Impact Assessment of Extended Overhaul Intervals on the Reliability and Efficiency of High-Power Outboard Motors

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Abstract—*This study investigates the impact of extending major overhaul intervals on the reliability and operational efficiency of high-power outboard motors (OBMs) used in the Sri Lanka Navy (SLN). As high-power OBMs are critical for operational requirements (Cedric Craft) and for civil transportation (Lagoon Craft) in SLN, their performance and maintenance schedules directly affect mission readiness, fuel economy, and lifecycle costs. Traditionally, major overhauls are performed at fixed intervals based on manufacturer recommendations or operational experience. However, the increasing demand for cost-effective maintenance practices and the shortage of spare parts during the COVID-19 pandemic and the financial crisis in Sri Lanka have led to a reevaluation of these intervals. This research aims to assess whether extending the overhaul schedule beyond standard recommendations can maintain acceptable levels of reliability and efficiency or if it increases the risk of mechanical failures, fuel inefficiency, and unplanned downtime. The study uses operational data from field-deployed OBMs, maintenance records, and insights of field expertise to analyze failure trends, performance metrics, and cost implications. Results are expected to inform optimized maintenance strategies that balance longevity, performance, and operational economy in high-power OBMs.*

Key words- **Outboard Motors (OBMs), Lagoon Craft, Major Overhaul (MOH)**

I. INTRODUCTION

High-power outboard motors (OBMs) serve as critical propulsion systems for various small craft in the Sri Lanka Navy (SLN), supporting both tactical and logistical operations in coastal and inland waters. Among these platforms, the 23-feet Cedric Craft, which is powered by 02 numbers of Yamaha 200 hp OBMs, stands out as a significant indigenous achievement, designed and constructed by the Naval Boat Building Yard between 2006 and 2009 (NBBY, 2025). With over 150 units launched, Cedric Craft was developed with the strategic objective of gaining supremacy in shallow waters and executing deliberate swarm-style attacks on enemy small boat formations by outnumbering and outmaneuvering them. In addition to these high-speed tactical units, the SLN also relies on Lagoon Crafts for civil transportation and internal mobility, making high-power OBMs vital across both combat and support roles.

200 hp Yamaha high-power outboard motors, widely used in Sri Lanka Navy craft such as Cedric and Lagoon craft, are known for their durability, reliability, and performance. These engines, particularly the 90º V6 models, are engineered to ensure high performance and reliability. Technologies such as loop-charged scavenging, precision-tuned intake and exhaust systems, and Power Trim & Tilt mechanisms contribute to enhanced fuel economy, combustion efficiency, and operational convenience. Built with reinforced pistons, durable gear systems, and anti-corrosion protection, including YDC-30 aluminum alloy and multi-stage coating systems, these OBMs are designed for long service life in harsh marine environments (KBA, 2015).

The 115HP Yamaha Enduro outboard motors, deployed in SLN Lagoon Crafts, are specifically designed for extended, high-load operation in coastal and shallow water conditions. Built for durability, they feature loop-charged scavenging for improved combustion efficiency and shallow water drive capability. Components such as the crankshaft, piston assemblies, and gear case are reinforced for longevity (KBA, 2015).

While such extensions offer potential short-term benefits in terms of cost savings and reduced downtime, they also pose critical questions regarding long-term reliability, safety, and operational performance. Prolonged use without timely overhauls may result in increased mechanical failures, reduced fuel efficiency, and elevated maintenance costs due to severe component degradation.

This study is conducted to systematically assess the operational and economic impact of extending major overhaul intervals of high-power OBMs in the SLN. By analyzing empirical data from deployed units, maintenance records, and the insights of experienced naval technicians, this research aims to determine whether such extensions are justifiable under current constraints or whether they compromise mission effectiveness and asset longevity. The findings are expected to support the development of optimized, context-specific maintenance strategies for high-powered marine propulsion systems within the SLN.

