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Performance Evaluation of Haulage Equipment in Niger Delta Region of Nigeria

Ojeiwa, A. C[1], Jinyemiema, T. K[2], Chiejine, C. M[3]
[1,2]*Department of Mechanical Engineering, Rivers State University, Port Harcourt*
[3]*Department of Electrical, Admiralty University of Nigeria, Ibusa, Delta State*

NOMECLATURE

t = Time to failure: this refers to duration a component function correctly before it experiences its breakdown.
β = Shape parameter: this refers to a value that determines the visual cure of a distribution, indicating whether failure rates are increasing, decreasing or constant

η = Scale parameter: this refers to value that stretches the distribution along the horizontal axis, effectively determining the characteristic life.

γ = Location parameter: this refers to value that shift the entire distribution curve left or right on the timeline, representing a threshold or waiting time before any failure can possibly occur.

Tpt = Total Operating Time: How long has the equipment been running (in hours).
N_f = Number of Failures: How many times have the components failed.
Z = Efficiency of the crane
Pz = Efficiency at maximum pressure
Kz = Loss factors of the crane efficiency
Pm = Maximum Pressure
Pn = Minimum Pressure
λ= Failure rate
MTBF= Mean Time Between Failure
MTTR = Mean Time To Failure
TMt = Total maintenance time
NR = Number of repairs carried out.
D.C = distance covered: Total distance covered in kilometer.
F.C = Fuel Used
T.d = Total downtime: Number of days / times the equipment is unavailable for usage
T.O.p = Total operation period: this refer to the period or times the equipment was in use.
Atc = Actual load carried
Mlc = Mass load capacity of the truck
CFt = Net cash flow at time t.
r = Discount rate (cost of capital)
t = the period of project
Ne.Pr = Net of profit: This refers to the profit generated from the investment.
Civ = Cost of investment: This refers to the initial capital invested into the business
IV = Initial investment.
T.d = Total downtime: Number of days / times the equipment is unavailable for usage
T.O.p = Total operation period: this refer to the period or times the equipment was in use.
CF = Annual cash inflow
St = Strength of material
Cr = Corrosion resistance
Dst = Density of the material
R(t) = Failure rate

Abstract— **This work presents a performance evaluation of haulage equipment used in oil and gas industry in Niger Delta region of Nigeria. It evaluates the critical equipment used in the industry, their critical components, causes of failures, performance, efficiency, and cost-effectiveness. The approach combines operational, maintenance, failure data, and cost analysis to identify key technical and economic constraints compared to equipment performance and develops a decision-making framework for optimal equipment operation. Crane and lowboy trucks are identified as critical equipment for lifting and transporting heavy equipment in the oil and gas industry. Using Weibull analysis and finite element analysis (FEA), the study evaluates the reliability and structural integrity of this equipment. The crane shows more failures (110 failures) than the lowboy truck (49 failures), with downtime of 30.1% compared to 13.4% for the lowboy, indicating that the lowboy is more reliable than the crane. The economic loss due to crane downtime is significantly higher at ₦105,500,000 annually compared to ₦12,250,000 for the lowboy. A contribution of this study is the FEA of the crane boom under rated load (850,000 N).**

Keywords-- **equipment, crane, lowboy, reliability, transporting, lifting**

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I. Introduction

The oil and gas sector plays a crucial role in the economic development of many nations. In Nigeria it is the main source of revenue. Niger Delta is in the southern part of Nigeria and is responsible for the bulk of the country's crude oil production, contributing significantly to national revenue and foreign exchange earnings (Okonkwo & Okoro, 2020). However, the efficiency of operations in the oil and gas industry is heavily dependent on the reliability and performance of haulage equipment. Haulage equipment, including trucks, cranes, and other heavy-duty vehicles, are used extensively for transporting crude oil, refined petroleum products, drilling equipment, and other materials necessary for exploration and production activities (Akinyemi & Mohammed, 2021). The demanding nature of haulage operations in the Niger Delta, characterized by poor road infrastructure, extreme weather conditions, and high operational loads, necessitates a comprehensive technical evaluation to optimize performance and ensure sustainability

