Proceedings of the International Conference on Industrial Engineering and Operations Management
Bandung, Indonesia, March 6-8, 2018

Aligning the Maintenance Strategy with the Business Context to eliminate hurdles in translating the Business Strategy

Peter Muganyi

Department of Engineering Management
University of Johannesburg
Johannesburg, South Africa
peter777.muganyi@gmail.com

Charles Mbohwa

Faculty of Engineering and the Built Environment
University of Johannesburg
Johannesburg, South Africa
cmbohwa@uj.ac.za

Abstract

The alignment of the broad maintenance strategy with the overall business strategy brings in the strategic fit of maintenance activities with the overall business objectives. Many times there is a misfit between the maintenance objectives and the business objectives, and this creates fissured priorities at the operational level, which mostly suffocates and derails the maintenance or reliability improvement initiatives in many businesses. The overall impact derived from the strategic misfit is not only limited to the viability of maintenance operations, but this is translated to the entire business, with oftentimes detrimental effects to the entire business' performance. Therefore, the strategic significance of maintenance activities need to be considered at business level, and be linked to the overall business strategy to eliminate any conflicting priorities in the operation of the business as a whole. This study was undertaken to examine the ways in which maintenance strategies are formulated and interlinked to the overall business context, and the means that can be established to eliminate any hurdles that may impede the strategic translation process.

Keywords

Alignment, strategic fit, strategy translation, hurdles

Introduction

Today's competitive business arena calls for businesses to compete on various dynamics that include time, pricing, technological superiority, innovational leadership, quality, service-reliability, and data control, in the midst of all these factors, asset care and assets availability are vital strategic considerations that affect the business' capability to strive in the market effectively. (Madu, 2000:937). Asset maintenance strategies are essential in the competitive running of business establishments nowadays, and with the escalating reliance on technological facets for the majority of operational facades, it is imperative that befitting maintenance and reliability strategies are developed to safeguard that these businesses are able to deliver suitable quality and appropriate service to their clients (Madu, 2000:938). The industrial maintenance scenario is characterized by the strategic significance of ensuring

acquiescence with safety, environmental and economic necessities (Queiroz, et al., 2017:3189). Reference to a maintenance strategy means consideration of a set of procedures that encompass the following:
1) The composition of maintenance team(s) hired and the way in which they are allotted to various assets.
2) The maintenance techniques like Preventative or Predictive maintenance that the team(s) should exercise.
3) The spin-off from Corrective Maintenance interventions on whether they take consideration of the system or relevant subsystem(s) states.
4) Dynamic considerations of assets ageing, limited repair scenarios and imperfect information
(George-Williams and Patelli, 2017:1311).

The maintenance strategy is aimed at attaining the utmost availability and efficiency of physical assets and systems (Queiroz et al.: 2017:3189). Time and resources are spend by businesses to maintain their physical assets, and the resultant effect should be a guarantee of the maintenance effectiveness and business competitiveness (Queiroz et al.: 2017:3190). The appraisal of maintenance strategies embraces the identification of the most appropriate maintenance strategy for diverse assets by exploiting the benefits through considering a set of constraints (Seiti, et al., 2017:274). The strategic fit of the maintenance strategy relative to the business strategy can be assessed in two different ways centred on contingency: whereby the bivariate-related model inspects the manner in which contextual factors are related to the structural aspects of business and relating this connotation with performance; and the systemic approach cogitates the manner in which various structural and contextual aspects associate in a multiplicity of means to increase performance (Ortega, et al., 2012:958). The selection criterion of the optimal maintenance strategy for each asset is crucial for asset intensive enterprises, and consideration of business goals linked to maintenance objectives need to be included within the context of varying operational constraints, safety facets and reliability aspects (Srivastava et al., 2017:2). Therefore, the business scenario calls for a direct link between business strategies and maintenance strategies, and business goals and maintenance goals.

2. The Strategic Significance of Maintenance to Business Success

Maintenance and its management are of strategic prominence to business enterprises (Fraser, et al., 2015:635). The continued existence of any business establishment hinges on its propensity to compete effectually (Madu, 2000:938). Generally, maintenance is augmented against different reliability and performance measures, which are dependent on the goals of the business, and the ultimate aim is to attain the optimum balance between costs and benefits, but while taking cognizant of crucial business constraints (George-Williams and Patelli, 2017:1310). Asset Maintenance is a requisite for the majority of multi-component set-ups, even though its benefits are habitually complemented with substantial initial costs (George-Williams and Patelli, 2017:1309). Maintenance carries a pivotal part in the increase and advancement of manufacturing and processing organizations, and it is leveraged for attaining desired levels of assets availability, reliability and performance that is linked with business profitability (Kirubakaran and Ilangkumaran, 2016:285). The suitability of a maintenance strategy is quantified by its ability to improve a business' prowess to outpace others in the market, while also maximizing profits (Seiti, et al., 2017:274).

