Autonomous Team for Information and Communication Technology Maintenance

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***Abstract*—Information and Communication Technology is equipments of telecommunication network system. ICT has many types and numbers which it are interrelated, spread in various geographical regions of service area. The system is complex and requires simultaneous handling. If the ICT is impaired then the overall network system would be disrupted. Therefore, the maintenance of ICT is essential to keep the function and reliability of the system to avoid downtime. The ICT maintenance activities are carried out by teams work from both internal and external companies. Each teams work has its working standards and must work in an integrated way in carrying out the maintenance activities. This paper presents the results of a case study on how did the team carry out the maintenance and what were the problems, how to solve the problems that might occur, and how team performance could make the performance of telecommunications network systems remained highest standard. The preliminary study is part of the dissertation on the implementation of autonomous maintenance team at Telecommunication Company.**

***Index Terms*—autonomous team, information and communication technology, telecommunication company**

I. Introduction

The telecommunications industry has a great contribution on the economic growth in Indonesia. In 2011 Indonesia's economic growth reached 6.5% [1] while the growth of the telecommunications industry reached 13.2% [2]. Although in 2012 and 2013 its contribution decreased significantly. The growth was only 9.98% in 2012 [3] and 10.19% in 2013 [4]. The Development and modernization of telecommunications infrastructure play an important role in the development of the national economy. In addition, the raise of population and a good economic growth over the last 10 years has driven demand for telecommunications services to increase.

The infrastructure characteristic of telecommunication system network is the used equipment has many types and numbers which are interrelated. The equipment is widespread in its geographic service area. The used telecommunication network system configuration is dynamic and has different operation [5]. To disseminate its services, the network system infrastructure uses information and communication technology (ICT). Information and communication technology is a set of equipment, service application which is used to process, transform, generate and distribute information [ESCAP, 2000; in [5]].

The change of telecommunication network system ICT is very fast and dynamic. Whenever the change occurs, then a renewal (replacement) of certain components will be done, so that the optimum service quality can be reached and the company is able to compete with other similar companies. The Re-placement of telecommunication network system components will work well and run optimally if all ICT equipments are maintained well. The ICT maintenance work is carried out by several teams from both internal and external teams. Each work team has an autonomy in carrying out its ICT maintenance activity. In addition, each team must be able to work cooperatively and coordinatively with other work teams when an interruption of telecommunication network system occurs [6].

II. Discussed Problems

This paper presents the results of preliminary study on how the ICT maintenance is done, how are the process of workteam autonomy and the cooperation between workteams on maintenance activities, What are the success barometer indicators and how is the measurement process of autonomous work team performances in maintenance activities and what are the problems. Therefore, a case study was conducted on ICT maintenance activities as elements of network system in telecommunication companies. It was done as a preliminary study in preparing a dissertation of model development of autonomous maintenance team implementation.

The pilot case study was conducted by doing a qualitative research using exploratory case study method. The data collection was done using in-depth interview method to Network System Departments of telecommunication companies. The sampling was done

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using a non-discriminative method of exponential snowball sampling to determine the selected informants. Field observations on ICT maintenance activities were also carried out to complete in-depth interview results which are supported by company's data documents. All collected data was analyzed using the triangulation method

III. Literature Review

A. ICT Maintenance

Maintenance is an attempt to keep the physical system remains productive in accordance with its previous function and performance [7]. A Proper maintenance can reduce financing cycle and guarantee operational activity and internal distribution run smoothly and effect company's performance [8].

The maintenance of ICT is technical combination activities, administration, managerial, and supervision (testing, measurements, replacements, adjustments, and repairs) with the aim to keep the facility or system functioning optimally. The strategy of maintaining ICT consists of [9]:

- Preventive maintenance is maintenance activities which are conducted regularly with a certain time period on each items to maintain the ability of the system and prevent system failure
- Corrective maintenance is maintenance activities which are carried out when the system failure occurs
- Adaptive maintenance is maintenance activities that focuses on software to keep it working properly when the environment changes.
- Perfective maintenance is maintenance activities when the system capabilities repair and existing functions modification are done including software implementation activities or new operating system to improve its performance.