Haulage equipment in the oil and gas sector must operate under rigorous conditions, often leading to frequent breakdowns, increased maintenance costs, and reduced operational efficiency (Ogunleye & Ojo, 2022). The performance and reliability of haulage systems are influenced by several factors, including mechanical design, material composition, environmental conditions, and maintenance practices (Eze & Nwachukwu, 2021). Given the critical role of haulage equipment, it is essential to understand the principal components that contribute to its functionality and identify those that are most susceptible to failure. This study aims to determine the order of criticality of various system components, enabling a focused approach to maintenance and performance optimization (Chukwuma & Udoaka, 2023). The findings from this analysis will help improve the overall efficiency of haulage operations and reduce downtime in the oil and gas industry.

Technical performance evaluation is a major component of this study, as it provides a comprehensive understanding of component failures in haulage equipment and how well haulage equipment meets operational requirements. Given the harsh working conditions in the Niger Delta, haulage equipment must be designed to withstand high temperatures, corrosive environments, and heavy loads. By assessing the technical performance of these machines, this study will provide data-driven recommendations for design enhancements and operational optimization.

Furthermore, a comparative analysis with industry benchmarks will be conducted to identify gaps and propose solutions for performance enhancement (Emmanuel, 2023).

One of the major challenges faced in the Niger Delta is the selection of appropriate materials for haulage equipment construction. The corrosive nature of the environment, due to high humidity and saline conditions, accelerates material degradation, leading to frequent failures and increased maintenance costs (Uche & Adebayo, 2020). Therefore, material analysis is a critical aspect of equipment design that must be tailored to the unique environmental conditions of the region. The study incorporates guidelines for selection of durable materials for design of critical components to enhance the lifespan of haulage equipment while reducing maintenance costs. Additionally, recommendations for optimal equipment design are provided, considering factors such as load distribution, aerodynamics, and structural integrity (Adekunle & Omotayo, 2019). These guidelines will help manufacturers and engineers develop more robust haulage systems suitable for the oil and gas industry in the Niger Delta.

The significance of this study extends beyond the technical evaluation of haulage equipment as major findings will provide valuable insights for stakeholders in the oil and gas sector, including equipment manufacturers, operators, and policy makers in identifying critical components, assessing reliability, and optimizing performance. The research has contributed to the development of a more efficient and sustainable haulage system in the Niger Delta.

One of the primary concerns in haulage operations in the region is the lack of systematic evaluation of equipment performance and reliability. Most operators rely on traditional maintenance approaches that are reactive rather than predictive, leading to unexpected breakdowns and costly downtime. Without a structured methodology to identify critical components and predict potential failures, maintenance strategies remain inefficient due to increasingly likelihood of operational disruptions. Another pressing issue is the inadequate optimization of material selection and equipment design for the specific conditions of the Niger Delta. Standardized haulage equipment in use scarcely considers the unique environmental and operational challenges of the region in their design. The result is accelerated wear and tear, reduced durability, and high replacement costs. No predictive maintenance strategies, hence leading to failure approaches amongst operators in the oil and gas sector.

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II. Materials And Methods

2.1 Research Materials

The materials and methods used to evaluate the performance and reliability of the haulage equipment in oil and gas operations in the Niger Delta incorporates field data collection, performance statistics and reliability analysis using Weibull distribution models. Additionally, technical performance assessment and material selection guidelines are developed based on empirical observations.

2.1.1 Haulage Equipment and Their Uses

This study will focus on crane and lowboy trucks for performance evaluation and reliability analysis using Weibull Analysis. The following materials will be used to carry out this research work.

i. The crane boom.
ii. The hydraulic system
iii. Outriggers / stabilizers
iv. The lowboy drop neck
v. The hydraulic system for lowboy
vi. Gooseneck

2.1.2: Data Source.

The data for this research work were obtained from the maintenance / operations department of Mb Hunt Logistics Services, a provider of haulage services to the oil and gas production company in Port Harcourt, Rivers State.