With the continued expansion and application of technology and the ever escalating complexity of contemporary systems in enterprises, the robustness of maintenance strategies in such highly competitive environments need to be in continuous check (Seiti, et al., 2017:274). The benefits generated from applying an efficacious maintenance strategy by far surpass the financial gains, as matters that include workers' safety, environmental impacts and the manufacturing performance are affected as well (Seiti, et al., 2017:274). Various enterprises recognize the significance of maintenance, but the process of determining the optimal or suitable strategy often present complex computations and decision reiterations that consider solid and vague aspects such as skillsets, organizational layout, manufacturing requirements, organizational situation and resources accessibility (Seiti, et al., 2017:274). Diverse maintenance strategies are applied in industrial setups, and it is common to interact with the likes of corrective (CM), preventive (PM), total productive (TPM), reactive (RM), predictive (PdM), reliability centred (RCM), risk-based (RBM) and time-based (TBM) maintenance strategies (Seiti, et al., 2017:274). It is prudent to say that the selection of maintenance strategies is a multi-criteria decision-making (MDCM) approach, as a multiplicity of criteria ought to be assessed while deciding on the optimal maintenance strategy amidst the numerous options (Seiti, et al., 2017:274).

An effective maintenance strategy improves the availability, manufactured goods quality, asset safety and reliability of physical assets, and so it acts as a profit contributor to the business and as an essential partner of enterprises to attain the global competitiveness (Srivastava et al., 2017:2).

3. Aligning Maintenance Strategy to Business Strategy

For businesses to succeed in their strategic thrusts, they need to construct an organizational culture that is fully supportive of enterprise-wide maintenance and reliability undertakings (Madu, 2000:938). The maintenance supportive aspects such as information management systems and data gathering, remain key to enhanced reliability and maintenance performance, therefore, they ought to be synchronized in a cohesive business approach (Madu, 2000:938). This calls for business common goal alignment, which ensures that maintenance strategic goals contribute to the overall business goals, and their management should reflect such (Madu, 2000:938). Even though the obligation of ensuring that every physical asset of the company is properly maintained and functional, lies with the maintenance function, it is the responsibility of every employee of the organization to certify that a highly reliable and dependable system is maintained (Madu, 2000:938). To realize this, information and ideas sharing should flow freely within the organization, and functional silos should be eliminated, or else sub-optimization will prevail and the organizational objectives will not be accomplished (Madu, 2000:938). The involvement of the entire organizational levels is the key to attaining improved cost effective maintenance performance (Madu, 2000:938). Therefore, the fine tuning of the strategic requirements like resources and technological support requires a business-wide amalgamation approach in order to attain optimality (George-Williams and Patelli, 2017:1309). Maintenance team sizing and operational considerations need to be derived from a business perspective, without isolating the maintenance function on its own (George-Williams and Patelli, 2017:1309).

The relational arrangement between the business and maintenance strategies need to follow a systematic approach with the vital settings, methodologies and performance trailing arrangements that entail easy management (Pinheiro de Lima, et al., 2013:525). An assortment of strategic management platforms have been developed from the strategic management literature, and the dominant frameworks encompass the likes of the balanced-scorecard (BSC) and the strategic-measurement-analysis-and-reporting-technique (SMART) (Pinheiro de Lima, et al., 2013:525). These platforms have the capability to link prominent measures like reliability monitors that cover Mean-Time-Between-Failure (MTBF), Failure-Rate (FR) and Mean-Time-To-Repair (MTTR) to the overall business strategy and objectives (Catelani, et al., 2015:140).

Ordinarily, effective strategic frameworks generate vital capability to congregate human and financial resources on particular physical assets in an industrial setup to propel the organization's strategic intents, and this can be achieved by:

- assessing value generated by the maintenance activities
- authenticating investment in physical assets
- valuing resources portioning
- impacts on safety and environmental performance
- demonstrating data control and management
- fluctuating to novel developments in the industrial arena and maintenance strategies, and

- enterprise's organizational adaptations to strategic intents (Simões, et al., 2011:117).

The strategic frameworks like the balanced scorecard are dynamic and can manage maintenance performance effectively (Muchiri, et al. 2011:297). Additionally, the strategic frameworks permit a vital interlink between the business strategy and the maintenance activities on the shopfloor, and for that reason they embolden application and utilization of collaborative implementation of strategic intents (Muchiri, et al. 2011:298). The figure below illustrates the link between the business strategy and the maintenance strategy.

