Proactive Maintenance Strategic Application to Advance Equipment Reliability

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Abstract

Proactive maintenance is one highly effective but overshadowed generic maintenance strategy, which when effectively implemented, is significant in improving equipment reliability. Proactive maintenance aims to eliminate, reduce, automate or simplify maintenance without compromising reliability or safety. Proactive maintenance concerns empowering individuals to solve problems and in its simplest form, it encompasses three core concepts: Maintenance elimination, Maintenance prevention and Maintenance improvement. Proactive maintenance involves moving beyond standard task lists and reactive repairs to an analysis about why a component failed in the first place. It may mean finding a process, product, or procedure that extends the life of a component and requires less frequent inspections. It can be as simple as standardizing screws, improving access to hard-to-reach inspection points, or showing internal customers how to fill out a work order correctly. This study was carried out to unveil the aspects of proactive maintenance that makes it superior to other generic maintenance strategies which have been popularized over the years at its expense.

Keywords
Proactive maintenance, reliability, strategic application, root cause.

Introduction

Operational conditions like cold or corrosive atmospheres and any other adversative conditions render physical assets to deleterious exposure and their accelerated degradation, thus adversely affecting their reliability and availability for operational requirements (Jungwirth et al., 2016:1). Without the provision of a proactive maintenance antidote, frequent equipment failures in such deleterious conditions are a common experience, and this ultimately impacts on the overall business performance, but these proactive maintenance solutions should consider the equipment design, materials of construction and maintenance actions (Jungwirth et al., 2016:1).

Proactive Maintenance encompasses diverse approaches and technologies for utmost reduction of reactive maintenance in reality, and it is an innovation in relative to predictive maintenance (Papic et al., 2009:537). The dominant trait of proactive maintenance is the contrivances of failure origins exploration, and to sum it up, proactive maintenance is represented as:

PROACTIVE MAINTENANCE = PREDICTIVE MAINTENANCE + FMECA (Papic et al., 2009:537).

Once the root causes of failures have been identified, project re-engineering undertakings are carried out and they permit the elimination of the adversative failure causes, which renders the equipment to be highly reliable (Papic et al., 2009:537). Proactive maintenance is underscored as a novel strategic maintenance thrust that aims to comprehensively elevate the machine parts' reliability and availability in the operational environment all the way through their useful life (Iung et al., 2003:313).

Within the contemporary landscape of modernity in technological applications in manufacturing systems, the proactive maintenance strategy offers a crucial component in plummeting operational running expenses, and aiding the effectiveness of manufacturing systems (Rusa et al, 2015). The competitive performance of manufacturing businesses is reliant on the availability, reliability and throughput of their manufacturing assets, and the poor performance in terms of productivity, equipment failures and reduced equipment performance is generally attributed to ineffective equipment maintenance (Jasiulewicz and Kaczmarek-Stachowiak:2016). Such dispensations have driven companies globally to pursue and clinch proactive maintenance strategies over the conventional reactive strategies that are costly (Jasiulewicz and Kaczmarek-Stachowiak, 2016). As the significance of maintenance has evolved from the limited mandate of reactive repairs or preserving assets availability and safety, to the proactive inclinations chiefly centred on prognosis techniques, proactive maintenance strategy has featured as a highly sought option by maintenance practitioners (Muller et al., 2008:234). The maintenance strategies have transformed from the reactive, to the predict-prevent e-based systems, and ultimately the proactive maintenance system with anticipation capabilities crafted on monitoring, diagnostic, prognostics and decision-making modules (Muller et al., (2008:235), Iung et al., (2003:314)). The prognostics capabilities analyze the effects of deterioration on the component(s) and on the other system dynamics to forecast system malfunctions or defects and explore prospective maintenance engagements for satiating the principal assignment of system availability and reliability in a safe manner (Muller et al., (2008:235), Iung et al., (2003:314)). Prognosis renders the capability to reliability and near accurately predict the remaining-useful-life of physical assets, and it is applied to project the prevailing health state of physical assets and translate it into the future state through extrapolation of futuristic application profiles (Muller et al., 2008:235). Below is a synopsis of the composition of a proactive maintenance strategy.

