Journal of Transportation Technologies, 2022, 12, 544-558
https://www.scirp.org/journal/jtts
ISSN Online: 2160-0481
ISSN Print: 2160-0473

A Comparative Study of Managing a Project Using Traditional Management Techniques and a Critical Chain Project Management Methodology in Aircraft Maintenance Field

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How to cite this paper: Yadav, D.K., Kulkarni, A. and Yao, H. (2022) A Comparative Study of Managing a Project Using Traditional Management Techniques and a Critical Chain Project Management Methodology in Aircraft Maintenance Field. *Journal of Transportation Technologies*, **12**, 544-558.
https://doi.org/10.4236/jtts.2022.124032

Received: July 5, 2022
Accepted: August 13, 2022
Published: August 16, 2022

Abstract

Aircraft on ground or down-time for its maintenance is a clear loss in revenue for an airline operation. With never ending competition and growing operating costs of aircraft, airlines continuously need to explore opportunities to reduce the aircraft down-time in order to remain sustainable. Due to round the clock operation feature of scheduled airlines, aircraft maintenance operations are generally carried out using traditional management methodologies instead of considering it as a project. Though aircraft heavy maintenance checks consist of several major tasks that can last from few weeks to a year, the maintenance organisations do not adopt modern project management methodologies. Therefore, this paper models a heavy maintenance check of an Airbus aircraft as a typical project and adopts contemporary project management methodology to explore the possibility of reducing the downtime. To this end, a case study has been done at an aircraft maintenance company to analyse the potential of this project management method in aircraft maintenance industry.

Keywords

Aviation, Airline, Aircraft, Engineering, Management, Maintenance, Operations, Planning, Project

1. Introduction

Project management methodologies to achieve efficient and quality assured deliverables of projects are being used in various industries for a while. Especially large civil engineering projects are executed effectively using modern project management methodologies. However, project management is not very popular in aircraft maintenance industry including airlines engineering operations or aircraft maintenance repair overhaul (MRO) companies. Though project management is now commonly used, and planning has become an essential part of a project, many companies plan their projects using Excel or PowerPoint instead of scheduling through critical path method, this traditional method does not guarantee the project completion as planned [1].

Aircraft maintenance managers confront with tight deadlines and handle tremendous pressure to start planned maintenance work packages as soon as possible (ASAP) once they receive the aircraft from flight operations for maintenance. Therefore, according to standard practices, maintenance tasks are scheduled ASAP even if all necessary aircraft parts required for the maintenance are not available at their maintenance facility. Such practices of starting tasks ASAP increase internal competition among different trades of aircraft maintenance or types of aircraft for available resources, which are generally limited. For example, trade supervisors of different fields, such as airframe, engine, avionics, and aircraft interior cabins start forcing their technicians for multitasking. As a result, work-in-progress (WIP) levels become unnecessarily high, and it overloads the back shops and the internal supply chain system. Likewise, other support departments, such as technical service and quality assurance also get strained, because they need to provide relevant documentation and technical support to execute the open tasks caused by multitasking. A combination of these factors actually increases delays that trigger a vicious cycle of starting more tasks ASAP leading to further delays. Consequently, hard work and expediting the tasks using labour overtime, the task cycle times remain long. As a result, the maintenance completion gets delayed, overall productivity remains low and costs overrun occurs frequently. According to [2], aircraft maintenance sector is extremely affected by fluctuations in the financial market and competitions. Hence, MRO organisations must reduce the maintenance costs and aircraft ground time for the maintenance. Furthermore, they should provide a high-quality service that meets airworthiness requirements and at a competitive cost [3]. Despite all these issues, maintenance managers are not very keen in adopting the modern project management methodologies as used by other fields of engineering industry, because they are not yet fully tested and validated in aircraft maintenance industry.

This paper is based on a case study, which was carried out using Airbus 320 aircraft that underwent a heavy maintenance check at a large MRO company located in Singapore. The study modelled the maintenance check as a typical project and used the critical chain project management method for executing the project tasks. Findings of the study clearly indicate that the project management methodology brings cost benefits and reduces the aircraft down-time period.