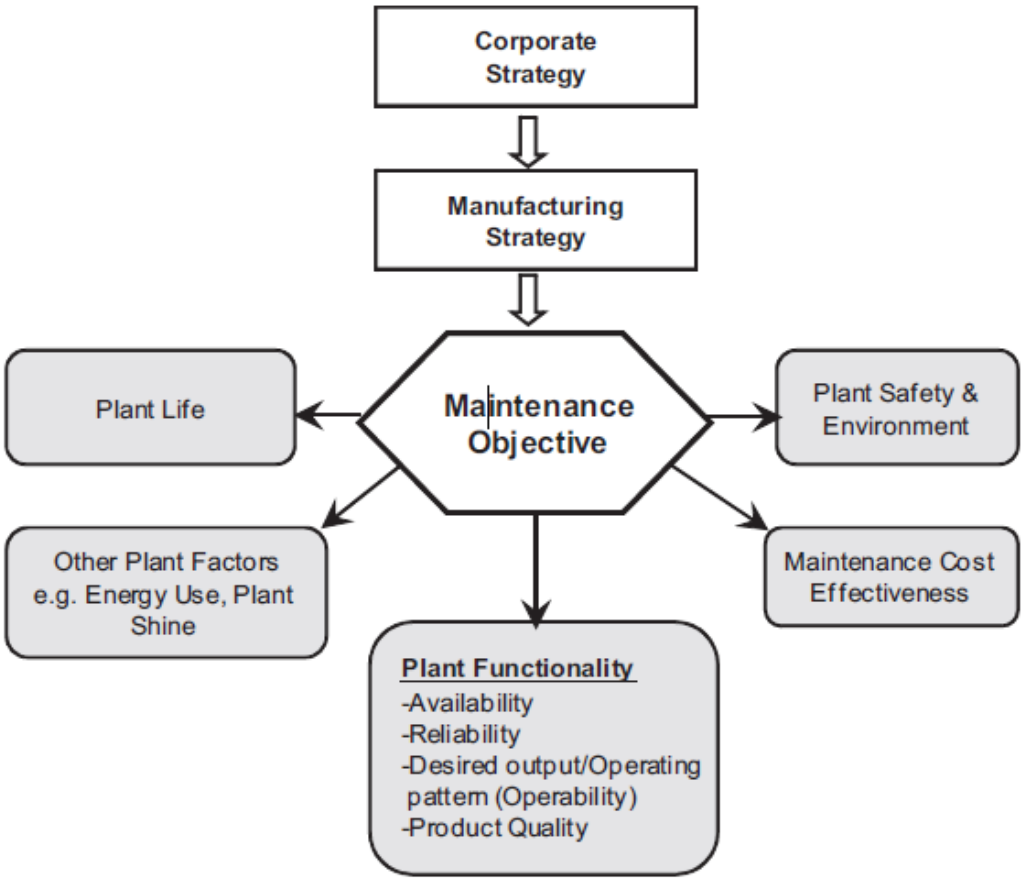

Figure 1: Link between business and maintenance strategies (Muchiri, et al. 2011:297).

Presently, there exist an insignificant drive to link the business strategies to the maintenance strategies and objectives, and more so, a small number of firms utilize maintenance activities that are influenced by corporate objectives (Van Horenbeek and Pintelon, 2014:34). It is imperative that maintenance strategies/objectives are allied to the business strategy and objectives (Van Horenbeek and Pintelon, 2014:35). The business strategies vary from company to company, but

below is a generic strategic workflow from the corporate level and down to the maintenance operational level.

