

PARALLEL SERIES SCHEDULING FOR AIRCRAFT OVERHAUL MAINTENANCE

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Abstract—Overhaul maintenance of an aircraft is carried out periodically based on the age standard of its flight hours. The overhaul maintenance can also be executed when there is an emergency condition which requires heavy maintenance. Hawk MK-209 aircraft previously needed overhaul time as per technical orders for 283 working days or equivalent to 14 months. By arranging the maintenance activities and considering the logic of dependence, using Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT), the aircraft's overhaul time can be accelerated to 81 working days, equivalent to four months. This achievement was continued by involving consideration of the parallel series maintenance scheduling method with the help of MS Project and Arena Simulation so that the total overhaul time was only 31 working days per aircraft. Thus, the combined CPM PERT and parallel series scheduling methods through Arena simulation, can result in total efficiency of overhaul time per aircraft from 283 working days to 31 working days, or equivalent to 89% efficiency.

Keywords—Parallel Series, Scheduling, Maintenance, Aircraft, Efficiency.

I. INTRODUCTION

In general, maintenance of aircraft is divided into three types, namely maintenance of light levels (routine maintenance) (Aungst et al., 2009), moderate maintenance and overhaul maintenance (Cheung et al., 2005; Rao et al., 2017). Heavy level maintenance or aircraft overhaul is carried out periodically and scheduled every certain number of flight hours or aircraft calendar years, whichever is achieved first (McFadden, M., 2012). The overhaul maintenance of aircraft is a heavy level maintenance that requires a very long time to process, it may take several months or even more than a year. The length of total maintenance time consumed in an aircraft overhaul, has a direct effect on the availability and readiness of the aircraft to be operated (Samaranayake, P., 2006).

Hawk MK-209 aircraft is tasked in supporting the defense of the state air force security. This aircraft

overhaul is carried out every 2000 flight hours or 10 aircraft calendar years. According to the technical order / maintenance manual, this aircraft requires overhaul time of 101,848 minutes or 1,697.46 hours or 283 working days, equivalent to 14 months. The duration of this overhaul has a direct impact on the readiness of the availability of aircraft to carry out security tasks. Considering that 14 months overhaul was felt too long, it was, thus, necessary to propose alternative solutions to shorten its overhaul time. Thus, the aim of this study is to propose alternative solutions to accelerate total maintenance time of aircraft overhauls, especially for Hawk MK-209.

II. LITERATURE REVIEW

This study developed a preliminary study carried out by the team of authors (Avief et al., 2016a; 2016b; Nursanti et al., 2018). In the preliminary study, aircraft overhaul maintenance activities were detailed and determined by optimistic and pessimistic time duration. They were then sorted according to the sequence of activities until a proposed overhaul maintenance time with time savings efficiency of 71% was obtained.

Several studies on aircraft maintenance scheduling have been conducted by many previous researchers, including through the PERT method (Smith, C.C., 2008), an aggregate approach (Arts, J. and Flapper, S.D., 2013), linear programming optimization (Elmabrouk, O. M., 2011; Pimapunsri, K. and Weeranant, D., 2018), and fuzzy (Atli, O. and Kahraman, C., 2012). However, from these studies, all relative assumptions are that, if one aircraft requires several days, then, when there are several, their total maintenance time will be several times, multiplied by the number of aircraft. Henceforth, this will be referred to as serial maintenance scheduling.

In fact, sequential serial maintenance per aircraft is considered no longer suitable, because it takes a very long time (Samaranayake, P. and Kiridena, S., 2012). When supporting facilities and resources for aircraft overhaul maintenance activities are sufficient, such as the availability of staff personnel, equipment, hangar area, spare parts and other supporting resources, then parallel series maintenance scheduling needs to be considered; “series” because the order of maintenance

is still carried out according to the established stages: pre-dock, in-dock and post-dock and “parallel” because overhaul maintenance is possible for several aircraft at once. Considering this, a parallel series scheduling method approach was sought to be developed in this study in an effort to accelerate the maintenance time of aircraft overhauls.

III. METHODS

The research of this paper is conducted quantitatively. Overall, this study is carried out through the following stages: first, maintenance scheduling for one aircraft unit (Avief et al., 2016a; 2016b; Nursanti et al., 2018) and second, develop serial and parallel series maintenance scheduling scenarios for several aircraft units at the same time using MS Project and Arena Simulation.

Maintenance scheduling for one aircraft unit is consist of: detailed maintenance activities of aircraft overhauls and their duration, sorting of activities based on dependence logic between maintenance activities, and by using CPM and PERT, a critical path to find the maintenance time of one aircraft unit overhaul was obtained.

Develop serial and parallel series maintenance scheduling scenarios for several aircraft units at the same time using MS Project and Arena Simulation, involves three scenarios: scenario 1, series scheduling (pre-dock, in-dock, post-dock), scenario 2, parallel series scheduling three stations (pre-dock, in-dock, post-dock) and scenario 3, parallel series scheduling 10 stations (pre-dock, eight stations in-dock, post-dock).

