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FLIGHT OPERATIONS MANAGEMENT SYSTEM ADAPTATION TO FUNCTIONING IN INCOMPLETE INFORMATION CONDITIONS

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Abstract

Purpose: *The purpose of this article is to present a new approach of Airlines Flight Operations Management System adaptation to functioning in incomplete information conditions.* ***Methods:*** *The article describes two runtime methods which increase the adaptation degree of Airlines Flight Operations Management System to functioning in incomplete information conditions, such as: exception handling and Quality of Service management.* ***Results:*** *The Airlines Flight Operations Management System adaptation overall architecture is given and their components relationships are described.* ***Discussion:*** *The proposed new approach will allow to adapt the Airlines Flight Operations Management Systems' architecture to functioning in a high degree of uncertainty and incomplete information conditions.*

Keywords: flight operations; management system; adaptation architecture; incomplete information conditions

1. Introduction

The area of flight operations management has had a substantial effect on the today's air transportation management. Wherein, actual flight operations conditions are characterized by a high degree of uncertainty and incomplete information, which, in turn, requires the adaptation of the relevant Airlines Flight Operations Management System (FOMS) to functioning in incomplete information conditions.

In this article, the FOMSs' adaptation techniques and flight operations management applications that are used in the air transportation industry are reviewed including the main external and internal factors that affect the FOMSs' effectiveness in such conditions. Also is present a set of comprehensive techniques to be used in the development of FOMSs to increase their level of adaptation, how adaptation process can be triggered, which adaptation strategies can be applied, and why dynamic changes are indispensable to carry out adaptation. For the adaptation strategies presented, will describe their implementation to the FOMS.

2. Analysis of the research and publications

Firstly, in accordance with the Ukrainian National Legislation [1] and Aviation Rules [2], to ensure the possibility of further aircraft operation and types of aviation works, it is recommended to lead Airlines Management Systems, Training Programs, Procedures and Manuals in line with the requirements of mentioned above documents.

To support dynamic workflow adaptations, authors [3] have developed a rule-based approach for the detection of logical failure events. Their approach has been implemented within the different adaptation systems. Their systems use a rule-based approach for the detection of logical failure events (exceptions). Moreover, their approach only deals with logical failure events, while we also address the problem of adapting instances to maintain a specified level of Quality of Service (QoS).

Authors [4] extend the applicability of Activity Theory to the implementation of more flexible adaptation systems. Activity theory offers a number of interesting solutions for workflow adaptability, flexibility, evolution and exception handling. Their research describes the activity theory principles that should be implemented when developing FOMSs. Unfortunately, no implementation has been done, and their work does not address QoS issues.

Author [5] proposes an integrated approach for adaptive workflow support. This work describes extensions to the system architecture in order to enable the execution of unstructured process and illustrates how an adaptive support layer can be

integrated to extend existing workflow management systems.

But current architectures do not incorporate adequate solutions that enhance FOMSs' adaptation to functioning in actual incomplete information conditions. The adaptive layers presented do not address directly the problem of handling exceptions nor QoS monitoring and adaptation.

3. Problem statement

Today, Airlines – large and small – can select Flight Operations Management Systems (FOMSs) to support their business processes. When processes are critical, it is fundamental that FOMSs' infrastructures continue to provide pre-established service levels to users in the face of disruptions. Adaptation addresses precisely this issue. Current architectures do not incorporate adequate solutions that enhance FOMSs' adaptation. So, its necessary to present a set of comprehensive techniques to be used in the development of FOMSs to increase their level of adaptation. There is not only target adaptation from a functional perspective, but also from an operational perspective.

As a result, considering all the inputs mentioned above, it is important to establish a wide range of Airlines decision making systems, including strategic planning and tactical level planning. It is very important to solve and analyze these problems with scientific methods.

4. Problem Solution

So, the major prerequisite in the achievement of the Airline's Flight Operations Mission is to support compliance with the ISO (International Organization for Standardization) standards, EASA strategy and Flight Operations Policy.