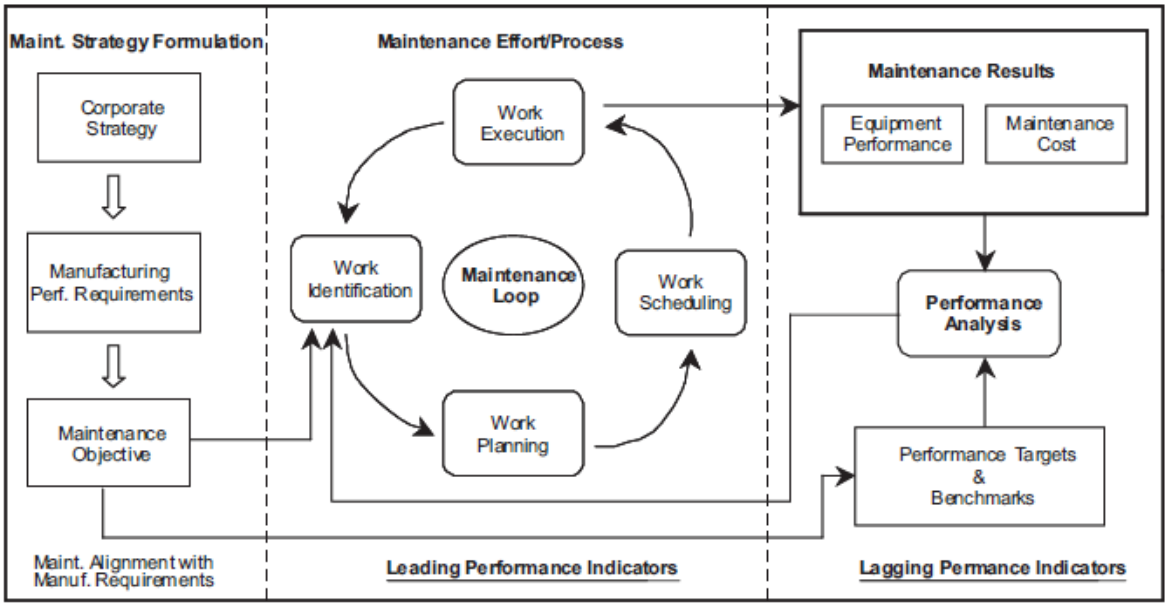

Figure 2: Linking business strategy to maintenance operational level (Muchiri, et al., 2011:298).

During the implementation of the business strategy, there is need of establishing multi-level implementation schemes, bestowing a tiered interrelation between the business strategy and the maintenance strategy and its objectives, signifying the drive of the maintenance function to satisfy the business strategic intents in an inclusive manner (Parida, et al., 2015:15).

Case Study – Eliminating Strategic Hurdles between Business and Maintenance

A case study was pursued at a manufacturing organization in Johannesburg with the intent of establishing how it links its business strategies and maintenance strategies. The first port of call was to establish if any business strategy and objectives existed, and this was all witnessed by a displayed balanced scorecard that listed all the business objectives in the various areas. Four (4) areas of strategic focus were established according to the case entity's balanced scorecard, and they comprised of the following subdivisions:

- Environment, Health and Safety
- Cost
- People
- Customers

A display of an extract of the balanced scorecard is shown in the table below.
Table 1: Organizational balanced scorecard