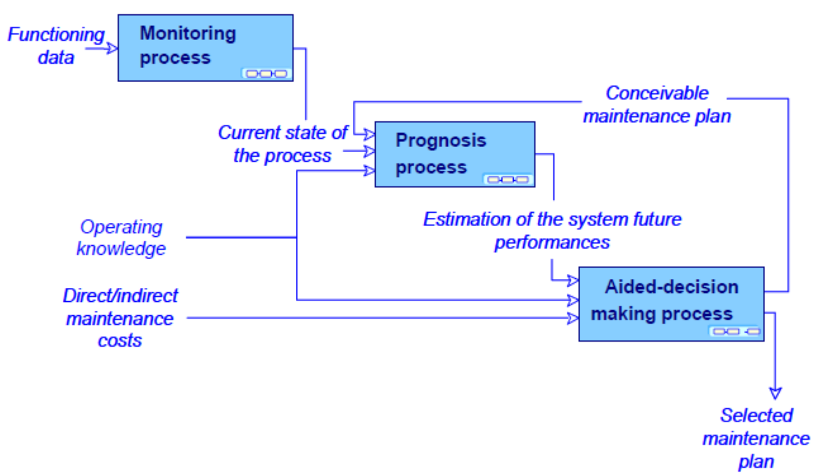

Figure 1: Proactive maintenance system overview (Muller et al., 2008:235).

Proactive Maintenance Strategy Remarkable Attributes

Maintenance encompasses preventive and corrective engagements undertaken to preserve an asset in or reinstate it to an operative situation, and optimum maintenance strategies target to deliver optimal assets reliability and availability performance at the bottommost conceivable maintenance expenditure (Do et al., 2015:22). Broadly maintenance strategies are categorized in literature as either reactive or proactive, where the reactive strategy refers to maintenance actions consequent to a malfunction and is generally unplanned, whereas the proactive strategy refers to planned maintenance actions that are carried before a malfunction occurs (Exner et al., 2017:331). A novel synoptic of maintenance has transcended different maintenance strategies, and it is more accomplished to be just corrective in nature, or to be preventive basing on perceived component status, but it is chiefly a proactive in nature and constructed on the proficiency gained on prior malfunctions, coupled with the understanding of the mechanisms of the components' defective states, all this done with the objectivity of enriching the forthcoming designs and to circumvent the reoccurrence of these malfunctions (Chaïb et al., 2014:187). The proactive maintenance strategy entails that maintenance aspects are incorporated at the design stage of a physical asset, whereby all anticipated probable prospective failures are identified and removed, based on the focused historical performance of the asset, with the purpose to prescribe suitable maintenance actions at the right intervals and component parts (Chaïb et al., 2014:187). The progression towards a proactive maintenance strategic position is displayed in the figure below.

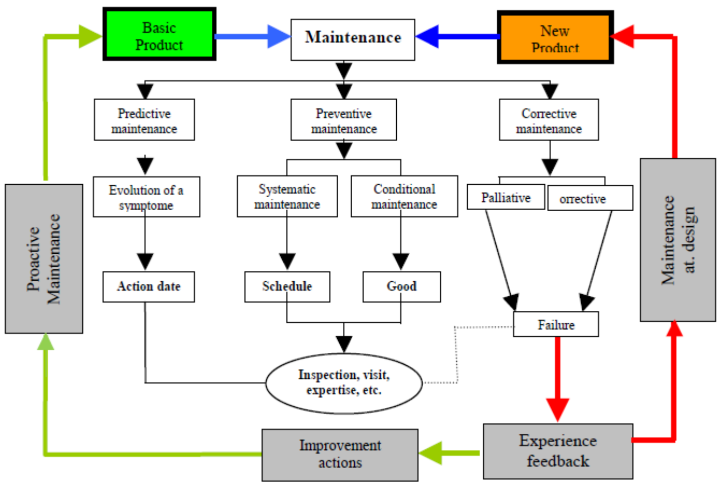

Figure 2: Progression towards Proactive maintenance strategy (Chaïb et al., 2014:187).

