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Critical needs for piston engine overhaul centre in Malaysia

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Abstract. Piston engine overhaul centre (PEOC) is the branch of aviation Maintenance, Repair and Overhaul (MRO) providers, which plays a pivotal role in maintaining the fleet of business and commercial aircraft in the world. The centre typically offers three main MRO capabilities: airframe, engine and component services. Companies holding a PEOC(s) are all subjected to stringent procedures and conditions regulated and audited by the International Civil Aviation Organization. Currently, piston engine maintenance and repair for Asian countries is conducted only in Singapore. The focus of this study is to establish the needs for a PEOC in Malaysia, which will cater almost all small local aircraft companies such as transport and flying school companies.

1. Introduction

Today, there are still many aviation companies that fly piston engine aircraft for their core business. Depending on their nature of business, some aircraft companies do have a significant preference in operating piston-powered or turboprop aircraft in their fleet. As a further indication on the continued relevancy of the piston engine use, there are also extensive studies on piston engine that are still being conducted, such as the study on reducing CO₂ gas emission from the aircraft exhaust [1]. The ongoing use of piston engine creates a need for its maintenance and repair services, which are provided by the piston engine overhaul centre (PEOC). This is a branch of aviation Maintenance, Repair and Overhaul (MRO) providers that typically offers three main MRO capabilities: airframe, engine and component services.

The Malaysian aviation industry has progressed immensely over the last few decades. Originally with only a single airline monopolizing the local industry, Malaysia now has at least six commercial airlines excluding charter flight companies and airfreight carriers [2]. These main local international airlines include AirAsia, AirAsiaX, Malaysia Airlines and Malindo Air while the other two, FireFly and MASWings focus on domestic destinations only. Aside from the commercial airline companies, the Malaysia's Royal Military Air Force fleet is also consisted of turbine-powered jets. Whilst these major airlines utilize turbine engines, many smaller private aviation companies and clubs actually have piston engine aircraft that are often being used for recreational purposes and activities. Table 1 shows the number of piston engine aircraft owned by several local companies and also their corresponding maintenance costs (by PEOC in Singapore). This data is obtained from interview sessions with the management team of the companies. Note that a pseudonym is used for each company in Table 1 to hide their actual names.



Table 1: Piston engine distribution in Malaysia and their maintenance cost

Name of Company	No. of Piston Engine	Repair Cost from Service at PEOC in Singapore per Engine			Transportation Cost per Engine
		4-cylinder	6-cylinder	8-cylinder	
Company M	32	RM 35000	RM 45000	RM 65000	RM 4000
Company H	25				RM 7000
Company A	41				RM 7000
Company S	9				RM 5000
Company A2	12				RM 5000
Company F	6				RM 2000
Company I	13				RM 14,000
Company C	6				RM 4000
Company A3	3				RM 5000
Company P	4				RM 4000
Others	57				RM 5500

It can be observed from Table 1 that the total number of piston engine in Malaysia is 207. Based on this significant number of engines and their relatively high maintenance costs, it is believed that there exists a crucial need for the establishment of a PEOC in Malaysia. Currently, there is no such centre locally or in other Asian countries except Singapore. For small aviation companies, having their own manpower for piston engine MRO is not practical due to the high cost. However, prior to getting the approval from the Malaysia's Department of Civil Aviation (DCA), there is a need for a study to be conducted to examine the existing needs of PEOC among local aviation companies that operate piston engine aircraft, which will support its establishment in Malaysia

2. Maintenance of Piston Engine

It has been stated that the MRO of complex capital goods is afflicted with challenges with regard to several processes [3]. Complex capital goods include diesel locomotives, aircraft engines, industrial gas turbines and wind turbines. The employees working in this field are highly qualified and specially accredited. Therefore, the supply of new employees is limited. At the same time, the wages for such labour are high. Consequently, the capacities have to be planned as accurately as possible.

This is one key challenge for MRO companies because the planning of regeneration processes is much more complex than that for customary production processes due to high diversity of parts and damage. The process cannot be standardized as easily because every new regeneration job is unique in its damage set. Thus, the workload of upcoming jobs is unknown beforehand, which makes them even harder to plan. The capacity planning in the field of MRO has hardly been studied scientifically and currently, no practical relevant, rule-based and thus transparent method or software application that is suitable for planning or controlling the regeneration of complex capital goods exists. The regeneration process for an aircraft engine begins after its removal from the wing. The engine is then transported to the designated facility, where an incoming inspection is carried out to determine the damage to the engine and the necessary work to be carried out. After disassembling the engine into its parts, the parts are inspected again to define the exact damage and the processing of the parts.