IV. RESULTS AND DISCUSSION

Aircraft overhaul maintenance is a heavy maintenance level. In general, maintenance activities of aircraft overhauls are divided into three major groups which are carried out sequentially, namely: Pre-Dock, In-Dock and Post-Dock.

- Pre-Dock. This is the handover activity of aircraft reception. At this stage, the aircraft document checking is carried out, which includes Aircraft Submission Letters, Equipment Inventory Lists, Aircraft Log Book, Component History Blangko, Airplane Daily History and Daily Motor History.
- In-Dock. This is the main overhaul maintenance stage, consisting of disassembly, cleaning, inspection, repair, assembly, setting up, testing, and weighing activities.
- Post-Dock. This is the final stage of overhaul maintenance, which includes screening, swing compass, test flight and concludes with the handover of the aircraft to its squadron.
- There were 435 activities in maintenance activities for overhauling Hawk MK-209 aircraft.

Based on the Technical Order, maintenance of the aircraft overhaul takes 283 working days or equivalent to 14 months (calendar). This clearly has a direct impact on the readiness of the availability of aircraft to be operated as per their assigned tasks.

Alternative solutions to speed up the maintenance time of overhauling the aircraft have been conducted by the research team through the Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT) approaches (Smith, C.C., 2008). by sorting each activity based on the logic of dependence on other activities: which activities must be done first, which activities follow, which activities can be carried out in parallel. With the help of POM software, the results show that the total maintenance time of the aircraft can be shortened to 81 working days, equivalent to four calendar months, so that 71% efficiency is obtained (Avief et al., 2016a; 2016b; Nursanti et al., 2018). Refer to Table 1.

TABLE 1. TOTAL OVERHAUL MAINTENANCE TIME PERIOD

STAGES	SUB STAGES	DURATION (DAY)	TOTAL TIME/ STAGE (DAY)
PRE-DOCK		1.09	1.09
IN-DOCK	1. DISASSEMBLY	6.3	73.36
	2. CLEANING	3.21	
	3. INSPECTION	14.14	
	4. REPAIR	0.99	
	5. ASSEMBLY	14.0	
	6. SETTING UP	9.5	
	7. TESTING	24.19	
	8. WEIGHING	0.87	
POST-DOCK		6.48	6.48
TOTAL OVERHAUL MAINTENANCE TIME PERIODE / AIRCRAFT			80.93

(reference: result from CPM and PERT)

Furthermore, three series scheduling and parallel series scenarios are developed for several aircraft units simultaneously using MS Project (Heizer and Render, 2011). and Arena Simulation to provide alternative solutions that can further shorten the maintenance time of the Hawk aircraft.

A. Scenario 1. Series Scheduling

Series maintenance scheduling sequentially involves one set (Pre-Dock, In-Dock, Post-Dock) for each aircraft unit, followed by other aircraft. Based on Table 1, it can be seen that the total maintenance time for one aircraft is 80.93 working days (equivalent to 81 working days). Using the assumption that one week is five working days, one year is 52 weeks, then one year is 260 working days (minus some national holidays). Thus, by using a series scenario, overhaul can be carried out in one calendar year for three aircraft. This is equivalent to 71% efficiency.

B. Scenario 2. Parallel Series Scheduling Three Stations

Parallel Series Scheduling Three Stations (Pre-Dock, In-Dock, Post-Dock) for several aircraft simultaneously. When aircraft 1 reaches the In-Dock stage, aircraft 2 enters Pre-Dock. When aircraft 1 is in the Post-Dock stage, aircraft 2 is at In-Dock stage, and so on. The sequence of the stages of work and the order of the aircraft being worked on, remains serial. But, at the same time, overhaul can be carried out on several aircraft. In this scenario, based on Arena simulation results, as shown in Figure 1, an overhaul of three aircraft can be carried out in one calendar year, with a total overhaul maintenance time per aircraft of 74 working days or equivalent to an efficiency of 74%.

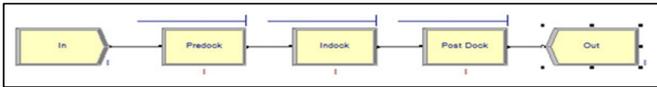


Fig 1. Simulation Modeling for Scenario Parallel Series 3 Stations (reference: Arena)

C. Scenario 3. Parallel Series Scheduling 10 Stations

(Pre-Dock, eight stations In-Dock, Post-Dock) for several aircraft at once. In Figure 1, there is a queue in Pre-Dock. This happens because of a bottleneck where the maintenance time in In-Dock requires longer than the time required at Pre-Dock. Considering this condition, in this scenario, the In-Dock stage is divided into several sub-stages, namely Disassembly, Cleaning, Inspection, Repair, Assembly, Setting Up, Testing, and Weighing so that the total stages and sub-stages become 10 stations (Figure 2). This has been done to reduce the bottleneck risk in the Pre-Dock stage (Principle of Line Balancing). In this scenario, based on the Arena simulation results, as shown in Figure 2, an overhaul of eight aircraft can be carried out in one calendar year. Thus, the total maintenance time for overhaul per aircraft can be reduced to 31 working days or equivalent to 89% efficiency.