Preventive and corrective maintenance are a critical factor in maintaining the availability and performance of ICT.

Maintenance of ICT systems can be improved [9] by:

- Designing an appropriate maintenance system and understanding the system or software structure
- Making a thorough and accurate documentation
- Using standards in terms of design, language, codification and others
- The availability of testing system completeness

B. Work Team and Autonomous Team

A work team is a group of people who work together and interdependence within the group to achieve a goal. A person must have certain requirements that have been set to join the work team. An effective work team is when each team member has a commitment and mutual support among team members. It also must be able to communicate accurately and effectively, follow the procedures of specified work, and participate actively and appropriately in decision-making. To deal with conflict in a work team, the members must have a proper trouble shooting procedure [10]. Work team also is defined as a group within an organization which is set up to perform specific tasks and achieve organizational goal. In an organization usually there are some work teams that connected one each another in achieving organizational goals which are in line with the context [Kozlowski & Bell, 2003, in [11]].

The work team integrity is a transparent and integrated teamwork to improve services. The success key of work team integrity is the existance of easy knowledge exchange by using information system, while the driver is working cultural development, the existence of standard procedure, policy flexibility in the organization in doing inter-team cooperation as well as work assessment promotion of team members. The Barriers of work team integrity are communication barriers, geography, status differences, cultural differences, behaviour differences, failure to perform the cooperation as agreed. Improper conflict dealing and unbalanced information become the main barrier of work team integrity [12].The Indicator of work team success is when the focus of work team is on the goals of the organization, collaboration among team members, trust and responsibility building among team members, effectiveness of communication, information sharring and use of integrated ICT [13].

Autonomous team is a formal concept of the group, which is designed as work group system. Autonomous team is formed due to the existence independent organization as a separate unit of the organization system. The work unit has a set of tasks and work separately from the company's internal monitoring and controlling [Chern, 1976, Emery, 1972; in [14]].

IV. Case Study

Case studies were conducted on the network system division of Telecommunication Company that uses CDMA cellular technology. In network division, maintenance activities are considered as an autonomous team because every employee has an authority to perform maintenance work independently either in a team or as individual. To know and understand the autonomous maintenance activities of the ICT network, an observation had been carried out using in-depth interview. Observation was carried out by observing the maintenance activities, recovering and auditing the implementation of network disruption maintenance of ICT network systems. The audit was carried out by measuring the achievement of key performance indicators (KPIs) that agreed between the partners and company.

In-depth interview was conducted to the operation and maintenance network division by use of a non-discriminative exponential snowball sampling to determine the selected informants (Castillo. 2009). The key informant was General Manager (GM) of Network Division and based on the information from key informant, the other informants were determined [15]. The informants selection are shown in Fig. 1.

Observation and in-depth interview were conducted for:

- Knowing the process of autonomous teams and cooperation between work teams in ICT maintenance activities.
- Knowing the success indicators of autonomous team activities for each work team in ICT maintenance activities.
- Knowing the benchmark of success indicator of autonomous team
- Exploring the arising autonomous team problems and how to handle them in ICT maintenance activities.

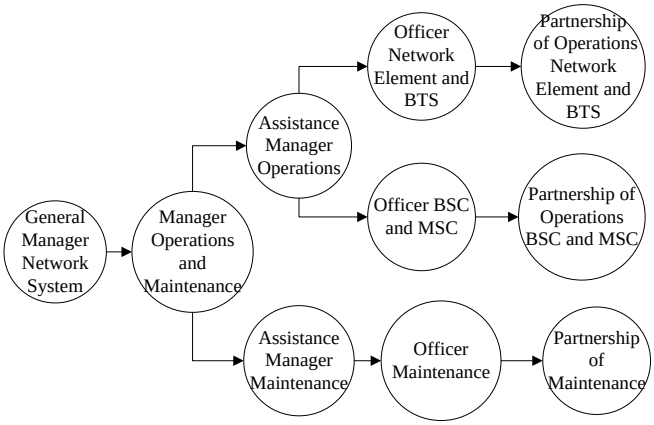

Figure 1. Selected informants.

