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Abstract

Purpose – Communication and Information Management (CIM) is crucial for any organisation and effectiveness of CIM can result in significant improvement to the bottom line and customer satisfaction. The purpose of this paper is to investigate and streamline the communication and information system within an "infrastructure support service" company using Six Sigma methodology.

Design/methodology/approach – The research involved a triangulation approach of case study and use of survey instrument to find a solution to the problem.

Findings – The paper highlights a significant concern with regard to CIM within all the business units of the group. The effectiveness of the present CIM system for the whole group is below industry average with regard to accuracy and timeliness of CIM, resulting in an inefficient management reporting system. Operating in a highly competitive and time-bound environment, correct and real time reporting is paramount. The main reasons for the ineffectiveness of CIM across the group can be attributed to two main factors; data management and communication systems being used. The paper also illustrates an appreciation of the use of Six Sigma within a transactional environment.

Originality/value – This study is a novel application of Six Sigma methodology within the communication and information management system.

Keywords Six Sigma, Process management, DMAIC, Communication and information management, Strategy, Quality

Paper type Case study

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Introduction

Six Sigma is a breakthrough business strategy used for quality and process improvement by using a set of structured tools and statistical measures to evaluate processes (Antony, 2004b). Six Sigma has evolved over the last two decades and continues to expand since its inception at Motorola in the mid-1980s (Hoerl, 2004). Six Sigma as a business strategy has been exploited by many world-class organisations such as Motorola, SE, Honeywell, ABB and Sony to name a few, resulting in million dollar savings on the bottom line (Snee, 2004). Edgeman *et al.* (2005) suggest that Six Sigma approach can help to develop solutions that jointly optimise multiple bottom lines. Senapati (2004) highlights that many of these companies have laid out specific blue prints for process improvement using the Six Sigma framework. More and more companies are discovering Six Sigma to gather customer input and gauge customer satisfaction within their products and services.

The current business trend of cut-throat competition is forcing organisations to look at ways of reducing costs. The scarcely available funds need to be deployed meticulously. Implementation of Six Sigma methodology is most suitable in such conditions as compared to any other traditional contemporary process improvement methodology due to the following reasons:

- The implementation of Six Sigma facilitates breakthrough results as evidenced by many organisations (Breyfogle *et al.*, 2001).
- Fact- and data-based approach, and the use of statistical methods reduces chances of error (Pande *et al.*, 2001).
- The resources required for Six Sigma can be drawn from within the organisation (Gupta, 2005).
- The time frame for implementation of projects is comparatively short; most of the projects can be completed within three to six months (Snee, 2001).

In today's business world information is considered power and a major source of growth and prosperity. However, if information is not analysed and acted upon in time, organisational effectiveness can be reduced hence affecting the competitiveness (Peipert, 2005). The importance of information is highlighted by the fact that without essential information, organisations do not know what they need to know, neither they are aware of what they do not know, hence the act of organising itself goes in vein. This case study investigates the effectiveness of communication and information management (CIM) system within an infrastructure support company, using the Six Sigma (DMAIC) methodology.

Literature review

Six Sigma has many definitions, each addressing one of the several aspects of its phenomenon of the pursuit of "near-perfection in meeting customer requirements" (Pande *et al.*, 2000). Since Six Sigma focuses on the customer and uses facts and data to deliver better solutions, it is regarded as an effective way to manage business (Pande *et al.*, 2001). According to Breyfogle *et al.* (2001), "Six Sigma is a team-based approach to problem solving and process improvement". Six Sigma's success has been attributed to embracing it as an improvement strategy (Antony and Banuelas, 2001; Snee, 1999), philosophy (Slack *et al.*, 2004) and a way of doing business (Pande and Holpp, 2002; Watson, 2001).

According to Breyfogle (2003), Six Sigma organisations have a well-defined management hierarchy within the organisation. Antony and Banuelas (2001) refer to this hierarchy of execution as one of the most powerful themes of Six Sigma approach. According to Breyfogle *et al.* (2001), in a Six Sigma organisation special titles are given to people within the organisation depending on their Six Sigma roles. All employees of the organisation should have the awareness of Six Sigma and preferably be trained as Yellow Belts to create a Six Sigma culture throughout the organisation (Gupta, 2005).

CIM within organisations is one of the most important and critical aspects especially in today's competitive world. Information flows throughout the organisation and follows various processes till it is complete in entirety and reaches the final destination. The changing business environments require organisations to manage the information effectively in order to create a knowledge base and utilise the same for business advantage and competitive edge. Timely communication of this information is referred to as knowledge management within the organisation, described as getting the right information to the right people at the right time, helping people create knowledge and sharing and acting on information (Holm, 2001).

