Modeling Aircrafts Operational Reliability

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Abstract. The success of an aircraft mission is subject to the fulfillment of some operational requirements before and during each flight. As these requirements depend essentially on the aircraft system components and the mission profile, the effects of failures can be very significant if they are not anticipated. Hence, one should be able to assess the aircraft operational reliability with regard to its missions in order to be able to cope with failures. This paper addresses aircrafts operational reliability modeling to support maintenance planning during the mission achievement. We develop a modeling approach to represent the aircraft system operational state taking into account the mission profile as well as the maintenance facilities available at the flight stop locations involved in the mission. It is illustrated using Stochastic Activity Networks (SANs) formalism, based on an aircraft subsystem.

Keywords: operational reliability, model-based assessment, aircraft system, maintenance planning

1 Introduction

With the increasing interest in air transportation and the competitive market aircraft operators have to deal with, aircraft operational disruptions become a key concern in the aviation field. In order to avoid economical losses due not only to inoperability but also to customer dissatisfaction, airlines need to anticipate on the events that may disrupt the achievement of their aircrafts missions. Aircraft missions are achieved in compliance with operational requirements depending principally on the current operational state of the aircraft system components and the mission profile. Thus, an attention must be paid to the effects of the aircraft system component failures and the corresponding maintenance actions. Failures that may disturb the achievement of the aircraft mission must be handled with adequate corrective actions. However, the ability to promptly cope with these failures depends on the location where they occur.

Maintenance facilities are not the same at all airports. Generally, airlines have more facilities at their main base than at the other airports. Therefore, the maintenance resources must be adapted to the aircraft missions. The issue is to have an assessment method that can support mission assignments and maintenance activities forecasting. Model-based dependability assessment is well suited to support this process.

Our work aims at developing an assessment approach, based on dependability modeling, that makes it possible to continuously assess the ability to keep operating up to a given time or location. The model will be used while planning the missions and during their achievement. To plan the mission, the model can be used to estimate the period of time during which the aircraft system can be operated without reaching adverse states. This allows to determine the mission profile the aircraft must be assigned. Once a mission is assigned to the aircraft, the model can be used during its achievement to assess the ability to succeed in continuing on the remaining part of the mission. The model can also support maintenance activities planning. The best maintenance strategy can be determined comparing the probabilities to accomplish the missions considering different alternatives.

To cover these issues, the model should be able to take into account the various situations in which it may be used. Our approach consists in developing generic stochastic sub models that can be dynamically updated and configured to represent the current state of the aircraft, with regard to the mission to achieve.

The remainder of this paper is structured as follows. Section 2 describes how aircraft missions are carried out together with the verification of the operational requirements fulfillment. Section 3 presents some related works. Section 4 is devoted to the modeling approach, which is implemented in section 6 using an aircraft subsystem as example. The subsystem is presented in section 5. Section 7 presents an example of evaluation result. Finally Section 8 concludes the paper.

2 Description of Mission Achievement

The achievement of the mission is such that each flight is followed by a stop where the aircraft is prepared for next flight. The preparation for the next flight consists of routine maintenance activities, cabin cleaning, catering, baggage and cargo processing, and passenger boarding.

At each stop, the aircraft is inspected and the discrepancies that are reported during the previous flight are checked. If a component is found inoperative, a dispatch decision is taken regarding the next flight. The flight captain refers to an approved document called *Minimum Equipment List* (MEL) where the components are listed with the status “go”, “go if” or “no go”:

- The “go” status is the case where the aircraft can fly with the component failed.
- The “go if” status allows the flight provided some conditions (on other components, operational performance and maintenance activities) are fulfilled. This includes a given deadline to repair the component.
- The “no go” status prevents the aircraft from flying. The failed component must be repaired before any flight.

The dispatch is allowed if there is no “no go” and all “go if” conditions are acceptable. When the aircraft does not meet the dispatch requirements following a failure, maintenance activities are initiated in order to solve the problem. The magnitude of the failure effect depends thus on the ability to solve the problem at the considered location before the planned departure time. Actually, the flight is considered delayed only after exceeding a given tolerable time frame. Figure 1 summarizes the possible outcomes of the dispatch decision.