Service of the network division is network system what generater strong signals in line with the set standard. In generating a signal, the network system used a set of interconnected ICT and it was widespread within its service area. ICT tools which used to generate the signal were transceiver base station (BTS), base station controller (BSC), mobile switching center (MSC), in building service (IBS) & repeaters, transmission medium, and variety of supporting hardware and software. All ICT tools were numerous and connected with one another. All ICT device maintenances were done by many stakeholders. The Parties which involved in maintenance activities came from internal and external parties that bound by an agreement. ICT operated automatically and the operator simply done monitoring and controlling operation process. Each ICT already had an operating and quality standard to make standard network performance. If the expected service quality of the signal can be received by the customers in, then the customers will get comfort when they communicate. The generated signal quality is according to standard, which sets up call success rate (CSSR> 98%), drop call rate (DCR <1.5%), hand of success rate (HOSR> 95%) and the blocking rate (BR <1%).

To get a standard quality of the signal, the ICT equipments must be maintained properly. ICT maintenance strategies were undertaken by each party including preventive maintenance, corrective maintenance, adaptive maintenance and perfective maintenance. Maintenance strategy was executed by each of the parties which mentioned in the contract agreement. Preventive maintenance was done routinely on hardware, software and other supporting ICT equipment periodically (daily, weekly, monthly). Corrective maintenance was done in case of network system disruption which caused by natural disaster or ICT element damage. Adaptive maintenance was done regularly to the software and ICT modules were used. Perfective maintenance was done both on the software and ICT modules when a module replacement or technology upgrade occured. Therefore, ICT equipments should be maintained properly. All parties that involved in the maintenance and restoration of the network system are shown in Fig. 2.

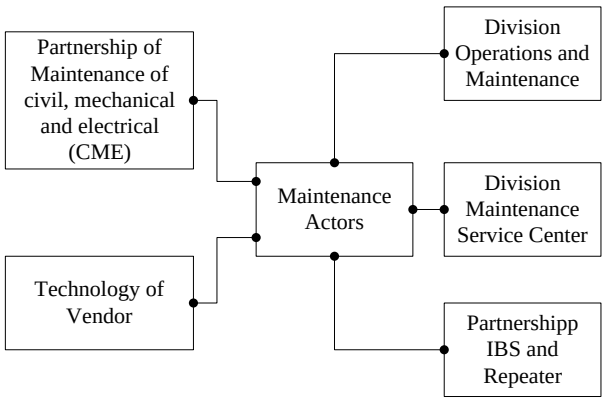

Figure 2. Actors maintenance team.

Maintenance activities of each maintenance actor of ICT, is in Table I.

ICT maintenance activities are elements of the telecommunications network system, each actor has a responsibility to maintain the maintenance system to remain standard and there is no downtime. ICT maintenance performed by the partners as shown in Table I, the complexity of implementation and responsibilities.