Proactive maintenance is totally different from preventive and predictive maintenance strategies, as preventive maintenance refers to machine maintenance on planned interims, while predictive maintenance monitors the health status of machine components and alerts when threshold levels are exceeded (Exner et al., 2017:331). The predictive maintenance strategy workflow is summarized in the figure below.

Figure 3: Summarized Predictive maintenance workflow process (Exner et al., 2017:332).

The categorization of maintenance strategies is shown in the figure below. This shows what constitutes the proactive maintenance strategy and the other maintenance strategic concepts that are harnessed by the proactive maintenance strategy.

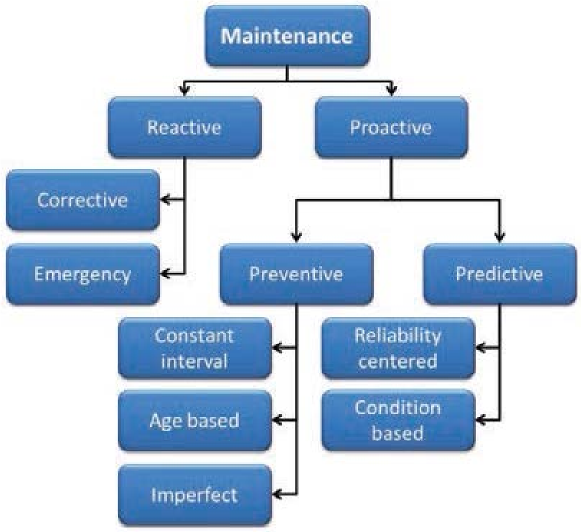

Figure 4: Various forms of maintenance strategies (Exner et al., 2017:331).

Proactive maintenance strategy is a superior strategy that is applied to reduce both planned and unplanned equipment downtime. Its purpose is to enable physical assets to run for prolonged periods of time without unnecessary stoppages, due to the inherent reliability attributes imbedded in the asset. The comparative display of the tenets of the various forms of maintenance strategies is shown below and the major highlight is the longest planned downtime interval derived under proactive maintenance compared to other concepts.

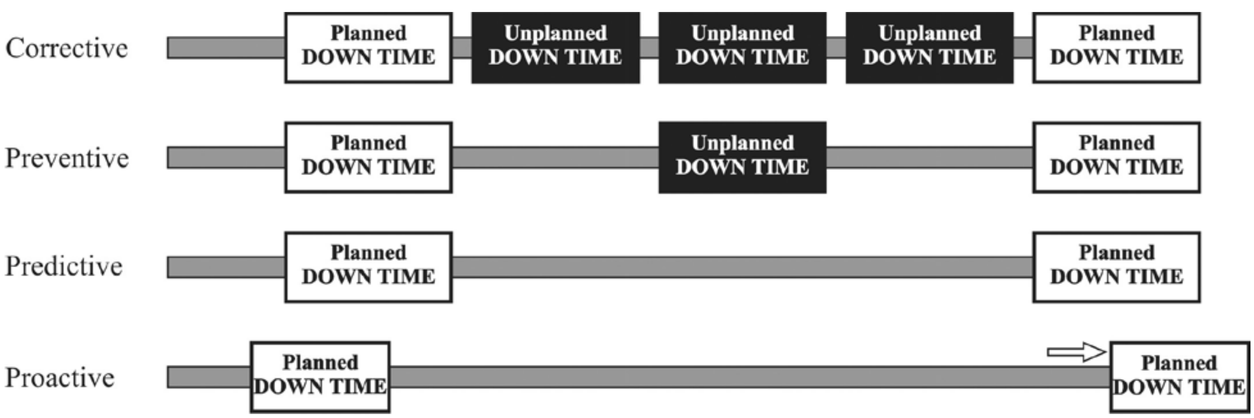

Figure 5: Maintenance models performance contrast (Papic et al., 2009:534).

