enterprise architecture of the non-Supply Chain support organization. Only use U2 is detailed below.

5.1.2.3 Architecture of the maintenance scheduling value (U2)

Management of the health card participates in control of the use plan through control of the maintenance plan.

Figure 1 describes the construction of the maintenance plan, the value of which will be enhanced to allow the use. This view is not truly representative as the process from health card to use is a continuous loop at all stages:

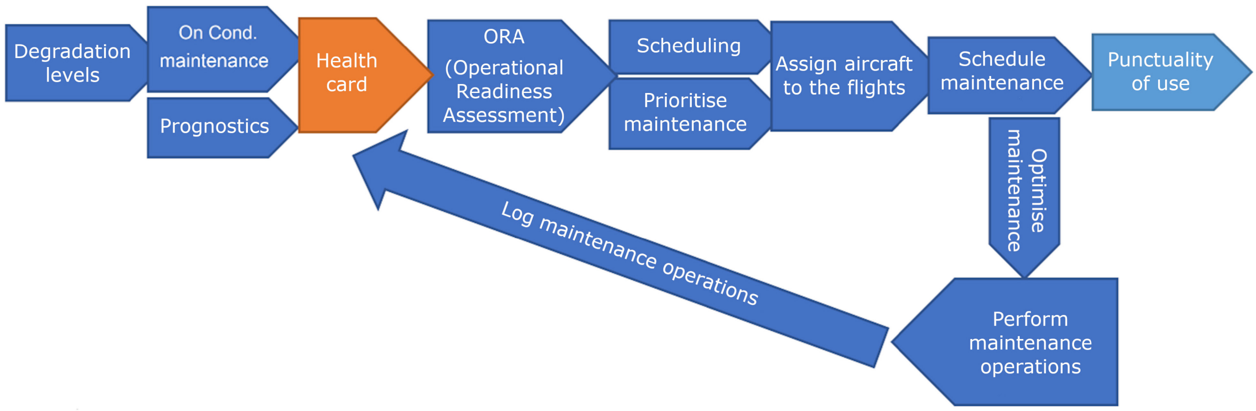

Figure 1 — Architecture of maintenance value enhancement

5.1.3 Use of the health card

5.1.3.1 Introduction

The health card is of use during the operational and maintenance phases of a system, but the “upstream” phases can also benefit from the information it contains, i.e. the level of degradation of the system and its components.

Consequently, an architecture interconnecting the maintenance data in the health card with operational and industrial data should be adopted, this is described in Figure 2.

The operational data shall be distinguished from the industrial data:

— the operational data are technical data recorded by the system in operation, along with the environmental data;

— the industrial data are technical design, manufacturing and maintenance data.

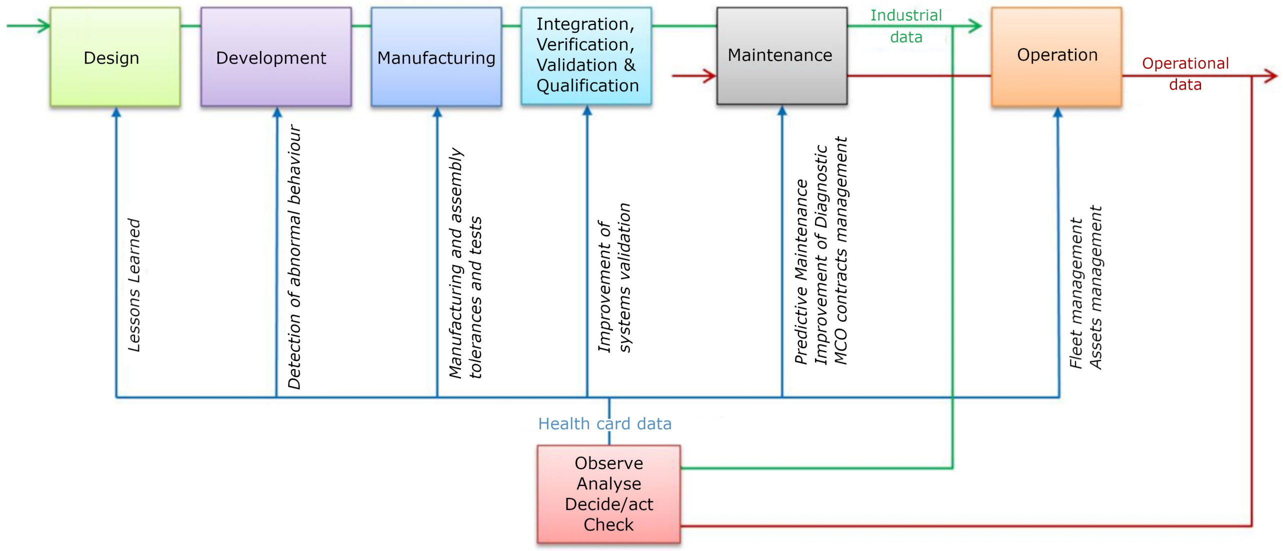

Figure 2 — Interconnection of the various phases in the lifetime of the system

The health card can be used to optimize the cost of ownership of the equipment concerned, whether to optimize its use or to optimize the corresponding maintenance operations. In the longer term, the lessons learned can also help optimize design and manufacturing.

The health condition of an equipment item can be obtained in different ways:

— direct measurement by sensors on the equipment;

— indirect measurement based on direct measurement by means outside the equipment (inspection);

— estimation by means of a model, a digital twin for example, supplied with direct measurements and readjusted by means of indirect measurements.

Knowledge of the configuration is often essential when associating measurements with an equipment item.