TABLE I. ACTIVITIES MAINTENANCE

Actors	Element of ICT	Maintenance Activities
Technology of Vendor	Software (Module) BTS, BSC and MSC	• Update Software • Routine Checking reliability • Improvement and replacement
Maintenance's partnership of Civil, Mechanical and Electrical (CME)	BTS purchasing pattern	• Maintenance all of element CME • Always guard condition to secure, hygiene and easy to access BTS's location • All of subsystem mechanical function always stand by and appropriate standard • Alarm function maintenance • Maintenance physical and function of BTS tower • Controlling of lighting and supply power • Always guard temperature and grounding system of shelter appropriate standard • Replacement and improvement all of CME element • Report maintenance activities to company • Preparing to KPI monthly
Partnership IBS and Repeater	CME and software IBS and Repeater	• Maintenance all of CME and software IBS and Repeater element • Selected location to rent of placement IBS and Repeater • Reporting operations and maintenance activity to telecom company • Preparing to KPI monthly
Division Operations and Maintenance	CME BTS's partnership; CME BSC; CME MSC; CME IBS and Repeater; software IBS and Repeater	• Supervision, controlling and evaluation partnership • Support operations and maintenance software NSS and BSS • KPI measurement • Administration of maintenance activity • Trouble ticket issued • Cooperation and coordination with Maintenance Service Center Division to maintenance and controlling all of CME that used except CME BTS purchasing pattern • Reconciliation with all of maintenance's partnership every 3 months
Division Maintenance Service Center	CME BSC, CME MSC, CME BTS purchasing pattern, IBS and Repeater granted	• Maintenance all of element CME • Maintenance all of IBS and repeater that expired operations and maintenance partnership after 10 years rented

Maintenance of BTS, BSC, MSC, IBS & repeaters and transmission media has its own complexity. It occurs because each of the ICT has a lot of maintenance officers. Activity of maintenance treatment also varied depending on the pattern of ownership of ICT as well as the classification of ICT in generating services to consumers in the form of signals in accordance with established standards.

Each of ICT maintainer partner is autonomus team but it must be cooperative, effectiveness and integrated. The maintenance team conducts its activities based on a contract agreement which is valid for 5 years. The contract will be extended if it has a good performance during the contract period. Autonomous teams and collaboration procedures of the team in the ICT maintenance activities has been mentioned in the memorandum of understanding (MoU) of each partner with Telecommunication Company.

The partners implement ICT maintenance activities in accordance with the performance standards that have been set. But how the system and the implementation of ICT maintenance activities is, each partner has its own performance standards. Even most partners do ICT maintenance activities performed by the third party. Nevertheless, the performance of ICT is responsibility of related partner.

To measure the success of each partner, Key Performance Indicators (KPI) was applied each month and evaluated every 3 months. The Key Performance Indicators (KPI) was conducted with a sample 20% of the total holding severy month. If the minimum KPI was achieved and the maintenance execution in accordance with the agreement during the audit then the partner's performance was good. The KPI conducted by Network Division a routine. The KPI was applied to ICT that used rental patterns and it was not applied to the ICT that used buying pattern. A rental pattern ICT is an ICT that its ownership and maintenance activities are implemented by partners and the company supervisor, controls and evaluates them. If the KPI results were not in accordance with the set standards then the partner had to make improvements during a certain period. If the partner could not fix them then there would be a penalty.

A buying patterns ICT is an ICT which is owned by a company, whether the result of purchase or grant from partner which is out of contract. On buying patterns, the ICT maintenance activities are performed less well. It happens because there is no control and evaluation of the maintenance implementation. Maintenance or repair is usually only done in case of interruption of telecommunication network systems. Basically the

maintenance of buying patterns ICT has its standards and procedures but are not implemented.

The treatment difference to ICT ownership in the maintenance activity has its own problem. Event If there is a network systems disruption and they want to perform a system recovery. There is no only the difference in ownership treatment but also maintenance treatment differences due to the classification of revenue that is resulted by related ICT.

Nevertheless every maintenance work team has its own autonomy in performing maintenance activities. The authority in the maintenance activities can run well, effective and integrated only if the work teams communicate and coordinate one another. The tools used to communicate and coordinate are mail lists, SMS robots, dash board online, and alarms.

Autonomous team in ICT maintenance activities and teamwork during a network system interruption can be clearly illustrated. The Network system disorders that occur can be knew through information submitted by robots or SMS alarms automatically. SMS robot will provide information the broken network system ICT element. The SMS robot will be sent automatically from the ICT network system. OMN management team and all relevant partners who carry out related maintenance activities of ICT receive the SMS. In addition to the SMS information from the robot, it is also covered by alarm installed in the office of the Network Systems division.