Go out there, the Flight Operations Management System is a single integrated system used by the Airline to manage the totality of its processes, in order to meet its objectives and equitably satisfy the stakeholders. So, all Airline planning, tasking, monitoring, checking and continual improvement should be organized within the FOMS by utilising the tools and methodology set up for it.

Therefore, the Airline should act and ensures the highest level of compliance with safety rules and applicable regulatory requirements. Consequently, the Airline identifies the customers who should benefit from the safest and the most environmentally friendly civil aviation system as the final stakeholder.

So, in accordance with the EASA Applicable Regulations, Implementing Rules, as well as, the corresponding Acceptable Means of Compliance (AMC), Guidance Material (GM) and Certification Specifications, the Flight Operations Management System have to consist of [6]:

A planning process that ensures the consistency of all objectives defined across various fields and at various levels [strategic, operational (processes), Directorate, individual];

Sound management of the Airline's processes to fulfil its missions and meet its legal requirements, process interactions identified and the necessary documents drafted (e.g., policies, procedures) and process performance is monitored to ensure proper competence, functioning, control and traceability over the processes;

Management of the Airline's risk and opportunities related to the Airline's processes and aviation safety risks;

Management of changes, including the management of related risks and opportunities;

Management of adequate resources in line with the objectives justified accordingly and with the possibility of adaptation in subsequent reviews;

Checks and measurements, including key performance indicators, for safety and efficiency, based on data analysis (e.g., safety analysis, stakeholders' feedback, audits and assessments etc.);

Review of the FOMS at planned intervals by the Directors to ensure its continuing suitability, adequacy and effectiveness (Management Review process).

As part of its FOMS, Airline has to comply with authority requirements in the respective domains: Flight Crew Licensing (FCL) via Approved Training Organisation (ATO) and Flight Simulation Training Devices (FSTD); Air Traffic Management (ATM); Aerodromes (ADR); Operations (OPS) (Air Operator Certificate (AOC)) and Maintenance via Continuing Airworthiness Management Organisation (CAMO).

The FOMS is applicable to all present and future processes performed by the Airline or on behalf of the Airline (Fig. 1).

Phase 1 – Planning

The planning process is defining a vision, policies and strategic objectives consistent with the Airline's Mission.

The strategic goals/objectives are broken down at directorate, department, section and personal level,

covering the safety, operational, quality and financial areas; and taking into account stakeholders' needs, regulatory requirements, potential risks and opportunities as well as the environment in which the Airline acts.

In addition, a high-level Risk Assessment exercise is performed at Airline level. The results of this risk assessment are taken into account in order to properly manage and mitigate risks. The most critical risks in the risk register have to be included in the Airlines Single Programming Document (which includes the Multi-annual objectives, Multi-annual work programme, the Financial & Human resources outlook and the annual work programme) and the status of the related mitigating actions is reported in the corresponding Consolidated Annual Activity Report (CAAR).

Phase 2 – Process implementation

All Airline staff should carry out specific operations in their own field of competence.

These end-to-end processes are performed in a controlled way to meet with the applicable requirements and stakeholder expectations, such as:

They have been identified and Process Owners have been nominated;

Process goals and risks have been identified by Process Owners;

They have been analysed and described properly by means of Quality Documentation, while ensuring that they comply with the applicable regulatory requirements;

They are documented via appropriate records;

They are monitored through proper Key Performance Indicators (KPIs) and key control points related to process goals and risks;

Necessary preventative and corrective actions are taken for continual improvement.

Phase 3 – Analysis & Measurement

For the third step "analysis & measurement", specific methods have been identified to assess, monitor and measure how the Airline is performing and fulfilling its mission and objectives:

Performance measurement of processes through Performance Indicators (PIs): The PIs are linked to the Airline's objectives as defined in the Airlines Single Programming Document (SPD). The final status of the Airline's objectives has to be reported in the Airline Consolidated Annual Activity Report (CAAR) of the corresponding year.