Table 1: Monthly Failure Distribution for Crane and Lowboy Using total Operating Time of 2,000hrs Annually, with an Average of 40hrs Weekly.

Month	Crane (Pred 315) Failures	Failure Rate (FR) (Failure/hr)
Jan	6	3 X10^{-3}
Feb	7	3.5 X 10^{-3}
Mar	10	5 X 10^{-3}
Apr	9	4.5 X 10^{-3}
May	8	3 X 10^{-3}
Jun	11	5.5 X 10^{-3}
Jul	12	6 X 10^{-3}
Aug	9	4.5 X 10^{-3}
Sep	10	5 X 10^{-3}
Oct	7	3.5 X 10^{-3}
Nov	6	3 X 10^{-3}
Dec	5	2.5 X 10^{-3}

(Source: Mb Hunt Logistic Services)

Month	Lowboy (Pred 207) Failures	Failure Rate (FR) (Failure/hr)
Jan	3	1.5 X 10^{-3}
Feb	2	1 X 10^{-3}
Mar	5	2.5 X 10^{-3}
Apr	4	2 X 10^{-3}
May	3	1.5 X 10^{-3}
Jun	5	2.5 X 10^{-3}
Jul	4	2 X 10^{-3}
Aug	6	3 X 10^{-3}
Sep	5	2.5 X 10^{-3}
Oct	4	2 X 10^{-3}
Nov	3	1.5 X 10^{-3}
Dec	5	2.5 X 10^{-3}

(Source: Mb Hunt Logistic Services)

Table 2: Crane/Lowboy Trucks Pressure

S/N	Crane Truck Pressure(bars)			Lowboy Truck Pressure(bars)		
	Critical Comp	**Min Pres**	**Max Pres**	**Critical Comp**	**Min Pres**	**Max Pres**
1	Outrigger	280	350	Suspension/Deck	172	207
2	Boom	280	350	Wheel/Tyre	6	9
3	Hydraulic system	280	350	Hydraulic system	172	207

(Source: Mb Hunt Logistics)

2.2: Methods

This study employs Principal Component Analysis (PCA) to identify critical equipment components, Weibull analysis for reliability assessment, and technical performance evaluation. Additionally, material selection and maintenance guidelines are developed. Furthermore, the results achieved will be validated with the international acceptable standard for haulage.

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2.2.1: Technical Performance Evaluation using Reliability Assessment & Using Weibull Analysis

Weibull analysis was conducted on Crane and Truck to estimate failure trends and predict future reliability. To model equipment reliability, the Weibull probability distribution function was used are;

The Weibull probability density function is given as:

$$f(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} \quad 2.1$$

Mean Time Between Failures

This is a reliability metric that estimates average time in a system or equipment operates without failing as;

$$MTBF = \frac{Tpt}{Nf} \quad 2.2$$

Efficiency of Crane was obtained as:

$$Z = Pz - kz\ x\ (Pm - Pn) \quad 2.3$$

Determination of Failure Rate

This is the frequency of failures, often usually expressed as failure per unit time

$$\lambda = \frac{1}{MTBF} \quad 2.4$$

Higher failure rate usually indicates lower reliability of the equipment

Prediction of Reliability Over Time

$$R(t) = e^{-\lambda t} \quad 2.5$$

Mean Time to Repair

Measures the average time taken to fix an asset after it fails.

$$MTTR = \frac{T.Mt}{NR} \quad 2.6$$

Fuel Efficiency

$$Fuel\ Efficiency = \frac{D.C\ (km)}{F.C\ (L)} \quad 2.7$$

Load Capacity Utilization

$$Load\ Utilization = \frac{Atc}{Mlc} \quad 2.8$$

Downtime

This refer to the time of period equipment is unavailable for its intended use.

$$Downtime\ (\%) = \frac{T.d}{T.O.p} \quad 2.9$$

Comparative Analysis for Equipment Viability

To determine the economic viability of the crane and lowboy trucks, below are some formulars to determine the risk and viability of an investment in equipment.

