PROGNOSTIC BASED MISSION- AND MAINTENANCE PLANNING

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1. OVERVIEW

Many efforts have been taken to maintain and improve the availability of aircrafts and the mission capabilities of aircrafts in operation. The related Key Performance Indicators (KPI) are, beside others, the aircraft availability rate and the mission capability rate. Cost savings, limited numbers of available aircrafts and the demand for specific operational capabilities to be provided by the aircrafts are the main drivers to improve these KPIs. Civil airlines as well as air forces are the main stakeholders to limit the maintenance costs on one side and to guarantee a high degree of aircraft availability on the other side. Especially military applications have an increasing demand to keep the mission capabilities of a limited number of available aircrafts in order to fulfil the operational tasks.

Hence the main goal is to enhance the Value in Operation of future Air Systems.

At present Mission Planning, Operational Scheduling, Maintenance Planning and Health Monitoring are mainly isolated functions:

- Limited knowledge about Maintenance Planning is available for Mission Planning and Operational Scheduling
- Flight specific stressors on the aircraft structure and components health condition are not sufficiently taken into consideration by Maintenance Planning.
- Maintenance & repair and Operational Scheduling are without predictive capabilities.
- Health monitoring information is not considered for Operational Scheduling.

The objective of the technology project described herein is to enhance the Mission Capability Rate on the operational level and the Mission Availability Rate on the technical/logistical level.

Within the concept of Prognostics based Mission Planning the involved process elements Mission Planning, Operational Scheduling, Maintenance Planning and Health Monitoring are not performed in an isolated manner any more. The Mission Availability Rate is expected to be improved by bridging Mission Planning and Maintenance Planning. Information is fused to provide prognostic capabilities.

The concept will be based on Operational Risk Assessments using the mission information (plans) of the aircrafts involved in a collective operation. It improves the decision making process by injection of additional information indicating operational risks for current or future missions by prediction of aircraft capabilities degradation caused by the executed missions. The outcome than feeds the rule based decision support engine, modelling the business rules of mission, fleet and maintenance planning with the aim to improve the mission availability rate.

The herein specified functional components Mission Planning, Operational Scheduling and Operational Risk Assessment (ORA) in conjunction with Maintenance Planning and Health Monitoring are implemented in a demonstrator framework.

2. THE CONCEPT OF PROGNOSTIC BASED MISSION PLANNING

The Prognostic based Mission Planning Concept integrates Mission Planning, Operational Scheduling and Operational Risk Assessment (ORA) functions with the aim to improve the Key Performance Indicators (KPI) Mission Capability Rate and Mission Availability Rate of the aircrafts in the fleet. Both, Mission Planning and Maintenance Planning are understood as cooperative processes to support each other. Mission planning information and predictive health status information generated on the operational level will be used to support the maintenance process and on the other side maintenance information generated on the technical level is used on the mission planning side to optimise the tasked operations.

Based on a given operational scenario a number of missions with related operational capabilities (tasks) are planned for a certain period of time and a related Mission Schedule is generated. But the use of the aircrafts according to planned flight profiles might lead to a degradation of the health status of the components of the system and hence might affect the planned execution of the missions. To take these stressors into consideration, the Mission Schedule is submitted to the Operational Risk Assessment (ORA) module. The ORA module uses the received information about planned missions and required mission capabilities to assess the technical risk for the missions. The risk might be caused by non available equipment due to repair actions or by the incidence of defects/failures at the equipment due to the operational impact. Both risk sources are taken into consideration by the ORA module.

The ORA process provides prognostic based information for both, Mission- and Maintenance Planning. This enables prognostic based mission planning on the operational side and prognostic based maintenance planning on the technical/logistical side. Mission information is provided to ORA to estimate the mission capabilities and to support maintenance planning. Maintenance information is provided to the operational

side to optimise time scheduling.

The relation between mission tasks, aircraft capabilities, aircraft components and the mission profile, which consists of mission segments, is graphically shown in figure 1.

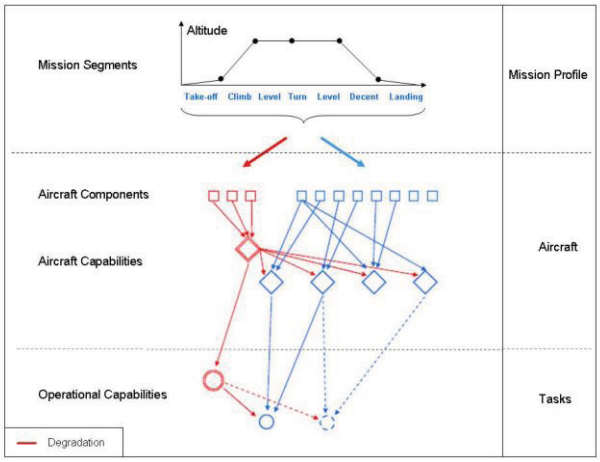

FIG 1. Degradation of operational capabilities

The mission segments act on the aircraft structure as well as on avionics and mission equipment (components). If this leads to health degradation, the operational capabilities of the aircraft might be limited too, with the consequence, that tasks can not be performed any more in the originally planned manner, or that they can not be performed at all.

These relations are used in the interactive process between Mission Planning, Operational Scheduling and ORA to predict the risk on planned missions.

Possible health degradations are predicted and submitted to Operational Scheduling. This predictive information is used to generate recommendations about re-planning and re-scheduling.

3. THE OPERATIONAL PROCESS

PbMP defines a process to integrate Mission Planning, Maintenance Planning and Health Monitoring with the aim to improve the Mission Capability and Availability. Figure 2 shows the architecture framework which is established to support this process.