Six Sigma has been successfully implemented within the manufacturing industry and now the awareness is growing towards application in the service, transactional and administrative processes (Bisgaard *et al.*, 2002). This paper is aimed at using Six Sigma (DMAIC) methodology in evaluating the efficiency and operational performance with regard to management of information and suggest improvements where gaps are identified.

Research methodology

The objective of identifying an effective communication system within the infrastructure organisation is achieved through case study strategy. "Case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and the context are not clearly evident" (Yin, 2003). This research is not restricted to identifying the root cause but also encompasses the development of a better framework. Hence a well-constructed case study strategy is employed in the research to test the existing theory.

In this case study, Six Sigma DMAIC methodology is applied to identify the root causes for an existing problem and proposes solutions that can have significant business impact. Positivist philosophy is used since large sample of data is involved and provides analysis of a wide range of situations. The research is based upon facts or reasons with regard to the phenomena with little consideration of the subjective state (Hussey and Hussey, 1997).

Triangulation approach is adopted for data collection. Since each data collection method has its strengths and weaknesses, the research encompasses two methods; case study and questionnaire to counterbalance the flaws if any, leading to credible findings. Moreover, if the results obtained from one-method backs up the results from another, the research is validated and hence accomplishes a reliable conclusion (Bulmer, 1984). The next section discusses the case study approach undertaken during the project and the implementation process of DMAIC Six Sigma methodology.

Case study

Introduction to case study

The organisation is an infrastructure support services group, which is focused on its core competencies in providing highest quality products and services within a number of industries including rail, plant, roads and facilities management. Considering the diverse nature of the business the organisation was interested in establishing a control centre for real time tracking of job progress at work-sites. Different businesses of the group are being operated on a different platform with no central control of information, with each depot operating as an independent entity spread across the country to provide services to their clients. Owing to the ever-growing need of customers to have access to real time information, the management has felt a need to develop an efficient CIM system for all functions of the group.

The project selection was done based on the strategic requirement of the company. In today's competitive world, information is of essence to any business and effective management of information is an ever-growing requirement. With diverse operations and customers spread across the country, centralisation and consolidation of information is even more important for the organisation. Since most of the operations are projects based where meeting deadlines and responsiveness to the customer requirements is paramount, slightest slack in information can result in huge penalties and loss of opportunity. The penalties in many cases could be extremely high since time is of essence, for example delay in handing over a high-priority rail track could result in penalties of thousands of pounds per hour. Considering the cut-throat environment organisation is operating in and the future growth, this project will provide a competitive edge in the market place.

The project aims at identifying the efficiency of existing CIM system, categorise problems within present CIM system and explore root causes of problems identified. Based on the management requirement from the CIM system and keeping strategic focus for the business in view, following aspects are identified as critical to the project:

- timely reporting of information;
- centralised data access for management reporting; and
- solution to be portable and applicable to all business units.

Application of DMAIC to the project

In order to deal with the problem highlighted and to achieve the research objectives, a case study approach was adopted considering the real-life context of the problem. Undertaking a case study approach, Six Sigma (DMAIC) improvement methodology has been adopted to embark on the research. In this case, Six Sigma methodology was adopted since it facilitates data and fact-driven approach. Six Sigma provides the management with concrete evidence of findings that facilitates in making the requisite decision. Since no solution was available and considering the scale of the problem, Six Sigma methodology was adopted to streamline the information flow within the organisation. Moreover, considering that CIM is an integration of human factor and the processes involved, Six Sigma is appropriate since it has the capability to integrate the human and process aspects of process improvement (Bisgaard *et al.*, 2002). Six Sigma DMAIC methodology helps to identify the root causes of the problem and define the control measures for the same. The phases of DMAIC and the tools used within each phase are discussed below.

Define phase. The aim of this phase is to determine the customer and process requirements and define the scope and goals of the improvement project accordingly. During the define phase various tools like SIPOC diagram, voice of customer (VOC) and affinity diagram were used to determine the focus points or requirements of the project.

SIPOC diagram. A SIPOC diagram is a tool used to identify all relevant elements of a process improvement project before work begins. It is used to define business processes where the team identifies and maps the basic relationships between the suppliers, inputs, process steps, outputs and customers, hence called a SIPOC diagram as shown in Table I. The SIPOC diagram was developed by the Six Sigma team after brainstorming and discussion with the stakeholders.

"VOC" analysis. To ensure that the objectives are realistic and in line with customer requirements data are collected and analysed based on "VOC" concept. Customer data in this case were collected from a sample of end-users of information within the management and operational environment. The VOC collected based on discussions and reviews with management representatives helped to determine the following:

- problems encountered on daily basis regarding information management; and
- process flaws causing hindrances.