A decision has to be made as to whether the part is serviceable, repairable or has to be purchased anew. The reassembly of the stored, repaired and purchased parts takes place as soon as the necessary parts are available. The regeneration ends when a test run of the reassembled engine is successful. The overall summary of the regeneration process is shown in Figure 1.

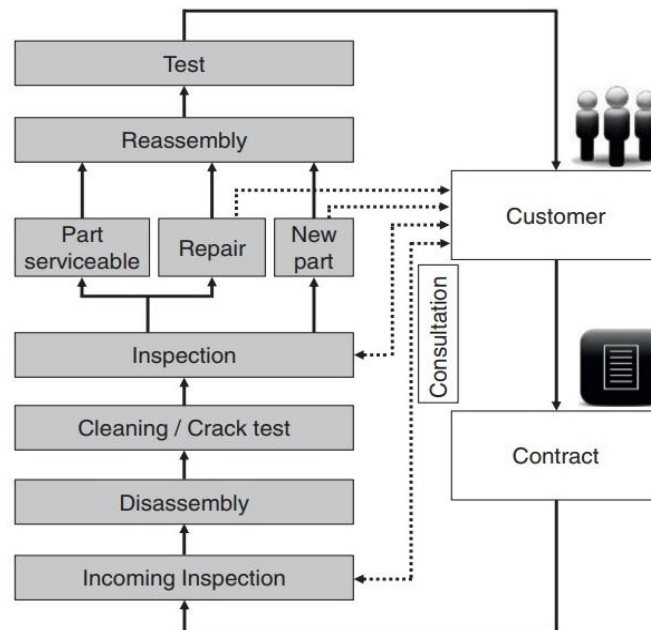


Figure 1: Regeneration process flow [3]

A significant challenge in aircraft engine is quantifying its residual life to overhaul. The algorithm described by Piancastelli et al. (2012) calculates the residual life of a petrol piston engine with a good level of reliability [4]. This method has been tested on few small, latest-generation, naturally-aspirated aircraft and racing piston engines, and has been demonstrated to be effective in several experiments. This method is implemented directly on the electronic control system of the engine with very few lines of C-code. The method can also be used in many industrial engines. This innovative method assumes that only two main factors (power level and wear) affect engine durability or time between overhaul. These two factors are considered separately and combined with the worst case criteria. The wear is assumed to follow the logarithmic law and a formula similar to the Miner's law for material fatigue is used, making it possible to calculate the power-level curve with the knowledge of only two points. The wear curve is also related to elapsed engine cycles. All in all, the algorithm is very simple and can be implemented with just a few lines of software code accessing data collected from existing sensors. The system is currently used to evaluate actual residual life of racing engines.

3. Comparison Analysis

Based on the data in Table 1, several comparison analyses can be made to justify the proposal for the establishment of PEOC in Malaysia. Like any other businesses, Malaysian aviation companies have always strived to offer the best services for their clients while acquiring high profits at the same time. However, the operational costs have been challenging their business model for years now, primarily because of several factors such as manpower, currency difference and transportation costs that include movement of their piston engines into another country.

The overhaul and repair services are important segments of the remanufacturing industry. Such services are traditionally characterized by complicated process plans, stochastic operations and the usage of routable inventory [5]. This includes, for examples:

- highly variable operations including disassembly that disassembles an asset into parts, part repair operations and assembly that assembles the repaired parts back into an asset. The disassembly operation is often time consuming and performed in conjunction with a “discovering” inspection process. The uncertain service scope is often a combined result of customer requirements and the inspection process
- highly variable processing time for various operations

- existence of serial-number-specific-parts (SNS) that are required to be assembled into the original assets they belonged to, rotatable parts that are refurbished parts satisfying certain qualifications for general use, and the concomitant rotatable inventory

With this in mind, PEOC has just the right touch as business opportunity in Malaysia: when there are customer needs, there are business needs [6]. This situation eventually reflects the Target Platform Needs and Certification Requirements at applicable standard for delivering aircraft with piston engine. This is called System Level Requirements (SLR) as shown in Figure 2.