Net Present Value: This is a core metric that calculates the total value of future cash flow in today's terms, discounted at a specific rate. A positive NPV generally indicates an economically viable project.

$$NPV = \sum_{t=0}^{n} \frac{CFt}{(1+r)t} \quad 2.10$$

Internal Rate of Return: This is the discount rate that makes the NPV of all cash flows equal to zero. If the IRR is greater than the cost of capital, the project is considered viable.

$$ROI = \frac{Ne.Pr}{Civ}\ x\ 100 \quad 2.11$$

Benefit-Cost Ratio (BCR): This ratio compares the present value of total benefits to the present value of total costs. A BCR greater than 1.0 suggests the benefits outweigh the costs, indicating viability.

$$Benefit\text{-}Cost\ Ratio\ (BCR) = \frac{PVB}{VC} \quad 2.12$$

Payback Period (PP) and Discounted Payback Period (DP): These metrics calculate the time it takes for a project's cumulative cash inflows to equal the initial investment. A shorter payback period is generally preferred, especially for risk assessment

$$Payback\ Period = \frac{IV}{CF} \quad 2.13$$

2.3.2: Mean Time Between Failures

This is a reliability metric that estimates the average time a system or equipment operates without failing

$$MTBF = \frac{Tpt}{Nf} \quad 2.14$$

2.3.3: Downtime

This refer to the time of period equipment is unavailable for its intended use.

$$Downtime\ (\%) = \frac{T.d}{T.O.p} \quad 2.15$$

2.3.4: Material Performance Index (MPI)

The Material Performance Index (MPI) is defined as;

$$MPI = \frac{St \times Cr}{Dst} \quad 2.16$$

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2.3.5: Maintenance Scheduling and Optimization

To avoid failures, we schedule maintenance based on reliability:

$$T_m = \frac{MTBF}{(1-R(t))} \quad 2.17$$

III. Results And Discussion

3.1: Crane and Lowboy Truck Reliability

This section presents the analysis and findings of performance analysis of haulage equipment in the oil and gas industry. Specifically, Crane and lowboy trucks which are known to play key haulage role in the oil and gas industry in the Niger Delta region, which includes lifting, loading, unloading and handling of heavy-duty equipment, spares, rig move, and materials used in the day-to-day operations. However, their technical reliability directly affects productivity, safety and operational cost. It presents detailed analyses of crane and lowboy truck by identifying their critical components, impact of each component failure to the system, and failure of each component to the entire operation. This technical insight was provided for improving the reliability, optimizing maintenance practices, and reducing downtime and cost of repair.

Table 3. shows the failure distribution of the crane and lowboy truck which is the primary data for the analysis and its findings its validated with the best international acceptable standard. The data show that the crane had more failures, downtime which shows that the crane is more complex in operation, maintenance compared to the lowboy truck.

Table 3: Monthly Failure Distribution for Crane and Lowboy

Month	Crane (Pred 315) Failures	Lowboy (Pred 207) Failures
Jan	6	3
Feb	7	2
Mar	10	5
Apr	9	4
May	8	3
Jun	11	5
Jul	12	4
Aug	9	6
Sep	10	5
Oct	7	4
Nov	6	3
Dec	5	5

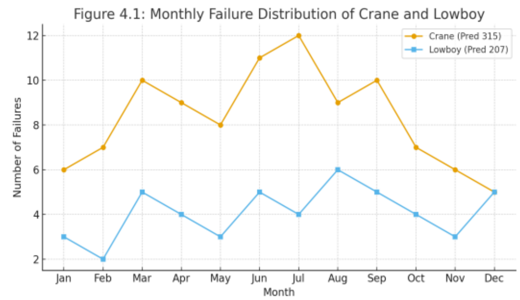

Figure 1: Monthly Failure Distribution of Crane and Lowboy

Table 4, shows that the crane consistently experienced higher monthly failures compared to the lowboy, peaking at 12 failures in July. This suggests poor preventive maintenance planning for hydraulically operated equipment, which are known to be failure-prone due to seal degradation and pressure fluctuations (Gopalakrishnan & Banerjee, 2020). In contrast, the lowboy maintained fewer failures monthly, indicating relative stability. However, both machines exhibit seasonal variations, implying workload or environmental influence on performance. ISO 14224 (2016) emphasizes structured data-driven maintenance to mitigate such recurring failures. Thus, the crane requires condition-based monitoring to reduce unplanned breakdowns and operational risks.

