PERCEPTION OF STAKEHOLDERS ON THE MAINTENANCE MANAGEMENT STRATEGIES FOR SPORTS FACILITIES IN SELECTED UNIVERSITIES IN SOUTHWESTERN, NIGERIA

Godwin E. Oseghale
Department of Building, Obafemi Awolowo University, Ile-Ife, Nigeria

Ime J. Ikpo
[1]Department of Building,Obafemi Awolowo University,Ile- Ife, Nigeria

Bridget O. Oseghale
Department of Building, Obafemi Awolowo University, Ile-Ife, Nigeria

Johnson D. Adetooto
Department of Building, Ambrose Alli University, Ekpoma, Nigeria

ABSTRACT: *The paper identified and examined facilities maintenance strategies adopted in selected universities in south-western Nigeria, examined maintenance planning and factors influencing the choice of maintenance strategies adopted in the study area. Data were sourced using a structured questionnaire administered on sportsmen and women and the maintenance staff of the maintenance department in the universities sampled. The sample size captured all the fifteen games, featured in Nigeria university games association (NUGA) in the three federal universities that had such facilities for the fifteen games and have hosted the national and international sporting event were purposively selected. Data were analyzed using frequency distribution, percentages and mean response analysis. The findings revealed that the most influencing factors for the choice of maintenance strategies were maintenance policy with a mean score of (3.90), technological factors (3.85), maintenance standard (3.76), maintenance tactics (3.74), economic factors (3.74), and environmental factors (3.73). The study concluded that the most widely used maintenance strategy was reactive maintenance strategy and identified its problem to be the adoption of a piecemeal approach to the maintenance of facilities thereby resulting in under-maintenance of sports facilities.*

KEYWORDS: factors, maintenance, management, sports facilities, strategies, planning

INTRODUCTION

The condition and quality of structures in an environment serve as indices of the quality of life. The majority of people spend over 95 percent of their time in / next to a structure

of one kind or the other, so the built environment remains our natural environment (Lee and Wordsworth, 2001). Maintenance management systems are meant to support the effective performance of physical facilities by reducing the frequency and severity of the failure. The quality of maintenance works does not only directly affect the technical performance of the facilities, but also the cost-effectiveness of their operations and services to the users and customers, as well as add value to the organization. Maintenance, as a support function, in organizations with significant investment in physical assets, plays an important role in meeting overall business objectives, which according to Tsang (2002), translates to asset availability and reliability.

Facilities maintenance management strategies such as routine, emergency, reactive, preventive, condition-based and reliability centred maintenance all involve complicated processes (Oseghale, 2016). Routine maintenance chore is the most frequently recurring type of maintenance activity which involves daily cleaning of facilities (buildings, ancillary equipment, and landscape). It has been observed that most organizations adopt a reactive maintenance strategy rather than proactive works. Reactive maintenance is the simplest form of maintenance strategy, it is also known as breakdown maintenance. Reactive maintenance is seldom organized and is the typical practice in most institutions of higher learning (Oseghale, 2016; Oseghale and Ikpo, 2018). This strategy postpones repairs and allows failure to compound; thus, accumulating an organization's problems and giving the superficial impression that it is costly. Preventive maintenance is aimed at preserving the physical integrity of the facilities and premises and eliminating corrective maintenance cost. This theoretical illusion lacks footing because failure is not a predetermined or planned event. Liu, (2009) argued that many types of failures could not be prevented or effectively reduced by such right-age overhauls no matter how intensively they were performed. Failure is stochastic in occurrence and therefore no planned preventive maintenance can be introduced to replace reactive maintenance with the primary objective of minimizing the total cost of repairs and facility/ equipment downtime (Mann, Saxena, and Knapo, (1995).

Other pro-active maintenance strategies such as condition-based maintenance [CBM] and reliability centred maintenance [RCM] programmes may only complement reactive maintenance to minimize maintenance costs, enhance availability, that may not be achieved by the traditional time-based preventive maintenance (Kennedy, 2006; Oseghale, 2016). CBM and RCM programmes which are based on the concept that every item in a facility or equipment has a right age at which complete overhaul is necessary to ensure safety and operating reliability.