Analysis of stakeholders' feedback: A number of vehicles are used to obtain, gather and analyse feedback from stakeholders. Formal feedback is obtained using questionnaires. The questionnaires are designed and tailored to obtain feedback from external and/or internal stakeholders on the effectiveness of processes, meetings or services. The feedback received is analysed Process Owner (and procedure owner(s) as appropriate) for consideration and identification of improvement actions. In addition, spontaneous feedback is collected during operational meetings with stakeholders, during conferences/events or by mail/emails received.

Safety analysis of issues (occurrence reporting, results of accident investigations, safety recommendations) are regularly reviewed and discussed. Some safety issues may therefore have an impact on how the Airline is organised and contribute directly to the identification of priorities and objectives at Airline level.

Formal process assessment by Process Owners: With continuous improvement in mind, Processes Owners perform, with the support of the Internal Audit, a formal assessment of their process for efficiency, risks and opportunities, at least once every 3 years. Based on the result of this assessment, process improvements and new risk mitigating actions may be implemented.

An internal audit capability is in place through internal audits performed by the Internal Audit Service (IAS) and the Internal Audit and Assurance section.

Compliance monitoring function resides within the Flight Safety Management and checks the compliance with applicable authority requirements. The results are reported to the national competent authority (CAA).

External audits: The Airline is subject to external audits. The Internal Audit and Assurance section is responsible for the coordination of all external audits. Relevant findings will be used as an input for improvement.

Analysis of exceptions (non-conformities): Under exceptional circumstances, deviation from established regulations, policies and procedures can be authorised by the relevant parties, on justified and documented grounds.

The outcome of the CHECK phase may lead to specific corrective/preventive/improvement action plans which contribute to the improvement of the Airlines FOMS.

Phase 4 – Review & improvement

This fourth step "review & improvement" consists of reviewing the FOMS for improvement on the basis of the outcomes of the CHECK phase. This is achieved through the following:

1. FOMS related actions follow-up: regular status of actions is reported to management.

2. Management Review meetings: the aim of this meeting is to assess the FOMS based on the data from previous phases.

3. In terms of safety management accountability, the Airlines Flight Safety Group have to act and decide on the tolerability of safety risks and confirms risk mitigation actions based on proposals from the Safety Risk Panel and the operational departments. The Airlines Flight Safety Group also decides on any action aiming at improvement of safety management related policies and processes.

The outcome of the ACT phase is the (re-definition of the actions for improvement of the FOMS and its processes.

Change Management Principles must be applied as soon as a change affects the organisation or the staff. Such a change may concern individuals, sections, departments or the whole organisation.

In Airline, this may include but is not restricted to the following internal or external changes: Political changes impacting Airline priorities; Change in Airline strategy; Extension of Airline remit; Change in applicable regulations; Decision to take up activities in new areas; Changes in the core processes of Airline; Changes in contracting of services in the core processes; Organisational changes; Technological changes affecting the Airline's capability to support emerging industry needs; Changes in aviation industry affecting the Airline's workload (contracting, increase); Changes affecting the National institutions or at EASA level that may impact the Airline scheme.

The related methodology and training include the need to: Identify the need for change; Assess the risks and/or opportunities and impact of change; Communicate the need for change; Create positive dynamics for implementation; Make the change effective; Consolidate and evaluate the change.

By approving this FOMS, the Airline Management clearly expresses his commitment to support, implement, maintain, and continuously develop the FOMS. This involvement is confirmed on the occasion of Management Review meetings which take place at least once per year and through the validation of all the Airline wide policies by the Accountable Manager.

Therefore, the Airline Strategy and FOMS policy have to periodically review and revalidate as part of the Airline Management Review process [7].

The main activities of the Airline are described and recorded in a wide range of documents. It is, therefore, of strategic importance that specific requirements are defined and documented to control the different types of documents in order to ensure that the appropriate information is available whenever needed and to prevent the inadvertent use of invalid information.

Such requirements are provided within: Internal reference documents; External reference documents; Electronic Document Management System (EDMS).

Quality documents are defined as all those documents produced internally to provide guidance and instructions on how activities are to be performed. These documents are managed according to the dedicated Work Instruction on Quality Documents, which defines the Airlines general rules.