Creation of affinity diagram. Affinity diagram is best suited in handling unstructured data from interviews and observations (Gitlow and Levine, 2005). Since there was a need to make clear representation of the collected data, affinity diagram was used to analyse and structure the gathered feedback to generate solution ideas. According to Cohen (1995), affinity diagram is used to handle large amount of qualitative data, where data are organised into subgroups based on similarities between them.

The raw "VOC" is taken as a base to construct the affinity diagram. The VOC data collected from the management and control centre team were analysed and possible reasons were discussed with the concerned and after brainstorming within the team arrived upon three focus points 1, 2 and 3 as shown in the focus point column in Figure 1. Each of the VOC was allocated to relevant focus points, e.g. inconsistent site reporting can result in incorrect information, relevant data missing or delayed information, therefore was allocated focus points 1, 2 and 3. Similarly all the raw VOC data points were identified with a focus point. The focus points provided theme to the affinity diagram and these focus points can be seen as the corporate quality requirement from the CIM system. The affinity diagram based on VOC analysis is shown in Figure 1.

Prepare a business case with a project charter. Final step of the define phase is the preparation of the business case based upon information collected from the SIPOC and VOC analysis. Along with the business case a project charter is also prepared highlighting the following main constituents to drive the business case (Table II).

Supplier	Input	Process	Output	Customer
Planning team	Broadcast/resource sheets	Review info.	Correction ascertained	Control centre
Depot/regional office	Confirmed information	Update database	Database updated	Control centre, work-site
Control centre	Work order, site supervisor information	Escalation	Awareness, timely corrective action	Senior management, external customers
Site supervisor	Job finish information	Update and log completion	Service delivery, support, system updated	Control centre, customers, contractors

Table I.
SIPOC diagram

Target Segment	Raw VOC Data	Affinity diagram theme (Focus Point)
Senior management	Inconsistent site reporting - **1, 2, 3**	1. Incorrect Information
	No defined KPI's / management reporting system - **2**	2.Relevant data missing
	Timely access to information - **3**	3. Delayed Information
	Customer concerns not notified in time - **3**	
	Real-time management of data - **3**	
	Legal agencies call up to notify the concerns - **3**	
Control Centre Team	Lack of information updation - **1, 2, 3**	
	Information does not reach Control Centre - **3**	
	Lack of effectiveness of system - **1, 2, 3**	

Figure 1.
Affinity diagram

Project title	Development of effective information management system within the organization to deliver accurate real-time access to information
Timeframe	Three months
Metrics	Measures of accuracy (correctness/completeness) and timeliness
Goal	Integration of existing systems and enhanced response time (speed)
Rationale	Gain competitive advantage by being responsive to customer requirements having centralized real-time information management system
Scope and boundaries	The project will look at the following Understand information flow within organization Identify key requirements to have centralized data collection at the control centre Study possibility of integrating existing systems Make recommendations to achieve the stated goal Owing to time constraint the implementation across the board is not feasible, keeping the scope to trial at single location Identify pilot location/site for implementation and record results
Constraints	Timeframe, data access, resource availability, commitment, finance
Project team	Six Sigma project comprising Project champion SS-Black belt Project leader Team member (control centre) Team member (IT) Team member (site)

Note: The authors took on the role of project leader (as well as the role of a green belt) within the project team

Table II.
Project charter

Measure phase. The measure phase involves the following main functions: establishing the Key output variable (KPOV) or metrics for corporate "Y"; determine operational measures and definition of the critical to quality (CTQ's); perform a gage repeatability and reproducibility (R&R) study for each CTQ.

First step for a measure step is to identify defects within the process. A defect is defined as anything not complying with requirement of the process or product. Each defect results in erroneous or delayed information. A CTQ tree is used to determine the measurable defects based on the corporate "Y" identified through VOC analysis. Following tools and techniques are used in the measure phase to establish further clarity on the CTQ's.

CTQ tree. In order to determine the metrics or the KPOV, a CTQ tree was drawn as shown in Figure 2. The KPOV's identified are also called CTQ's since these outputs directly affect the customer, construction of CTQ tree requires appreciation of the organisations corporate requirement as understood from the VOC analysis. The corporate-level CTQ, "Y" is broken down to represent the "Y" to be solved. This "Y" is also referred in Six Sigma terminology as project or problem solving "Y". Figure 2 shows how the corporate "Y" from VOC has cascaded into more specific Six Sigma project focus activities in the form of business critical "Y". From the CTQ tree three metrics are identified:

(1) completeness;

(2) correctness; and

(3) timeliness.