II. LITERATURE REVIEW

Effective equipment maintenance is essential to ensuring operational continuity, asset longevity, and cost efficiency, particularly in high-demand environments such as naval operations. Maintenance philosophies can be broadly categorized into several types, including reactive (corrective), preventive, predictive, and condition-based strategies. According to (BIN95, 2003) these approaches range from basic "fix-when-fails" models to advanced predictive systems that rely on data analytics and real-time monitoring to anticipate failures and schedule interventions accordingly. Modern industrial practices increasingly favor predictive and condition-based maintenance (CBM), particularly for mission-critical or high-performance machinery.

Adding further depth, (Gackowiec, 2019) defines maintenance strategy as: “A systematic approach to upkeep the facilities and equipment involving identification, researching and execution of many repairs, replacements and inspections and is concerned with formulating the best life plan for each unit of the plant, in coordination with production.”

This definition underscores the evolution of maintenance from merely fixing failures to embedding strategic, lifecycle-focused planning within operational processes. It highlights a comprehensive view: maintenance must balance reliability, cost, safety, and efficiency by integrating corrective, preventive, predictive, and condition-based methods.

Researchers in the field categorize these strategies as follows:

1)Reactive maintenance: or “run-to-failure,” is the response after a breakdown, useful when repair costs are lower than prevention.

2)Time-based preventive maintenance: follows scheduled intervals regardless of actual engine conditions.

3)*Condition-based maintenance (CBM):* often overlapping with predictive maintenance, relies on real-time monitoring to assess equipment health and forecast issues before failure occurs, optimizing resource use and minimizing downtime.

This shift toward proactive maintenance is widespread across industries. (Gackowiec, 2019) The review identifies preventive and condition-based approaches as the most frequent in academic literature between 2000 and 2018, and global trends continue to prioritize predictive maintenance.

Additional disadvantages are highlighted by (EUAutomation, 2014), which points out that CBM is not universally applicable; certain components may not exhibit predictable degradation patterns, rendering real-time monitoring ineffective or misleading. Moreover, false alarms or overlooked signals can lead to either unnecessary interventions or critical failures, both of which reduce the system’s overall reliability and increase operational risks.

A major engine overhaul is one such form of preventive maintenance. As per (Powerhouse, 2024) a major engine overhaul is a comprehensive and meticulous process undertaken to restore the optimal functioning of an internal combustion engine. Over time, due to wear and tear from continuous use, harsh operating conditions, and age, engines begin to degrade, leading to reduced performance, fuel inefficiency, and increased risk of failure. An overhaul involves disassembling the engine, inspecting and replacing worn parts, and reassembling it to original specifications. This process helps prolong the engine’s operational life, restore performance, and ensure reliability, especially critical in high-speed applications such as naval outboard motors.

III. METHODOLOGY

This study employs a mixed-methods approach to assess the impact of extended overhaul intervals on the performance of 200 hp and 115 hp Yamaha outboard motors used in Lagoon and Cedric Craft of the Sri Lanka Navy. Operational records from SLN maintenance logs, including engine hours, overhaul history, and fault reports, will be analyzed alongside maintenance logs detailing actual vs. scheduled overhaul intervals and component failure types.

Quantitative analysis will apply statistical methods, such as failure trend analysis and regression, to evaluate performance under different overhaul schedules. Qualitative analysis will interpret interview feedback from SLN technical personnel to capture field-level perspectives on reliability, risks, and maintenance decision-making.

A comparative assessment will contrast OBMs under standard and extended intervals, focusing on performance differences, wear patterns (from available teardown data), and instances of downtime. Findings will be validated through workshops with SLN engineers and crew to ensure practical relevance. Recognized limitations include limited teardown data, possible gaps in historical logs, and varying environmental conditions that may affect results indented, run into the text in their sections, and are followed by a colon.