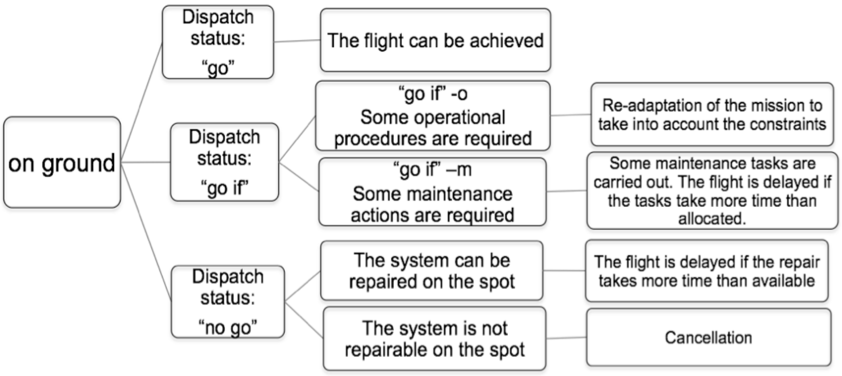

on ground
Dispatch status: “go”
The flight can be achieved
Dispatch status: “go if”
“go if” -o Some operational procedures are required
Re-adaptation of the mission to take into account the constraints
“go if” –m Some maintenance actions are required
Some maintenance tasks are carried out. The flight is delayed if the tasks take more time than allocated.
Dispatch status: “no go”
The system can be repaired on the spot
The flight is delayed if the repair takes more time than available
The system is not repairable on the spot
Cancellation

Figure 1 Dispatch status outcomes

When the dispatch is allowed, the aircraft can depart after passenger, cargo and the other ground service processing. Then, the flight begins by the taxing of the aircraft to runway where the takeoff is initiated. During this period or even after the takeoff, the flight can be aborted as a result of a critical failure. The aircraft then returns back to the departure airport. Actually, during the entire flight, it may be diverted if the aircraft capability is degraded. Procedures, stated in the Flight Manual (FM), the Flight Crew Operating Manual (FCOM) or the Quick Reference Handbook (QRH), are used to determine whether the flight must be diverted or not [1].

The adverse situations while operating an aircraft are operational interruptions, namely flight delays, cancellations, in flight turn-back and diversions. Delays and cancellations occur on ground, while turn-back and diversion occur in flight.

3 Related work

To the best of our knowledge, aircraft operational reliability modeling has been seldom addressed in the literature. The studies carried out are rather concentrated on safety aspects (see [3, 10, 14] for instance), and most works about operational reliability are for design enhancement purpose [2, 13]. In [6], the issues of delays and safety in airline maintenance are addressed. A probabilistic risk analysis model is developed in order to quantify the effect of airlines maintenance policies on their aircrafts operability. A decision support approach to maintenance planning is presented in [7]. That is, thanks to redundancy, the aircraft can continue operating with some equipment inoperative, however, it is time limited and can increase the risk of occurrence of an interruption. The approach proposes a method to schedule the repairs taking into account some optimization criteria: cost, remaining useful life and operational risks. The approach is based on generating alternatives on which is defined a utility function. It is worth noting that the work does not account for reliability measure. It uses the reliability measure as input. In [1], the operational consequences of system failures are studied using event tree analysis. The paper discusses the possible consequences of failures taking into account the flight phase during which they have occurred. A modeling approach based on the fault trees of the targeted aircraft system is presented in [2], together with a computing algorithm to estimate the bounds of the considered probability measure. The approach considers a series of flight cycles and provides a means to evaluate the probability of occurrence of one of three events at each cycle: "No Go dispatch", "Accepted Degraded Mode" which corresponds to the case where a "go if" occurs and the airline accepts to perform the corresponding tasks, "Refused Degraded Mode" which is a "go if" that is not accepted by the airline. Note that the paper only deals with dispatch events and does not consider in-flight operational consequences. The probability of failure of more than one component during a flight is also neglected.

Concerning modeling aspects, the problem is generally categorized, with regard to the system, as a Phase Mission System (PMS) problem. Mura and Bondavalli [8] analyze the PMS and present a dependability modeling approach. It is shown that, under some given conditions, the model can be processed using an analytical method. Chew et al. [9] address the problem using the concept of maintenance-free operating periods; the system evolves through a series of phases with no possible maintenance. The developed model is solved by simulation.