Operational definition of CTQ's (project "Y"). Once the critical "Y" is identified and the data sources located, the final concern is to facilitate error free analysis of the data collected. In this regard it is vital to have the operational definitions of the "Y". This facilitates the team members to have a common understanding of the measures involved. Operational definitions of correctness, completeness and timeliness are provided below.

Correctness. Correctness is defined as the accuracy of details about occurrence of events, i.e. correct time of the event or other details, as defined in the standard operating procedures (SOP) for the process. Correctness of data for the project has been ascertained based on the entry of time and dates of the events. Any date or time field not in line with the occurrence of events, i.e. dates recorded at control centre before the actual date of occurrence at site, is recorded as a defect.

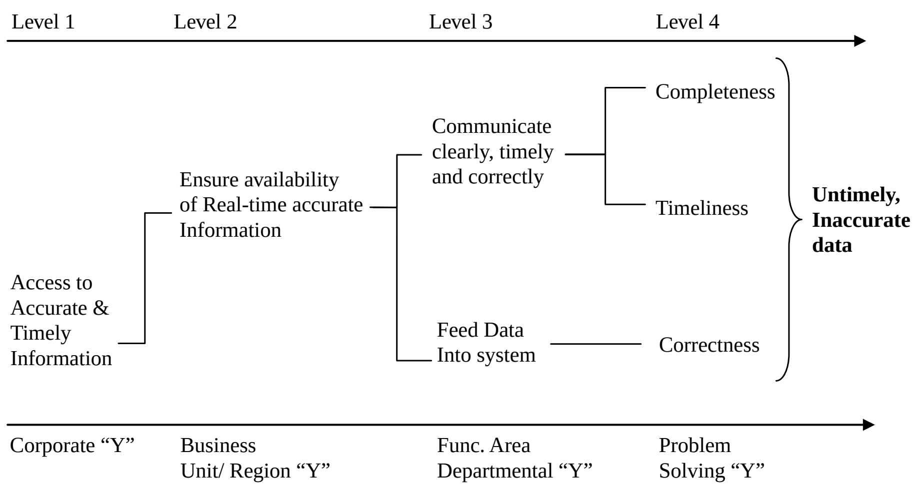

Figure 2. CTQ tree – communication and information management

Completeness. Completeness in this case refers to the requirement of all the mandatory fields in a form to be filled in completely. The mandatory fields were determined after consultation with the concerned personnel in respective departments. Any mandatory field found in complete is recorded as a defect.

Timeliness. In order to determine the criteria for timeliness for reporting the events, a baseline of half-an-hour lead time was drawn in consultation with management representative. It means information from work-sites needs to be reported at control centre within half-an-hour of the event at the maximum. Any entry reported in excess of half-an-hour from the occurrence of event is treated as a defect.

Data collection plan for the CTQ (project "Y"). Required data were not readily available since the organisation had poor data management system and no effective utilisation was done of the little data available. Therefore, a plan was worked for retrieving archival data, where applicable. Lack of centralisation and system utilisation also become hindrance with some business units. In such cases, data were generated from the most recent records available for study purpose. Where data access was feasible six monthly data was procured to make the generalisation of results close to reality.

Perform a gage R&R study on each CTQ. Gage R&R study is conducted for each CTQ to determine the appropriateness of the measurement system. Gage R&R study in the case of pilot study depot was not feasible for timeliness "Y", due to the dynamic nature of the activity and data access; hence the study was conducted for completeness and correctness "Ys".

Gage R&R study for correctness and completeness. The data were evaluated for checking R&R factors. The total variance for correctness amounted to 7.16 per cent. The measurement system is considered acceptable when the measurement system variability is less than 10 per cent of total process variability (Antony *et al.*, 1999; Breyfogle, 2003). Since the total variance is less than 10 per cent the gage system is satisfactory. Hence the measurement system is acceptable to measure correctness.

Similar considerations as undertaken for correctness study were made with regard to the "completeness" for checking the variation in the data collected for the same. The total variance for completeness amounted to 3.82 per cent, which implies that the measurement system is acceptable to measure completeness as well.

Determining the present situation. First step in the measure phase involved exploration of the collected data in order to identify the defects with regard to correctness, completeness and timeliness. The defect rates for each of the "Y" as determined from the collected data were summed up for the whole group. A Pareto chart as shown in Figure 3 was constructed to see the overall effect. This determined that completeness of information was a major contributor for error rate amounting to 60 per cent of the errors followed by correctness and timeliness at 21 and 15 per cent, respectively.

From the Pareto chart it is observed that completeness and correctness together contribute to 85 per cent of the errors hence further focus on these two "Y" will facilitate a directed approach to resolve the problem with regard to accuracy of problem. Moreover, since both the factors affect the accuracy of information and have impact on each other, these will be the focus for further research. A further analysis was conducted to check the stability of the process with respect to completeness and correctness of data. The result of the study clearly indicated that the process is stable.

