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eMaintenance—Information logistics for maintenance support

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ABSTRACT

Today's providers of maintenance and in-service support related to modern aircraft are facing major challenges. A central problem with Maintenance, Repair and Overhaul (MRO) as well as support of aircraft and other complex technical systems, is to manage the ever-increasing information flow and system complexity. Both military and commercial operators need to reduce aircraft downtime and maintenance man hours. Increased manual information management has the opposite effect, inducing unnecessary cost and affect efficiency negatively. Organizations developing and providing maintenance support products and in-service support does also need to improve the capability to efficiently exploit the increasing amount of digital product information and design data provided together with hardware (HW) and software (SW) products from aircraft manufacturers, sub-system suppliers and Original Equipment Manufacturers (OEM). One way to increase aircraft availability and improve maintenance and support efficiency, is to speed up the turnaround time for scheduled and unscheduled maintenance. The ultimate goal is risk-based utilization and support, where true Condition-Based Maintenance (CBM) is integrated with current operational requirements and available resources in real-time. This aims at the elimination of all preventive scheduled maintenance based on fixed time intervals and execution of only corrective maintenance that has been predicted and turned into scheduled maintenance facilitated by proper support. To address the challenge of information logistics of digital product data and information within maintenance in-service support, providers need to adapt new methodologies and tools that enable full utilization of the advantages of digital product data and information in processes and business models, e.g., Service-Oriented Architecture (SOA). To implement such improved support solutions in a global-support environment, eMaintenance is seen as one important building block. eMaintenance includes monitoring, collection, recording and distribution of real-time system health data, maintenance-generated data as well as other decision and performance-support information to different stakeholders independent of organization or geographical location, 24 h a day, 7 days a week (24/7). eMaintenance has the potential to improve the management and performance of activities related to the whole maintenance process, and thereby improve the dependability, safety and Life Cycle Cost (LCC) of critical systems. This can be realized through a coordinated application of Information and Communication Technology (ICT) throughout the maintenance and support processes, thus integrating Built-in Test (BIT) systems, external tests at different maintenance echelons, technical information, diagnostics, prognostics and other sources of support information.

The purpose of this paper is to present some results from a joint academic and aerospace industry research project, describing requirements and expectations that are important in a global-support environment, and also to propose some central components in an eMaintenance framework that integrates maintenance and ICT perspectives.

1. Introduction

Aircraft manufacturers, as well as maintenance and in-service support providers, are experiencing ever-increasing customer requirements to increase dependability and decrease Life Support Cost (LSC). To achieve this, a central problem for the industry is to manage the rapidly increasing information flow that follows the development of more complex and technologically advanced

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aircraft systems [1]. Customers are also demanding improved system availability, safety, sustainability, cost-effectiveness, operational flexibility and tailored worldwide support 24 h a day, 7 days a week (24/7). This changing business environment requires new and innovative solutions as support products and services to satisfy the needs of customers and end-users.

Maintenance and support concepts for modern complex technical systems, such as civil airliners and military combat aircraft, can be described as focussing on optimizing two fundamental and interdependent elements. The first element is the aircraft (i.e., the system-of-interest), which should be designed to maximize the inherent availability through proper reliability and maintainability design within available Life Cycle Cost (LCC) constraints. This design should be balanced with the support system, which is the second element. The support system should be designed to provide necessary support during the utilization and support phases of the system-of-interest's life cycle, which is measured through the support system's maintenance support performance. The support system is an enabling system, i.e., a system that complements a system-of-interest during its life-cycle stages [2], but does not necessarily contribute directly to its function during operation [3]. An enabling system provides functions and services to users and other stakeholders to ensure a proper and efficient function of the system-of-interest [2].

On an operational level, end-users and managers utilizing the support system of a modern aircraft are confronted with a multitude of computerized functions and Information and Communication Technology (ICT) solutions. However, today there is little or no integration of functions and services related to the support system, such as technical information (publications), maintenance programmes, maintenance plans, job cards, fault diagnosis support, amendment services, health and usage monitoring and operational feedback [4,5].

