

Scheduling of Aircraft Design Project: A Comparison of Critical Path Method, Design Structure Matrix and Genetic Algorithm Approaches

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Abstract. The purpose of this study to minimize the overall duration of aircraft design project in Indonesia. This study proposes a combination method of Design Structure Matrix (DSM) and Genetic Algorithm (GA) for scheduling aircraft design project activities. DSM is used to identify the information flow between project activities. GA use reworks data, which was the result output of DSM, and activity duration to optimize the task sequence by considering the human resource constraints. A comparative analysis was conducted between the schedule based on DSM and GA and schedule based on Critical Path Method. Combination of DSM and GA obtained 63 days shorter project durations compared to CPM. This research is convenient for design projects scheduling with limited resources that can be obtained by using alternative methods other than traditional methods.

1 Introduction

In the next 20 years, IATA [1] predicts that the number of passengers in Indonesia will reach 220 million passengers and ranks five in the world. The aircraft production in Indonesia establishes connectivity between regions, especially in remote areas. The aircraft project is a product development project that is influenced by uncertainty factors and requires high technology [2]. Currently, aircraft projects in Indonesia have never been completed and require additional time for the design and production process. Delays in design projects often occur due to legal, technical, design changes and improper planning [3]. The complexity of the information flow may lead to rework or iteration of activities that related to project delays [4]. The aircraft design project requires optimal project scheduling that can help overcome the delays caused by rework, resource and precedence constraints [5].

2 Literature Review

Project management is an application of knowledge, skill, tools, and techniques to undertake project activities to meet project requirements[6]. The project management processes consist of initiation, planning, implementation, monitoring and control, and closure. It is important

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for every organization to have good project management [7]. The scope of a project must be clearly defined and limited. The project scopes include the number of systems implemented, the number of business units involved, and the necessary business process re-engineering. Any proposed changes then evaluated against business benefits, and if possible, will be implemented in the next phase[6]. The timing of the project should be well managed so that the available deadlines and budget can be met. Projects that fail to reach the targeted time, budget costs or meet the needs of stakeholders would have a negative impact on business, government, and individuals themselves [8]. In project planning, the project team may face uncertain or unexpected things [9]. Uncertainty factors can lead to performance variability that affects the project planning and scheduling process [10]

Planning and scheduling process are important factors that affect project success. There are several methods used in project scheduling, including Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Critical Chain Project Management (CCPM), Design Structure Matrix (DSM), and metaheuristic methods such as Genetic Algorithm (GA). Some studies suggest that traditional methods, such as CPM, PERT, and CCPM, have limitations in project scheduling that have complex information flows [2, 11]. This suggests that alternative methods should be proposed in addressing complex project information flow issues.

In contrast to traditional methods, DSM more effective for managing feedback information on construction projects, engineering design, and product development [4]. DSM could manage project activity efficiently especially on complex projects. GA have been widely used in project scheduling compared to other metaheuristic methods, particularly in DSM analysis [5]. DSM and GA used to optimize the project scheduling model[5]. DSM utilized to identify complex inter-activity relationships. Meanwhile, GA modeling used DSM framework to obtain decent initial solution candidates.

Combination of DSM and GA not only can be applied to projects with complex information flows, resource constraints, overlapping and iterative activities, but also identify the relationships between project activities, task sequence optimization, and resources allocation. Efficient task sequencing are required to obtain optimal project scheduling and resources allocation. Therefore, the purpose of this research is to develop scheduling of aircraft design project to get the shortest duration using Design Structure Matrix and Genetic Algorithm and compare it with Critical Path Method. The combination of both methods is expected to overcome the challenges of the complexity of the information flow and simultaneously optimize project scheduling with several constraints considered.

3 Methodology

In this study, an aircraft design project data from an aircraft design company in Indonesia were used. The data consist of 128 activities including activity duration, activity dependency, and human resources. The data that were verified and validated by project manager. Validated data processed using CPM and the combination of DSM and GA.

Data were processed by submit into DSM matrix. The interaction between project activities could be clearly seen. Project activities weredivided into three types: parallel, sequential, and coupled activities. Partitioning and tearing process utilized to minimize coupled activity on DSM matrix. Partitioning and tearing process obtained new task sequence. The new task sequence becomes the input on GA modeling.

The initial parameters used in GA modeling are population number, chromosome length, generation number, crossover rate, and mutation rate. The initial population is a set of chromosomes where each chromosome represents a solution vector composed of genes. In this study, chromosomes are a sequence of activities and genes are the identity of a project

activity. The chromosome generated in each population must comply with the predecessor and rework constraints.

Each generated chromosome is checked for its fitness and improved in each iteration. The function of the iteration is to obtain the best chromosome from each iteration process. The new chromosomes generated after the crossover and mutation process are examined based on their constraints and its fitness. Iteration stops after fulfilling the stopping criteria.

GA simulation used two scenarios obtained from DSM. Both scenarios were determined based on partitioning and tearing results on DSM. Comparative analysis conducted between schedule result of DSM and GA combination and CPM. Microsoft project were used to evaluate the effectiveness of the proposed method.

4 Result and Discussion

4.1 The Result of GA simulation: Scenario 1

Scenario 1 based on activity data obtained by DSM partitioning. Duration of each rework activity identified in scenario 1 assumed to be 0.25 of initial duration. Iteration activity in scenario 1 assumed to occur only once. The result of the solution obtained for each combination of modeling parameters shown in Figure 1. Based on Figure 1, the total project duration for scenario 1 is 966 working days. The minimum total duration obtained in combination 9 with the crossover rate is 0.9 and the mutation rate is 0.1.