BALANCED SCORECARD 2018

NO.	SD	MWB	TOP LEVEL OPERATIONS KPIs	UOM	RESPONSIBLE		2016	2017	Jan 18	Feb 18	2018 YTD
EHS											
1	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	TF 1/2 & EVE 1/2	Per Event	SAFETY OFFICER	Target	0	0	0	0	0
						Actual	0	0	0	0	
2	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	TF4 reporting (Group target 25% increase YOY)	# of reports	SAFETY OFFICER	Target	80	120	10	10	120
						Actual	97	107	9	5	
3	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	RISK RATING (Group target 30% reduction YOY)	Risk Score	SHEQ COORDINATOR	Target	12,000	52,800	4,000	4,400	67,400
						Actual	50,050	71,852	4,024	4,402	
4	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	SAFETY STANDARD COMPLIANCE (27 SG standards)	# stds above 90%	SHEQ COORDINATOR	Target	5	15	20	20	20
						Actual	3	9	9	11	
5	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	WATER USAGE (Group target 6% over 3years(2013) = 2% reduction YOY)	kL / t produced	ENV pillar owner	Target	0.9	0.3	0.3	0.3	0.3
						Actual	1.3	0.1	0.1	0.1	
6	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	WASTE TO LANDFILL (Group target 6% over 3years(2013) = 2% reduction YOY)	t / t produced	ENV pillar owner	Target	300	65	80	80	80
						Actual	1087	105	98	138	
7	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.6: WCM BACK 2 BASICS	ENERGY CONSUMPTION	kwhr / t produced	PROCESS ENGINEER	Target	620	558	558	558	558
						Actual	594	621	638	745	
COST											
1	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.6: WCM BACK 2 BASICS	COST SAVING (Target 3%)	ZAR x 1000	WCM FACILITATOR	Target	2,100	5,000	558	558	6,696
						Actual	2,805	5,984	458	569	
2	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.6: WCM BACK 2 BASICS	40 kg Rhinolite PRODUCT COST	ZAR / kg	CR PILLAR OWNER	Target	1.7	2.2	2.3	2.3	2.3
						Actual	1.6	2.1	2.1		
3	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.6: WCM BACK 2 BASICS	NET SALEABLE YIELD (Total Plant)	%	PRODUCTION MANAGER	Target	97.0	98.0	98.0	98.0	98.0
						Actual	96.3	97.1	99.9	99.8	
4	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.5: IMPROVE PLANT AVAILABILITY	ENGINEERING RELIABILITY (Line 1)	%	ENGINEERING MANAGER	Target	98.0	99.0	98.0	98.0	98.0
						Actual	98.9	97.0	94.7	95.0	
5	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.5: IMPROVE PLANT AVAILABILITY	AVAILABILITY (Line 1)	%	ENGINEERING MANAGER	Target	96.0	98.0	96.0	96.0	96.0
						Actual	94.7	94.0	83.9	81.5	
6	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.2: IMPROVE BUSINESS CONTROL COMPLIANCE	TOTAL COST BUDGET VARIANCE (Fixed + Variable)(Cost Center)	ZAR xmil	PLANT MANAGER	Target	34,601	59,443	4,871	4,930	58,880
						Actual	48,807	50,911	3,244	6,727	
7	SD 3: OPERATIONS EFFECTIVENESS	MWB 3.2: IMPROVE BUSINESS CONTROL COMPLIANCE	CAPEX BUDGET	ZAR x 1000	ENGINEERING MANAGER	Target	2,471	15,940	0	40	1,340
						Actual	0.42	16189	0	40	
CUSTOMERS											
1	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	CSIp	%	WAREHOUSE MANAGER	Target	95.0	97.0	97.0	97.0	97.0
						Actual	95.5	96.3	88.6	85.0	
2	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	OTIF order	%	WAREHOUSE MANAGER	Target	95.0	97.0	97.0	97.0	97.0
						Actual	94.8	92.7	70.0	69.0	
3	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	PSA (Production Schedule Adherence for plant)	%	PRODUCTION MANAGER	Target	85.0	85.0	85.0	85.0	85.0
						Actual	82.1	84.9	85.1	78.8	
4	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	CUSTOMER COMPLAINTS (valid Complaints)	#	PROCESS ENGINEER	Target	1	1	1	1	1
						Actual	0.3	0.8	0	1	
5	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	SRA (Stock Record Accuracy)	%	WAREHOUSE MANAGER	Target	96.0	97.0	97.0	97.0	97.0
						Actual	97.4	98.1	98.4	100.0	
6	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	PRODUCTION OUTPUT	TONS	PRODUCTION MANAGER	Target	44,952	36,363	2,450	2,900	35,382
						Actual	41,627	36,897	2,361	2,867	
7	SD 1: MARKET & CUSTOMER ENGAGEMENT	MWB 1.6: IMPROVE CUSTOMER EXPERIENCE	TRUCK TURN AROUND TIME (Average / Total trucks loaded)	Min	WAREHOUSE MANAGER	Target	45	45	42	42	42
						Actual	43	41	39.2	41.2	
PEOPLE											
1	SD 4: PEOPLE DEVELOPMENT	MWB 4.5: INCREASE EMPLOYEE ENGAGEMENT	PDR COMPLETED (Performance development Review)	#	PLANT MANAGER	Target	8	11	6	0	22
						Actual	24	11	6	0	
2	SD 4: PEOPLE DEVELOPMENT	MWB 4.5: INCREASE EMPLOYEE ENGAGEMENT	ABSENTEEISM RATE	%	HR BUSINESS PARTNER	Target	2.0	2.0	2.0	2.0	2.0
						Actual	0.5	0.9	0.8	0.4	
3	SD 4: PEOPLE DEVELOPMENT	MWB 4.5: INCREASE EMPLOYEE ENGAGEMENT	PROJECT COMPLETION RATE (F-matrix compliance)	%	WCM FACILITATOR	Target	85.0	85.0	85.0	85.0	85.0
						Actual	75.6	63.4	100.0	80.0	
4	SD 4: PEOPLE DEVELOPMENT	MWB 4.5: INCREASE EMPLOYEE ENGAGEMENT	PEOPLE INVOLVEMENT IN WCM (using WCM tools)	# people	WCM FACILITATOR	Target	80.0	80.0	80.0	80.0	80.0
						Actual	86.7	71.1	75.0	77.2	
5	SD 4: PEOPLE DEVELOPMENT	MWB 4.5: INCREASE EMPLOYEE ENGAGEMENT	HUMAN ERRORS	# Events	PD PILLAR OWNER	Target	5	5	5	5	5
						Actual	6	6	7	6	

The next assessment was to confirm whether there was any link between the business objectives and the maintenance objectives, and this was done through assessing the departmental objectives and plans for the maintenance function. The reliability development plan was assessed and it is as depicted below, which affirmed that the plan was in agreement with the business objectives under the COST section of attaining 98% assets reliability. The plan included reliability improvement projects for specific physical assets that were found to have low reliability. Below is a bridge graph that summarized the reliability improvement plan.

