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ADOPTION OF COMPUTER AIDED FACILITIES MANAGEMENT (CAFM) TO IMPROVE SERVICE QUALITY

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Abstract: The complexities of service delivery in Facilities Management (FM) necessitates efficient tools to be up to the challenge. One of the significant elements in evaluating FM service quality is the Service Response Time (SRT), as improving it leads to better customer relationship. This requires integrating Computer-Aided Facilities Management (CAFM) tools to facilitate processing and data logging, which minimizes the SRT. This paper presents a model for measuring the improvement in SRT due to applying a CAFM system. The model calculates the average SRT from CAFM system's logs using request's start time and close time. Then, it uses the request priority as the criteria for grouping requests, after which the average SRT was calculated and compared to the average SRT before applying a CAFM system. A case study was utilized as the model's data source with two main data sets and each data set contains requests' priorities, start time and close time. One set is the log of year 2013 before implementing the CAFM system with 1,464 sample points. While the other is for year 2014 after utilizing CAFM system with 3,134 sample points. The results obtained quantify the improvement in service delivery for the year 2014 after adopting a CAFM system.

Keywords: Facilities Management, CAFM, Service quality, Service response time.

1. INTRODUCTION

It's undeniable the gap that is needed to be bridged between the FM services that would be performed, and the customer satisfaction that needs to be measured upon the customer's feedback. This gap would be narrowed simply by the introduction of new technologies that would make this process a leaner one. It would consider the Performance measurement in FM, a management instead of a measurement (Amartunga, 2002).

FM is a resource management (Nik-Mat et. al, 2011) that make use of process management as one aspect of achieving the business objectives. Process management aiming for streamlining inter-processes will find technology very helpful in this target, CAFM systems with its variety of modules and inter-connectivity offer a one packaged solution for streamlining processes, implementation, and data collection.

CAFM software enables Facility Managers to plan, execute and monitor all activities involved in reactive and planned preventative maintenance, space and move management, asset management, operational facility services, room reservations and other customer services. Service delivery to customers requires that a procedure is properly streamlined to ensure minimizing the service delivery time and maximizes the quality at which the service is delivered.

The database of a CAFM system creates what is known as a ‘4-D’ simulation, including the time dimension, which can be used to plan, schedule and optimize changes, evolving more into managing changes. Other dimensions, such as cost and performance, which can be added to provide further modeling of facilities and conditions within them. The collective term for this technology is n-D. As time passes. Ultimately, facilities will be modeled digitally in a single system. Information will not need to be handed over in the conventional sense, as the model will evolve through the different phases over the project life cycle (Atkins and Brooks, 2009). Adding to the above key benefits the integrality between CAFM databases and manufacturer’s recommendations and maintenance history, facilitates service delivery by imparting a strict maintenance instructions ruling out that the quality criteria are left to the competence of employees stating out that an engineer shall know what is to be done (Lepkova and Uselis, 2013), this in turn adds up to speeding and enhancing the service delivery for customers, through eliminating wasted time on reviewing change history or maintenance records by extracting the previous history and controlling the dispatching procedure of the service, thus, speeding the actual time taken to close the customer’s request with positive feedback, mainly the service response time.

The process flow for a service request issued by a customer through a CAFM system could be summarized in Figure 1. The ticket is issued as a service request made by the customer and is recorded as an entry with a timestamp on CAFM system which dispatch it to the correct trade and the available manpower, after the request is actually handled the ticket is closed on the CAFM system after the customer’s feedback and a new timestamp logging the actual closure time is added.

Figure 1: Service request workflow

Requests are categorized on CAFM system according to priorities which identify the Service-Level-Agreement (SLA) which defines what services will be provided and the required level or standard for those services. Adopting CAFM software speeds up and control the above work flow which will shorten the time taken between dispatching process, which includes evaluating the current manpower against the assigned task, to the actual assigning of the task; so as keeping back logs for all requests with their details for more analysis and planning. Planned-Preventive-Maintenance (PPM) could be planned according to the times of the year where the number of requests drops.