Of all these works, none is aimed directly at modeling aircraft operability during its missions' achievement. The closest works [1, 2] are carried out for long-term operational dependability analysis and are based on event trees and fault trees. This paper addresses aircraft operational reliability using stochastic state-based models. Our work is intended to develop a reliability model that one can use to cope with operability issues during aircraft missions' achievement. The modeling approach is presented in the following section.

4 Modeling Approach

As presented in section 2, the aircraft has to fulfill some operational requirements (dispatch requirements) before flying and some requirements (in-flight requirements) during the flight. We distinguish:

- the minimal system requirements given by MEL (Min_Sys_Req) that are independent of the mission profile and which must be fulfilled in order to operate the aircraft whatever the mission.
- the requirements (M_Prof_Req) that are specific to the mission profile. These include the mission dependent dispatch requirements and the requirements in flight. They are composed of the requirements specific to the flights composing the mission.

The evaluation is based on the fulfillment of these requirements. The objective is to evaluate the probability of occurrence of the adverse events that may lead to an operational interruption. We distinguish two reliability measures:

- While planning a mission, the aircraft system reliability (SR) is evaluated with regard to Min_Sys_Req in order to determine the maximum number of flight hours that can be achieved without maintenance. This is used to determine the length of the mission or to plan maintenance activities.
- Once a mission is assigned to the aircraft and during its achievement, the reliability measure (MR) which corresponds to the probability to achieve the mission without an operational interruption, is evaluated with regard to Min_Sys_Req and M_Prof_Req in order to determine whether a preventive action must be initiated or not.

4.1 Structure of the Model

Figure 2 shows the overall structure of the model composed of four levels.

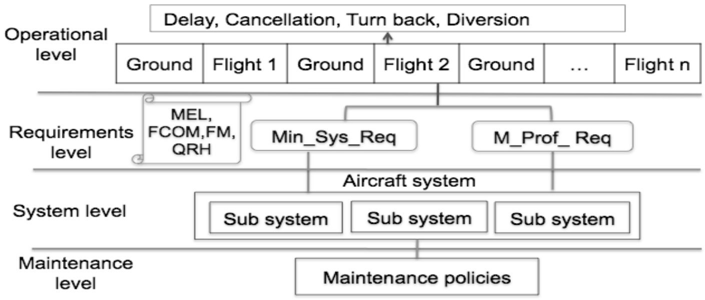


Figure 2: Overall structure of the model

Operational level: it represents the succession of periods during which the aircraft is either flying or on ground.

R**equirements level**: it consists of the aggregation of the requirements from the potential contributors to the continuity of the mission. These requirements are the representation of Min_Sys_Req and M_Prof_Req. These requirements are formulated as complements of Boolean expressions, representing the different combinations leading to an operational interruption.

System level: It describes the aircraft system. The system is decomposed into subsystems and atomic components according to its design logic or its functions. This level describes the components failure scenarios.

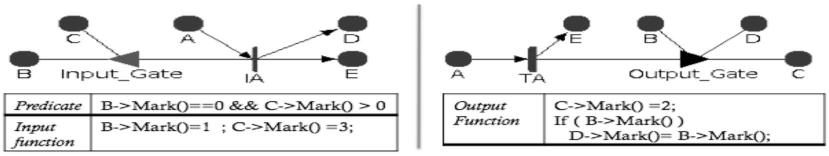
Maintenance level: It describes the maintenance possibilities at the various airports involved in the mission profile. It is intended to represent the predefined maintenance policies related to the airports. This has an impact on the repair time of the system components at a given stop. The maintenance activity itself is modeled at the system level.

We build generic sub models corresponding to each of the main levels in the above structure. The composition of these sub models will form an initial model, which is to be configured and parameterized with online data in order to obtain the overall model.

The approach can be implemented using an appropriate formalism. In this paper, we consider the Stochastic Activity Networks (SANs) formalism and the associated Möbius tool [5], which provide compositional operators that are convenient to master the complexity of the model. A brief description of SANs is given in the followings.

