Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 99 (2015) 214 – 218

Procedia Engineering

www.elsevier.com/locate/procedia

“APISAT2014”, 2014 Asia-Pacific International Symposium on Aerospace Technology, APISAT2014

Modeling the Performance of Aircraft Utilizing Maintenance Free Operating Periods

Zhanyong Ren,Yueqin Wu*

China Aero-Polytechnology Establishment, Beijing, 100028, China

Abstract

Maintenance free operating period (MFOP) philosophy is proposed by the UK Military Aerospace industry, which has advantages for both the operation and maintenance of aircraft. An MFOP is a period of time for which the aircraft will operate without failure and without the need for any maintenance, however, faults and minor planned, contractually agreed maintenance are permissible. Each MFOP is followed by a Maintenance Recovery Period (MRP) during which maintenance is performed on the aircraft to correct any failures which have occurred, carry out servicing and prepare the aircraft for the next period of operation. There are several advantages to operating aircraft in this manner. The first is that it will be known, with a high degree of confidence, how many products will be available for operational purposes at any time. This enables accurate, effective mission planning. However, the aircraft must be designed to operate in this way and be able to carry faults in the MFOP without an unacceptable risk. This paper will model the performance of aircraft utilizing maintenance free operating periods and explore issues relating to the design and operation of aircraft in this manner. An example is provided to expatiate on the proposed approach.

Peer-review under responsibility of Chinese Society of Aeronautics and Astronautics (CSAA)

Keywords: Reliability modeling, maintenance free operating period;

1. Introduction

MFOP is a period during which the system will operate without failure and without the need for any maintenance, however, faults and minor planned, contractually agreed maintenance are permissible. After every

* Corresponding author. Tel.: 8610-84380290; fax: 8610-64639893.
E-mail address: wuyueqin@buaa.edu.cn

Peer-review under responsibility of Chinese Society of Aeronautics and Astronautics (CSAA)
doi:10.1016/j.proeng.2014.12.528

MFOP there is a maintenance recovery period (MRP), where the aircraft is repaired to such a level that it is capable of completing the next MFOP[1]. It is should noticed that an MFOP is not defined to contain absolutely no maintenance, rather it is considered that minor actions, such as refueling, rearming and repairing important safety related features, will still need to take place. Since MFOP has the potential that can significantly improve the operational capability and reliability of the aircraft applying it and therefore provide a way of better meeting the customer's needs, many reliability researchers have paid attention to it[2,3]. However in order to achieve a high value of MFOP with a high confidence level, we can endeavour from five different areas, which are inherent reliability of systems and components, redundant systems, reconfigurable systems, prognostics and diagnostics. The aim of this research is to develop a modeling capability for the aircraft undergoing an MFOPS maintenance strategy based on Petri net method.

2. Petri nets

In 1962, Petri proposed the Petri net (PN) concept in his thesis[4]. Petri net is a directed bipartite graph with two distinct types of node: places, which are drawn as circles, and transitions, which are shown as bars. These nodes are connected to one another using directed arcs. These arcs which go from a place to a transition are considered as input arcs. If they are directed the other way are considered as an output arc. The transition is enabled if the number of tokens in all of the input places to the transition contains at least the weight number of tokens. Once the transition is enabled, it fires, taking one token from each input place and depositing one token in each place with an arc leading away from the transition. The marking of the net has thus been altered. The system state represented by the first marking has now changed to the one shown by the second. If a time delay for the transition is considered, the switching takes place once the time period has passed, following the transition being enabled. During this process the number of tokens is removed from each input place according to the weight of the linking arc and tokens are created in the output places, again according to the weight number on the associated edge. The time associated with delaying transitions can be either deterministic or stochastic. If a PN is required to model processes that have a random (or pseudorandom) nature to them, and this randomness follows a certain pattern such as a statistical distribution, the transitions can sample their switching times from this distribution. When transitions of tokens are immediately happen, they will be represented as solid bars. If transitions with a time delay, they will be represented as an empty bar.

Petri net is a kind of graphic deductive method. When we analyze system fault by Petri net, we often take the system unwanted event as the top place, then gradually find out all possible factors which lead to this event and take them as an intermediate place and a bottom place. The fault tree can be regarded as the logical relationship of fault propagation in the system, a coherent fault tree usually contains only and gate and or gates. So the fault tree can be conveniently expressed by the Petri net. PN versions of the AND and OR logical gates featured in fault tree are shown respectively in Fig1[5]. In the following Section, we will discuss the method to model the performance of aircraft utilizing maintenance free operating periods by Petri net. In the model we will consider the affect of prognostics on the performance of aircraft.

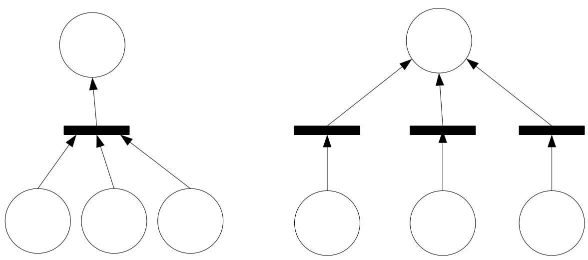

Fig. 1. Petri net AND gate and OR gate respectively