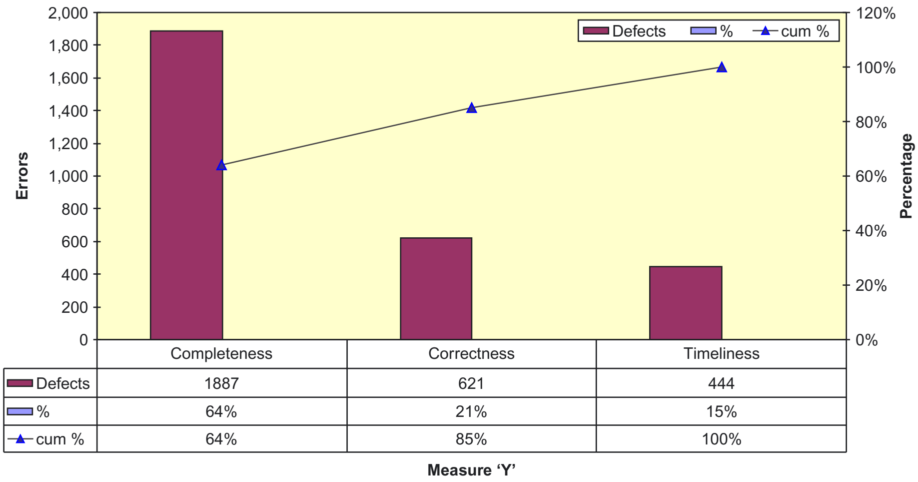

Figure 3.
Pareto chart for identified "Y"

Analyse phase. The purpose of analyse phase is to explore the collected data, analyse, verify and prioritise the possible root causes and their relationship to "Y" or outputs. The analyse phase involves identifying the possible causes "X" for the identified CTQ "Y" and further narrow the root causes to the vital few, identifying the significant variables for each CTQ, and understanding the effect of the Xs on each CTQ. The first step in this case is identification of the possible causes; a cause and effect diagram is used for this purpose.

Cause and effect analysis. This step involves analysis of potential causes of the problem in order to identify the potential causes which affect the "Y". Cause and effect analysis was conducted to identify the possible causes for untimely and inaccurate data as shown in Figure 4. The cross-functional team brainstormed the reasons for the "effect" based on the data collected and their understanding of the process. The output of the cause and effect diagram depends to a large extent on the quality and creativity of the brainstorming session. After performing a number of brainstorming exercises and using a multi-voting method, the team members arrived at the conclusion that there are four major causes referred to as broad-level "X" (data management, communication methods, measurement and people) affecting the output. Further 22 "xs" (input variables) were identified under the four broad "X" that can be considered for data collection plan.

Having identified the possible causes the next step is to prioritise the broad-level "X" (data, communication, process/method and people) to have a focussed approach to identify the root causes. For this purpose a survey instrument was designed that was distributed across the group involving management and supervisors directly involved with the flow of information. Likert scale has been used for rating the questions since it provides more precise answers than just yes/no or true/false statements.

The objective of conducting the survey was to identify the main areas of concern from the four broad "X". Since all the respondents answer a standard questionnaire with same set of questions, it provides an effective way of collecting responses from a large sample and statistical analysis of the results is facilitated (Saunders *et al.*, 2003).