Within the university setting, facilities are places where people live, work, learn, teach, and carry out activities and conduct research (Olarewaju, Mohd and Arazi, 2010). A university facility may be seen as a factor of production. They are procured to create a suitable, conducive and adequate environment that can support, stimulate and

encourage learning, teaching, innovation and research activities (Olanrewaju et al, 2010; Oseghale, 2016). Universities contain unique and sophisticated buildings and sports complexes that are used to perform various types of activities and functions. However, little focus and attention has been given to the management and maintenance of the sport facilities by university leaders and managers, despite the growth of university students in all campuses (Brunton and Mackintosh, 2017; Clearing House for sport 2017; International university sports Federation (IUSF) 2017). Most Nigerian tertiary institutions do not have adequate facilities and equipment for sports (Bichi, 2018), hence the critical need for the selection of optimal strategy for the maintenance of existing sport facilities in the institutions.

Maintenance strategies need to be carefully selected since not all strategies would optimally address set objectives of an estate – residential, commercial, agricultural, cultural, educational, industrial, or recreational. Though independent studies have been conducted on each of the listed estates in developed countries, in Nigeria there exists a preponderance of literature only on the management of residential properties. This study, therefore, examined maintenance strategies adopted in selected universities in southwest Nigeria, sports facilities maintenance planning, frequency of maintenance operations and factors influencing the choice of maintenance strategies adopted in the study area to determine optimal strategy.

LITERATURE

There is a paucity of literature on the maintenance of sports facilities. Ikpo 2001 only examined the major attributes of sports buildings, which distinguish them from other building types. Lee and Scott (2009) only focused on building maintenance operation processes in sports and leisure facilities. Their studies help to minimize the gaps between the top management at the strategic level and maintenance personnel at the operation level in performing building maintenance. The studies of Akinsola, Faphumda, Ogunsanmi, Ajibola, and Fatokun, (2012) were limited to investigating the state of sports stadium facilities in Southwestern Nigeria and their level of compliance with international and national standards. Also, Harun, Salamuclin, and Hushin (2013) only aimed at obtaining important information related to maintenance management practices of public sports facilities managed by the Stadium Corporation in Malaysia.

Ali and Kamaruzzaman, (2010) examined factors affecting housing maintenance cost. Tse 2002, assessed maintenance practices in Hong Kong, while Wae and Pintelon, (2004) provided some information on how to use maintenance concept and framework to provide some guidelines which can be helpful when making the decision which maintenance policy to use. Khazraei and Deuse (2011) provided information on the concrete and well-structured classification of different maintenance types that are accepted globally. The study gathers and reviews several examples of maintenance classifications and viewpoints from different geographical regions in the world. Fraser,

Hvolby, and Tseng (2015) Assessed maintenance management model and used published literature to identified empirical evidence to develop a model to shed light on the various models and their use in real-world applications, and in doing so, explores the gap between academic research and practice. Literature addressing sports facilities maintenance strategies and the factors influencing the choice of strategies are scanty and limited hence this study.

METHODOLOGY

A total of fifteen (15) games have been identified to have featured in the Nigeria University Games Association (NUGA). The statistically required sample size for the games is calculated from the formula given by Sediary (1994) as follows:

$$n = n1/(1+n1)/N \qquad (1)$$

Where n is the sample size;

$$n1 = S1/V2 \qquad (2)$$

$$S1 = Pq \qquad (3)$$

In which N is the total estimated population; and V, the standard error of the sampling distribution = 0.05, S1, the Maximum standard deviation in population, P is the proportion of population element that belongs to a defined class (assumed to be 0.5), q is the population proportion without the required class.

$$q = (1-P \qquad (4)$$

$$N = \text{total estimated population} \qquad (5)$$

With a total error = 0.1 at a confidence level of 95%. From Equations 3 and 4, S1 = 0.25, then the sample size for the game will be (Equation 1) n = (0.25/0.052)/(1+ (0.25/0.052)/15 = 13.04 which is approximately 13 games.

A total of thirty-two (32) Universities were identified in Southwestern Nigeria based on information from the National University Commission (NUC). For this study, purposive sampling was used to draw samples from the selected Universities. The choice of Universities selected for this study was dependent on the Universities having all the sporting activities selected for the study and have hosted National / International sporting events. The sporting activities selected for this study include Athletics (Tracks and field events), Badminton, Basketball, Cricket, Football, Handball, Hockey, Judo, Squash Racket, Swimming, Table Tennis, Tennis, and Volleyball.