2. Problems Associated with Traditional Aircraft Maintenance Practices

Aircraft is a multi-technology machine involving many engineering fields including mechanical, electrical, electronics, structures, computer technology, material science, etc. As a result, a typical heavy maintenance check of an aircraft is to be performed by several technical personnel from these fields and concurrently often. The check involves completion of numerous engineering and testing tasks, and they must be completed within a specified amount of time in order to reduce the aircraft grounding period. [4] believe that the grounding time for a heavy maintenance check can be influenced by strategic and tactical issues of the maintenance company including available technical personnel, required spare parts of the aircraft, and financial value of the planned tasks. Furthermore, the checks must meet the civil aviation regulatory requirements and airworthiness standards, because aviation is still a highly regulated industry. This exerts a tremendous professional pressure on the personnel and also on revenue of MRO companies and the airline operators. Therefore, aircraft maintenance is a multidisciplinary task that frequently requires tradespersons from different engineering fields, such as airframe, propulsion, and avionics to work concurrently on a typical aircraft system. Therefore, it is not an engineering or a supply-chain issue. Instead, it is a project management problem, if a cost overrun happens or aircraft downtime increases. Consequently, a management approach that cut across traditional functions fields becomes necessary in order to meet planned goals and deliverables in time and within the cost. According to [4], a teardown execution approach and modern project management methodology should be considered by aircraft maintenance managers to make MRO companies more cost effective and also to improve the situation of prolonged aircraft downtime required for carrying out heavy maintenance checks.

[5] argue that aircraft maintenance scheduling is considered as an end-stage in an airline operation, but it has possibilities of cost reductions. Traditional aircraft maintenance management system considers a mission accomplished if individual tasks are completed within stipulated time. Therefore, every individual task duration estimates must be accurate with a high probability of completing the task on time. Consequently, a safety buffer or contingency period is added to the task duration in planning stage itself to ensure that task completion probability remains high. This may absorb the lost time caused by multitasking and variation in tasks, if any. However, this safety buffer remains hidden in the task inflating the task duration as a result. With the inclusion of safety buffer into a task duration, there is more than the required time available for completing the task. Furthermore, this management practice does not generally offer any incentive to complete the task before a deadline. This behaviour triggers unproductive situations, occasionally. For example, student syndrome where people try to put off the task until the task deadline approaches. The task in this case is often delayed (**Figure 1**).

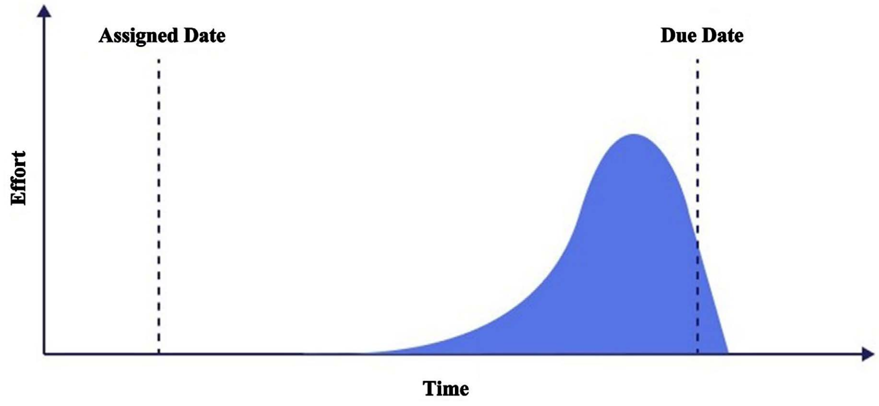

Figure 1. Student syndrome in project management (after [6]).

According to [6], student syndrome is a legitimate part of any project life cycle that may end up in a constraint. This demonstrates that human factors play an important role in a project execution, because it influences the time of task completion. It may also affect the whole project path, if the project has tasks which are interrelated. As a result, the whole project may get delayed. The researcher believes that the student syndrome generally occurs, if a participant has been allocated excess time for carrying out a task. Similarly, according to Parkinson's Law, tasks are executed at a slower pace to fill the available time duration. As a result, the safety buffer included at the planning stage is wasted and if a task duration increases due to some reason, the project deadline also gets affected.