NOTE The digital twin represents the behaviour and configuration of a real object using operating data collected in real time. Historically, the digital twin appeared with video games: the driver of a car saw a representation of the car's digital twin at the top-right. As this was a game, the player did not have any proprioceptive information (knowing where one's body is in space). The digital twin provides the player with information: skids, jolts, etc. that the player actually feels. With regard to maintenance, the digital twin enables a remote expert to find out about the degradation condition of the actual object. In principle, the digital twin is based on a representation model reflecting what the human would observe if in direct contact.

5.1.3.2 Design phase

Analysis of the health card, and more precisely evolution of the degradation of the system and its components, may make it possible to steer the design of new products (for example improve the reliability of certain components which degraded too rapidly in the past), through improved knowledge of use of the products. Study of the health cards can thus make it possible to set targets such as reliability, testability, etc., for new products.

5.1.3.3 Development/manufacturing phase

Monitoring the health condition as of the prototyping phase (or on the first production runs or during flight testing) is a means of verifying that during the first hours of operation of a new product, the rate of degradation is normal. If degradation is too fast, this can indicate a design or manufacturing problem. Very early in the life cycle, this can thus generate corrective solutions and measures.

One example is the first Concorde, which was fitted out with a host of sensors to verify the correct working of the various systems.

5.1.3.4 Integration, Verification, Validation and Qualification phase (IVVQ)

Monitoring the health condition of the system and its components during the IVVQ phases can be used to enhance the validation process (extremely binary, i.e. OK or NOK) for the functions and performance of the products, by also focusing on their remaining useful lifetime (or level of degradation). It would appear legitimate for any equipment item delivered to the customers to be at its full remaining useful lifetime and the industrial contractor shall therefore ensure that this is the case.

Study of the health card can also explain certain performance non-conformities during the validation phase, which may be caused by the degradation of certain mechanical components for example.

5.1.3.5 Maintenance phase

The health card will of course be most valuable for maintenance activities. Using the health card can help:

— to improve the diagnostic by not simply using the result of built-in tests (indicating whether or not the equipment is operational at a given moment), but also by estimating the level of degradation of replaceable items;

— to replace scheduled preventive maintenance (based on presumed wear) by predictive maintenance based on actual degradation;

— to reduce corrective maintenance (random and unpredictable), replacing it with predictive maintenance right before failure of the equipment. This helps optimize operational availability (by avoiding failures during missions) and/or reduce support costs through improved scheduling of maintenance tasks;

— to evaluate and predict the workload of the maintenance crews according to the health condition of the fleet. Optimization could even go as far as grouping work on products with a similar remaining useful life [optimization of predicted preventive maintenance steps by means of RUL (Remaining Useful Life) calculations];

— to optimize the predictive models for supply of replacement equipment (which is profitable for forward planning of the logistical supply chain);

— to reduce fault propagation following failure of an item not replaced in time (reduced cost of replacing an item which suffered from the failure of another item and reduced diagnostic time);

— to acquire the necessary information for achieving the best trade-off between support costs and operational availability;

— to generalize the use of MCO contracts with product operational availability undertakings;

— to forward plan for logistical resources for additional work triggered following inspections carried out during overhauls (major maintenance carried out by the industrial contractor).

5.1.3.6 Operational phase

The health card can also play a major role in the operation of systems or products. It can help customers or operators improve how they manage their fleet. This comprises:

- fleet management enabling the licensees to select the most appropriate equipment for the next missions;
- assets management which, more generally than simple fleet management, allows improved management of the equipment base (know which equipment is operational, under repair, used for training, in stock, etc.);
- individual monitoring of the remaining useful life of each product would improve management of the fleet through optimal tailoring of the product to the exact needs of the type of mission required by the customer. Each product would thus optimally consume its remaining useful life which would increase operational availability and optimize maintenance costs.

Whatever the phase in the system lifetime, the non-quantifiable advantages of the above gains are mainly associated with the human aspect: customer confidence in the support services proposed by the industrial contractor for their products.

NOTE Annex F presents the use cases and operational scenarios for the different phases.

When preparing for the mission, the operator shall carry out a specified number of missions but will aim to optimize the distribution of their equipment fleet for these missions in order to ensure that all the missions are successful while limiting any resulting maintenance costs. The time an equipment item is used may for example be maximized before a major maintenance operation, by reassigning the equipment to less severe missions. The operator shall thus be able to extrapolate the impact of a mission or group of missions on each equipment item, in order to optimize its assignment.

There are two pre-requisites during this operational phase:

- familiarity with the health condition of the equipment before the operational phase and then on a daily basis (remaining useful life or level of wear, absence of failure early warning signs, etc.). This acts as the starting point;

- familiarity with the mission profiles and the corresponding degradation trajectories. The types of uses guided by parameters that influence the equipment's remaining useful life shall be categorized. Experience will be used to fine-tune the understanding of the equipment's uses and their impacts. The arrival point (condition of the equipment at the end of the operational phase) is thus deduced from the starting point and the trajectories.

The missions which are unsuccessful generally lead to unexpected costs (customer compensation, AOG costs, loss of depreciation, etc.), in addition to the repair costs. Certain degradations causing these events arrive suddenly with no advance warning and cannot be avoided. Others will lead to symptoms on the available measurements (weak signals: drift, abnormal noise, etc.), which will provide a means of alerting the user sufficiently in advance of the mission.

This implies that the time between retrieval of the data, their processing and production of the alert report is short enough with respect to the dynamics of the equipment's degradation. These dynamics shall thus be well-known before attempting to introduce maintenance recommendations.

Recommendation: A knowledge base should be created, containing the fault and degradation signatures, along with the forms in which they develop.

The alert reports for physical phenomena shall not be discredited by an excessively high number of false positives.

Annex E gives a degradation model based on a physical understanding of the phenomena which enables knowledge to be widely shared and lessons learned to be extensively applied to systems or components under design.