A pilot survey conducted for this study reveals that only three Federal Universities have all the sporting events for the study and have hosted National and international sporting events. The Federal Universities include Obafemi Awolowo University, Ile-Ife; the University of Ibadan and the University of Lagos. Thirteen games were calculated as the sample size for this study since the difference between thirteen and fifteen which is the sample frame for the games is not significant, the researcher sampled all the fifteen games. For each of the fifteen games Two Coaches were selected, four members of NUGA technical committee, Two grandsmen from each university, Director of Sports and Two other members of the sport Council, Director of Works, Four maintenance Supervisors, and Two maintenance administrative staff, and eighteen maintenance operatives in each of the selected University, and Six sportspeople (4male, 2 female) in each of the fifteen games in the selected universities. Therefore the total sample size calculated was four hundred and fifty-four respondents. Details of this as shown in table 1

S/N	Category	No. of Games	No. of respondents	No. of university	Total
1	Coaches 1-male team 1-female team	15	2	3	90
2	Grandsmen		2	3	6
3	Maintenance staff		7	3	21
4	Maintenance operatives		18	3	54
5	NUGA Technical Officials		4		4
6	Sports council members		3	3	9
7	Sports Men and Women(3male, 3female)	15	6	3	270
Total					454

Table 1: Summary of Sample Size

To collect relevant data for the study, two sets of the questionnaire was designed and administered. The first questionnaire was administered to the staff of maintenance department, while the second questionnaire was administered to Coaches, Sports Men and Women, Members of the Sports Council and members of NUGA Technical committee in the selected universities. Also, an interview guide was used to conduct interviews with some unit/departmental heads of the maintenance department in the selected Universities in Southwestern Nigeria. The questionnaires were designed in such a way to be a combination of closed and open-ended questions. The open-ended questions allowed the respondents to give detailed answers in cases where their intentions or experiences cannot be easily calculated, into a few options.

The questionnaire is divided into two sections. The first section (Section A) deals with the background of respondents and general information about the Universities Sports complexes, while the second (Section B) asks questions on the various physical condition of the facilities and maintenance strategies being practiced in the universities.

Both descriptive and inferential statistical techniques were used to analyze the data for this study. Analytical techniques used depend on the normality of the data collected.

Data required were on available maintenance strategies, the frequency of use and the effectiveness of the maintenance strategies for sports facilities, Frequency of sports facilities inspection, Frequency of maintenance operations, response to a maintenance request, number of administrative/maintenance technical staff, Length of Facilities downtime, Frequency of failure. Analytical tools adopted were frequency, percentages, mean score, relative index.

RESULTS, FINDINGS AND DISCUSSIONS

Maintenance Strategies used in the Study Area

Maintenance staff was asked to rate the maintenance strategies used in their universities, eight (8) maintenance strategies were identified. The respondents were asked to indicate their perception on a 5 – point scale ranging from 1 – very low, 2 – low, 3 – moderate, 4 – high and 5 – very high. This is presented in table 2.

Types of maintenance strategies	Mean	Std	Ranking
Reactive(Corrective)	4.1111	1.04881	1
Planned Preventive	3.6500	.99492	2
Condition based	3.5375	1.03047	3
Performance based	3.4938	1.06211	4
Renovation based	3.4568	1.12971	5
Time based	3.3797	1.13571	6
Breakdown based	3.1605	1.19851	7
Integration based	2.8148	1.19851	8

Table 2. Maintenance strategies used in the study area as perceived by maintenance staff

Mean response analysis was calculated in order to know the most frequently adopted maintenance strategies used for the maintenance of sport facilities in the universities sampled. The result showed that reactive (corrective) maintenance strategy ranked highest with a mean rank of 4.11 followed by planned preventive maintenance with a mean rank of 3.65, condition-based maintenance with a mean rank of 3.54, performance-based maintenance with a mean rank of 3.49, and renovation based

maintenance with a mean rank of 3.46. The implication is that reactive maintenance strategy is the most widely adopted maintenance strategy used for the maintenance of sports facilities in the study area. The findings agreed with Olarewaju et al, 2010 and oseghale, 2016 which showed that maintenance departments in universities adopted corrective maintenance practices. It also shows that maintenance works carried out were corrective and that maintenance works for sports facilities were suppose to be proactive to eliminate or reduce sports facilities downtimes. This finding agreed with Leosemore and Hsin, 2001; Shen and Lo, 1999; and Tse 2002 who argued that the maintenance department still concentrates on failure driven strategies without a comprehensive maintenance approach.