4.2 SANs Formalism

Stochastic activity networks are an extension of Petri nets (PN). SANs consist of four primitive objects: places, activities, input gates, and output gates. Activities are the equivalent of transitions in PN. They are either timed or instantaneous. Timed activities have durations and a time distribution function. Instantaneous activities represent actions that complete immediately when enabled. Input gates are used to control the enabling of activities and define the marking changes that will occur when an activity completes. Each input gate is defined with an enabling predicate and a function. Output gates are like input gates and are used to change the state of the system when an activity completes. An output gate is defined only with a function. The function defines the marking changes that occur when the activity completes. Input gates and output gates are represented graphically as triangles (see Figure 3).



Predicate	B->Mark()==0 && C->Mark() > 0
Input function	B->Mark()=1 ; C->Mark() =3;

Output Function	C->Mark() =2;
	If (B->Mark())
	D->Mark()= B->Mark();

Figure 3: Input and output gates

An activity is enabled when the predicates of all input gates connected to the activity are true, and all places connected to incoming arcs contain tokens, i.e., have non zero markings. Once enabled, the activity samples its delay distribution function to determine the time delay before the activity fires. When the activity fires, it updates the state of the model by subtracting tokens from places connected by incoming arcs, adding tokens to places connected by outgoing arcs, and executing the functions in input and output gates.

Möbius allow the construction of composed models. Indeed, for a large system, it may be helpful to compose the overall model based on sub-models that have less complexity. This is feasible using the Join and Replicate operators. The Join operator combines several models sharing some state variables. The Replicate operator is used to create copies of models; the copies are combined into a global model. The copies may hold some state variables in common. A Join node may have other Joins, Replicates, or other sub models defined as its children.

This formalism is used to develop a case study implementing the modeling approach. The case study concerns a subsystem that controls one of the movable surfaces of the aircraft [11], referred to as CMS in the rest of the paper. The subsystem is described in the following section.

5 CMS Presentation

The subsystem is composed (see Figure 4) of three primary computers (P1, P2, P3), a secondary computer S1, three servo-controls (ServoCtrl_G, ServoCtrl_B and ServoCtrl_Y), a backup control module (BCM) and two backup power supplies (BPS_B and BPS_Y).

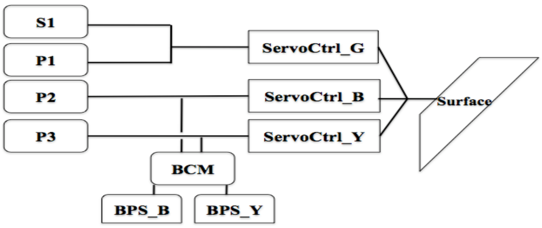


Figure 4: The subsystem

The computers are connected to the servo-controls, which move the surface. S1 and P1 are connected to the servo-control ServoCtrl_G, P2 is connected to ServoCtrl_B, and P3 is connected to ServoCtrl_Y. The connection between a computer and a servo-control form a control line that can act on the surface. We have:

P1 control line (PL1): formed by the connection between P1 and ServoCtrl_G,
P2 control line (PL2): formed by the connection between P2 and ServoCtrl_B,
P3 control line (PL3): formed by the connection between P3 and ServoCtrl_Y,
S1 control line (SL): formed by the connection between S1 and ServoCtrl_G.

We have also Backup control line (BCL), which is based on BCM, BPS_B, BPS_Y, ServoCtrl_Y and ServoCtrl_B.

Initially the secondary computer S1, the backup control module BCM and the backup power supplies BPS_B and BPS_Y are inhibited. The surface is then controlled by the three primary control lines (PL1, PL2, PL3). When the three primary control lines fail, S1 is activated and the system switches to SL. If the latter also fails, BCM, BPS_B and BPS_Y are activated enabling the backup control. Therefore, three control modes can be distinguished: the primary control (PC), the secondary control (SC) and the backup control (BC). Figure 5 summarizes the control modes.