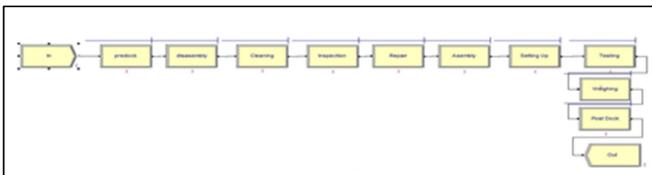


Fig 2. Simulation Modeling for Scenario Parallel Series 10 Stations (reference: Arena)

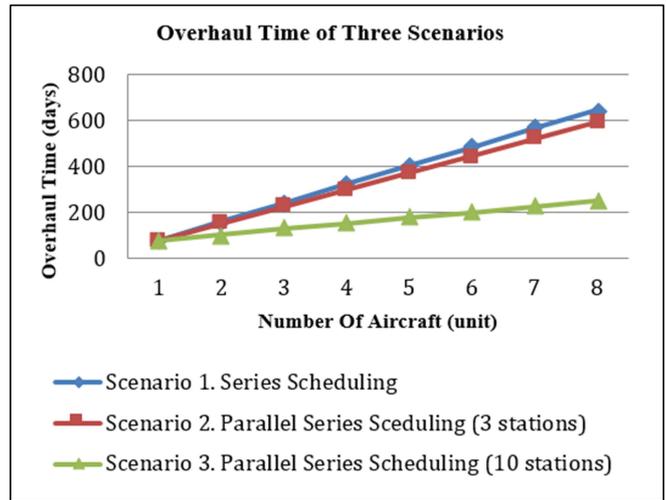


Fig 3. Overhaul Time of Three Scenarios (reference: Arena)

When comparing between the three scenarios, as shown in Figure 3, it can be found that, for eight aircraft units, scenario 1 requires 648 working days, scenario 2 is 594 working days and scenario 3 is 251 working days (one calendar year). Based on these data, scenario 3 contributes to the savings of overhaul time by 397 working days compared to scenario 1.

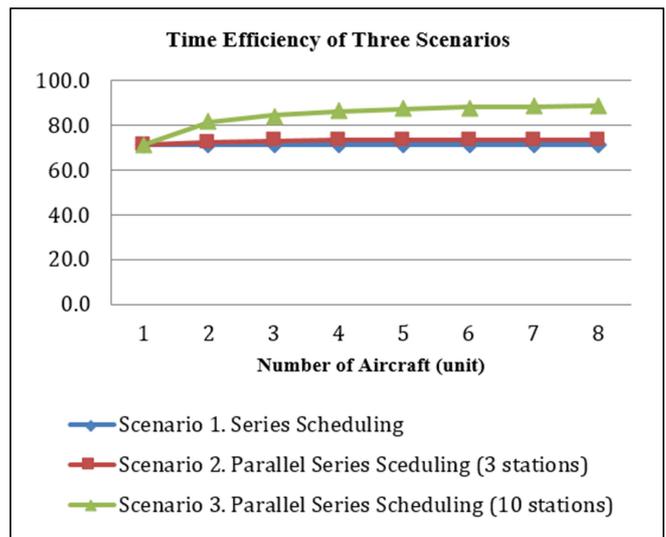


Fig 4. Time Efficiency of Three Scenarios (reference: Arena)

In Figure 4, it can be seen that, for eight aircraft units, scenario 1 provides efficiency of 71%, scenario 2 provides efficiency of 74%, and scenario 3 provides efficiency of 89%. Scenario 3 delivers greater efficiency compared to scenario 1 and scenario 2. In scenario 3, eight aircraft units require an overhaul of 251 working days. Thus, one plane, requires 31 working days. In the previous conditions, according to technical orders, the overhaul time per aircraft is 283 working days. Thus, an efficiency of 89% is obtained. This clearly contributes significantly to improving the

availability and readiness of the Hawk MK-209 aircraft.

However, this saving condition will only be achieved if sufficient and adequate amounts of maintenance support resources are available (Lee et al., 2008; Al-Shayea, A. M., 2012). These resources are a team of technicians, maintenance personnel (Rodrigo et al., 2016), software (technical order), equipment, which includes general tools, special tools, GSE power & non-power, spare parts and maintenance facilities / installations such as hangar, workshop, electrical, water installation, etc.

V. CONCLUSION

As a result, it can be concluded that the combined CPM PERT method and parallel series maintenance scheduling method can provide savings in the maintenance time of overhauling Hawk MK-209 aircraft from 283 working days to 31 working days or equivalent to an efficiency of 89%. This huge maintenance time savings significantly contributes to the availability and readiness of the aircraft to carry out the defense and security duties.

In further research, this study will be developed by the author using a combination of aircraft types constrained to supporting resources availability.

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