The current maintenance management practices of starting the maintenance tasks as soon as possible once the aircraft is grounding for a maintenance check without ensuring availability of all required resources force maintenance personnel to work on more than one task at once. This creates multitasking situation that turns unmanageable occasionally. According to [7], multi-tasking happens due to high demand on a resource's time. Consequently, the resource is forced to try their hand on a task before completion to work on another task. Though the intention of high resource utilization looks good on surface, but it adds wasteful practice into managing the project [8]. **Figure 2** indicates the hidden cost of multi-tasking.

Similarly, the unknown-work phenomenon also pushes the schedule towards potential delays. For example, an aircraft sometimes reaches its performance limits long before its compressor limiting operating cycles [9]. As a result, it needs extra restoration work. Similarly, some maintenance incidents are impossible to predict. For example, unscheduled engine removals occur due to foreign object damage, bird strikes or other environmental impacts that brings in unknown work. Thus, the personnel keep switching between tasks that leads to elongation of planned time estimates and it further wastes the embedded task safety buffer in execution. Likewise, according to classical maintenance management techniques, tasks are managed by deadlines or milestones and task

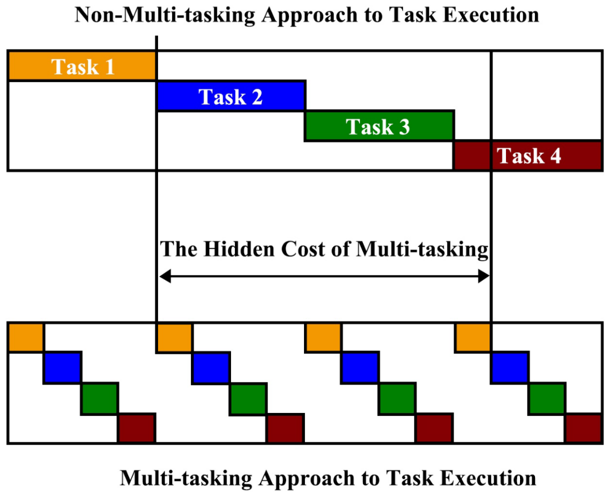

Figure 2. Execution approaches in a project (adapted from [8]).

owners are held accountable for any delay related to their respective task completion. As a result, the task owners resist reporting any early finishes. The belief is that if an early finish is reported, the task owner is held responsible for over estimation. Furthermore, the management may also tend to shorten the duration of similar task on other similar projects. This shorter time estimate may not offer sufficient safety buffer to the project in case of variation though. Hence task owners ensure that sufficient safety margin is always available in each task estimate, the margin remains hidden, and it is used in execution of the task. Though the resulting longer task completion duration affects the entire project, but benefits from tasks finished early are not passed on to the project.

3. Hypothesis and Case Study

Available literature related to aircraft maintenance suggests that delays in aircraft maintenance tasks completion are primarily caused by uncertainty and variation in tasks that leads to multitasking and overestimation. Secondly, the safety margin built into the task duration is wasted due to student syndrome and Parkinson's Law that delayed the whole project as a result. Thirdly, the current management practices of managing the tasks by milestones and deadlines that force managers to start jobs as early as possible without considering the availability of resources leading to multitasking and increasing the task duration. Finally, the policy of no incentive for finishing the task early. Modern project management methodology, such as a critical chain project management method may present a solution to mitigate the uncertainty and task duration variation by incorporating safety buffers that reduces the wastage caused by the student syndrome and Parkinson's Law phenomena. This can be done by using aggressive task duration estimation steps. Similarly, the multitasking issue can be handled by designing a critical chain path based on resources and task constraints. Similarly, managing the completion deadlines and milestones by monitoring the progress based on buffer consumption. Therefore, it can be hypothesised that the modern project management methodology can be applied in aircraft maintenance industry by considering the aircraft maintenance checks as projects. The case examined by this paper is mentioned below:

A maintenance check of an Airbus 320 *transport aircraft was professionally observed from beginning to the end at a civil aircraft maintenance facility approved under civil aviation regulatory framework. The aircraft underwent a heavy maintenance check at this large MRO organisation located in Singapore and the maintenance check was modelled as a typical project. Subsequently, it was managed and executed according to critical chain project management methods and principles. As a result, a detailed planning was carried out defining the scope of work scope and preparing required job cards after negotiating with the aircraft owner about the value and period of the project. Hence a maintenance schedule was created and handed over to the maintenance management team of the project.*