The alarm and the resulting color indicators give an indication of the level alarm system network disruption that occur. If the disturbance is red alarm then the category is critical and need immediate handlers. If it is yellow color so the disturbance is moderate and treatment usually depends on the broken ICT element. Whereas if it is green, then the disturbance is typically mild and the system will improve automatically. However, if the system can not perform automatic recovery, the alarm will turn into yellow in some time later.

Based on received SMS robot and red alarm, responsive management team will perform immediate repair to the network system. Based on information from the SMS robots, team operation and maintenance of the core network (OMNC) trace the cause of disturbance. Search results disseminated to all related teamwork through maillist, SMS and online dashboard. Based on the information, the related entire team immediately coordinate to repair network system.

Network system repair that categorized as critical, must be handle immediately. The whole team must work quickly, effectively and integrated. The OMNC investigation results, types and elements of ICT, the type of disorder, the location and responsible partner with the ICT can be known. All such information is complete and can be viewed on integrated online dashboard. Based on the information Representative Office (RO) teamwork and the units of public optimization and coverage area (OPCA) and the associated partner network coordinate to repair network system.

After coordinating and determining corrective actions, the entire team work independently in accordance with their responsibilities. Any corrective actions taken by each work team has a time frame for implementation. The time frame is determined based on the classification of the related revenue ICT and its maintenance action. The classification is platinum, gold, silver, and brounce. Pattern maintenance of each of the different classes. Platinum and gold pattern class preventive maintenance 4 times a year and allowed to be off just 2 hours in a year. While the silver class and brounce preventive maintenance 2 times a year and allowed to be off for 4 hours in a year. In the event of disruption and needs corrective maintenance action, adaptive or perfective maintenance must be authorized for cut interruption for 15 minutes.

OMNC internal work teams, RO and OPCA publish the trouble ticket to the relevant impaired maintenance partner of ICT network system. Trouble ticket is issued in accordance with the type of disorder and in accordance with the former service level agreement (SLA). The ICT Maintenance partner actors repair element of the ICT based on trouble ticket.

Partner actors perform ICT maintenance of network system elements repair in accordance with the trouble ticket which is immediately obtained. Related internal work teams and other partners are also monitor and control the repair process. They work together and coordinate to make improvements to the network system performance for each work team. If the network system repair managed properly in accordance with specified time frames then the performance of the work team is good. It is a barometer of success and achievement of KPI of autonomous teams that will be audited every month.

Indicators are the barometer of success of autonomous ICT team maintenance activities in achieving KPI which is determined every month. The result of the audit team of autonomous maintenance activities each month must achieve minimum KPI of 98.5%, the payment will be done without pinalty. The payment will be done after repaired the records of ICT maintenance activity that do not comply with the agreement.

If the result of autonomous audit team do not reach the minimum KPI, then the partners must improve their performance. Improvements is given time up to the 20th of every month then will be re-audit. If the minimum KPI is not reached, there will be a payment pinalty. Magnitude scale % pinalty form of payment depends on the achievement of KPI after re-audit.

The payments of ICT lease to all partners of ICT maintenance is made every 3 months. Payment is made after reconciliation between the partners and the telecommunication company. In the reconciliation process the discussion and bargaining on achievement of KPI each month will occur as well as payment and imposed pinalty. If the agreement has been reached the payment will be made. Reconciliation is also to review the company cooperation with maintenance partner. The review made to consider the lease contract extension and review items in the contract agreement.

To analyze the activity of ICT maintenance in telecommunication companies, triangulation approach

was used, based on the summary of in-depth interview results, field observation and documentation of company [16].

V. Analysis

ICT maintenance activities which were carried out by partners had dependencies. The dependencies were from work team itself and work team of other partners who had responsibility to perform existing ICT in accordance with set standards. The dependence of the work had clear work procedures and cooperation which were stipulated in the contract. Thus, when a problem occured between partners in carrying out their maintenance activities, then the telecommunication company could solve it effectively using available communication tools. It was consistent with the theory [10] in terms of team work and problem resolution.