2. LITERATURE REVIEW

“Facilities management (FM) is a resource management that combines people, property, and process management expertise to provide vital services in support of the organization” (Nik-Mat et. al, 2011). One of the major concepts to assess whether the Facilities Management as a service is up to its level of performance is; Performance Management (PM). PM is considered as a major tool to test the level of performance of FM through feedback and analyses conducted by the end users of the service (Nik-Mat et. al, 2011). According to the article published on the 2nd International Building Control Conference in 2011, a positive correlation has been seen between the two concepts of the performance of maintenance and the maintenance management system that is applied such as CAFM. The International Facility Management Association (IFMA) defines CAFM as a high-tech tool used by facility professionals to track and manage virtually any facility-related asset (Keller & Keller, 2004). This technology is intended to reduce management costs by creating a central and comprehensive resource of facilities information (Saengratwatchara, 2007). Nevertheless, FM isn’t merely about the issue of delivering a particular service, it is rather about providing this service in the most efficient way “within an ever-evolving world and industry” (Noor, 2009). Other developing concepts have arisen under the umbrella of FM including; maintenance management, space management, and accommodation standards.

Webster and Hung state in their article in 1994, that is essential for a measurement process to occur as it is a key to the management activity to carry out proper decisions. Yet alone, monitor the performance and effectively allocate the resources available. Later on, it was proven by Nutt in 2000, that another positive relation between performance and satisfaction is present. There are three major aspects of PMS (Performance Maintenance System) in the FM services that’s include; functionality, technicality, and imaging. For a successful Performance Measure to occur, all three aspects must be considered (Nik-Mat et. al, 2011).

It was researched that the perceived performance is a dominant construct in the service quality formation process (Cornin and Taylor, 1992). This forms a part of the expectations which represent the level of service consumers will receive in a given service encounter (Boulding et al., 1993; Prakash, 1984; Tse and Wilton, 1988). This, in turn, makes expectations float increasingly or decreasingly at relatively fast rates according to a wide variety of information resources (Boulding et al., 1993). This points out the importance of having an insightful, and flexible management plans satisfying the current expectations and conditions, these insights, in turn, need Information Technology to process data and turn them into insights.

More to be considered is the strong yet hidden human factor involved. The initial purpose of FM was to really fix the relation between any resident and the building. Time revealed that lack of building maintenance allowed for the residents and/or users to feel a loss of ownership towards the asset; hence losing the motive of investing in it to make it in a better shape (Lepkova, 2013). The ideology of FM being served is different according to the context and condition at which the asset is in. The article written after the 11th International Conference on MBMST in 2013, highlighted this aspect clearly. FM services are different according to the regions, where according to the needs of the users one needs to satisfy them, and accordingly build the proper level of service and performance to meet their needs which is a difficult factor in service delivery (Lepkova, 2013).

To ensure perfect quality in FM services and the above raised topics, it is necessary to realize the need for a technology that would allow for a proper inter-relative and developmental process. Thus the need for a CAFM system that would allow for this bond to be successful, despite all the difficult factors involved to meet the customer requirements and satisfaction. Also, studies have revealed that facility professionals are not so willing to adopt CAFM application (Saengratwatchara, 2007).

3. RESEARCH METHODOLOGY

3.1 Concept and algorithm

A service is said to be at two service response rate when it’s handled in half its assigned SLA time. So, a Service Response Rate (SRR) is the number by which a task could be performed and closed inside its assigned SLA time, refer to Equation 1. Where, planned time is the time at which the request must be closed according to its assigned priority and SLA. Close time is the actual time at which the ticket was closed. A unit manpower utilization was calculated to be the number of tasks one unit of manpower can handle. So, the higher the number is the higher the utilization will be, as the actual output of a unit manpower is increased respectively to the potential output a unit manpower is assigned to carry, as per Equation 2. The total number of requests carried in Equation 2 reflects the actual output of manpower. The lower the unit manpower utilization is the lower number of requests there are. Consequently, the more time there is for each individual to carry Planned Preventive Maintenance (PPM) tasks, which are not by direct request. The higher the unit manpower utilization is, the higher number of requests there are, and the less time there is for each individual to carry PPM tasks.

[1] $$\mathrm{SRR} = \frac{\text{Planned time} - \text{Close time}}{\text{Planned time}}$$

[2] $\text{Unit Manpower Utilization} = \frac{\text{Total number of requests carried}}{\text{Total number of individual workers}}$

Figure 2 shows the methodology adopted in measuring the improvement in service quality; the Service-Response-Rate (SRR) is calculated for each request for the range of years under study and is compared to the total number of requests for the same range of years, the calculations were made on daily basis and averaged out across each month for the range of years; after then the unit manpower utilization was calculated on monthly basis and compared to the SRR and the total number of requests. A software tool was written and developed for satisfying the above targets to fit CAFM output log and provide further insights on the effect of adopting a CAFM software by facilities managers.