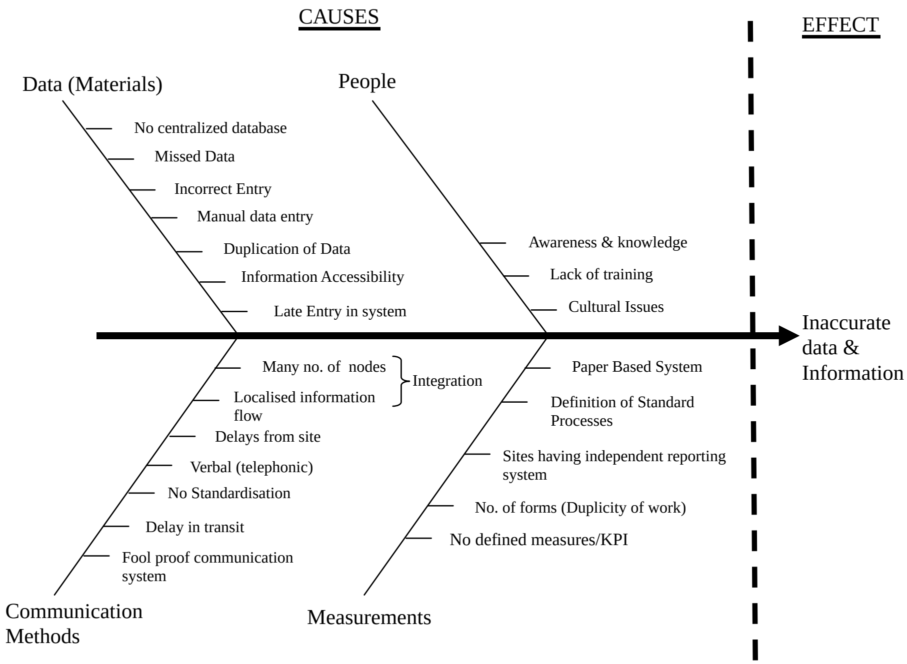

Figure 4.
Cause and effect diagram to identify "X" for the "Y"

The questionnaire was divided into four sections based on the discussions and findings of cause and effect diagram:

- Section 1 aimed at understanding the role of data management in error rate.
- Section 2 was targeted on the role of communication methods.
- Section 3 highlights the measurements required.

People issues are not considered at this stage since these are intangible and involve cultural concerns. Moreover, cultural issues involve substantial change in organisational structure and infrastructure (Coronado and Antony, 2002). People issues can only be addressed after establishing an effective management system.

Findings of the survey instrument. The survey instrument shown in the Appendix was completed by 30 people across the organisation. The purpose of conducting this survey was to develop an understanding of the criticality of possible causes for the problem as identified from the cause and effect diagram. The findings of the survey were further validated by the team by matching with their own results obtained from the brainstorming sessions followed by multi-voting of team members. From the findings of the survey instrument it can be concluded that data management followed by communication systems are the main concerns within the organisation as shown in Figure 5.

Further the data gathered from the survey are analysed to identify the main impact area from "x" for data and communication methods, required to resolve the problem. In this regard the ratings provided by the respondents were analysed based on the severity level assigned on the Likert scale. Based on the prioritisation of questions

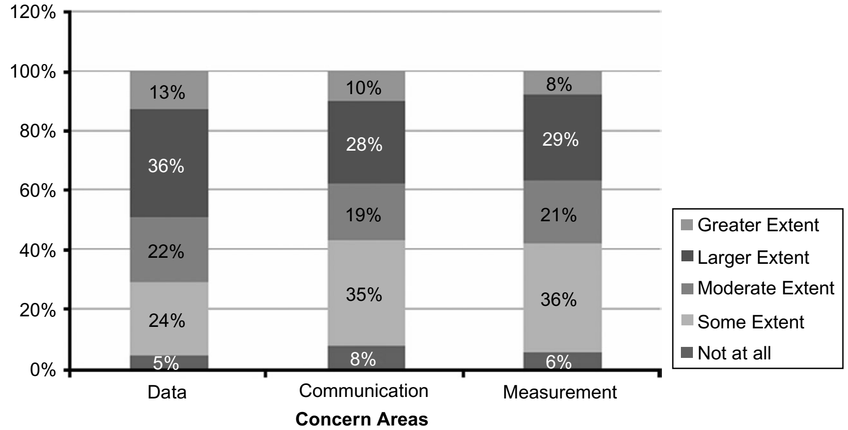

Figure 5.
Staff rating of the concerns based on questionnaire

and brainstorming sessions, the reasons for the "inaccurate information" can be attributed to the following key "x":

- duplication of data;
- manual data entry;
- centralised data base;
- standardisation and integration of communication; and
- fool proof communication system.

Based on the variables "x" shown in Figure 3, three concerns are attributed to data management and two are related to communication systems. Next step involved identifying the impact of the two "X", data and communication for the entire group. Figure 6 shows the ratio of split observed for the two main "X" for the group.

Operational definition of "X". Data errors. Data errors are defined as errors that occur due to reasons like manual entry of data resulting in typographical errors, wrong entries due to lack of training or awareness, etc. Any wrong data entry as an account of these reasons is classified as data error.

Communication errors. Communication errors occur as a result of poor communication from the site and vice versa. These errors can be attributed to various reasons such

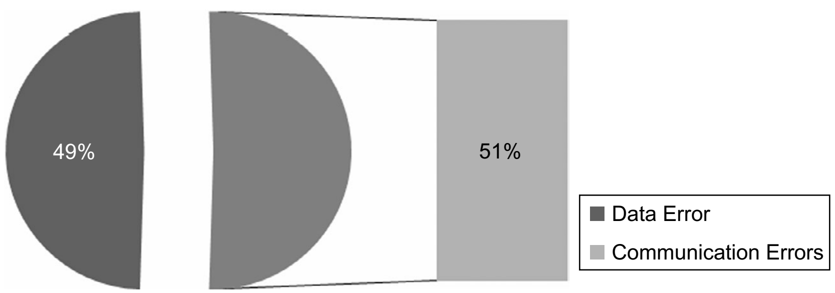

Figure 6.
Ratio of data and communication errors

as information not captured correctly, information not supplied to the concerned or importance not realised for communicating effectively. Any required information found missing is classified as a communication error for the purpose of this study.