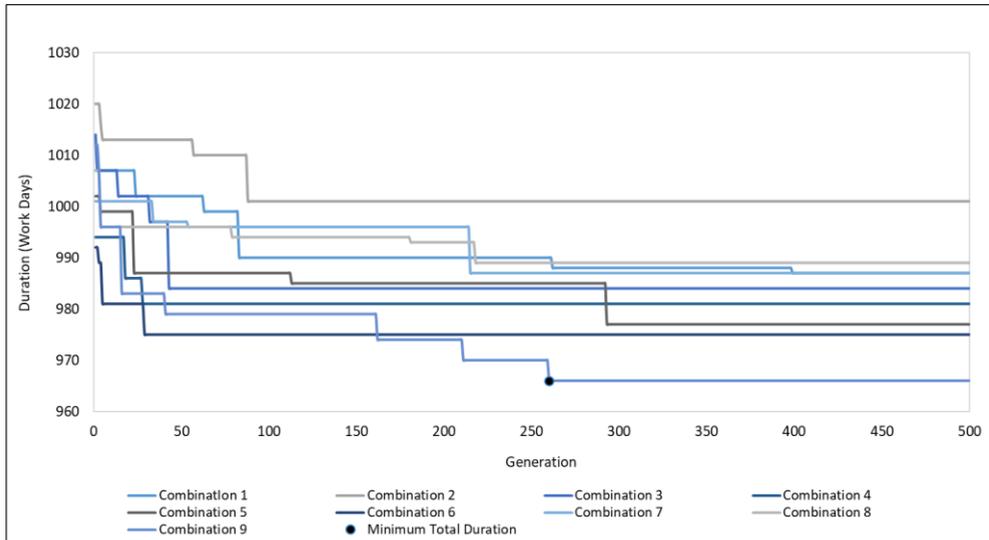


Fig1. GA Simulation Result: Scenario 1

4.2 The Result of GA simulation: Scenario 2

Scenario 2 based on activity data obtained by DSM tearing. The duration of each rework activity in scenario 2 divided into two, which are 0.25 and 0.15 of initial duration. The difference of rework factor due to feedback information received by some rework activities fewer than other rework activities. Iteration activity in scenario 2 assumed to occur only once. The result of the solution obtained for each combination of parameters is shown in Figure 2. Based on Figure 2, the total project minimum duration for scenario 2 is 941 working days.

The minimum total duration obtained in combination 5 with the crossover rate is 0.8 and the mutation rate is 0.05.

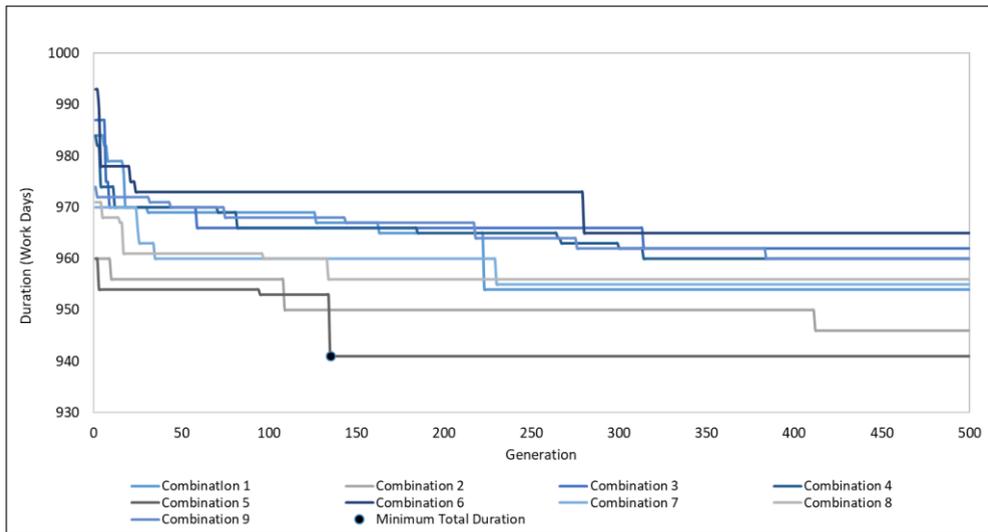


Fig2. GA Simulation Result: Scenario 2

4.3 Comparative Analysis

The use of DSM and GA in aircraft structure design projects resulted in a shorter total project duration. Based on CPM method, the total project duration obtained is 1.004 days. In scenario 1, project duration is 38 days faster than CPM. Meanwhile in scenario 2, the project duration is 63 days faster than CPM. CPM has a disadvantage in identifying rework activities. Rework of unidentified activities resulted in less optimal total duration.

The duration difference in both methods can be due to several things. In CPM method, the sequence of activities and the allocation of human resources applied to the project are processed manually. By using DSM, the complexity of the information flow can be identified. Complex projects such as an aircraft development, an information flow that unidentified lead to increase in the complexity of the project. Therefore, accurate activity identification is essential in project implementation.

Total duration of project is related to project cost and the sequence of activities related to the scope of the project. By using DSM and GA, the total project duration could be minimized by limiting the use of human resources. The sequences of activities obtained using the DSM and GA are more varied than CPM. This sequence of activity variations can result in optimal project schedule by fulfilling project constraints such as predecessor and rework activities.

5 Conclusions

This research combines DSM and GA to shorten the duration of the overall design project by considering the complexity of the information flow and human resources. Combination of DSM and GA obtained 63 days shorter project durations compared to CPM. Variations of activity sequences and the allocation of human resources are convenient to illustrate the project scheduling scenarios in aircraft project design.

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