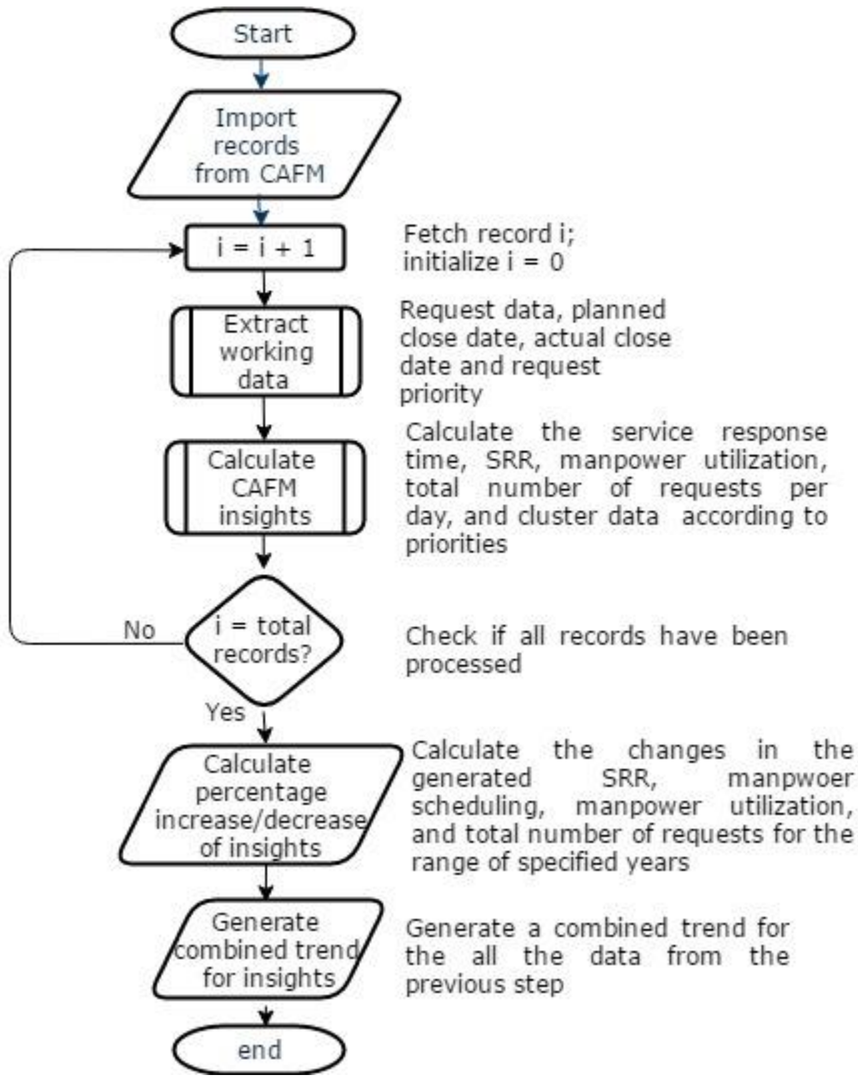

Figure 2: Service request workflow

The above methodology was developed to quantify the service delivery improvement by using a CAFM system to further increase the speed at which requests are carried and the consequences that follow as the below:

1. Improving the service response rate

2. Improving unit manpower utilization
3. Properly plan for PPM

3.2 Software Interface and Implementation

The proposed software interface was developed in .NET framework using the C# programming language and it consists of a simple Graphical User Interface (GUI) that imports the log file from CAFM system containing all requests data, applied here on MAXIMO, and process every record to meet this paper's purpose.

The log file from a CAFM system contains the data of every request, as illustrated in Figure 3, which includes but not limited to the below:

1. Request/Work order number
2. Discerption
3. Request priority
4. Site
5. Reported date
6. Targeted finish date
7. Actual finish date

The software identifies the key data and starts extracting them for processing to give the below insights:

1. Manpower efficiency.
2. Total number of requests per day.
3. Service response rate per day per priority.
4. Average service response rate trends.
5. Dates of the maximum number of requests.