The proactive maintenance approach incorporates other applicable techniques like diagnostics and prognostics to drive unreliability down, and its construction is as shown below.

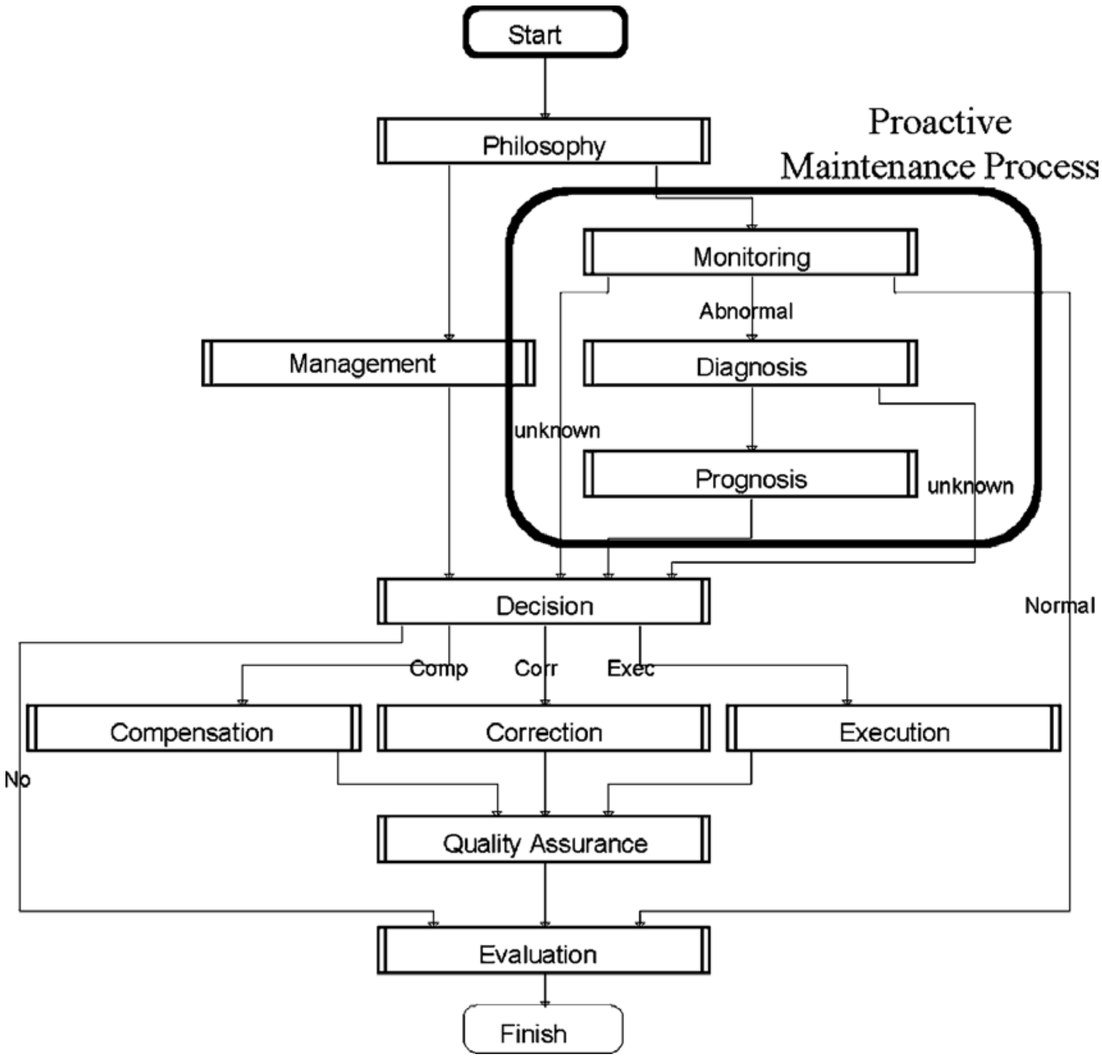

Figure 6: Basic elements of the proactive maintenance process (Iung et al., 2003:316).