PC	SC	BC
PL1, PL2, PL3	SL	BCL

Figure 5: The control modes and associated control lines

Related Operational Requirements: According to [4][1], the failure of P2, ServoCtrl_G, ServoCtrl_Y, ServoCtrl_B, BCM, BPS_B or BPS_Y leads to "no go" status. P1, P3 and S1 are "go if" items with "go if" conditions stated respectively at sections MMEL 27-93-01-1, MMEL 27-93-01-3 and MMEL 27-94-01-1 of the

[1] [4] is actually a Master MEL(MMEL). MELs result from the completion of MMELs with airline specific policies and are not public documents. MMELs are established by the aircraft's manufacturer.

document. The dispatch conditions resulting from these sections are respectively (P1=ok) ∨ (S1=ok ∧ P3=ok); (P3=ok) ∨ (S1=ok ∧ P1=ok); (S1=ok) ∨ (P1=ok ∧ P2=ok ∧ P3 =ok)[2]. In the three cases, the failed component must be repaired before the deadline of 10 days. These conditions are not dependent on any mission profile. Therefore, they are part of Min_Sys_Req.

$$\begin{aligned}\text{Min\_Sys\_Req} = (\ & P2 = ok \wedge BCM = ok \wedge BPS\_B = ok \wedge BPS\_Y = ok \wedge \\ & (P1 = ok \vee (S1 = ok \wedge P3 = ok)) \wedge ServoCtrl\_G = ok \wedge \\ & (P3 = ok \vee (S1 = ok \wedge P1 = ok)) \wedge ServoCtrl\_Y = ok \wedge \\ & (S1 = ok \vee (P1 = ok \wedge P3 = ok)) \wedge ServoCtrl\_B = ok\ ).\end{aligned} \tag{1}$$

Using the control lines previously defined, this expression becomes:

$$\begin{aligned}\text{Min\_Sys\_Req} = (\ & PL2 = ok \wedge (PL1 = ok \vee (PL3 = ok \wedge SL = ok)) \wedge \\ & (PL3 = ok \vee (PL1 = ok \wedge SL = ok)) \wedge BCL = ok \wedge \\ & (SL = ok \vee (PL1 = ok \wedge PL3 = ok))\ ).\end{aligned} \tag{2}$$

There is no operational requirement related to the subsystem in the FCOM.

6 The Model

The model is the aggregation of sub models corresponding to the levels presented in section 4.1. Note that only one subsystem is considered here. Due to space limitations only the operational, requirements and system levels sub models are shown.

6.1 The System Level Sub Model

The system level sub model consists of the representation of CMS. To simplify its presentation, it is decomposed into three sub models corresponding to the control modes given in Figure 5. In all the three sub models, places representing the subsystem's components functional state (ok or failed) are named after these components. Activities named *xxx_failure* represent failures events. Their enabling is conditioned by the presence of a token in place *flight.* Activities *Maintainxx* represent maintenance activities and their enabling is conditioned by the presence of a token in place *Maintain*. Places *flight* and *Maintain* represent respectively whether a flight is ongoing or not, and whether a maintenance period is ongoing or not. Their markings are controlled by the operational level sub model (Figure 10). For clarity purpose, some places involved in the predicate or function of the input gates are not explicitly linked to them; this is allowed by SANs.

Primary control (PC) model is given in Figure 6. The transitions representing the maintenance activities (*Maintainxx*) are at the left side and the failure events (*xxx_failure*) at the right side of the places. Their associated input gates control their firings. For example *IGP1F* and *IGMP1* are defined as follows:

[2] These are not actually the full conditions, we only consider the conditions related to the components involved in the subsystem described.

IGP1F Predicate : P1->Mark() && flight->Mark() Function : P1->Mark()=0; PL1->Mark()=0;
IGMP1 Predicate : P1->Mark()==0 && Maintain->Mark() Function : P1->Mark()=1;
if (ServoCtrl_G->Mark()) PL1->Mark()=1; P1defExp->Mark()=0;

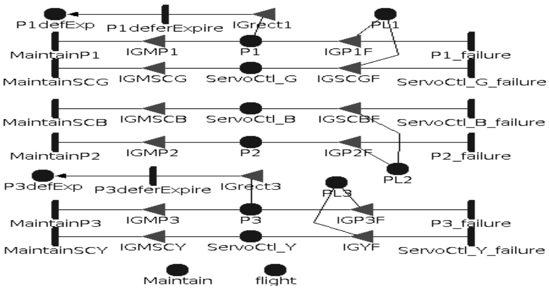


Figure 6: PC sub model

Transition *P1(3)deferExpire* represents the expiration of the deadline before which the computer must be repaired after being failed. This doesn't concern P2 since its status is “no go”. Places *PLi* represents the state of the lines PLi. *PLi* is marked when *Pi* and the corresponding *ServoCtrl_x* in the line are marked. The markings of places *Maintain* and *flight* are used in the predicates of the input gates to enable the failure and maintenance activities as explained above.