The Adequacy of Maintenance Strategy

To examine the adequacy of maintenance strategy for sports facilities questions were asked on maintenance planning, policy, staffing of maintenance departments, frequency of maintenance operation, frequency of maintenance inspections and response time to a maintenance request. The results are presented in tables 3

The results of sports facilities maintenance planning showed that 14.2% the respondents rated the maintenance planning not adequate, 16.9% rated less adequate, 35.3% rated fairly adequate, while 26.1% rated adequate and 7.6% rated very adequate, 66.4% on the respondents rated their sports facilities maintenance planning below average. Also, 70.6% of the respondents rated the sports facilities as a component of the overall university planning for her facilities below average. The implication of this is that the sports facility is not rated very high in the planning and maintenance of university facilities.

Respondent	Frequency	Percent
Adequacy of sports facilities maintenance planning		
Not Adequate	1	1.2
Less Adequate	6	7.4
Fairly Adequate	24	29.6
Adequate	34	42.0
Very Adequate	16	19.8
Maintenance planning a part of overall organizational planning		
Very poor	4	4.9
Poor	4	4.9
Average	20	24.7
Good	30	37.0
Excellent	23	28.4
Long Range Planning		
VC/DVCs	13	16.0
Director of maintenance	20	24.7
Maintenance supervisors	3	3.7

Director of sport	31	38.3
Unit heads	9	11.1
Technical staff	1	1.2
I do not know	4	4.9
Span of long range maintenance planning		
1 to 2 years	21	25.9
3 to 4 yrs	24	29.6
5 to 6 yrs	12	14.8
7 to 9 yrs	6	7.4
9 to 11 yrs	8	9.9
Above 11 yrs	10	12.4
How often it is updated		
Every 6 months	15	18.5
Every 1 year	32	39.5
Every 2 years	4	4.9
Every 3 years	11	13.6
Not applicable	9	11.1
Never been updated	10	12.4
Short range facilities maintenance planning		
VC/DVCs	12	14.8
Facilities maintenance manager	16	19.8
Maintenance supervisor	4	4.9
Head of depts.	24	29.6
Unit heads	12	14.8
Maintenance technical staff	7	8.7
I do not know	6	7.4
Span of short range maintenance planning		
1 month	18	22.2
2 to 3 months	22	27.2
6 months	15	18.5
1 year	15	18.5
More than 1 year	8	9.9
Not applicable	3	3.7

Table 3. Sports Facilities Maintenance Planning

The finding reveals that the long-range planning of university sports facilities includes the Vice-Chancellor and Deputy Vice-Chancellor, Director of Works and Director of sports, maintenance supervisors, unit heads and technical staff. Also, the finding reveals that long-range sports facilities maintenance planning span up to 10 years and updated every three years while the short-range maintenance planning carried out every year. The results of sports facilities maintenance operation are presented in table 4.

The results of factors influencing the choice of sports facilities maintenance strategy are presented in table 4.

Factors Influencing Choice of Maintenance Strategy

Maintenance staff was asked to rate the identified factors influencing their choice of maintenance strategies. The respondents were asked to indicate their perception in a 5 point scale ranging from 1 – very low, 2 – low, 3 – moderate, 4 – high and 5 – very high. This result is presented in table 5.

Factors	Mean	Standard deviation	Ranking
Maintenance Policies	3.8987	1.02024	1
Technological	3.8462	1.06998	2
Maintenance Standard	3.7625	1.19327	3
Maintenance tactics	3.7375	1.13342	4
Economical	3.7370	1.02801	5
Environmental	3.7250	1.10207	6
Legal	3.5443	1.19612	7
Mean Time To Repair	3.5065	1.16555	8
Social	3.4805	1.07128	9
Users reporting defects	3.3750	1.09516	10
Political	3.3704	1.13407	11
The reporting delay time	3.0897	1.15304	12
The Predictability of failure	3.0741	1.21221	13
Mean Time Between Failure	2.9753	1.16163	14

Table 4. Factors influencing the choice of maintenance strategies as perceived by maintenance staff

The result of the analysis reveals that the five most influencing factor on the choice of maintenance strategies were: 1 – maintenance policies, 2 – technological factors, 3 – maintenance standards, 4 – maintenance tactics and 5 – economic factors. The highest rating of maintenance policies as influencing the choice of a maintenance strategy is

that maintenance policy defines the ground rules for the delivery of maintenance management services (Wae and Pintelon, 2004). The research finding agreed with Lee and Scott, 2009 who opined that maintenance policy provides a management framework to determine appropriate maintenance strategy. Also, maintenance policy is an integration of different strategic approaches, which include reactive, preventive and condition-based maintenance (Horner et al, 1997; Lee and Scott, 2009).