After establishing the broad-level "X" for corporate "Y", next step is to identify the real root causes "x" resulting in the impact on broad "X". Process map was used to identify the critical "x" in this case.

Process maps to identify critical "x". Process maps enable identification of the inputs and outputs of the processes and help to identify any missed links, bottlenecks and rework loops. A detailed flow chart explaining all the activities involved in the process, provide a sound base to identify the critical few "x" for the process under consideration. Further analysis of the process identifies the critical steps in the process that create output "Y" as shown in Figure 7.

From the flow chart, eight root causes "x" are identified for the output "Y", i.e. inaccurate information. It is observed that many of the "x", are in line with the findings of the cause and effect diagram and the results of the survey instrument. It is observed that all of the "x" for the pilot depot are broadly related to data management and communication systems, the broad-level "X"; As discussed earlier data management and communication system are affecting the overall "Y" for the whole group.

Analysis of the root causes (x1, x2, x3…). Based on results of the survey, brainstorming sessions with the team members facilitated in identification of six measurable "x's", as incorrect entry, information accessibility, typographical errors (due to manual entry), delay from site (resulting in the late entry in the system), missed data and awareness common across the whole group. This prompted analysis of data on these root causes. The critical x's identified are in consensus with the C&E diagram as discussed in the start of the analyse phase.

The analysis of the root causes was done for the whole group. The findings of the analysis are shown in Figure 8.

From Figure 8, it is evident that incorrect entry, information accessibility, typographical errors and delay from site contribute to 80 per cent of the errors related to data and communication systems, resulting in issues with correctness and completeness of information.

Further to determining the root causes, next step within the DMAIC methodology is the improve phase which involves identification of possible solutions and implementation of the same to resolve the problem.

Improvement phase. The causes identified during the measure phase and the relationship derived in the analyse phase provide input to the improve phase. Hence, the objective of improve phase is to select solutions to eliminate these causes. As a result, the team had a focus on eliminating the communication and data related concerns that were identified to have significant impact on corporate "Y" (correctness and accuracy of data).

As a first step towards improving the CIM system the information flow process for the pilot depot was revisited and the non-value adding activities identified. Non-value adding activities are those parts of the process those can be eliminated or redesigned to make the overall process more effective. The process was analysed for duplicity and recurring activities resulting in unnecessary hand-offs. These activities were removed by redesigning the process thereby centralising the information flow.