The systematic monitoring of the use of these Quality Documents and corresponding rules ensures consistency and transparency of the Airline activities, standardisation and rationalisation.

An Airlines Business Process Management (ABPM) platform can be established to allow the effective management of processes and all its associated Quality documentation.

Management Board and Accountable Manager (AM) Decisions. In addition to the Quality documents, other reference documents can directly affect the Airline's FOMS in view of ensuring that the Airline's processes are managed effectively and efficiently, for example: Management Board Decisions, which records the decisions, made by the Management Board of the Airline; AM Decisions, which records the decisions made by the Airlines Accountable Manager. The powers of the Authority empowered to conclude contracts of employment (AECC) conferred by the Staff Regulations and Conditions of Employment have been delegated by the Management Board to the AM. Therefore, decisions on the daily management of the Airline and in particular on individual staff matters are taken either by the AM, in the capacity of the AECC or the temporary agent(s) to whom those powers have been subdelegated. The control and approval of these documents is managed independently within each process through specific Airline's procedures.

External reference documents are defined as all documents produced externally to provide guidance and instructions on how all activities are to be performed (e.g. EU Regulations, ICAO Standards, Technical Standards etc.). Access to these documents is ensured through an updated source database.

All incoming and outgoing *mail* (technical, administrative etc.) is managed with software system, unless specified differently in the Work Instruction on mail attribution and registration rules. All the details and responsibilities are described in the in the Airlines referenced procedures.

A "record" is defined as information whatever its medium, created, received and maintained as evidence by Airlines, in pursuance of its legal obligations or in the transaction of its business.

The objective of the Records Management process is to establish record management principles in accordance with relevant legislative and regulatory requirements, standards and best practices and to ensure that records are properly created, managed and disposed in the interest of corporate accountability, orderly administration and memory.

Records contain information that is a valuable resource and an important business asset.

Accordingly, the Airline shall manage authentic, reliable and usable records capable of supporting business functions as long as they are required. This implies that: Records are proven to be what they purport to be (authenticity); Records contents can be trusted as a full and accurate representation of the transaction activities or facts to which they attest (reliability); Records are proven to be complete and unaltered (integrity); Records are located, retrieved, presented and interpreted as directly connected to activity or transaction that produced it (usability).

5. Flight Operations Management Systems' adaptation architecture

The adaptation of FOMSs is a complex issue. This is even more so in distributed systems because of the existence of underlying infrastructures that are not frequently encountered in more traditional centralized management systems. The adoption of adaptation strategies has a critical impact on early decisions in system development; it is both cost-effective and efficient to conduct adaptation analyses at the architecture level, before substantial resources have been committed to development [8].

Therefore, the first step is to conduct an analysis in order to obtain a clear and accurate understanding of FOMSs' architecture.

We extend classification of FOMSs' architecture with the addition of the schema layer. Therefore, we view workflow systems as having a four-tier layered architecture: instance level, schema level, workflow level, and infrastructure level. Each level corresponds to a functional division of the FOMS, and each has a precise and specific mission (Fig. 2).

To better understand the purpose of each architectural level, we briefly describe them.

The Infrastructure Level includes all the elements that compose the underlying FOMS infrastructure. It includes servers, databases, operating systems, communication protocols, hardware, etc.

At the Workflow level we find the modules that compose a workflow management system. The modules typically include the enactment engine, the monitor, and the repository.

The Schema Level includes workflow schema definitions. A workflow schema is a business process representation that can be interpreted by a FOMS. Workflow schemas are generally stored in a repository and are subsequently used by the FOMS.

At the Instance Level – issues that are closely related to workflow instances or application executions. In this level, adaptation may occur when the design of a workflow schema does not anticipate a possible error related to the execution of workflow tasks.

Fig. 2 presents overall FOMSs' adaptation architecture, which includes: the FOMS and the functional levels (the instance, schema, workflow, and infrastructure levels) at which specific types of events can occur; the detection and forwarding of events between levels; and event handling.