A vital stride in harnessing the exact potential of any equipment or factory setup and improve its reliability and sustainability is to shift the maintenance strategic position from a reactive/preventive stance to a proactive dispensation (Henderson et al., 2014:450). Proactive maintenance entails implementation of a system dedicated to:

- Assets criticality assessment to determine failure impacts on the overall business performance, operations, human safety and environment
- Preserving machine basic conditions to prevent failures – tightening, cleaning, lubrication and alignment of rotating machines
- component failure prediction and prevention
- correct lubrication, machine tolerances and fits, and alignment
- Suitable material of construction to withstand functional conditions
- Experience based failure cause elimination
- Continuous assets reliability improvement
- Right skills and competence to deliver the results
- Perfect maintenance information

(Henderson et al., 2014:450).

Operationalizing a Proactive Maintenance Strategy

Prior to embarking on a proactive maintenance strategy journey, it is imperative that there is a clear understanding of the firm's current maintenance status, and then strategically map its route towards attainment of the proactive maintenance status, and not to drag along any fads that are trending within the maintenance spectrum (Henderson et al., 2014:450). A structured assessment methodology need to be adopted to come up with the rating for the current status, and the performance metrics for the future state need to be established as well. Below is a sample for a status mapping after the maintenance status assessment.

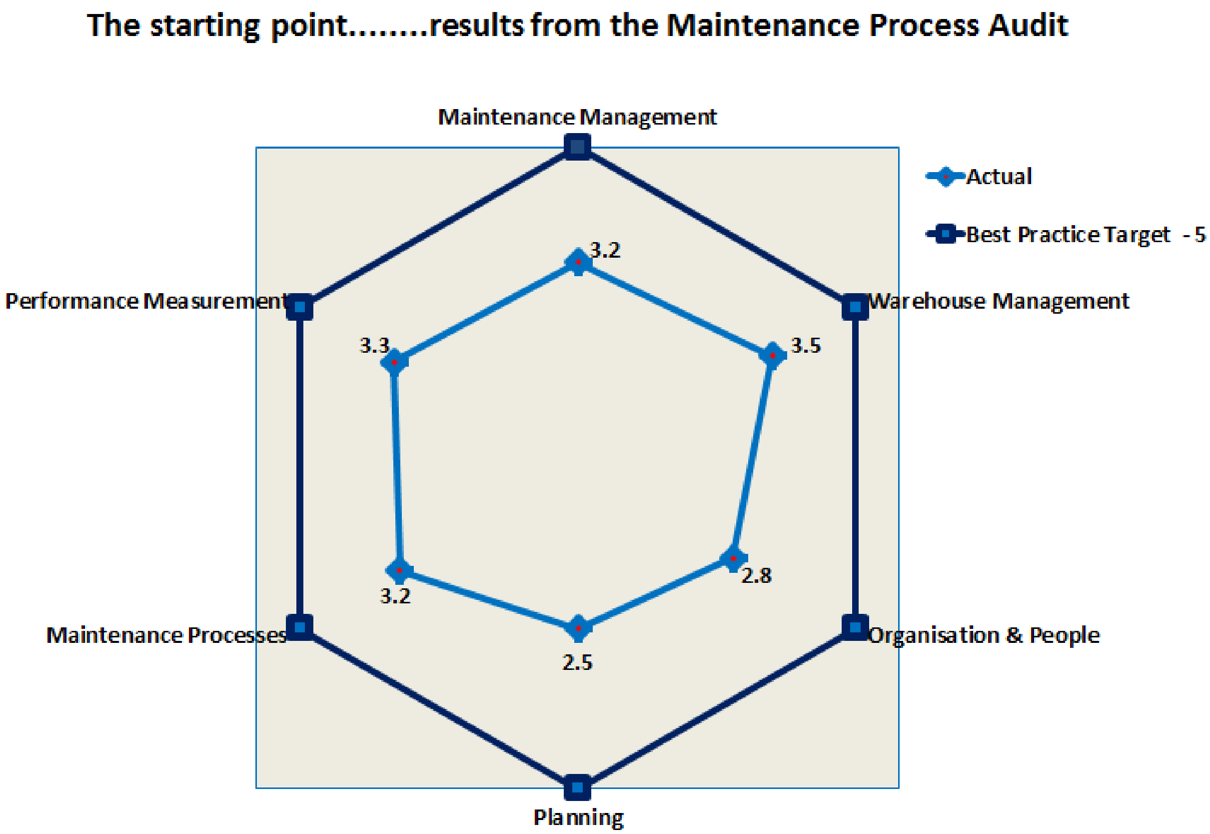

Figure 7: Maintenance assessment spider diagram example (Henderson et al., 2014:451).

Issues like jumping to introduce the likes of vibration analysis to trend defects on bearings without addressing the correct installation fitment and alignment aspects of rotary equipment, won't eliminate breakdowns at all, and failure is guaranteed whether or not the vibration analysis in being applied (Henderson et al., 2014:450). The trending towards proactive maintenance follows the understanding first of other maintenance concepts like corrective, preventive and predictive maintenance and their limitations, and making them a basis for improvement towards proactive maintenance. The implementation progression towards proactive maintenance is displayed in the figure below.

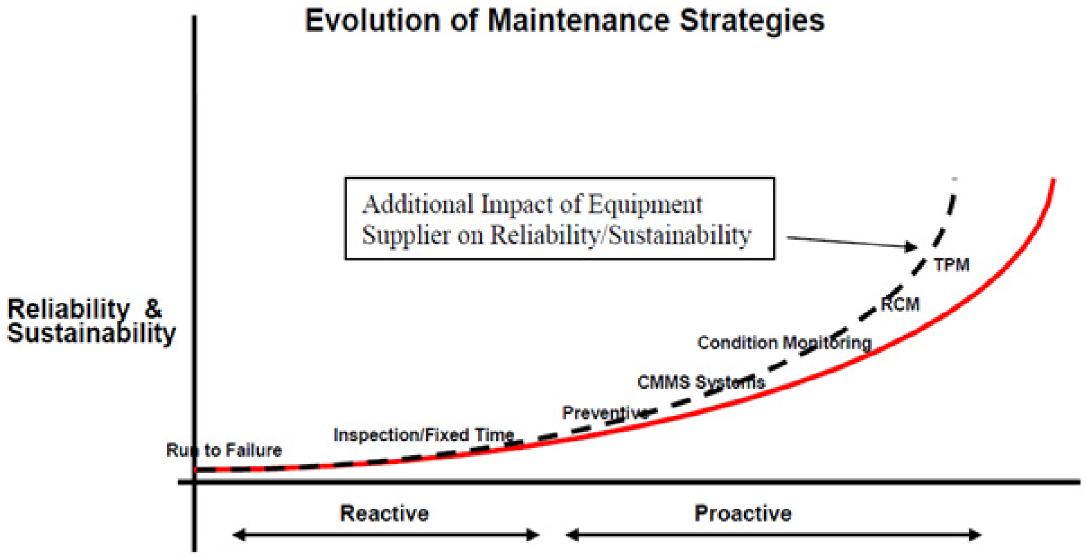

Figure 8: Superiority and progression towards Proactive Maintenance Strategy (Henderson et al., 2014:451).