WOs Within Specific Period

Work Or	Description	Locati	Custon	Sta	Prio	S	Work Ty	Actual Fin		Target Fin		Reported D	
47004	FM,landscape,Landscape,Landscape irrigation fitting damage	MARASSI CATANIA P1 E5-G-1	6877	CLOSE	4	MSA	VI	3/16/14	12:09:25 PM	12/8/13	10:36:57 PM	12/2/13	10:36:57 AM
46856	FM,landscape,Landscape,Irrigation Main Lines and Fitting	MARASSI VECTORIA P1 V-V-169	6052	CLOSE	4	MSA	VI	12/6/13	3:07:39 PM	12/4/13	3:27:59 AM	11/27/13	3:27:59 PM
47026	DLP,Technical Support,Civil,Main door lock	MARASSI AREZZO P1 TH-TH-12	6455	CLOSE	1	MSA	VI	12/4/13	5:34:58 PM	12/4/13	10:42:01 PM	12/4/13	5:15:01 PM
46819	FM,landscape,Landscape,Damage of plant elements for trees	MARASSI AREZZO P1 V-V-161	6612	CLOSE	4	MSA	VI	4/24/14	4:46:12 PM	12/3/13	12:59:39 AM	11/26/13	12:59:39 PM
46818	FM,Technical Support,Electrical,Power socket	MARASSI CATANIA P1 F3-G-2	6864	CLOSE	2	MSA	VI	11/26/13	1:20:33 PM	11/27/13	11:55:03 AM	11/26/13	12:28:03 PM
46992	DLP,Technical Support,MEP,Heavy water leak	MARASSI ISOLA P1 V-V-136	7727	CLOSE	1	MSA	VI	11/28/13	7:30:26 PM	11/28/13	8:50:23 PM	11/28/13	3:23:23 PM
46994	DLP,Technical Support,Civil,Fly screen damaged	MARASSI ISOLA P1 V-V-136	7727	CLOSE	5	MSA	VI	11/28/13	7:33:21 PM	12/19/13	4:52:54 AM	11/28/13	4:52:54 PM
46995	FM,landscape,Landscape,Irrigation Main Lines and Fitting	MARASSI CATANIA P1 A5-G-2	6550	CLOSE	4	MSA	VI	3/16/14	12:05:32 PM	12/5/13	7:11:04 AM	11/28/13	7:11:04 PM
47002	FM,landscape,Landscape,Irrigation Main Lines and Fitting	MARASSI CATANIA P1 A5-G-2	6550	CLOSE	4	MSA	PM	12/6/13	3:27:20 PM	12/7/13	9:21:18 AM	11/30/13	9:21:18 PM
49916	DLP,Technical Support,Civil,Floor tile broken	MARASSI CATANIA P1 E6-G-2	6885	CLOSE	5	MSA	VI	1/5/14	4:10:23 PM	1/5/14	3:46:23 AM	12/15/13	3:46:23 PM
52179	DLP,Technical Support,Civil,Main Door not	MARASSI CATANIA P1 D2-4-2	10691	CLOSE	1	MSA	VI	1/5/14	4:08:53 PM	1/5/14	7:35:18 PM	1/5/14	2:08:18 PM
51567	FM,Technical Support,Electrical,Power socket	MARASSI AREZZO P1 V-V-150	7706	CLOSE	2	MSA	VI	12/24/13	10:26:07 AM	12/24/13	1:57:50 PM	12/23/13	2:30:50 PM

Figure 2: CAFM system log sheet output

The software's GUI asks the user to import the log file and sets the range of years for which all the calculations should be carried on and gives options for different insights as shown in Figure 3. The software identifies the project ID and the total number of requests/work orders from the imported log file and generates excel files objects and starts working directly on them as the data holders, the software utilizes three modules for three different types of insights as below:

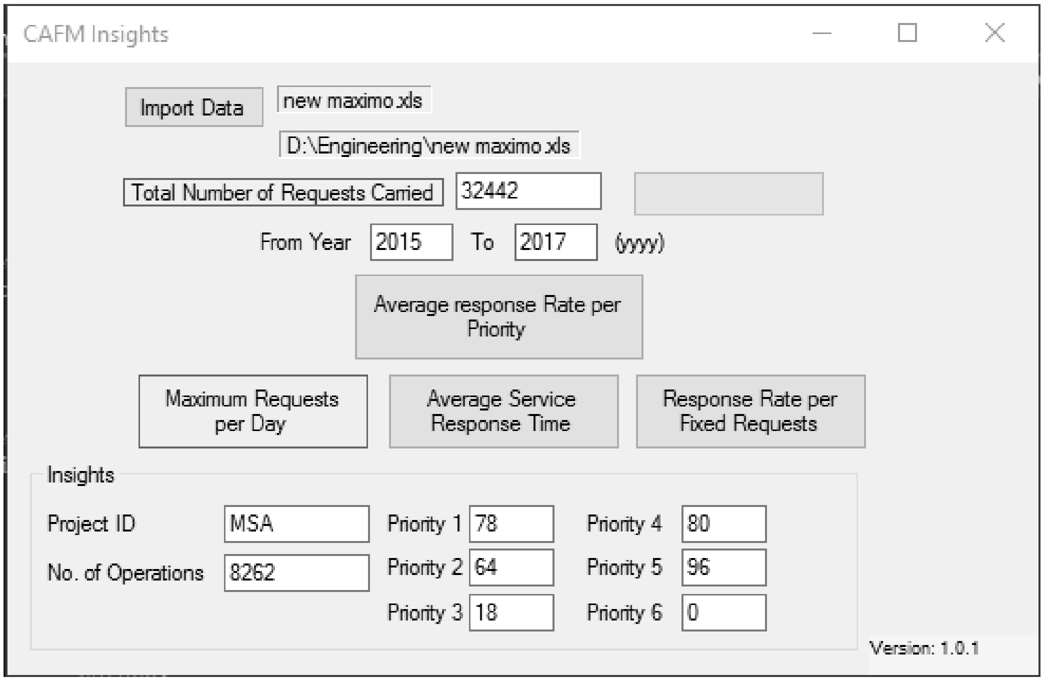

Figure 3: Software tool's GUI

3.2.1 Maximum Requests per Day

The program iterates through the records in this mood and count the number of requests there are for each day and reports the total number of requests for each day and identifies the maximum number of requests per month. The total number of requests per day is then calculated and compared to manpower to calculate the unit manpower utilization for handling requests/work orders.

3.2.2. Average Service Response Rate

This initiates a fast version for the response rate calculations algorithms that reports the average response rate per year.

3.2.3 Response Rate per Fixed Requests

This module initiates a search algorithm for the fixed requests count per day and calculates the average service response time for each day. The calculated data is helpful in identifying man power utilization efficiency over extended periods.

3.2.4 Average Rate per Priority

This procedure initiates a sorting to group priority 1 and 2 requests and calculates the total number of requests and their corresponding average response rate. The software algorithms could be adjusted further to give deeper insights for future researches. Figure 4 is an example of one module while operating. The algorithm could be tailored for custom clustering of priorities according to each project's specifications.

All modules use excel automation as the core for presenting the data, however major calculations were carried and optimized inside the program.

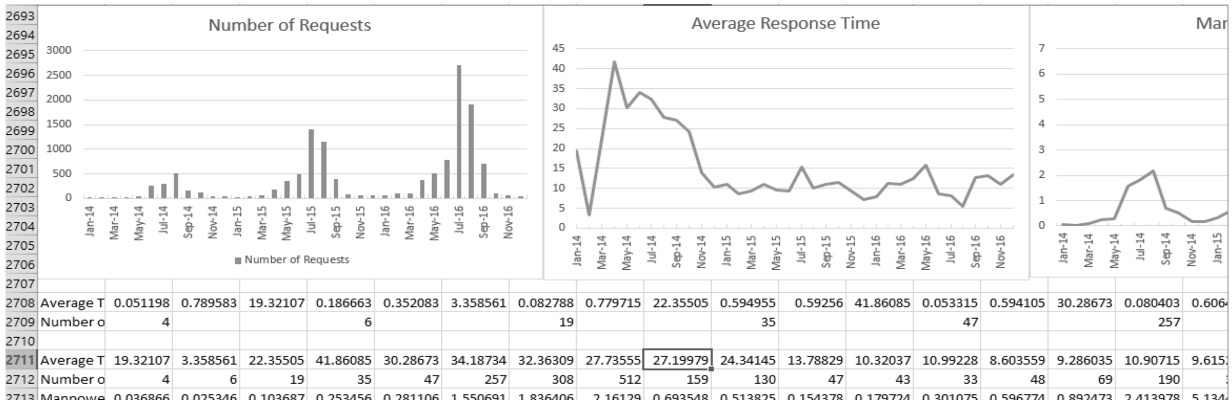

Figure 4: Average Response Rate output

4. CASE STUDY

A case study is established utilizing a site project considered as a remote area with seasonal quality, a coastal city on the north coast of Egypt, a mega project set out for completion in 2024. The site is still expanding and more construction works are yet to be carried. The CAFM system was applied from 2014. The range of years taken was from 2014 to 2016 to extend the sample data and give further reliable insights, and data available by manual logging in 2013 before CAFM adoption was ruled out because they didn’t give reliable insights and further deep insights such as the manpower utilization and the average system response rate. The SLA on the project had six priorities having the first two priorities under 24 hours and the rest exceeding the 24 hours, for that specific fact and to reduce unwanted variance in data priorities three to six were excluded for the below reasons:

Priority one and two requests form the critical operations and service requests and reflect the true utilization of manpower. The total number of requests carried for this project is 32,424 requests, and every year, and due to this project seasonal quality, requests peak in July and August substantially, and a mild increase in requests is detected in April to May. This, in turn, required that the total manpower increases and normalized according to each month’s peaks. Table 1 shows the manpower scheduling per year for the project.