The plan was then executed by the team corresponding to the schedule, and the tasks were carried out by appropriately qualified aircraft engineers and technicians according to their respective trades. Consequently, the tasks were carried out by specialized technical personnel from airframe, engine, avionics, and non-destructive testing (NDT) fields. The personnel were further divided into various sub-teams covering aircraft wing, fuselage, engine, interior cabin, etc. Required resource allocation was done by the management team on a daily basis to ensure and monitor effective utilisation of the resources. Similarly, the tasks were completed daily and the job cards were signed off and handed over to the planners. In addition, the scientific or engineering problems encountered were tackled by professional engineers using engineering judgements or by consulting the aircraft manufacturer.

4. Methodology and Data Collection

The single case analysis method was used in this paper a research methodology. Consequently, a heavy maintenance check of an Airbus 320 was modelled as a project for data collection. Therefore, the maintenance planning documents supplied by the aircraft manufacturer was used to plan and prepare the aircraft maintenance schedule. A direct observation of planning and execution of the aircraft maintenance tasks was done by the second author while the maintenance work was carried out by the relevant technical personnel of the MRO establishment at its facility. This assisted the authors to identify the maintenance management issues experienced by the organisation and its stake holders. The case study methodology was chosen, because there were not enough data related to aircraft maintenance management are available in public domain. From direct observation of various maintenance task procedures, it was also become possible to know whether the tasks were carried out in accordance with the civil aviation regulatory standards or not. As multiple case studies were not feasible, a single case analysis was considered adequate, and the problems identified in the case study were generalized for all types of aircraft maintenance checks performed by an MRO facility.

A maintenance schedule for the maintenance check was designed in accordance with guideline of the maintenance planning document (MPD) of the aircraft manufacturer, which the Airbus Company in this case (**Table 1**). A typical heavy maintenance check requires 40,000 to 50,000 man-hours of schedule work and it may be extended to additional 10,000 man-hours of unanticipated work [10]. The maintenance check schedule is a large document which not possible to reproduce here in total. So, **Table 1** shows only a part of it. Furthermore, references and identity information of the related MRO organisation has been removed from the schedule document to protect privacy as requested by the organisation. Therefore, evidence by direct observations of the maintenance planning and project execution process was undertaken by the authors in unclassified manner. As operational planning involves short-range detailed planning and execution of the heavy maintenance check, after the project was accepted more detailed information about resource and material requirements were made available from technical services department and process planning section of the organisation. The work packages from the customer were broken down into smaller activities with specific duration and resource usage based on technical and detailed process planning information. As a result, the planning and execution was done according to critical path method. In fact, most aircraft maintenance projects must deal with tremendous uncertainties. They are caused primarily by unknown work, which is usually hard to predict. Hence, it is difficult to plan. The unknown work is generally related to aircraft structural damages caused by stresses [11]. Unfortunately, aircraft spare parts are not readily available at maintenance facilities often for the unknown work. The unknown work also contributes to project delays and a delay in tasks on the project work chain path feeding into the longest chain can impact the project by delaying a subsequent task on the critical chain. Therefore, feeding buffers were required on a feeding path and the critical chain to absorb this delay.

At the project execution stage, resources were dedicated to a typical task until it was completed to prevent multi-tasking. Consequently, each task was started as soon as the resource was made available and prerequisite tasks completed. Additionally, all resources on the project were given clear priorities considering the project as a whole. The tasks were prioritised based on rate of buffer consumption and priorities were assigned to completing the task that had potential to affect the project critical chain before completing any other task on feeding path. Likewise, the project staff were encouraged to follow the roadrunner approach, so that the work could be performed at the fastest possible speed to the completion without compromising quality of deliverables. As task duration estimates margin reduces, they drive resources to meet more aggressive durations and limit the student syndrome and Parkinson's Law behaviours. Similarly, the managers monitored the buffer consumption and acted to reduce its rate of consumption. In this situation, it was important to monitor the buffers and the remaining duration of tasks.

Table 1. First week tasks of a typical maintenance schedule of an aircraft.