The very high rating of technological factors as influencing the choice of maintenance strategy agreed with Khazraei and Deuse (2011). Also one of the reasons for the wide adoption of the reactive strategy in the maintenance of sports facilities in the universities sampled is because of the low level of technology among the maintenance personnel.

The high rating of maintenance standard is associated with sports facilities belonging to the hospitality industry which are to provide services at all times and be highly service. Also for sports facilities to meet the requirements of national (NUGA) and international standards which are ever on the increasing scale, then optimal maintenance strategies need to be carefully selected and adopted for the maintenance of sports facilities.

The high rating of maintenance tactics as one of the determinants in the choice of a maintenance strategy is that while planning a strategy might be easy the real challenge is in translating that plan into action and communicating it to the people who need to work with it. Implementing maintenance strategies is made possible through forming and employing the right tactics which agreed with the findings of Khazraei and Deuse, 2011.

The high rating of economic factors as one of the influencing factors in the choice of maintenance strategies could be as a result of the allocation of maintenance resource. The finding agreed with Lee and Scott, (2009) who opined that maintenance personnel chooses different maintenance strategies depending on the allocation of maintenance resources. The findings also agreed with Ali and Kamaruzzaman, (2009); Khazrei and Deuse, (2011) who listed economic factor as one of the most influencing factors in the choice of maintenance strategies.

Implication to Research and Practice

The research finding reveals that the most widely used maintenance strategies used in the study area were reactive maintenance strategy, followed by preventive maintenance. This shows that maintenance work was corrective in nature and maintenance work for sports facilities which is required to provide service at all times ought to be proactive to eliminate or reduce facilities downtime and increase the reliability of the sports facilities.

There is need to consider and adopt the finding on the factors influencing the choice of maintenance strategies identified in this research as this will enable the maintenance department to identify the optimal strategy for the maintenance of the sports facilities. The five most influencing factors for the choice of maintenance strategies were maintenance policies, technological factors, maintenance standards, maintenance tactics, and economic factors. Maintenance policy, for example, provides a management framework to determine appropriate maintenance strategy. Also, the wide adoption of reactive maintenance strategies by maintenance personnel in the universities sampled is because of the very low level of technology among maintenance personnel.

The finding of this research will enable the university community, university management, and the sports council to know the adequacy of sports facilities maintenance planning and maintenance operations. The contribution of the study to the literature on sports facilities maintenance is both methodological and theoretical. The methodological contributions involve efforts at establishing a relationship between maintenance strategy and the physical condition of sports facilities. The paper also provides reliable data on the state of sports facilities, and the maintenance strategies adopted in the universities in order to improve their availability and enhance reliability while the theoretical contribution lies in establishing the link between maintenance staff and their attitude toward maintenance of facilities, and their preference in the choice of a particular maintenance strategy.

CONCLUSION

The study assessed the facilities maintenance management strategies used in sports facilities maintenance in southern Nigeria, adequacy of maintenance planning and factors influencing the choice of maintenance strategies. Findings revealed that the most widely used maintenance strategy in the universities sampled was reactive/corrective maintenance strategy.

The adequacy of maintenance strategies used for sports facilities was evaluated by examining maintenance planning, maintenance policy, staffing of maintenance departments, frequency of maintenance operations, frequency of maintenance inspections and response time to a maintenance request. The research revealed that 70.6% of respondents rated sports facilities maintenance planning below average, 67.4% of respondents equally rated the frequency of maintenance work below average. The finding reveals that the response time to maintenance request was over one week (downtime). The main reason adjudged to be responsible for delay in response to maintenance request was unavailability of funds. The findings also showed that the sports facilities were regularly inspected by the groundsmen for maintenance.

The research found that the most influencing factors responsible for the choice of maintenance strategies were maintenance policy with a mean score of (3.899),

technological factors (3.846), maintenance standard (3.763), maintenance tactics (3.738), economic factors (3.737) and environmental factors (3.725).