Table 4: Pressure Drop Difference for Crane

%	P1(Bar)	P2(Bar)	Pd(Bar)	EFF
0	350	350	0	89
5	333	316.7	16.30	88.6
10	315	285.75	29.25	88.5
15	298	255.4	42.60	87.4
20	280	228	52.00	86.1
25	263	201.1	61.90	84.5

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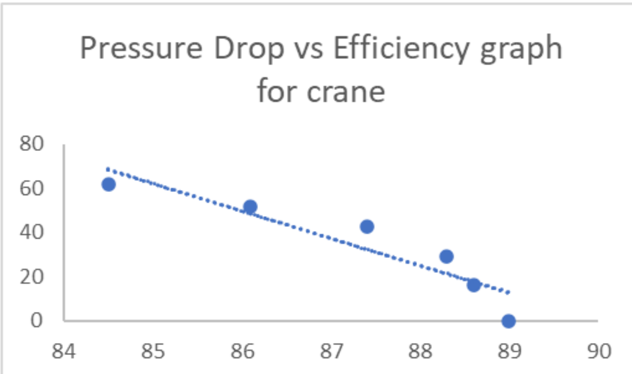

Fig 2: Pressure Drop vs Efficiency Graph for Crane Truck.

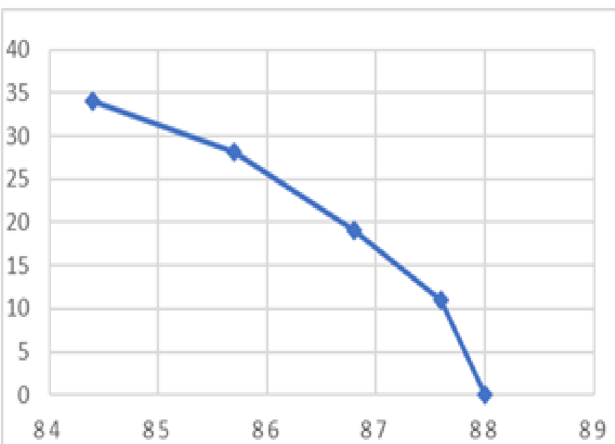

FIG .3: PRESSURE DROP VS EFFICIENCY FOR LOWBOY TRUCK

Table 5: Pressure Drop Difference for Lowboy Truck

%	P1(Bar)	P2(Bar)	Pd(Bar)	Eff
0	230	230	0	88.0
5	219	208.05	10.95	87.6
10	207	187.95	19.05	86.8
15	196	167.8	28.20	85.7
20	184	150	34.00	84.3

3.1.2: Technical and Operational Efficiency

The first objective of this research was to analyze the technical performance and operational efficiency of the crane and lowboy truck.

Table 6: Reliability and Efficiency Indices

Equipment	Failures	MTBF (Days)	Efficiency %
Crane (Pred 315)	100.0	3.65	86.9
Lowboy (Pred 207)	49.0	7.45	85.7

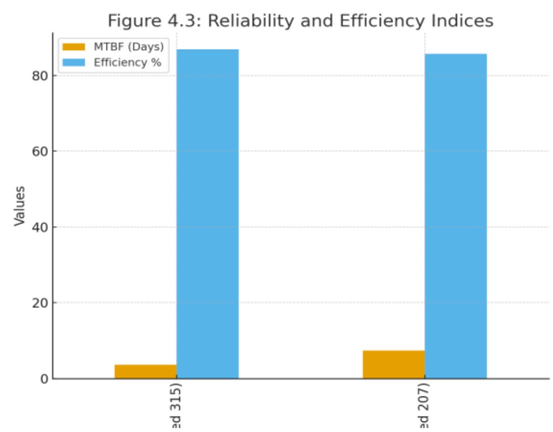

Fig.4: Reliability and Efficiency Indices of Crank and Lowboy Trucks

3.1.3: Crane Truck.