SN	Workshop transit items	7 Oct 12	11 Oct 12	5 days
1	NLG torque link apex pin for MPI	7 Oct 12	7 Oct 12	1 day
2	Perform magnetic practice inspection Of the elevator inboard and Outboard servo controls rod eye ends	7 Oct 12	9 Oct 12	3 days
3	Portable halon fire extinguishers for weight check	7 Oct 12	11 Oct 12	5 days
3	Remove lavatory A, E, D fire extinguisher bottle for weight check	7 Oct 12	11 Oct 12	5 days
4	Fwd and Aft gallery drain valve for cleaning (if applicable)	7 Oct 12	11 Oct 12	5 days
5	Fwd cabin vacuum toilet rinse valve for cleaning	7 Oct 12	11 Oct 12	5 days
6	Functional check Of pressure reducer for cargo fire extinguisher system	7 Oct 12	11 Oct 12	5 days
7	Eng #1; clean integrated drive generator (IDG) Oil cooler	7 Oct 12	11 Oct 12	5 days
8	Avionics—cleaning of Oxygen masks	7 Oct 12	11 Oct 12	5 days
SN	**Major modifications**	**6 Oct 12**	**12 Oct 12**	**7 days**
1	Mod intro bearing assy On retract jack SB A320-57-1157 V00 R00	6 Oct 12	9 Oct 12	4 days
2	Avionics—Mod inst wiring prov for ATC/XPDR	6 Oct 12	12 Oct 12	7 days
3	Avionics—Mod install RS422 wiring	6 Oct 12	13 Oct 12	7 days
4	Avionics—Mod inst FDIMU from teledyn	6 Oct 12	14 Oct 12	7 days

Continued

5	Avionics—Mod intro wiring provision for FDIU/DMU	6 Oct 12	15 Oct 12	7 days
6	Avionics—Mod-wire harness inst at interface section 19/19.1	6 Oct 12	16 Oct 12	7 days
7	Wing: Install trunnion sliding panel with new attachment IAW SB A320-57-1147 Rev 03	7 Oct 12	9 Oct 12	3 days
8	Eng #1, Eng #2; O/w mod rpl deploy tube adaptor "o" ring	7 Oct 12	9 Oct 12	3 days
9	Mod cockpit door module improvement	8 Oct 12	8 Oct 12	1 day
SN	**Major restoration**	**10 Oct 12**	**13 Oct 12**	**4 days**
1	All required access panels and fairings	10 Oct 12	13 Oct 12	4 days
2	All fuel tank access panels	10 Oct 12	13 Oct 12	4 days
3	Electrical power On	13 Oct 12	13 Oct 12	1 day
SN	**Functional checks**	**13 Oct 12**	**14 Oct 12**	**2 days**
1	System functionals	13 Oct 12	14 Oct 12	2 days
2	LDG retraction test	14 Oct 12	14 Oct 12	1 day
SN	**Final checks**	**14 Oct 12**	**15 Oct 12**	**2 days**
1	Refuel/leak check	15 Oct 12	15 Oct 1 2	1 day
2	Eng wash+ Eng run	15 Oct 12	15 Oct 12	1 day
3	Aircraft handover	15 Oct 12	15 Oct 12	1 day

5 Oct 12	6 Oct 12	7 Oct 12	8 Oct 12	9 Oct 12	10 Oct 12	11 Oct 12	12 Oct 12	13 Oct 12	14 Oct 12	15 Oct 12
day 1	day 2	day 3	day 4	day 5	day 6	day 7	day 8	day 9	day 10	day 11

5. Discussion and Analysis

The aircraft maintenance heavy check direct observation and analysis of various data including task completion rate indicates that the project budget overrun and project completion time delays are affected by interdisciplinary trade tasks interdependency, resource usage overlap, unknown-work and sudden variation of tasks because of the unknown-work. Multitasking occurs when maintenance managers insist to start the tasks as early as possible without ensuring the availability of all the required resources. MPD was not effectively used to address the tasks and resources interdependency early as the project progressed (**Table 2** and **Table 3**). The direct observation had also presented the opportunities to examine compliance with standard project planning, execution and tracking methods used during the project in addition to civil aviation regulatory compliance and airworthiness standard conformity.

Table 2. Example of project task time overestimation.