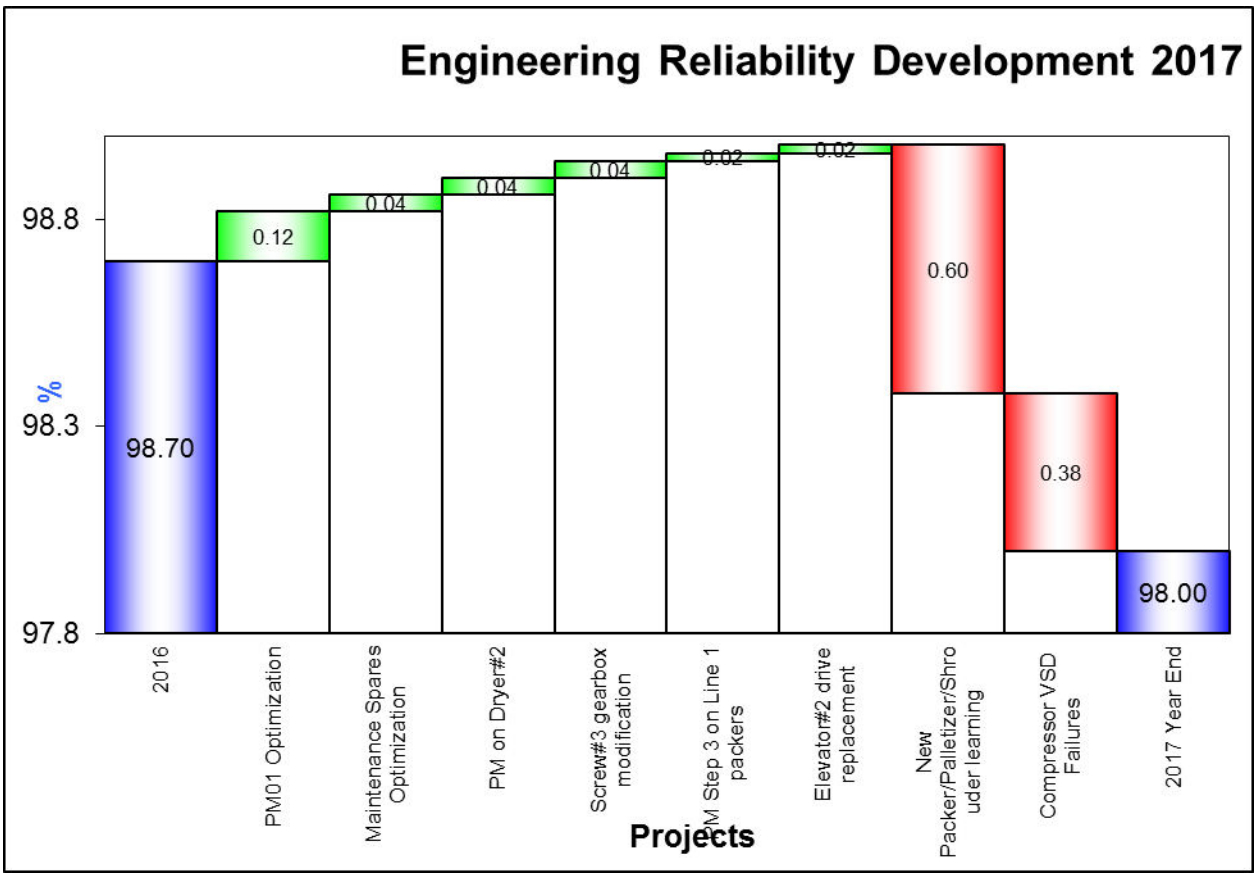

Figure 3: Reliability improvement bridge graph

The detailed reliability improvement plan was also tabulated in the table below detailing the projects.