The production of strong standard signal by network system was a major objective to be achieved by the telecommunication company through its Network Division. However, to achieve its target the company cooperated with actors of maintenance partner. It was in line with the statement of Kozlowski and Bell [2003, in 11]]. Each partner of ICT maintenance had to communicate effectively and integrated with other partners in order to generate a standard network system. It was in line with the statement [13].

Maintenance partner actors had autonomy to do the maintenance activities. Autonomous team was conducted in accordance with the maintenance activities which had been stipulated in the cooperation contract. The task execution of maintenance activities was set independently. It was in accordance with the theory [Chern, 1976, Emery, 1972; in14]]

Each internal and external team work which was involved in ICT maintenance activities had its own working system. The system was designed to ensure the autonomous work team could run well and produced a good work team performance. A workteam performance depended on the other workteams. Therefore each workteam had to be able to communicate and coordinate well, effectively and integrated. A member of team work actor of ICT maintenance had an expertise and capability in accordance with his duties and responsibilities. Each team member had a commitment to carry out maintenance activities with both ICT and mutual support among team members. Any received information had to be communicated accurately and effectively in accordance with the agreed work procedures. Thus ICT maintenance activities could run effectively and in maximum performance of team work. A good performance would be achieved by the workteams when all members of workteams exchanged their knowledge mutually. This knowledge exchange occured during the transfer of knowledge through learning by doing. Knowledge transfer underway with various available communication tools and network system disorders management collectively.

Integrity could result a good work team only if it was supported by working culture building and sense of responsibility for any existing ICT. The environment would encourage each member of team to be able to carry out autonomous maintenance. Standard operation procedures in ICT maintenance activities, means of communication as and network system disruption handling had been established by using a modern technology to support the integrity of the work team in ICT maintenance activities.

ICT maintenance and handling of network system disorders conducted by an effective work team [10]. The teamwork is an integrated work [12]. Supported by a high-tech communication equipments which were integrated with the responsibility of ICT maintenance activities and focused on achieving standard network system performance [13]. The tasks in ICT maintenance activities were determined independently according to sevice level agreement [Chern, 1976, Emery, 1972; in [14]] and the telecommunication company audited the implementation of ICT maintenance periodically. In maintenance activities and ICT network system disorders handling, the autonomous teams worked independently [Chern, 1976, Emery, 1972; in [14]]. While the work team's Integrity [12] was reflected on the maintenance actor performance. The Indicator of the success of team work [13] was measured by KPI achievement which audited periodically.

Although sometimes the disorder handling could not be done immediately because the received information was translated differently between partners and company. Further more throwing responsibility often occurred between partners or just awaiting the reaction of other partners. A conflict between work teams might occur if the received information was not appropriate or delayed. The conflict of maintenance activities was handled by a management team which led the operations and maintenance manager. If it could not be resolved by the management team and maintenance manager, then it would be handled by the Network General Manager. However, it rarely happened because each member of the work teams already had a good working culture. The relationship between work teams in carrying out autonomous maintenance activities had been established and the work teams worked well together, so that the maximum KPI could be achieved.

VI. Conclusions

The ICT that used on telecommunication network systems which was generated and appropriate standards of services were very complex. It happened due to numerous types, amounts and widespread in the geographic service area. Each partner of ICT maintenance of telecommunication network system had its own authority in carrying out maintenance activities and network system recovery. Maintenance activities would be successful, effective and integrated if each team could communicate and coordinate well with other teams and company's work team.

A Common perception in addressing the received information from the mail list, SMS robots, dash board online and the alarm would make the work teams faster in

responding to any system disruption that was caused by not optimal maintenance activities. Autonomous maintenance team in ICT activities were indispensable. Giving ICT as an important and critical element role in the network system. The achievement of standard network system performance depended on the ICT performance. While the ICT performance would be good if it was done well and there was an ease in handling network system disorders. Autonomous role in the ICT maintenance activity teams was very important based on type and amount of used ICT.