A typical scenario that requires adaptation is described as follows. When an event is generated at any functional level, it is the responsibility of the level where the event occurred to restore its own consistency. Depending on the type of event, it may not be possible for the level to self-adapt. This is because additional knowledge may be needed to assess the event which is simply not available to the level. In such a case, the event is forwarded to the workflow level. Upon receiving the report of an event, the workflow level will try to find a local solution to the problem. The workflow level is a good candidate for deriving a solution since it is the central point that coordinates the instance and schema levels. If a solution is found locally, then a set of adaptive actions are applied. On the other hand, if the workflow level cannot find a solution, the event is forwarded to the adaptation module.

The adaptation module is a specialized service that incorporates knowledge and various algorithms to derive solutions for specific problems. When the adaptation module receives an event, it tries to derive a valid solution. Depending on its implementation, the adaptation module can rely on several distinct methods to obtain a solution. There are two adaptation methods – one to deal with workflow exceptions and the other one to manage QoS requirements. If a solution cannot be found or if only a partial solution is created, then this information is forwarded to another module which waits for human involvement. During the procedure described, at any point when a valid solution is derived it is sent to the workflow level, which applies corrective actions. If corrective actions are necessary at the instance level, it is necessary to use the dynamic change, interface to guarantee that the changes are applied in a consistent manner.

Adaptation strategies can be hard-coded into the workflow system. In this case, they are called built-in. The advantage of using such strategies is that the user does not have to set up or configure any mechanism in order for the workflow system to handle events. The disadvantage is that there is no flexibility for a user to customize the system.

There are two runtime strategies which increase the adaptation of workflow systems: exception handling and Quality of Service (QoS) management.

The first system deals with exceptions – a well-defined class of events that may occur during the realization of a workflow instance. The second system is responsible for adapting workflow instances when their QoS reaches threshold values. While the first system handles functional errors, the second one deals with operational errors. These two adaptation methods cannot successfully accomplish their objectives without having the support of a dynamic change layer. Adaptive methods rely on a dynamic change layer to adapt running instances.

As workflow processes are instantiated, changes in the environment or generated by previous activities may invalidate the current workflow instances, requiring reparative actions. Long running applications which are heterogeneous, autonomous, distributed may require support for dynamic reconfiguration when machines fail, services are moved or withdrawn, and user requirements change. In such environments, it is essential that the structure of applications be modified to reflect these changes.