IV. ANALYSE

The initial data for this study were collected from high-power outboard motors (OBMs) belonging to Cedric Craft and Lagoon Craft, which are currently deployed in the Northern Naval Area (NNA). The focus was on two key platforms: Cedric Craft and Lagoon Craft, both of which utilize Yamaha OBMs for propulsion and tactical mobility. At the time of conducting the study, the NNA operated seven Cedric Crafts and five Lagoon Crafts. In total, there are 31 high-power OBMs, which include both operational (OP) and non-operational (NOP) units. Further, it is observed that no major defects are observed in 07 No's of Yamaha 115 hp OBMs throughout the operation period and only 03 No's OBMs are Non-operational due to completion of major overhaul (MOH) running hours. Hence, only Yamah 200 hp OBMs were considered for the analysis.

Further, data was collected from 61 No's 200 hp OBMs belongs to the Special Boat Squadron (SBS), which are used for Cedric craft deployed in other naval commands.

The breakdown of these Yamaha 200 hp OBM operational status is as follows:

Table 1. High Power OBM Status at NNA and SBS HQ

	OP	**Preserved**	**NOP**	**Total**
NNA	14	-	10	24
SBS	40	8	13	61
Total	**54**	**8**	**23**	**85**

The recommended Time Between Overhaul (TBO) as defined by SLN for both Yamaha 115 hp and 200 hp OBMs are 900 hours considering the critical operational requirement during time of purchasing. But currently, SLN practicing extensions up to 100 hours and 200 hours for the MOH of 115 hp and 200 hp OBMs, respectively, by restricting the max speed to 4250 RPM only after being proven by the performance test. As per this schedule, a performance test (PT) will be carried out once the TBO is completed at 900 hours. The MOH will be extended by 100 hours if the performance test is satisfactory. For 200 hp OBMs another PT can be conducted at 1000 hours to extend the TBO up to 1100 hours.

Among the above Yamaha 200 hp OBMs, major defects are observed in 13 OBMs as indicated in Table 2.

Table 2. Major Defects of Yamaha 200 hp OBMs

Sr. No.	**Engine Sr. No.**	**TRH**	**AMRH**	**1st MOH**	**2nd MOH**	**3rd MOH**	**Remarks (Brake down after)**
01	X 1033642	2063.30	253.30	900	910		2nd MOH
02	X 1038506	3555.10	755.10	900	900	1000	3rd MOH
03	X 1036780	1980.10	980.10	1000			1st MOH
04	X 1033645	1840.00	840.00	1000			1st MOH
05	X 1036789	1737.00	737.00	1000			1st MOH
06	X 1035850	2900.00	900.00	900	1100		2nd MOH
		3093.00	1093.00	900	1100		
07	X 1036025	1257.50	289.50	968			1st MOH
		1374.25	406.25	968			
		1492.50	524.50	968			
		1526.30	558.30	968			
08	X 1036046	1928.20	928.20	1000			1st MOH
09	X 1035848	2943.00	943.00	900	1100		2nd MOH
10	X 1033656	809.00	-				Before 1st MOH
11	X 1036784	1620.20	620.20	1000			1st MOH
12	X 1033635	2213.45	213.45	900	1100		2nd MOH
13	X 1030931	2230.40	230.40	900	1100		2nd MOH

As per Table 2, all the defects occurred after the first MOH, except for one OBM. Further, the occurrence of those defects can be categorized according to the last MOH that has been carried out before the respective defect.

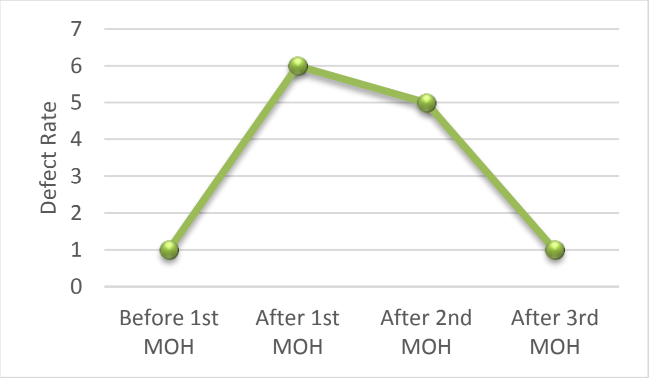

Figure 1. Defect Rate Over Running Hours

As per the above figure 1, it is observed that the defect rate of the OBMs is higher after the first and second MOH. Further, the highest defect rate indicates after the first MOH. As per the running hour and MOH details, most of the OBMs which lie under higher failure rates have undergone at least one MOH extension during operation.