Figure 4 compares mean time between failures and efficiency for the crane, which shows that the crane has higher failure rate and a low time between failure of 3.65 days, the mean time between failure is below the industry benchmark of 7 days (Mobley, 2020). The efficiency graphs Figures 2 followed a similar trend, which shows that the efficiency of the crane drops as the pressure drops linearly, this indicates that the efficiency of the crane depends on the pressure sustainability for effective and optimal lifting operations.

3.1.4: Lowboy Truck

Figure 3 compares mean time between failures and efficiency for the lowboy truck, it shows that the lowboy truck has a low failure rate and a higher time between failures of 7.45 days, meeting with the industry benchmark, but the efficiency graph shows that efficiency and pressure drops is a linear relationship indicating that the drop in pressure is mostly a gradual process that leads to efficiency drop as well, eventually leading to failure of the lowboy truck.

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Efficiency followed a similar pattern, with the crane slightly outperforming the lowboy (86.9% vs. 85.7%). Despite marginally better efficiency, the crane's high failure frequency renders it less dependable overall. Thus, predictive pressure monitoring would improve both reliability and efficiency outcomes.

3.2: Economic Evaluation of Crane and Lowboy.

This section presents the financial assessment of the 85-Ton All terrain crane and a 50-Ton lowboy truck to determine their investment feasibility.

Table 7: Analysis of Investment Costs

Cost item (CAPEX)	85-Ton Crane (₦)	50-ton Lowboy (₦)
Purchase Price	350,000,000	85,000,000
Clearing / Import Duties	70,000,000	15,000,000
Registration / Logistic	5,000,000	3,000,000
Total Initial Investment	425,000,000	103,000,000

(Source: Mb Hunt Logistics)

Table 8: Operational Expenditure and Revenue

Operational Metric (Annual)	85-Ton Crane	50-Ton Lowboy
Avg Rental Rate	₦950,000 / Day	₦250,000 / Trip
Avg. Utilization (Day/Year)	180 Days	220 Days
Gross Annual Revenue	₦171,000,000	₦55,000,000
Fuel and Maintenance	₦45,000,000	₦22,000,000
Staff and Security	₦12,000,000	₦8,000,000
Net Annual Cashflow	₦114,000,000	₦28,000,000

(Source: Mb Hunt Logistics

Table 9: Comparative Profitability Indicators using a 5 Year

Indicator	85-Ton Crane	50-Ton Lowboy	Decision
Net Present Value (NPV)	₦110,450,000	₦19,200,000	Crane is Viable
Net Rate of Return (IRR)	22.4%	11.2%	Crane exceeds cost of capital
Payback Period (PBP)	3.7 Years	4.1 Years	Crane recover faster
Benefit-Cost Ratio (BCR)	1.26	0.81	Crane is ≥ 1(Viable)

Project Life at 15% Discount

3.2.1: Economic Evaluation of Crane

The economic evaluation of the crane shows that the crane is a critical equipment used in day-to-day operations in the oil and gas industry. The initial investment cost for a refurbished 85-Ton all terrain crane is about ₦350,000,000 for a used foreign crane. The operational cost for a crane indicates that the crane is more complex, critical and valuable in industry, standing at about ₦57,000,000, with an annual cash inflow of ₦114,000,000.

Using a discount or payback of five years duration, the investor would have paid back within 3 ½ years of operation of five-year project life cycle. This indicates that the crane purchase investment is a Viable one. The findings validate the objective that crane acquisition is a viable investment.

3.2.2: Economic Evaluation of Lowboy

The economic evaluation of the lowboy shows that the lowboy is a critical equipment use in day-to-day operations in the oil and gas industry, in that it is used for transporting heavy-duty equipment, compressors, even cranes to various site locations.