The application of proactive maintenance strategy is a platform for an integrated asset management system that encompasses equipment manufacturers or suppliers to ensure a complete feedback loop of improvements emanating from failure experience learnings (Henderson et al., 2014:452). The essence is to capitalize on the reliability asset performance improvement initiatives in terms of harnessing equipment manufacturers' expertise and resources basing on feedback from the equipment users, and this exceptional collaboration can be summarized as:

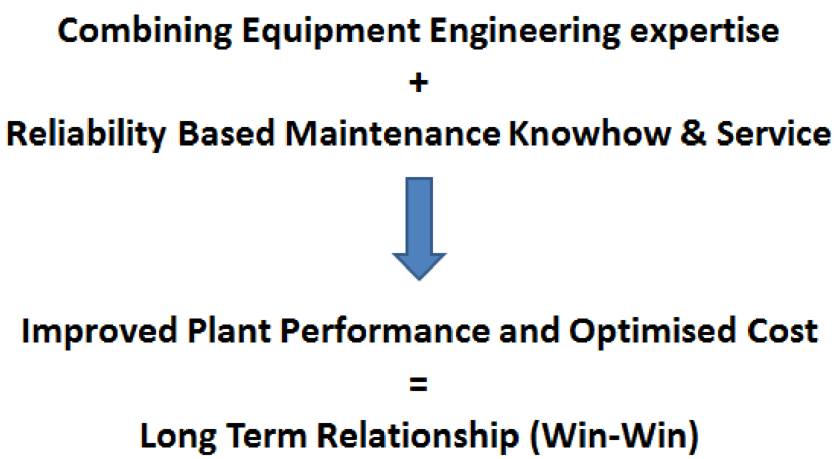

Figure 9: Collaborative platform in Proactive Maintenance for Reliability Improvement (Henderson et al., 2014:453).

In a nutshell, the proactive maintenance strategic implementation follows a process cycle format, which is premised on the concept of continuous improvement and can likewise adopt the four quadrants of the continuous improvement cycle (Exner et al., 2017:332).

Figure 10: Strategic Proactive maintenance cycle (Exner et al., 2017:332).

Discussion – Strategic push towards Proactive Maintenance

The implementation of proactive maintenance is a trip towards maintenance excellence, and the thought process need to surpass the conventional norm of maintenance practice. The escalation towards maintenance excellence through implementation of proactive maintenance is shown below.

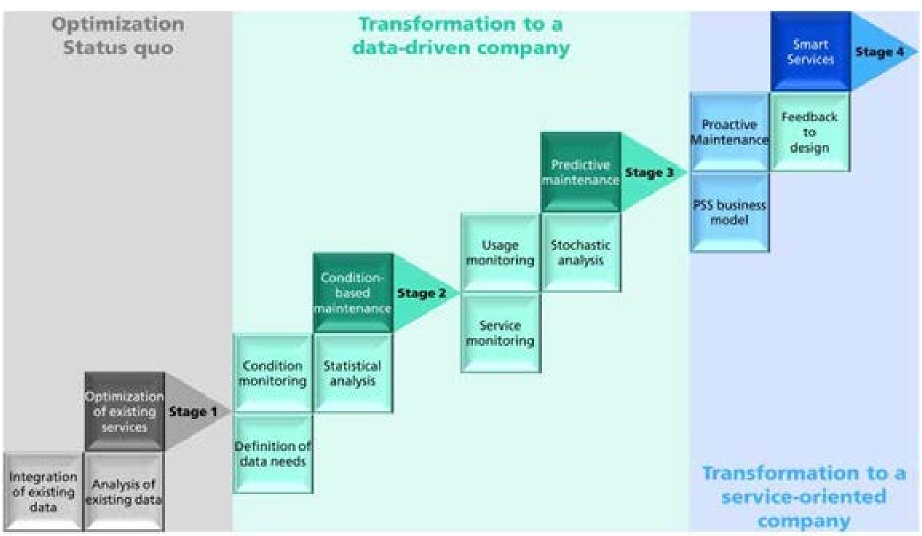

Figure 11: Transformation towards maintenance excellence through Proactive Maintenance (Exner et al., 2017:335).