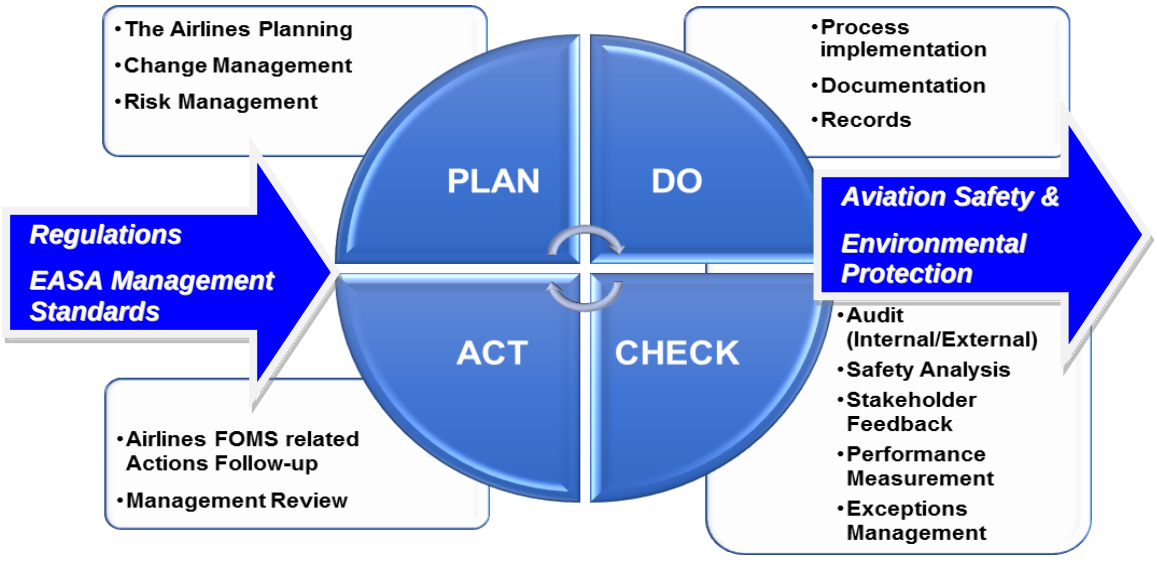

Fig. 1. The Airlines Flight Operations Management System

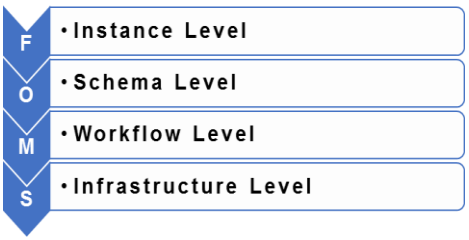

Fig. 2. Overall Flight Operations Management Systems' adaptation architecture

6. Conclusions

The new requirements of modern management systems in our highly technological flight operations demand that critical systems be adaptable. This work focuses on the adaptation of Flight Operations Management Systems (FOMSs).

This article presents a set of comprehensive techniques to be used in the development of FOMSs to increase their level of adaptation. To develop a successful solution, the first step is to develop a conceptual architecture for FOMSs which will provide a fundamental framework for developing an adaptable FOMS architecture. We have defined an adaptable architecture that functionally divides FOMSs into 4 levels: instance level, schema level, workflow level and infrastructure level. There is not only target adaptation from a functional perspective, but also from an operational perspective. It is important to understand that adaptation does not restrict its span to functional errors, how is the FOMS or tasks working. Adaptation also addresses operational issues, such as the QoS management of workflow instances. To illustrate how functional and operational deviations can be handled, two adaptive modules are described (exceptions and QoS of workflows). Finally, we explain the importance and discuss the development of a dynamic change layer to carry out adaptation strategies.

Although the majority of the ideas presented can be implemented in management system, the concepts and ideas are independent of the FOMS chosen. Therefore, it is, in principle, possible to add the notions presented in this article to most of the workflow management systems available today.

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Адаптація системи управління льотної експлуатації до функціонування в умовах неповноти інформації

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Мета: Метою даної статті є викладення нового підходу до адаптації системи управління льотної експлуатації авіакомпанії до функціонування в умовах неповноти інформації. **Методи**: У статті розглянуто два методи виконання, які збільшують ступінь адаптації системи управління льотної експлуатації авіакомпанії до функціонування в умовах неповноти інформації, такі як: обробки виключень та управління якістю обслуговування. **Результати**: Наведені адаптивна загальна побудова системи управління льотної експлуатації авіакомпанії та описані взаємозв'язки її компонентів. **Обговорення**: Запропонований новий підхід дозволить адаптувати систему управління льотної експлуатації авіакомпанії до функціонування в умовах високого ступеня невизначеності та неповноти інформації.

Ключові слова: льотна експлуатація; система управління; адаптаційна побудова; умови неповноти інформації

А.С. Бондик

Адаптация системы управления лётной эксплуатации к функционированию в условиях неполноты информации

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Цель: Целью данной статьи является изложение нового подхода к адаптации системы управления летной эксплуатации авиакомпании к функционированию в условиях неполноты информации. **Методы:** В статье рассмотрены два метода выполнения, которые увеличивают степень адаптации системы управления летной эксплуатации авиакомпании к функционированию в условиях неполноты информации, такие как: обработки исключений и управления качеством обслуживания. **Результаты:** Приведена адаптивная общая архитектура системы управления летной эксплуатации авиакомпании и описаны взаимосвязи её компонентов. **Обсуждение:** Предложенный новый подход позволит адаптировать систему управления летной эксплуатации авиакомпании к функционированию в условиях высокой степени неопределённости и неполноты информации.

Ключевые слова: лётная эксплуатация; система управления; адаптационное построение; условия неполноты информации

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