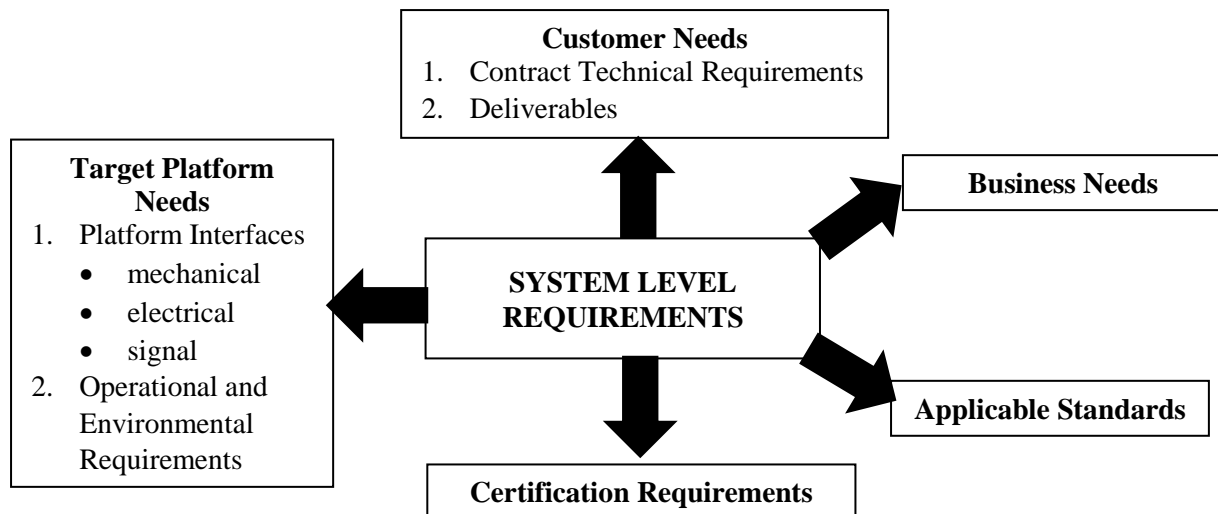


Figure 2: System Level Requirements (SLR) [6]

For SLR, the main contributors are target platforms' need (the interfaces as well as operational and environmental conditions), customers' need, business needs, applicable standards and the certification basis, if applicable. Table 2 tabulates the overview of elements forming the engine system requirement set. The initial phase of the project agreement among the stakeholders is the most affordable and a significant assignment to be accomplished. Project's incorporator makes an effort to reach agreement among the stakeholders on what to be delivered, how the product should comply with the customer requirement and when it should be accomplished considering the acceptance criteria of the product. Project stakeholders perform brainstorming, interface analysis, interviews, observation, requirements workshop, surveys and questionnaire. The main purpose of these activities is to obtain and understand project business needs. In this way, technical requirements of contract are established. Also, customer defines all relevant deliverables to the contractor. At this stage, agreement is accomplished, technical requirements of contract are set and deliverables are declared between the engine developer and the customer. This model can be applied when PEOC needs to be established by adjusting the model in the form requirements in Malaysia. Hence, the relevant companies will no longer have to comply with additional Singapore's aviation law requirements as they can simply proceed with their current local Department of Civil Aviation (DCA) regulations.

With the piston engine maintenance, the main focus of Target Platform Needs is definitely from the mechanical perspectives. Besides having sufficient manpower for the tasks, it is crucial to note that doing the maintenance work locally in Malaysia is also considerably easier especially in assembling and re-assembling engine parts, not just because of the geographical advantages but also due to similar operational and environment requirements by the local DCA. For instance, in Malaysian Institute of Aviation Technology, piston engines experts are not only experienced trainers but they are also fully-certified by DCA for maintenance work. Apart from that, the aviation companies previously listed in Table 1 already have their own in-house manpower for maintenance as tabulated in Table 2. Despite having these numbers, the companies still have to outsource the maintenance to Singapore because of the absence of a PEOC here in Malaysia.

Table 2: Available manpower for piston engine maintenance by company

Name of Company	Engineer	Technician	Mechanics	Manager	Finance Manager	Total
Company M	2	15	6	1	1	35
Company H	2	12	5	1	1	21
Company A	3	20	6	1	1	31
Company S	1	3	3	1	1	9
Company A2	1	2	1	1	1	6
Company F	1	1	1	1	1	5
Company I	1	3	3	1	1	9
Company C	1	1	1	1	1	5
Company A3	1	1	-	1	1	4
Others	6	6	15	9	9	35

In addition to having their own manpower, the numbers can actually increase occasionally because, if PEOC is established in Malaysia, the actual maintenance costs would be lower compared to what other countries such as Singapore and USA are offering because of the currency differences. From that point onwards, it will be more competitive as more companies, especially from Southern East Asian regions, would be looking forward to cheaper rates compared to current Singapore's prices. Hence, the possibility of more job tasks, which will undeniably require more manpower, is substantial and this is nothing short of good prospects for the piston engine industry in Malaysia.

4. Conclusion

Currently, piston engine maintenance and repair for Asian countries is conducted only in Singapore. It has been highlighted in this paper that the demand for maintenance and repair of piston engine aircraft, either from local or international companies, is significant especially from the perspectives of cost and logistics. In addition, the readiness of local manpower for the work tasks seems to be adequate. Hence, it can be taken that the needs for a PEOC in Malaysia has been established.

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