S. No	Maintenance task	Project planned man-hours	MPD suggested man-hours
1	Aircraft engine removal or installation	39.00	16.00
2	Aircraft avionics compartment smoke detectors replacement	65.00	2.00

Table 3. Sample page of maintenance planning document (after [15]).

Task Number	Zone	Description		Threshold Interval	Source	Reference	Men	M/H	Applicability
552600-01-1	335 345	Elevators attach fittings: check of elevator attachment fittings for wear, LH/RH	AF CHK	I: 12YE	SIL	552600-200-002. SIL55-35	1 1	2.50 2.50	All
		Prep: elevator removed; elevator servocontrol removed					*	TBD	
		Access: 334BB, 334DB, 334FB, 334HB, 344BB, 344DB, 344FB, 344HB					* *	0.13 0.13	
553600-01-1	325	Rudder attachment fittings	AF CHK	T: 6YE	SIL	SIL55-038	1	6.42	All
		Check of rudder attachment fittings for wear		I: 6YE					
		Access: 325BL, 325BR, 325CL, 325CR, 325DL, 325DR, 325EL, 325ER					*	0.16	
554611-01-1		*****task deleted*****							
		*****end*****							
Systems and powerplant program: Stabilizers Rev. Date: Jun 01/12 Section: 2 - 55 page 1									

The critical chain methodology had effectively managed these issues. However, [12] had investigated the possibilities of implementing the critical chain method for product development program. They achieved mixed results that were not very promising in that sector. Nevertheless, a very useful feature of this methodology is that it especially tackles various human factors issues [11]. The research also indicates that the methodology reduces the amount of work during execution stage by calculating the work according to constrained resources, because this resource affects the work that can be completed. Similarly, it eliminates safety margin buffers from individual tasks and add them into total project buffer. This can provide an extra cushion to the project timeline. Secondly, there is no need to prepare precise timeline for resources at planning stage and develop the timeline while executing the project depending on the residual buffer remaining. Consequently, the tasks with lowest buffer remaining will get the highest priority. This improves overall efficiency of the project. However, allocation of resources for multitasking needs to be discouraged. This can also reduce strain on project support services that provide technical documents, spare parts and engineering advice related to unknown work. [11] did a similar study and found that the critical chain project method used at a United States Air Force maintenance facility managed to reduce the aircraft down-time by five days for a typical heavy maintenance check. As a result, the aircraft was available for additional flight operation time that translates into extra revenue generation of US$40,000 per day. Though revenue or finance balance sheet may not be important for military operations, but readiness of aircraft for flight is crucial. According to [13], the readiness depends on a total number of available aircraft as well as the total remaining flight time of all available aircraft in a fleet. Hence, one of the objectives of maintenance is to achieve maximum availability of the aircraft for flights. This certainly presents a convincible case for adoption of the method not only at civil MRO companies, but also for military aviation maintenance facilities.

Releasing work according to availability of overloaded or limited resources may seem counterproductive at times, because it is against the practices of completing the work rapidly. Conversely, releasing work without considering the situation of constrained resources may negatively affect the project completion time, it was observed. The critical chain methodology had assisted in measuring the project progress against the plan differently than the traditional style. For example, visual signals were used to indicate the progress instead of conventional methods such as Gantt charts and due dates. For example, showing the project status as amber colour means prepare a recovery plan. Likewise, the red indicates that implementing the recovery plan is necessary. This helped in reducing the student syndrome issues. Likewise, the project indicators were updated regularly, so that the management team could keep a strategic control on the task completion period. This was analysed using direct observation of multiple teams that carried out different tasks during the execution stage of the project. The results prove the hypotheses that the critical chain methodology can reduce the student syndrome problem. [14] suggests that the critical chain project management supports Murphy strikes and risks that improve on-time delivery of a project. The researcher further stated that this feature shares the safety margins that benefit the overall project. Additionally, it also assists in specific time allocations for unplanned tasks emerged as a result of unknown work. However, these buffers need to be estimated according to statistical data collected from other similar projects.