Further, there is only one defect observed after the 3rd MOH. The main reason for this drastic decrease in defects in this range is that the Total Running Hours (TRH) of most of the OBMs have not reached the 3rd MOH. AS per the running hours data, only 02 No's Yamaha 200 hp OBMs have completed the 3rd MOH.

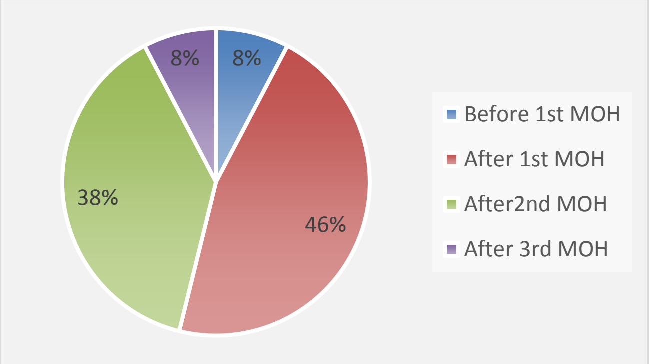

Figure 2. Defect Rate as a Percentage

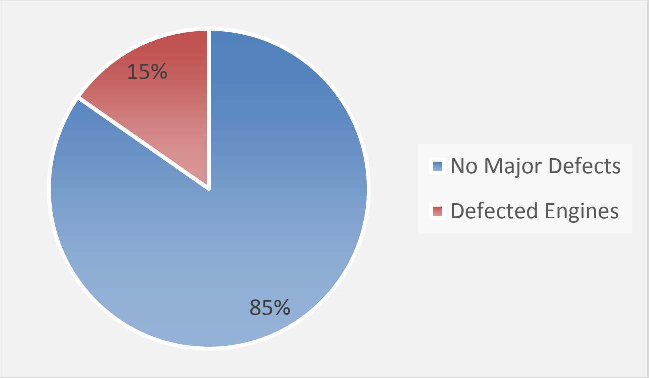

Figure 3. Defected Engines as a Percentage of Total Engines

Figure 2 illustrates the defect rate as a percentage of total defective engines, and Figure 3 illustrates the number of defective OBMs as a percentage of total OBMs.

Another significant observation of the OBMs which completed the 3rd MOH is that both OBMs have undergone their 1st and 2nd MOH at 900 hrs. However, one of these OBMs defected once given a 100-hour extension prior to the 3rd MOH (Sr. No. 2 of Table 2). This indicates a 50% defect rate beyond the 3rd MOH as per the current data. The defect rate in each MOH stage is illustrated in Figure 4.

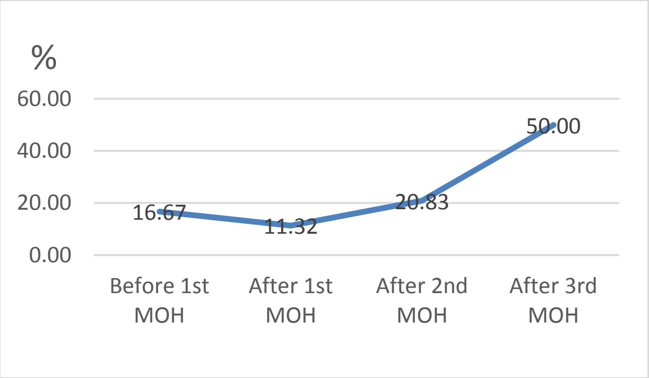

Figure 4. Defect Rate at Each MOH Stage

As per the manufacturer, the life span of an outboard motor lasts up to 1,500 hours to 3,500 hours prior to major repair or replacement. Further, this life span depends upon the amount of usage and the quality of maintenance (Yamaha, 2025).