Secondary control (SC) is represented in Figure 7. Place *S1Active* represents the activation state of S1. That is when PC fails, the instantaneous activity *S1_active* fires in order to mark place *S1Active,* representing the failover to SL. *S1_inhib* models the inhibition event. It fires when one of *PL1*, *PL2* and *PL3* becomes marked again, removing the token from *S1Active*. *PL1*, *PL2* and *PL3* are shared with the PC sub model, which controls their makings. They are only used in the predicates of *IGS1A* and *IGS1I* to express whether PC is failed or not. *S1_hidden_failure* and *S1_active_failure* model respectively the failure events of S1 while inhibited and activated. *SL* represents the functioning state of the secondary control line. It holds when *S1* and *ServoCtrl_G* hold. *ServoCtrl_G* is shared with PC sub model.

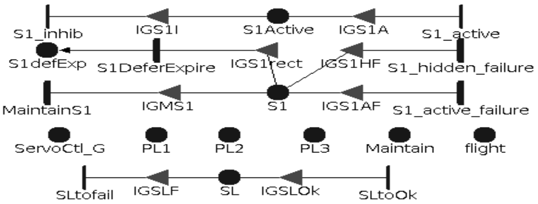


Figure 7: SC sub model

The Backup control (BC) model is depicted in Figure 8. *BPS_BActive* and *BPS_YActive* describe the inhibition and the activation of BPS_B and BPS_Y. That is, when PL1 and SL are inoperative, BPS_B and BPS_Y are activated to supply power to BCM. They are inhibited when PL1 or SL is operative. *BPS_BActive* and

BPS_YActive are updated by their associated instantaneous transitions, which fire according to the marking of *PL1* and *SL* as described above.

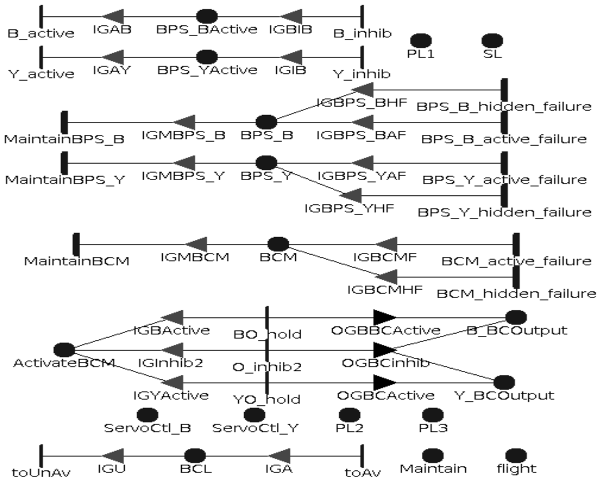


Figure 8: BC sub model

ActivateBCM represents the use of the BCM to control the surface; when none of the primary and secondary control lines is operative and BPS_B or BPS_Y supply the BCM with electric power, the BCM is activated to attempt to control the surface via ServoCtrl_Y or ServoCtrl_B. *B_YCoutput* and *B_BCoutput* represent respectively the use of power from BPS_Y and BPS_B. *BCL* represents the fulfillment of the requirements on the components of the line. It is marked when *BCM, BPS_B, BPS_Y, ServoCtrl_B* and *ServoCtrl_Y* are marked. Places *Maintain* and *Flight* are shared with the operational level sub model; *PL1, PL2, PL3, ServoCtrl_B* and *ServoCtrl_Y* with PC sub model; and *SL* with SC sub model. Their marking are used as input to the BC sub model as they are involved in the activation and inhibition of the BC.

As only one subsystem is considered in this case study, the system level sub model corresponds to the composition of PC, SC and BC sub models (see Figure 11).

6.2 The Requirement Level Sub Model

Figure 9 shows the aggregation of the requirements fulfillments from the system level sub models.