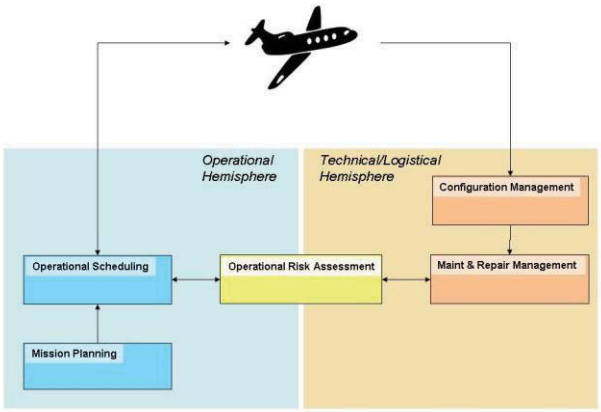

FIG 2. Architecture of the PbMP Concept

The blue field on the left side represents mission planning and operational scheduling. The orange field on the right side shows the maintenance and related activities. Both hemispheres are integrated by the Operational Risk Assessment function, using information from both sides and providing prognostics capabilities.

At the beginning missions are planned for each aircraft nominated to perform the operational task, according to the headquarters tasking data (Air Task Order, Airspace Coordination Order). The route of each mission is defined by waypoints with related attributes of the specific aircraft. These mission data include the information about the environmental stress acting on the aircraft and its components which will later be used by the Operational Risk Assessment to estimate the effect on the aircraft capabilities in terms of Mission Capability Status. For each mission a Mission Template (Plan) is generated.

The timing information within the Mission Plans is used by the Operational Scheduling function to generate the Flying Programme for the overall operation. The Flying Programme includes the mission timing of each aircraft involved.

The Flying Programme in conjunction with the Mission Templates is then used by ORA to estimate the Mission Capability Status, which includes the prognosis that mission capabilities will be achieved with a certain probability. The result is displayed to the operator as basis for optimising the Flying Programme.

4. OPERATIONAL RISK ASSESSMENT

Operational Risk Assessment (ORA) is a function that determines the health status of a system and predicts its future degradation. The health assessment part is performed by using condition based maintenance techniques or classical inspection-based diagnosis. The predictive part takes into account planned use of the system.

ORA is compatible to Mimosas OSA-CBM-framework. The risk assessment is performed dynamically and on-line if a connection to an OSA-CBM-framework is established. This means that changes in condition as well as changes

in configuration of an aircraft is taken into account. The Risk Assessment also considers planned/preventive and condition-based maintenance-tasks in the past and the future.

The future condition of an aircraft is extrapolated by assessing the current condition and calculating the expected stress of each (sub-)system. The failure rate of each system is aggregated to aircraft level. It is kept in mind that systems can be designed redundant. At aircraft level there are no longer failure rates of parts or components because at aircraft level it is not important to know which specific part has a certain failure rate. It is more important to know if the aircraft is capable of performing certain actions like taking-off or flying with high velocity. ORA is able to calculate future failure rates of these capabilities at aircraft level.

4.1. Operational Risk Assessment based decision support

To perform decision support (DS) based on ORA, additional information from an operational control center is mandatory. ORA-DS is an algorithm that varies the operational schedule based on strategic planning constraints in order to find a new operational schedule that requires fewer resources (cost reduction, more efficient material usage or smaller workforce) or is more robust to operational incidents (i.e. bird strike).

This requires a communication between the DS-function and ORA. The following Graph shows the dataflow within the entire decision support systems and its periphery.

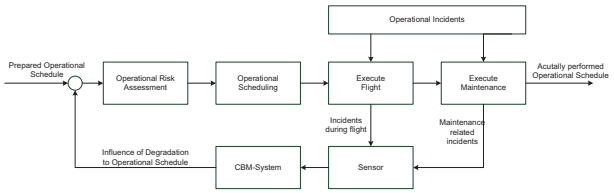

FIG 3. Functional view of ORA-based DS

Input to the decision support system is a prepared operational schedule. ORA takes this input and simulates the stress of all involved components and parts. Output of this simulation is a risk profile that contains information when there will be operational risks during the future execution of the flying program. This data is used by the operational scheduling to refine the flying program. While the flying program is executed, operational incidents may occur. Some of these incidents are predictable (i.e. degradation or logistic delay) and some are not (i.e. bird strike). Occurrence of these incidents is detected by sensors (or during inspection). A sensor will report any health status changes to a CBM-system. This system will evaluate the impact on operational availability of the detected incident. If the impact is significant there will be influence on the operational schedule.

5. ABBREVIATIONS

ATO	Air Task Order
CBM	Condition Based Maintenance
DS	Decision Support
KPI	Key Performance Indicator
OSA-CBM	Open Systems Architecture for Condition Based Maintenance
PbMP	Prognostic based mission Planning

6. SUMMARY

The objective of the research activities described herein is to enhance the Mission Capability Rate on the operational level and the Mission Availability Rate on the technical/logistical level.

Within the concept of Prognostics based Mission Planning the involved process elements Mission Planning, Operational Scheduling, Maintenance Planning and Health Monitoring are not performed in an isolated manner any more. The Mission Availability Rate is expected to be improved by bridging Mission Planning and Maintenance Planning and information is fused to provide prognostic capabilities.

The concept will be based on Operational Risk Assessments (ORA) using the mission information (plans) of the aircrafts involved in a collective operation. It improves the decision making process by injection of additional information indicating operational risks for current or future missions by the prediction of aircraft capabilities degradation, caused by the executed missions.

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