As per the MOH schedule of SLN, it is assumed that the minimum life span of an OBM is 3,600 hours, and it will include three major overhauls. In cases such as Sr. No. 12 in Table 2, the defect occurred after 213 hours and 45 minutes (Approx. 214 hours). Hence, the 3rd MOH will only sustain up to 3,114 hours. Considering 02 times of 100-hour extensions, it will be a maximum of 3,314 hours. Hence, the total lifetime cannot be achieved within three MOH while 286 running hours remain. Considering the approximate cost for a MOH (Rs. 2,400,000.00) and the TBO (Maximum 1,100 hours) cost for the remaining running hours is around Rs. 624,000.00.

A fuel consumption test was carried out for the following craft in NNA which are attached to SBS. Among the sample OBMs, some engines were running at rpm restriction due to TBO extensions. Hence, the test was carried out at 4,200 rpm at the gear neutral position as a comparison, and the test results are given in Table 3.

Table 3. Fuel Consumption Comparison

Craft	Fuel Consumption (L/hr)	Engine Sr. No.	TRH	AMRH	1st MOH	2nd MOH
Z 215 Port	19.80	X 1035852	1100.00			
Z 215 Stbd	16.76	X 1033642	2143.20	333.20	900.00	910.00
Z 196 Port	19.17	X 1035854	1000.45	-		
Z 196 Stbd	19.67	X 1036040	1870.40	7.40	900.00	963.00
Z 212 Port	18.07	X 1038330	1385.20	385.20	1000.00	
Z 212 Stbd	18.75	X 1033641	2444.20	644.20	900.00	900.00
Z 235 Port	20.20	X 1036798	2581.05	811.20	900.00	869.45
Z 235 Stbd	21.05	X 1038335	1958.40	958.40	1000.00	

It is observed that the lowest fuel consumption is in the Stbd OBM of Z 215, which is running at 333 hours and 20 minutes after the MOH. Further, the OBM has undergone 1st and 2nd MOH around 900 hours. The fuel consumption is higher in the Z 215 Port engine and the Z 196 Stbd engine, even being just after the MOH. This observation can be possible because the engine may still be in the break-in period.

Further, it is observed that fuel consumption increases when OBM reaches MOH (Both OBMs of Z 235). The highest fuel consumption is indicated in the Z 235 Stbd OBM, which is given an extension for TBO.

During the recently occurred major defects, it was observed that the following failures occurred in the engine components.

- Sized connecting rod big end bearings.
- Scuffing cylinder sleeves and piston rings.
- Damaged connecting rods.
- Damaged Pistons.
- Damaged cylinder block.

These observations indicate that the symptoms of overheating and overload in the cylinders and pistons, which ultimately affect the connecting rods and bearings as a result of knocking (Figure 5). The knocking can happen due to various reasons such as ignition advance, insufficient cooling (overheating), insufficient lubrication, lean air/fuel mixture, low octane fuel etc.

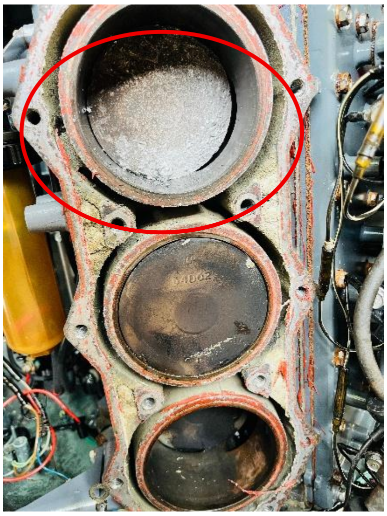

Figure 5. Damaged Cylinder Sleeves and Pistons

Further, it is observed pitting corrosions in the exhaust inner covers of most OBMs during performance tests and replaced, which were in critical condition (Figure 6).