Table 2: Reliability improvement plan

Plant KPI's Bridge Model Template For PM Pillar Board

How to use notes	1. only add data (text or numbers as specified) into the cells that are YELLOW. Everything else is automatic.	2. if you have to add more project columns, use copy and insert.		3. at the end of the year, delete all unused project	4. adjust Y Axis scale to be suitable					
Type current year here>>>>	**2017**									
Type plant here>>>>	**Germiston Plaster Plant**									
Type X axis title here>>>>	**2017 Projects**									
	Previous Year End	**For each project completed, input the Full Year Impact of that project on Plant**								**Current Year End**
		Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	New Issue	New Issue	
	Previous Year Reliability%	***PM01 Optimization***	***Maintenance Spares Optimization***	***PM on Dryer#2***	***Screw#3 gearbox modification***	***PM Step 3 on Line 1 packers***	***Elevator#2 drive replacement***	***New Packer/Palletizer/Shrouder learning***	***Compressor VSD Failures***	**Year End Performance**
	2016									**2017**
Type Customer Satisfaction improvment da	98.70	0.12	0.04	0.04	0.04	0.02	0.02	0.60	0.38	
	2016	PM01 Optimization	Maintenance Spares Optimization	PM on Dryer#2	Screw#3 gearbox modification	PM Step 3 on Line 1 packers	Elevator#2 drive replacement	New Packer/Palletizer/Shrouder learning	Compressor VSD Failures	2017 Year End
	98.70	98.70	98.82	98.86	98.90	98.94	98.96	98.38	98.00	98.00
		0.12	0.04	0.04	0.04	0.02	0.02	0.60	0.38	

To further confirm whether there was a complete link between the maintenance objectives and the business objectives, the engineering department's balanced scorecard was also assessed to identify if there was any point of departure from the business scorecard. All the business objectives were found to be addressed in the departmental business objectives as per the table shown below.

Table 3: Departmental balanced scorecard

ENGINEERING DEPARTMENT - BALANCED SCORECARD 2018

NO.	SD	MWB	TOP LEVEL OPERATIONS KPIs	UOM	RESPONSIBLE		2017	Jan 18	Feb 18	2018 YTD
EHS										
1	SD3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	TF 1/2 & EVE 1/2	Per Event	ENGINEERING MANAGER	Target	0	0	0	0
						Actual	0	0	0	0
2	SD3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	TF4 reporting (Group target 25% increase YOY)	# of reports	ENGINEERING MANAGER	Target	0	2	2	14
						Actual	14	0	0	0
3	SD3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	SMATs observation (full SMAT discussion)	# of reports	ENGINEERING MANAGER	Target	4	4	4	4
						Actual	4	5	4	5
4	SD3: OPERATIONS EFFECTIVENESS	MWB 3.1: IMPROVE SAFETY CULTURE	OSAs	# of reports	ENGINEERING MANAGER	Target	25	22	25	22
						Actual	25	17	12	29
COST										
1			WCM COST SAVING (Target 3%)	ZAR x 1000	ENGINEERING MANAGER	Target	0.0%	R 83.30	R 83.30	R 999.60
						Actual	not measured	0	0	0
2			TOTAL COST BUDGET VARIANCE (MANTAINANCE)		ENGINEERING MANAGER	Target	105%	R 429,000.00	R 429,000.00	R 858,000
						Actual	not measured	R 302,000.00	R 624,895	R 463,448
ENGINEERING PERFORMANCE										
1	SD3: OPERATIONS EFFECTIVENESS	MWB 3.3: IMPROVE PLANT AVAILABILITY	TECHNICAL STOPS	#	ENGINEERING MANAGER	Target	10.0	10	10	10
						Actual	18.0	19	12	16
2	SD3: OPERATIONS EFFECTIVENESS	MWB 3.3: IMPROVE PLANT AVAILABILITY	ENGINEERING RELIABILITY	%	ENGINEERING MANAGER	Target	98.0	98.0	98.0	98.0
						Actual	98.9	94.6	95.0	94.8
3	SD3: OPERATIONS EFFECTIVENESS	MWB 3.3: IMPROVE PLANT AVAILABILITY	MTBF	HRS	ENGINEERING MANAGER	Target	300	100	100	100
						Actual	323	27.88	42.13	35.0
4	SD3: OPERATIONS EFFECTIVENESS	MWB 3.3: IMPROVE PLANT AVAILABILITY	MTTR	HRS	ENGINEERING MANAGER	Target	1.5	1.5	1.5	2
						Actual	1.3	1.57	2.20	1.9
PEOPLE										
1	SD4: PEOPLE DEVELOPMENT	MWB 4.3: INCREASE PEOPLE ENGAGEMENT	TRAINING PLAN COMPLIANCE	%	ENGINEERING MANAGER	Target	80%	80%	80%	80%
						Actual	55%	100%	100%	100%
2			ABSENTEEISM RATE	%	ENGINEERING MANAGER	Target	2%	2%	2%	0
						Actual	3%	1.50%	4.40%	3.0%
3			WCM INVOLVEMENT	%	ENGINEERING MANAGER	Target	80%	80%	80%	80
						Actual	89%	82%	86%	1
3			PROJECT COMPLETION RATE (F-matrix compliance)	%	ENGINEERING MANAGER	Target	85%	85%	85%	85%
						Actual	93%	76%	83%	80%
4			HUMAN ERRORS	# Events	ENGINEERING MANAGER	Target	2	2	2	2
						Actual	0	0	0	0