At the same time, producers and suppliers of maintenance products and customer support services are facing escalating challenges trying to sustain high quality and increase service levels for increasingly complex technical systems in an environment characterized by multiple products, suppliers and customers with increasingly stringent requirements. This environment is also to a great extent becoming purely digital, i.e., an increasing amount of software (SW) and hardware (HW) products, design data and other information exchange is provided and communicated solely in digital form. Hence, both customers and suppliers are facing increased complexity levels regarding information related to configuration control and change management for both the aircraft and its support system. This high complexity level of information logistics will hamper the operational effectiveness and drive LCC.

Therefore, suppliers need to change methodologies, tools and processes for information logistics to be both more customer-focused and more efficient for internal development and sustainability. New concepts for the application of ICT need to address information quality, lead time, accessibility 24/7, usability and an overall reduction of cost for information logistics related to maintenance and support. Simultaneously, since much of the managed data and information related to military aircraft are sensitive and confidential the aspect of information security is of outmost importance and need to be considered, e.g. through content classification, authentication and authorization. In fact, information security is so fundamental that it can override the functionality of any solution.

Information logistics need to integrate and exploit the use of maintenance data and consider fleet status, flight operations and maintenance sources. This would provide, maintenance planners, operations and others with tailored information for decision support, derived from common data sources [6].

Examples of these trends are manufacturers' airline in flight information system. It can include multifunction e-applications for flight operations, passenger, cabin crew and maintenance features. Capabilities in flight operations include performance calculations, electronic manuals, technical logbook, crew e-mail, graphical weather, and charts and maps. For maintenance it includes technical logbook, manuals, maintenance tools and performance monitoring [7].

Capability also needs to be developed to enable more agile and efficient use of new maintenance and support functions integrated in the aircraft, exploitation of operational feedback, as well as rapid supplier adaptation to continuously changing customer specific requirements on HW and SW products as well as services.

An example of such solutions is again manufacturers' innovative support strategies, where customers pay for a significant portion of purchased services with data collected during operations. Maintenance, Repair and Overhaul (MRO) providers are also required to provide data such as man hours, downtime and reliability data. In return the manufacturer commit to include promotion of services from the MRO providers, information exchange in terms of access to specific information (draft service bulletins, information on market requirements, advance information on major retrofit programs) and management reviews [7].

2. Scope

This paper focuses on a concept for ICT-based products and services for maintenance of modern aircraft. However, it is believed to be extensively applicable to similar challenges regarding maintenance of other complex technical systems, e.g. within the transport, process and power industries, as well as telecom and health care. The paper presents requirements and needs regarding the mentioned products and services that are important for both suppliers and customers (operators) of modern aircraft systems in a global-support environment and proposes some central components of an information logistic concept for maintenance purposes, called eMaintenance Management Framework (eMMF), that integrates maintenance and ICT perspectives to address the challenges presented above.

The discussion of central characteristics of system-of-interest (e.g. aircraft) and enabling systems (e.g. a support system external to the aircraft) uses nomenclature based on established and agreed international standards. Availability is used as a general term referring to availability performance and its influencing factors: reliability performance (the way the aircraft is designed to eliminate the need of maintenance, i.e., reducing or eliminating the probability of loss of required functions); maintainability performance (the way the aircraft is designed to facilitate maintenance, i.e., to retain or restore the aircraft's required functions); as well as maintenance support performance (effectiveness and efficiency of the maintenance organization). See Ref. [8].

3. Maintenance within aviation

Experience from maintenance and support system development and real-life operations [9], combined with expectations for future scenarios, stress the importance of supporting the operational capability and competitiveness through high availability of aircraft. Increasing civil requirements on mobility and availability, and military operations from provisional bases combined with rapidly shifting conditions, increase the importance of information and decision support to personnel that maintain systems in operation. This high impact of integrated logistic support on