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The initial investment cost for a 50-Ton all terrain crane is about ₦85,000,000 for a used foreign crane. The operational cost for a lowboy indicates that the lowboy is complex, critical and valuable in industry, standing at about ₦30,000,000, with an annual cash inflow of ₦49,000,000. This high operational cost is due to challenging situation lowboy trucks faces during transit in the Niger Delta region, which includes regular security checkpoints with higher fuel consumption that reduce its profit margin. This makes the lowboy more vulnerable and less viable than the crane truck that is measured in per hour and its security and operations is tied to that of the flow-station security.

Using a discount or payback of five years duration, the investor would have paid back within 4 years + of operation of five-year project life cycle. This indicates that the lowboy purchase investment is a viable one, but slow to recover investment cost.

3.3: Comparative Maintenance Cost for Crane and Lowboy Truck

Perform comparative maintenance cost analysis for the crane and the lowboy trucks and validating the findings with the industry standard.

Table 10: Total Downtime for Crane and Lowboy

Equipment	Downtime Days	Downtime %
Crane	110.0	30.1
Lowboy	49.0	13.4

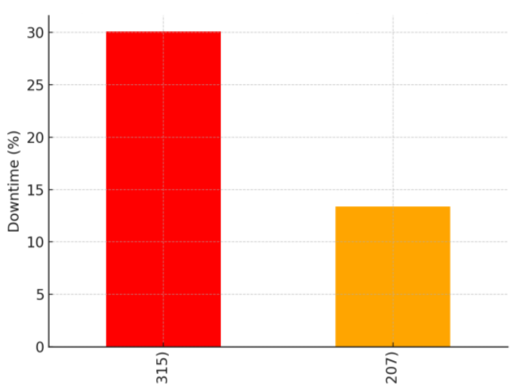

Fig. 5: Downtime Percentage Comparison

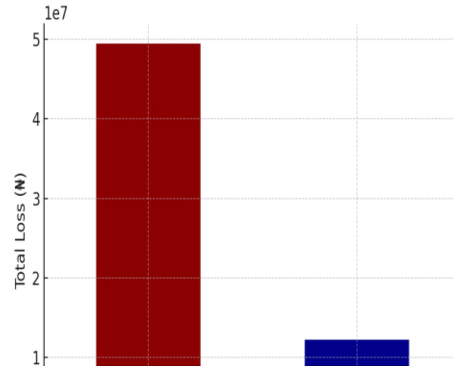

Fig 6: Economic Loss Due to Downtime

Table 11: Economic Loss Due to Downtime / Maintenance

Equipment	Downtime (Days)	Cost to hire per Day (₦)	Total Loss (₦)
Crane (Pred 315)	110	950,000	105,500,000
Lowboy (Pred 207)	49	250,000	12,250,000

3.3.1 Maintenance / Downtime Cost for Crane

The cost of maintenance of crane in Table 11 shows that the crane often breaks down requiring maintenance (plan and unplanned) which is far higher compared to the cost of maintaining the lowboy truck.

Figure 5, highlights crane downtime recorded as 30.1% downtime, falling short of the Oil and gas producers (OGP's) (2010) recommended availability standard of >85% uptime. This indicates that the crane's reliability is unacceptable by industry standards and poses a significant productivity bottleneck. Extended downtime suggests insufficient predictive maintenance or lack of spare parts availability.

3.3.2 Maintenance / Downtime Cost for Lowboy

Figure 5; highlights the lowboy downtime / maintenance as 13.4%. Validating the lowboy availability time for the project operation, 13.4% Downtime indicates that the lowboy truck meets the OGP's (2010) recommended availability standard of >85% uptime, the lowboy achieved 86.6% availability, just above the threshold. This indicates that the lowboy demonstrates better maintenance responsiveness or adequate maintenance activity has been carried out to ensure the availability of the lowboy.

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3.3.3: Economic Loss Analysis for Crane.

Unplanned downtime was assessed in terms of direct economic impact. Assuming an average loss per day of downtime, the total economic loss for crane was calculated. Table 11 and Figure 6 summarize the results.