Discussion of Results and Conclusion

The link between the business objectives as per the business balanced scorecard and the maintenance objectives as per the maintenance department's balanced scorecard showed that in order to gain alignment of strategic intents, the functional objectives need to relate to the business objectives. This scenario removes the ambiguity of understanding the maintenance plans that need to be carried out in order to attain the business objectives. This further removes the hurdles in acquiring resources required by the maintenance function for them to meet their own objectives which are in alignment to the business objectives. The alignment of strategies and objectives removes the counterproductive debates and justification for maintenance expenditures in the absence of concrete plans. The budgetary processes also need to follow the strategic derivatives which are generated from the maintenance plan that is put in place with the objectivity to meet the business goals.

References

Catelani, M., Ciani, L., Graditi, G. and Adinolfi, G., Measurement and Comparison of reliability Performance of Photovoltaic Power Optimizers for Energy Production, *Metrology and Measurement Systems*, vol. XXII, iss. 1, pp. 139–152, 2015.
Fraser, K., Hvolby, H. H. and Tseng, T.L., Maintenance management models: a study of the published literature to identify empirical evidence: A greater practical focus is needed, *International Journal of Quality & Reliability Management*, Vol. 32 Issue: 6, pp.635-664, 2015.
George-Williams, H. and Patelli, E., Maintenance Strategy Optimization for Complex Power Systems Susceptible to Maintenance Delays and Operational Dynamics, *IEEE Transactions on Reliability,* vol. 66, no.4, pp. 1309 – 1330, 2017.
Kirubakaran, B. and Ilangkumaran, M., Selection of optimum maintenance strategy based on FAHP integrated with GRA–TOPSIS, *Annals of Operations Research*, vol. 245, pp. 285–313, 2016.
Madu, C. N., Competing through maintenance strategies, *International Journal of Quality & Reliability Management*, Vol. 17 Issue: 9, pp.937-949, 2000.
Makinde, O. A., Mpofu, K. and Ramatsetse, B., Establishment of the best maintenance practices for optimal reconfigurable vibrating screen management using decision techniques, *International Journal of Quality & Reliability Management*, Vol. 33 Issue: 8, pp.1239-1267, 2016.
Muchiri, P., Pintelon, L., Gelders, L. and Martin, H., Development of maintenance function performance measurement framework and indicators, *International Journal of Production Economics*, vol. 130, pp. 295 – 302, 2011.
Ortega, C. H., Garrido-Vega, P. and Machuca, J. A. D., Analysis of interaction fit between manufacturing strategy and technology management and its impact on performance, *International Journal of Operations & Production Management*, Vol. 32 Issue: 8, pp.958-981, 2012.
Parida, A., Kumar, U., Galar, D. and Stenström, C., Performance measurement and management for maintenance: a literature review, *Journal of Quality in Maintenance Engineering*, vol. 21, iss. 1, pp. 2-33, 2015.
Pinheiro de Lima, E., Gouvea da Costa, S.E., Jan Angelis, J. and Munik, J., Performance measurement systems: A consensual analysis of their roles, *International Journal of Production Economics*, vol.146, pp. 524–542, 2013.
Queiroz, A. R. S., Senger, E. C., Queiroz, L. C. L., Rangel Jr., E. and de Paula, V. S., Maintenance Strategy for Electrical Equipment Based on Integrated Operations, *IEEE Transactions on Industry Applications*, vol. 53, No. 3, pp. 3189 – 3197, 2017.
Seiti, H., Tagipour, R., Hafezalkotob, A. and Asgari, F., Maintenance strategy selection with risky evaluations using RAHP, *Journal of Multi-Criteria Decision Analysis*, vol. 24, pp. 257−274, 2017.
Simões, J.M., Gomes, C.F. and Yasin, M.M., A literature review of maintenance performance measurement: A conceptual framework and directions for future research, *Journal of Quality in Maintenance Engineering*, vol. 17, iss. 2, pp.116-137, 2011.
Sinha, P., Towards higher maintenance effectiveness: Integrating maintenance management with reliability engineering, *International Journal of Quality & Reliability Management*, Vol. 32 Issue: 7, pp.754-762, 2015.
Srivastava, P., Khanduja, D. and Agrawal, V.P., A framework of fuzzy integrated MADM and GMA for maintenance strategy selection based on agile enabler attributes, *Mathematics-in-Industry Case Studies*, vol. 8, no. 5, pp. 1 – 23, 2017.
Van Horenbeek, A. and Pintelon, L., Development of a maintenance performance measurement framework—using the analytic network process (ANP) for maintenance performance indicator selection, *Omega*, vol. 42, pp. 33–46, 2014.

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.