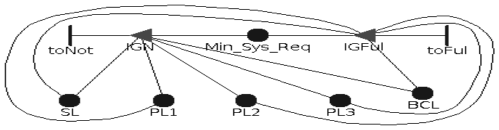


Figure 9: Requirement level sub model

Place *Min_Sys_Req* models the requirements fulfillment. The firings of the instantaneous activities *toFul* and *toNot* update the place according to the condition expressed in section 5 (expression (2)). *Min_Sys_Req* is used at the operational level. Places *PL1, PL2, PL3, SL and BCL* are shared with the system level sub model. M_Prof_Req is not represented here due to the fact that the subsystem has no mission profile related requirement. Nevertheless, its representation will be similar.

6.3 The Operational Level Sub Model

The operational level sub model is shown in Figure 10. The upper part represents a flight and the lower part represents the activities on ground at a stop. Place *Maintain* is shared with the system level sub model indicating the ongoing of a maintenance period. Place *Req_fulfilment* is an extended place representing the requirements fulfillment. It should be composed of Min_Sys_Req and M_Prof_Req, which are shared with the requirements level sub model. Since no mission profile related requirement is considered here, the share concerns only *Min_Sys_Req* at the requirements level. A flight is represented by three phases *Taxing_to_Climb*, *In_Flight* and *Landing*. During the *Taxing_to_Climb* the flight can be aborted and it can be diverted during the *In_Flight* phase. The input gates *AbortCondition* and *Diversion_Condition* represent the conditions under which these interruptions can occur (in-flight requirements fulfillment). The conditions are stated using the marking of *Req_fulfilment.* Place *flight* indicates whether a flight is ongoing or not. It is shared with the system level sub model.

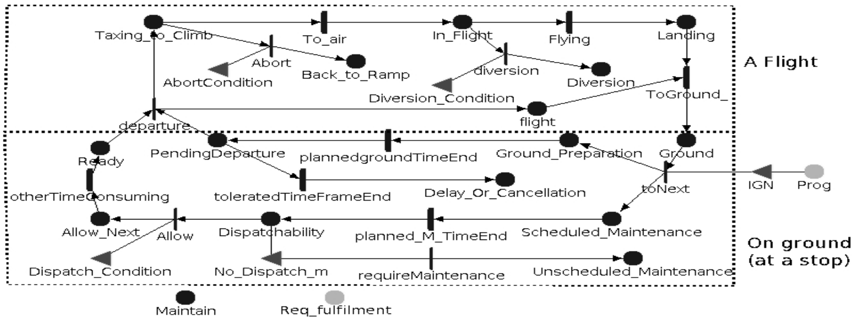


Figure 10: Operational level sub model

The sub model of a ground period consists of the representation of the preparation for the next flight and the readiness for departure on time. The beginning of the preparation for the upcoming flight is represented by the marking of places *Ground_Preparation* and *Scheduled_Maintenance,* stating that the scheduled ground period is ongoing and the system is under scheduled maintenance (routine check for instance)[3]. When the scheduled maintenance is finished (activity *planned_M_TimeEnd* fires), the place *Dispatchability* then holds and the instantaneous activity *Allow* can fire if the dispatch requirements, stated in the predicate of *Dispatch_Condition*, are fulfilled. Otherwise the instantaneous activity *requireMaintenance* fires if the corrective action requires maintenance tasks (stated

[3] These tasks are aimed at detecting failures, and not to repair any failed component.

by the predicate of *No_Dispatch_m*), place *Dispatchability* still holds until the corrective action succeeds (predicate of *Dispatch_Condition* becomes true) and the flight is allowed. In the current illustration, the dispatch requirements fulfillment consist of testing if the marking of field Min_Sys_Req in the extended place *Req_fulfilment* is zero or not. Until then, the scheduled ground duration may have elapsed (firing of activity *plannedgroundTimeEnd* moving the token to place *PendingDeparture*) and the tolerable delay may be running out. A delay or cancellation occurs if the tolerated time to dispatch is exceeded. The timed transition *OtherTimeConsuming* represents the other activities (passengers and baggage processing …) that may consume time, causing delay. Place *Prog* (at right) is an extended place representing the list of flights to be achieved. The input gate *IGN* indicates whether there is a next flight to achieve or not (end of the mission or not).