Implementation of a proactive maintenance strategy means reducing overall maintenance costs expenditures for the entire maintenance function. Cost saving initiatives are introduced as failures are pre-meditated upon and eliminated or counteracted against before they even occur. This means that the frequency of equipment failures is drastically curtailed in advance, instead of waiting to react to failures, which happens to be a costly option. A comparative display of the cost structures under various maintenance strategies is as shown in the figure below.

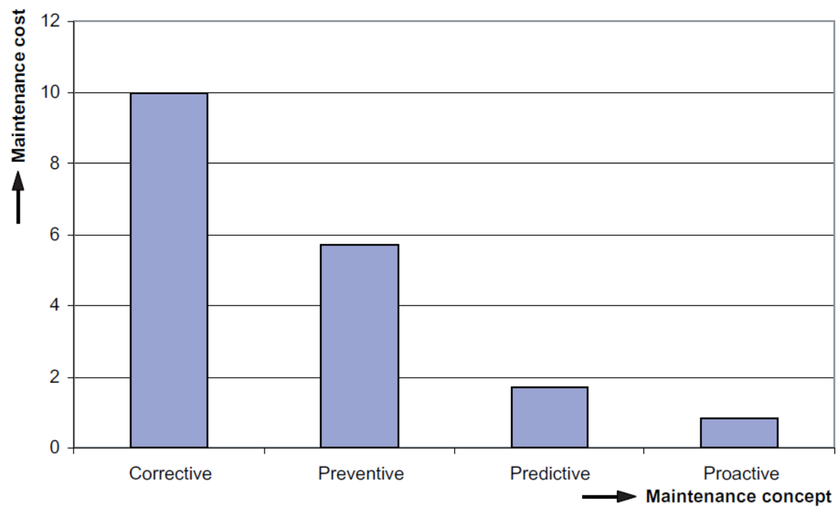

Figure 12: Comparative cost structures under various maintenance models (Papic et al., 2009:534).

Overall cost leadership and high reliability are obtainable under the auspices of a proactive maintenance strategic application, but its successful application need to be done in a structured way, otherwise the bad implementation will scupper the immense benefits inherent in this noble maintenance strategic intent. An optimized maintenance system will however comprise of a mix of maintenance strategies that contain applicable corrective, preventive, predictive and proactive maintenance activities, therefore an integrative approach will in reality produce the optimum results, as the benefits of each strategic concept is capitalized on (Papic et al., 2009:534).

Conclusion

The literature research is explicit about the benefits derived from the application of the proactive maintenance strategy and its superiority with regards to equipment failure elimination, asset reliability improvement and lessening overall maintenance costs. However, like any other strategy, any lack of a structured approach to implementing proactive maintenance will result in no reliability performance improvement realized, and a failure to reap any benefits allied to proactive maintenance.
The benefits derived from the application of proactive maintenance strategy include the following:

- Optimization of the overall performance of the plant manufacturing assets
- Increased useful life of physical assets
- Freeing up the maintenance function to concentrate on value adding activities rather than on reactive maintenance
- Reduction of the maintenance cost structure
- Improved Equipment performance, resources utilization, environmental & safety performance.
- Sustainable maintenance policy deployment

Further research efforts need to be focused on approaches for effectively implementing proactive maintenance strategy in various business set-ups.

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Biographies

Peter Muganyi is a doctoral candidate in Engineering Management at the University of Johannesburg, South Africa and he is an Engineering Manager at Gyproc. His research interest covers the areas of Lean Six Sigma effectiveness, Strategic Maintenance Systems deployment and Business Process Modelling.

Professor Charles Mbohwa is the Vice-Dean Postgraduate Studies, Research and Innovation at the University of Johannesburg's (UJ) Faculty of Engineering and the Built Environment (FEBE). As an established researcher and professor in the field of sustainability engineering and energy, his specializations include sustainable engineering, energy systems, life cycle assessment and bio-energy/fuel feasibility and sustainability with general research interests in renewable energies and sustainability issues.