References

Akinsola, E. O., Faphumda, J. A., Ogunsanmi, O. E., Ajibola O., Fatokun, A. O. (2012) *Evaluation of the scenarios of facilities maintenance management of sport complexes in South West Nigeria*, Journal of Sustainable Development, 5(4) 99- 115

Ali, A., Kamaruzzaman, S., Sulaiman, R. and Cheong Peng, Y. (2010) *Factors affecting housing maintenance cost in Malaysia*, Journal of Facilities Management, 8(4) 285-298.

Bichi, S. M. (2018). Constraints of sport development in tertiary institution in Nigeria. Available at https:www.researchgate.net (Accessed 13 September 2019).

Brunton, J. and Mackintosh, C. (2017). University sport and public policy implications for future research. *International Journal of sport policy and politics*. 9(3), 373-376.

Clearing House for sports (2017). Australian sport history. (online)(Accessed13 September 2019)

Frase, K., Hvolby, H., and Tseng, T., (2015) *Maintenance management models: a study of the published literature to identify empirical evidence*. International Journal of Quality and Reliability Management 32(6) 635-664

Harun, M. T.; salamuclin, N; and Hushin; H. F. (2013) *Appraisal of sport facilities maintenance management practices of Malaysian stadium corporations*. Journal of Asian Social Science. 9(12) 93-98.

Horner, R. M. W., EI-Haram, M. A and Munns, A.K (1997) *Building Maintenance Strategy: a new management approach*, Journal of Quality in Maintenance Engineering. 3(4) 273-280. .http://www.graphsystems.com/htm/books.htm.

Ikpo, I.J. (2001) *Management strategies for university sports facilities.* African Journal of Physical, Health Education, Recreation and dance. 7(2) 349-360.

International University sports Federation (IUSF), 2017. IUSF history. Available at http://www.fisu.net.fisu/history. (Accessed 13 September 2019)

Kennedy, R. (2006) *Examining the processes of RCM and TPM: what do they ultimately achieve and are the two approaches compatible?* The centre for TPM (Australasia www.ctpm.org.au)

Khazraei K. and Deuse J. (2011) *A strategic standpoint on maintenance taxonomy*, Journal of Facilities Management. 9(2) 96-113.

Lee, H.H.Y and Scott. D (2009) *Overview of maintenance strategy, acceptable maintenance standard and resources from a building maintenance operation perspective*. Journal of Building Appraisal.4 (4) 269-278.

Lee R. and Wordsworth, P. (2001) Lee's building maintenance management, Blackwell Publishing,

London.

Liu, Y. D. (2009) *Implementing and evaluating performance measurement initiative in public   leisure facilities: an action research project*. Journal of Systemic Practice and Action Research. 22(1) 15-30

Mann, A., Saxena, L. and Knapo, G (1995) *Statistically based or condition based preventive maintenance*, Journal of Quality in Maintenance Engineering 1(4) 46-59.

Olarewaju A,L, Mohd F.K; Arali, I (2010) *Building maintenance management in a university campus: a case study*. *Australian* Journal of Construction Economics and Building. 10(2) 76-89

Oseghale G. E. (2016) Maintenance management strategies for sports facilities in selected universities in Southwestern Nigeria. Unpublished Ph.D thesis, Department of Building, Obafemi Awolowo University, Ile-Ife.

Oseghale, G. E. and   Ikpo, I. J. (2018) *Perception of stakeholders on sports facilities provision and maintenance in selected universities in South West Nigeria*. British Journal of Marketing Studies, UK. 6(2) 20-28.

Sediary, S.T. (1994) *Management of conflict; public sector construction in Saudi Arabia*. International Journal of Project Management, 12 (3) 143-151.

Shen, Q. P. and Lo, K. K. (1999) *Optimization of Resources in Building Maintenance: an analytical approach*. The Journal of Building Surveying. 1(1) 27-32.

Tsang, A. H. C. (2002) *Strategic dimension of maintenance management*. Journal of Quality in Maintenance Engineering. 8 1-22.

TSE, P. W. (2002) *Maintenance practice in Hong Kong and the use of the intelligent scheduler*, Journal of Quality in Maintenance Engineering. 8(4) 369-380.

Wae, G. M. H., and Pintelon, L., (2004) *Maintenance Concept Development: a case study*. International Journal of Production Economics. 89(3) 395-405