While analysing the number of man-hours allocated for any typical maintenance task by the MRO Company and the required hours suggested by the MPD supplied by the aircraft manufacturer, a rampant overestimation was noticed (**Table 2** and **Table 3**). At time, it seems that the overestimation is intentional instead of a professional error or technical misjudgement. For example, the aircraft avionics compartment smoke detectors replacement task was planned to be completed in 65 man-hours by the project management team, but MPD suggests only 2 hours for this task. Similarly, removal or installation of an engine from the aircraft was planned to be completed in 39 man-hours. However, the MPD suggests 16 hours for this task. Likewise, many other overestimations of the task completion man-hours have been noticed throughout the project plan. This might be done to mitigate the delays caused by unknown-work or it could be driven by financial reasons to enhance profit for the company, because MRO companies charges their customers according to number of man-hours spent on the maintenance tasks in addition to other charges, such as cost of spare parts, consumable, insurance, etc. This may not be the case, if an airline carryout the maintenance in-house at its own maintenance facilities. Hence, the overestimation issue seems to be subjective and depending on where and how the maintenance is being performed. Though the task durations estimated in the MPD are the minimum duration required to complete the tasks assuming the availability of all resources and after carrying out required facilitation of the tasks, they still can be considered as aggressive. The facilitation work may involve access panel removal, opening of enclosed sections of the aircraft, securing the electrical wiring, and plumbing to prevent damage and protecting aircraft instrument. For example, many panels are required to be opened before performing maintenance, and they need to be closed after the maintenance task is completed. This interdisciplinary work causes task interdependency which is not considered in MPD suggested man-hours.

6. Conclusions

Many fields of engineering use critical chain project management methodologies to efficiently manage and control large projects, but it is not yet popular in aircraft maintenance industry. According to current aircraft maintenance practices, the maintenance work is to be started and completed ASAP upon receiving the aircraft from flight operations department or from external customers. This initiates the work without even ensuring the availability of necessary resources, such as required spare parts, sometimes. Consequently, an internal competition for taking over the resources occurs among various trade supervisors involved in the maintenance. Subsequently, it overloads the resources and negatively affects the internal supply chain system. It brings additional strain on support services too, which are responsible for providing technical documents, quality assurance, aircraft spare parts and consumables. Finally, these factors increase the probability of delay in project completion. On project management front, it opens the flood gate for multitasking that is not considered as an efficient practice in a project environment, because it may lead to labour overtime that put pressure on project costs. However, it is observed that many maintenance managers are not very keen in adopting the modern project management methodologies despite experiencing these issues.

This study was carried out at an MRO company facility located in Singapore using direct observations while an Airbus 320 aircraft was undergoing a heavy maintenance check. Therefore, in order to examine the feasibility of applying the critical chain project management method in aircraft maintenance field for executing the maintenance tasks the check was modelled as a typical project. The results demonstrates that the project management methodology reduces the aircraft grounding time, thereby cutting the maintenance cost and enhance the aircraft operator's revenue by improving the aircraft availability for flight operations. Aircraft flight dispatch reliability was not evaluated in this study though. This research presents that combining the feeding buffer into the total project buffer assists in mitigating the overall project delay. Likewise, using visual indicators instead of traditional due date method for project progress evaluations helps in reducing the student syndrome in a project.

Extensive overestimation of man-hours allocation for many maintenance tasks by the MRO maintenance team was noticed during this study. These are more than ten times than the hours suggested by the MPD supplied by the aircraft manufacturer. As MRO companies charges their customers for aircraft maintenance based on several man-hours spent to carry out the planned work, it seems to be a revenue enhancement exercise for the MROs. The estimation may be very different in case of the maintenance carried out in house by the aircraft owner or operating airline, it is assumed. Though the task durations estimation provided by the aircraft manufacture does not include facilitation work required to carry out the maintenance, the planned duration by the MRO may still look excessive. While the skillset of a maintenance worker team may affect the deliverable of an engineering project, this study did not examine the capabilities and competency levels of the aircraft maintenance teams, because it was assumed that they all meet the qualifications standards laid down by the relevant national civil aviation administration.

7. Future Research

This research is primarily focused on one type of civil transport aircraft. Aircraft maintenance is evolving rapidly with time and different manufactures may have different approaches for maintaining the continuing airworthiness of their aircraft and aeronautical products. Different aircraft types have different operating situations and capabilities. Therefore, their maintenance needs also differ. Consequently, it will be interesting to see, if a similar study can be done on aircraft manufactured by other manufactures including military aircraft producers.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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