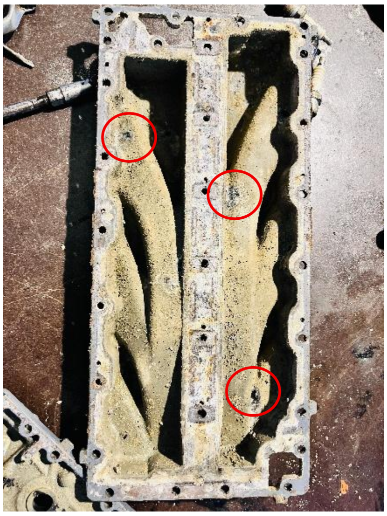

Figure 6. Corroded Exhaust Inner Cover

These kinds of failures can lead to seawater seeping into the cylinders through the exhaust ports, specially at lower RPMs, which can lead to catastrophic engine failures.

As a result, hydrolock can occur, which can prevent the engine from turning. At the minimum level, it can prevent starting the engine and, since liquid water is incompressible, it can lead to mechanical failures such as engine block damage or piston connecting rod and bearing damage. This hydrolock can occur basically due to the failure of components such as cracked exhaust manifolds or a faulty head gasket (Shackleton, 2021).

As per (Log, 2023), hydrolocking can have different effects on the engine depending on how much water is in the cylinders and how fast the engine is running. When the engine is turned off or idling, hydrolocking may lead to the engine stalling or having difficulty starting. If the engine is operating at higher RPMs, hydrolocking could cause loud or abnormal noise and an abrupt pause in the engine's operation. Further, the rapid expansion of gases can lead to the failure of gaskets or cracks in cylinders. The primary type of damage resulting from hydrolocking is bent or broken connecting rods, which link the pistons to the crankshaft.

Considering the above observations, the root cause is most likely to insufficient cooling caused by degradation of engine components due to prolonged usage. As per the current practice of the SLN, some components such as pistons, crank shafts and exhaust covers remain unchanged even in MOH repairs. Further, the engine block also remains same with the corrosions and blockages in cooling passages being used in harsh marine environments.

The empirical data highlights an increased defect rate correlating directly with extended intervals between overhauls. Specifically, OBMs that experienced extended overhaul intervals demonstrated notably higher rates of mechanical failure, emphasizing increased maintenance requirements and potentially diminished fuel efficiency. This observation supports the point that risks associated with inadequate predictive and condition-based maintenance are highlighted by (EUAutomation, 2014).

Extended overhaul intervals, while initially appearing cost-effective by reducing immediate maintenance expenditures, pose significant risks. Increased mechanical failures result in higher long-term costs due to more frequent repairs, component replacements, and operational downtime, negatively impacting mission readiness and overall fleet efficiency.

V. CONCLUSION

In conclusion, the analysis demonstrates that significantly extending overhaul intervals can adversely affect reliability, operational efficiency, and overall lifecycle costs of high-power OBMs. Aligning maintenance schedules closely with recommended intervals and integrating advanced predictive and condition-based maintenance techniques are crucial for sustaining operational readiness and reducing long-term costs. Further, conducting investigations into individual component wear patterns during extended intervals could be helpful to refine maintenance practices. Furthermore, these maintenance techniques and trend analysis should be able to identify in which occasion to phase out such OBMs beyond economical repair conditions. As an immediate action, it is recommended to discontinue the differing of the initial TBO interval of 900 hours, considering the increment of fuel consumption and potential escalation of maintenance costs resulting from unplanned breakdowns. By implementing these optimized maintenance practices, SLN can effectively ensure that the high-power OBMs perform reliably under various operational demands, achieving an optimal balance between immediate cost savings and long-term operational effectiveness.

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