Figure 6; demonstrates the significant economic impact of downtime, with the crane incurring ₦105,500,000 million annually which is very high. The high cost of losses reflects not only higher downtime but also higher hire costs for crane operations. According to International association for Drilling Contractors (IADC) (2019), equipment downtime is a leading contributor to project cost overruns in oil and gas operations, particularly for capital-intensive assets like cranes. This reinforces the importance of prioritizing crane reliability improvements. Implementing ISO 14224-based maintenance data collection and predictive maintenance would reduce downtime costs. The results validate economic risk assessments in petroleum equipment reliability studies.

3.3.3: Economic Loss Analysis for Lowboy

Unplanned downtime was assessed in terms of direct economic impact. Assuming an average loss per day of downtime, the total economic loss for each equipment was calculated. Table 11 and Figure 6; summarize the results.

Figure 6; demonstrates the significant economic impact of downtime, with the Lowboy incurring ₦12.25 million annually. The high loss reflects not only higher downtime but also higher hire costs for lowboy operations, the high loss also resulted from the deteriorating infrastructure in the Niger Delta, cost of security and communities' settlement before gaining access. According to IADC (2019), equipment downtime is a leading contributor to project cost overruns in oil and gas operations, particularly for capital-intensive assets like hydraulic operating equipment. This reinforces the importance of prioritizing equipment reliability improvements. Implementing ISO 14224 based maintenance data collection and predictive maintenance would reduce downtime costs. The results validate economic risk assessments in petroleum equipment reliability studies.

IV. Conclusion

This study has successfully demonstrated that the high failure rate of the crane (110 failures annually, 30.1% downtime) is not merely an operational issue but a fundamental structural deficiency.

The FEA proves that the crane boom is under-designed for its rated capacity, with average stresses 94% above the material yield strength and a safety factor of 0.51 failing to meet ASME B30.5 requirements. The performance evaluation confirms that while the crane remains a viable investment (IRR 22.4%, payback 3.7 years), its profitability is severely undermined by annual downtime costs of ₦105.5 million. The lowboy, while less profitable, demonstrates better reliability and meets industry availability standards.

REFERENCES

[1] Adekunle, F., & Omotayo, I. (2019). Material selection for harsh environments: A case study of oil and gas equipment. *Materials and Design, 180*, 108091.

[2] Akinyemi, J., & Mohammed, K. (2021). Challenges and solutions in Nigerian oil and gas logistics. *Oil and Gas Journal, 78*(5), 55-72.

[3] Bakare, T., Adeyemi, K., & Nwosu, J. (2022). Indigenous haulage technology innovations in Nigeria. *African Journal of Engineering, 39*(4), 102-118.

[4] Caterpillar Inc. (2020). Heavy Haulage Solutions: Lowboy Trailer System and Gooseneck Operations. Caterpillar Global Mining & Haulage.

[5] European Committee for Standardization (CEN), (2020). Cranes-General Design-Part 1: General Principles and Requirements (EN 13001-1). Brussels CEN.

[6] Grove Cranes. (2019). Operator and Maintenance Manual for Hydraulic Truck Crane. Manitowoc Company.

[7] International Association of Drilling Contractors (IADC). (2019). *Equipment downtime report in drilling operations*. Houston: IADC Publishing.

[8] ISO. (2016). *ISO 14224: Petroleum, petrochemical and natural gas industries – Collection and exchange of reliability and maintenance data for equipment*. Geneva: International Organization for Standardization

[9] Nwosu, C., & Adeyemi, B. (2021). Load optimization for Nigerian oil haulage operations. *Nigerian Journal of Engineering Research, 19*(2), 255-270.

[10] Ogunleye, K., & Ojo, A. (2022). Equipment reliability assessment in the Nigerian oil and gas industry. *Reliability Engineering Journal, 14*(3), 189-202.

[11] Okoro, C., & Ekezie, R. (2021). Environmental impact on equipment durability in Niger Delta haulage operations. *International Journal of Oil and Gas Engineering, 18*(2), 101-118.