Table 1. Manpower scheduling for the project

2015				2016				
SR	Profession	June	July, Aug, Sep.	SR	Profession	June	July, Aug	Sep.
1	AC	3	4	1	AC	4	6	4
2	Carpenter	3	4	2	Carpenter	3	4	3
3	Aluminum	2	2	3	Aluminum	2	3	2
4	Electrician	3	4	4	Electrician	4	5	2
5	Plumber	4	5	5	Plumber	4	6	4
6	Painter (walls/wood)	1	2	6	Painter (walls/wood)	1	2	1
7	General labor	0	1	7	General labor	1	2	1
8	Tiler	1	1	8	Tiler	1	1	1
Total		17	23	Total		20	29	18

5. ANALYSIS RESULTS

Table 2 shows a sample of the data generated for the year 2014 from the software tool where the actual close time and the planned close time were extracted from the CAFM record per each entry and converted into days. The response rate is calculated by dividing the actual response over the planned response, while the actual and planned responses were calculated by subtracting the ticket/request's start time from both respectively, the software tool uses a double precision floating point format to express differences as total days so that a value of 0.5 would mean half a day while a value of 1 would be a whole day. The samples stretch to include all the daily records of every month for the years 2014, 2015, and 2016; then it calculates the average response rate per month.

Table 2 Response Rate per day sample data

March			April			May		
Actual Response	Planned Response	Response Rate	Actual Response	Planned Response	Response Rate	Actual Response	Planned Response	Response Rate
0.4693	0.9770	2.0817	0.0594	0.2270	3.8223	0.4558	0.9770	2.1433
0.0703	0.9770	13.8940	19.8411	0.2270	0.0114	0.0728	0.9770	13.4149
0.0282	0.2270	8.0245	0.0329	0.9770	29.6930	0.0178	0.2270	12.7485
0.0357	0.9770	27.3115	0.0071	0.9770	136.820	0.0083	0.2270	27.1369
0.1141	0.9770	8.5592	0.0279	0.2270	8.1104	0.0067	0.9770	144.3077
0.0119	0.2270	18.9382	0.0355	0.9770	27.4800	0.0473	0.9770	20.6305
0.0840	0.9770	11.6297	0.1188	0.9770	8.2184	0.0452	0.9770	21.6018
0.0108	0.9770	89.9041	0.0131	0.2270	17.2559	0.1737	0.2270	1.3066
0.0415	0.2270	5.4621	0.0068	0.9770	141.8824	0.1539	0.9770	6.3454
0.0310	0.9770	31.5000	0.0066	0.9770	147.8459	0.1308	0.2270	1.7349

The insights generated from 2014 to 2016 are as follows:

1. Figure 5 illustrates the number of monthly requests.
2. Figure 6 illustrates the average monthly service response rate.
3. Figure 7 illustrates unit manpower utilization on monthly basis.
4. Figure 8 illustrates a combined trend for the above insights from 2014 to 2016.

From Figure 5, the total number of peak requests increases by 175% from 2014 to 2015, and by 91% from 2015 to 2016 peaking at 2017 requests in July 2016. This is due to the increasing in the total number of residents as more constructions works are finished each year and more units are handed over to clients. The peak months were found to be July and August of each year as apparent in the repeating pattern each year in Figure 5. While the increase in the total number of requests from 2014 to 2015 might falsely suggest that manpower should be increased by the same percentage; however, this doesn't hold to be true, as it overlooks the utilization of manpower on site, for if the unit manpower utilization was increased this means that the number of service delivery/requests carried by a unit manpower is increased which doesn't call for an analogous increase in the manpower. Looking further into the insights generated, it was found out that the service response rate in 2014 was very high compared to the average SRRs as per Figure 6 which indicated a lower utilization of manpower shown in Figure 7, this was detected and corrected by the facility manager because of the CAFM insights available back then, correction was made by downsizing the manpower increase percentage relative to the increase in the total number of requests. Once CAFM system's data are used, more insights reveal tools for optimum service delivery, looking at Figure 6 the average SRR is enveloped into a trend that shows that from 2015, after the correction of manpower was made, the average SRRs peak at 15.9 times faster than SLA in May-2016 which is a sound improvement in the service delivery time but indicates a non-utilized manpower which conforms as a waste of resources. For that reason, further improvement was made in 2016 in manpower utilization by reducing the percentage increase in manpower that was analogous to the percentage increase in the total number of requests. This was reflected in a reduction in SRR which was 15.9 times faster than SLA in July-15 down to 8.19 times faster in SLA, achieving the targeted service delivery time and increasing the manpower utilization by 26% as per Figure 8 which also shows a proportional relationship between requests number and the SRR value which is enhanced by using a CAFM system which speeds up service request workflow, and maintaining a database with logs and PM data that saves time in the decision making process.