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REFERENCES

[1] Pertumbuhan Ekonomi Indonesia, *Berita Resmi Statistik* No.13/02/Th. XV, 6 February, 2012.

[2] M. Firman and I. Kurniawan. (December 2011). Tifatul: In 2012, An ICT Business had reached Rp. 500 million (In 2010 Business telecommunication had contributed 13.2% of the economic growth in Indonesia). *Viva News*. [Online]. Available:http://teknologi.news.viva.co.id/%20news/read/273951-tifatul--2012--bisnis-ict-capai-rp500-triliun.

[3] D. Purwanto. (February 5, 2013). The Economic Growth of Indonesia was 6,23% in 2012. [Online]. Available: http://nasional.kompas.com/read/2013/02/05/12192140/Pertumbuhan.Ekonomi.2012.Hanya.6.23.Persen

[4] P. P. Lelyemin, "The Transportation & Communication sectors have supported to the first Indonesia's economic," *Fiskal dan Moneter OkeZone*. (February, 2014). [Online]. Available: http://economy.okezone.com/read/ 2014/02/05/20/936318/sektor-angkutan-komunikasi-penopang-utama-ekonomi-ri

[5] J. F. G. Fernandez and A. C. Marquez, "Framework for implementation of maintenance management in distribution network service providers," *Reliability Engineering and System Safety*, vol. 94, pp. 1639-1649, Oct. 2009.

[6] L. A. Ogunsola and W. A. Aboyade, "Information and communication technology in Nigeria: Revolution or evolution," *Journal Social Science*, vol. 11, no. 1, pp. 7-14, 2005.

[7] M. C. Eti, S. O. T. Ogaji, and S. D. Probert, "Implementing total productive maintenance in Nigerian manufacturing industries," *Applied Energy*, vol. 79, pp. 385-401, December 2004.

[8] G. Waeyenbergh and L. Pintelon, "A framework for maintenance concept development," *International Journal of Production Economics*, vol. 77, no. 3, pp. 299-313, 2002.

[9] (2012). ICT Maintenance. Europe Union, ICT Standards Institusional and Sector Modernisation Facility (ISMF), document number ISMF-ICT/3.11, Version 1.00, Software AG Planet (News Phone), Project Funded by European Union. [Online]. Available: http://www.moct.gov.sy/ ICTSandards/en_pdf/21.pdf

[10] R. Kreitner, A. Kinichi, and N. Cole, *Fundamentals of Organizational Behaviour*, 2nd Edition, McGraw-Hill Ryerson Ltd, 2007, ch. 7, pp. 148-171.

[11] R. Rico, C. M. A. de la Hera, and C. Tabernero, "Work team effectiveness, a review of research from the last decade (1999-2009)," *Psychology in Spain*, vol. 15, no. 1, pp. 57-79, 2011.

[12] S. E. Maslin-Prothero and A. E. Bennio. (2010). Integrated team working: a literature review (research and theory). *International Journal of Integrated Care*. [Online]. Available: http://www.ijic.org/index.php/ijic/article/view/529/1042

[13] C. K. C. Ibrahim, S. B. Costello, and S. Wilkinson, "Key practice indicators of team integration in construction projects: A review," in *Proc. 2nd International Conference on Construction and Project Management*, 2011, pp. 230-235.

[14] W. H. W. Mahmood, A. R. Mahmood, and I. Abdullah, Autonomous Maintenance Program For Job Base In Technical University, *Faculty of Manufacturing Engineering*, 2012, pp. 497-511.

[15] J. J. Castillo. (2009), Stratified Sampling-subjects Proportionally Selected from Subgroups. The Scientific Method, Science, Research and Experiments. [Online]. Available: http://www.experiment-resources.com/stratified-sampling.html

[16] R. K. Yin, *Case Study Research (Design and Methods)*, 5th ed., Sage Publications, Inc, 2014, ch. 4, pp. 103-129.

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