6.4 The Global Model

The global model results from the composition of the sub models corresponding to the four levels. It is shown in Figure 11.

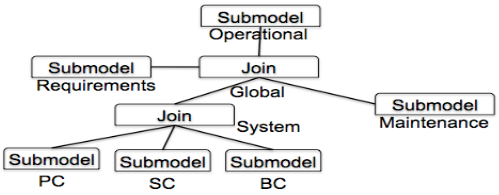


Figure 11: The global model

7 Example of Results

Since the model is intended to be used during the achievement of the mission, the initial markings and the parameters such as the distribution laws of the timed activities are to be set online using online data. In order to provide an example of evaluation, some values of the parameters are assumed here. We assume that all the events represented by timed activities at system level (Figures 6, 7, 8) have exponential distributions, except *P1deferExpire and P3deferExpire,* which have deterministic durations. The values of failure rates used for the example are between 10^{-4}/hour and 10^{-6}/hour. For the parameters of the operational level sub model, we consider a mission of 4 flights per day over a week. We assume that the timed activities of the operational level sub model have deterministic durations. Each flight takes 3 hours. The planned duration of a ground period is of 1.5 hour during the day and 7.5 hours at the end of the day (after 4 flights). We evaluate the mission reliability; MR(t). For illustration purposes, we consider that the in-flight requirements are the same as the dispatch requirements (Min_Sys_Req). The mission reliability MR(t) is the probability to have no tokens in places *Delay_Or_Cancellation*, *Back_to_Ramp* and *Diversion* of Figure 10. Figure 12 shows the mission reliability considering two initial states of the primary computer P1: P1-OK (P1 is OK at the starting of the mission), and P1-KO (P1 is in failure at the starting of the mission), the other components are assumed to be OK at the starting of the mission.

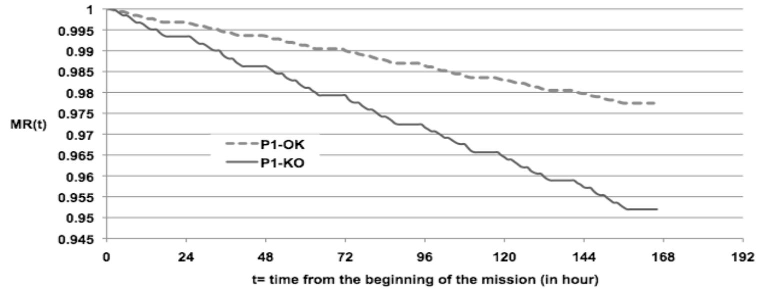


Figure 12: Mission Reliability

From the evaluation, the time from which the reliability becomes lower than a given threshold can be determined. For example, considering 0.98 as reliability threshold, one has to consider strengthening its ability to maintain after 144h in case of P1-OK and 72h in case of P1-OK. The curves also illustrate a situation where one has to decide on whether it is preferable to defer the maintenance of computer P1, knowing that there is one week remaining mission to achieve. With the assumed parameters, the reliability of the one-week mission will increase from 0.952 to 0.978 if P1 is repaired before the starting of the mission. Other examples of missions and of system reliability measures are given in [12].

8 Conclusion

This paper is aimed at developing a model that one can use to assess aircrafts operational reliability. The model is intended to be used before and during aircrafts mission achievement. A modeling approach has been developed considering aircrafts systems particularities and how the missions are achieved. The proposed model is composed of generic sub-models corresponding to components that may be involved in aircrafts operability. An illustration of the modeling approach with SANs formalism has been given using an aircraft subsystem.

The current work is focused on the construction of the initial model that will be used to assess the operational reliability. The model, however, must be updated during the achievement of the missions in order to take into account the current situation during which it will be used. The modeling approach is designed to facilitate these updates. Changes concerning the aircraft system components states and failures distributions will be taken into account in the system level sub model. Missions' update will be managed with the operational level sub model. It is expected that the system level sub model update will rely on diagnosis and prognosis modules. Data from the flight plans will be used to configure the operational level sub model.

The model update is currently achieved manually. Methods to dynamically integrate the updates and automatically re-assess the reliability, after the occurrence of a major event, are under investigation [15].

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