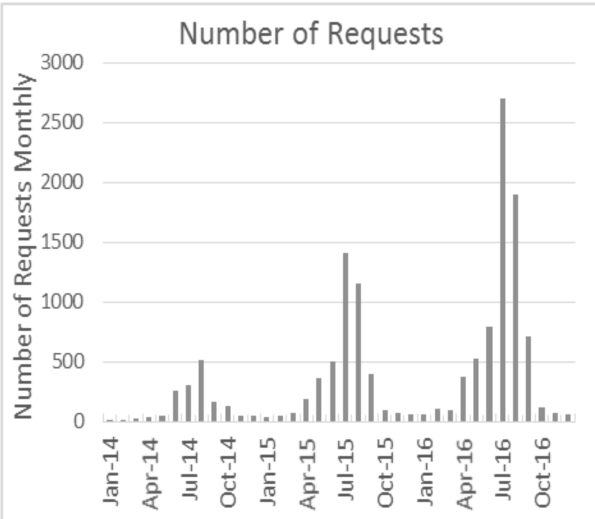

Figure 5: Total number of requests per month

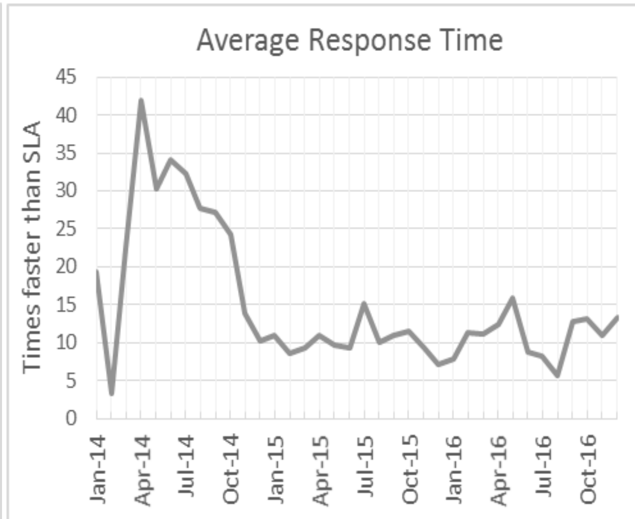

Figure 6: Average monthly service response rate

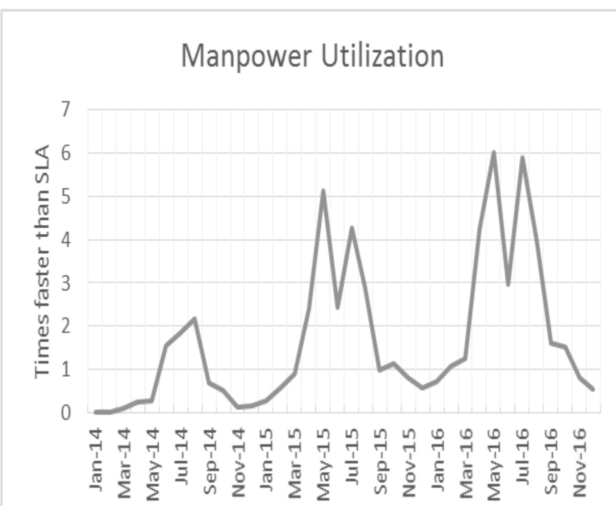

Figure 7: Unit manpower utilization per month

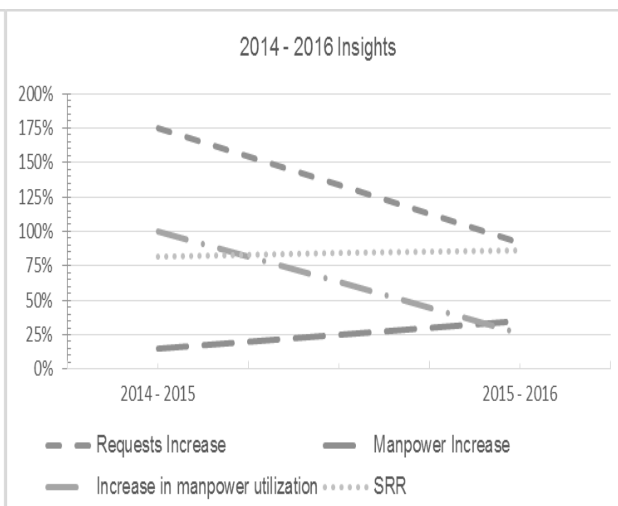

Figure 8: Percentage changes in insights

Figure 8 also shows that the manpower utilization has increased by 100% from 2014 to 2015, and 26% from 2015 to 2016, this was due to the fact that after implementing the CAFM system in 2014 the manpower utilization was improved substantially in 2015, and fine tuning took place in 2016 optimizing it more with a 26% based on insights which helped the FM manager shape decisions, this continuous improvement and fine-tuning with the number of requests that had a 175% increase from 2014 to 2015, and a 91% increase from 2015 to 2016.

6. CONCLUSION

This paper addressed the effect of adopting CAFM system in FM and its direct effect on service response time for improving the service quality, and its passive effect on optimizing the manpower utilization. This required developing a software tool to process the CAFM records to generate the insights discussed. This showed the importance of data available at hand through using CAFM system, turning these data into insights could lead to great outcome related to cost saving and optimization as shown, all of which could not be achieved using obsolete logging and workflow techniques which rely only on manual operation and handling of requests for service delivery, the automation of workflow process offered by CAFM cannot be waived in the vast amount of data flowing each day. This method showing the direct effect of CAFM adaptation on service deliver by improving the service response rate could be refitted to show a direct effect on the quality aspect of service delivery, as well as the software tool developed which could be further optimized with edge search and generic algorithm enabling the tool developed to automatically learn from any CAFM system available, or will be released in the future, and the type of data required for processing giving more insights to further improve the service quality.

7. REFERENCES

Atkins, B. and Brooks, A. 2009. *Total Facilities Management Third Edition*, Wiley-Blackwell, Chichester, West Sussex, United Kingdom.

Amaratunga, D. & Baldry, D. 2002. Sample View of Current Performance Measurement Practices in Facilities Management. *Proceedings of International Postgraduate Conference*, the University of Salford, 10-11. Pp. 193-202.

Boulding, W., Kalra, A., Staelin, R. and Zeithaml, V. 1993. A dynamic process model of service quality: expectations to behavioral intentions*, Journal of Marketing Research*, Vol. 30, February, pp.7-27.

Cornin, J. and Taylor, S. 1992. Measuring service quality: a re-examination and extension*, Journal of Marketing*, Vol. 56, July, pp.55-68.

Lepkova, and Uselis R. 2013, “Development of a Quality Criteria System for Facilities Management Services in Lithuania”, Vilnius Gediminas Technical University, 2013, pp. 697-706.

Mohd Noor, M.N. and Pitt, M. 2009. A Critical Review on Innovation in Facilities Management Service Delivery, *Facilities*, Vol.27. No.5/6, pp.211-228.

Nik-Mat, N. E. M., Kamaruzzaman, S. N., and Pitt, M. 2011. *Assessing the Maintenance Aspect of Facilities Management through a Performance Measure System: A Malaysian Case Study*, The 2nd International Building Control Conference 2011,Bartlett School of graduate studies, university college London, United Kingdom. pp. 329-338.

Nutt, B. and McLennan, P. 2000. *Facility Management Risks and Opportunities*, Oxford: Blackwell Science Ltd.

Prakash, V. 1984. Validity and reliability of the confirmation of expectations paradigm as a determinant of customer satisfaction, *Journal of the Academy of Marketing Science*, Vol. 12, Fall, pp.63-76.

Saengratwatchara, S. 2007. Antecedents of Intention to Adopt Web-Based Computer Aided Facility Management (CAFM) by Facility Managers, Michigan State University, United States.

Tse, D. and Wilton, P. 1988. Models of consumer satisfaction formation: an extension*, Journal of Marketing Research*, Vol. 25, May, pp.204-12.

Webster, C. and Hung, L. 1994. Measuring Service Quality and Promoting Decent ring, *The TQM Magazine*, Vol. 6 No. 5, pp. 50-55.

Wilson, E. and Sherrell, D. 1993. Models of consumer satisfaction formation: an extension*, Journal of the Academy of Marketing Science*, Vol. 21, Spring, pp.101-12.