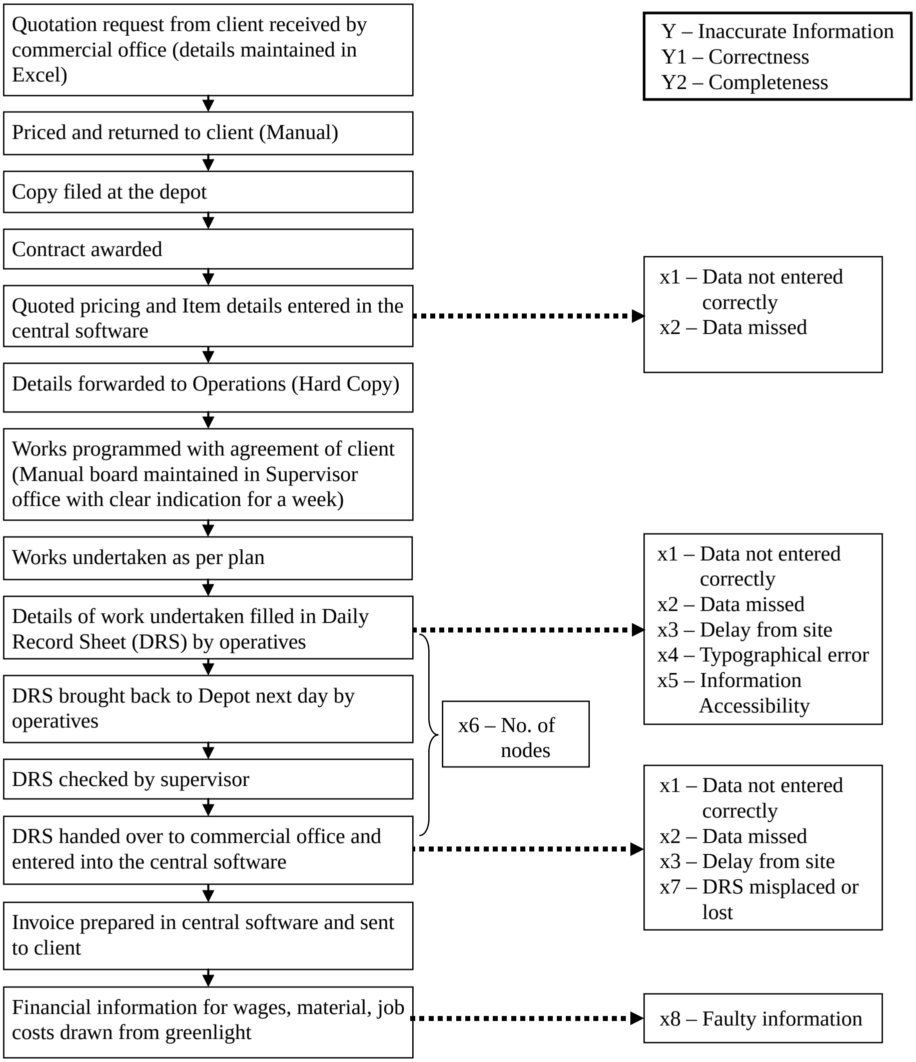

Figure 7.
Flow chart of information flow for test depot

Owing to the time constraint and the involvement of system changes as suggested with regard to the improvements a full-scale implementation of the plan was not feasible. Therefore, this paper will list the recommendations made in this regard. Although, the study was focussed on one of the pilot depots but the nature of business and the systems being followed are primarily the same, hence the recommendations made can be adapted to the whole business unit.

Recommendations for improvement. In order to improve the identified "Y", information reliability by providing complete and correct information, following recommendations for improvement were made:

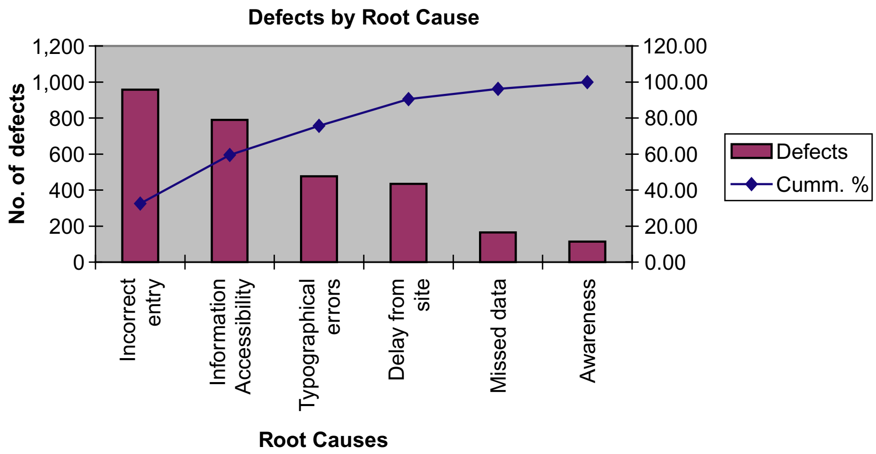

Figure 8.
Pareto chart for defects by root causes

- Centralise the flow of information at one nodal point, say control centre for all the operations within the business units providing 24-hour access to site employees to update their details on real-time basis.
- Installation of centralised software system at the control centre for information handling. Since a computerised software system is already being used at the depots, it will facilitate ease of implementation and adaptation and save the efforts for integration.
- Reduction in nodes through which the information flows such as movement of daily record sheet from site to supervisor to commercial office for entry into the software.
- Standardisation and consolidation of forms where possible, resulting in reduction of forms.
- Eliminate paper-based management of information and avoid manual entry where possible. This can be accomplished by automating the information flow and making the sites on line with the control centre through handheld PDA's or other suitable solution can be explored.
- Introduce work force scheduling and integrate with the systems being followed.

Since poke-yoke is the first step in truly error-proofing the system, adequate measures should be put in place to prevent errors by designing processes and utilising techniques so that an operation cannot be performed incorrectly.

All the improvements suggested could not be implemented simultaneously, therefore it is important to identify the critical improvement variables for the business. In order to determine the priority for effective implementation a rating scheme was designed involving the team members and the management team. The rating involved providing weightings to the suggested improvements on a Likert scale of 1-5. Hence critical improvement variables for the business were identified as shown in Table III.

From Table III it can be concluded that centralisation of information flow need priority along with automation of the processes to gain maximum advantage from the improved CIM system.

Control phase. The control phase is significant since all the efforts put in by the Six Sigma team will be in vain if proper measures are not adopted to sustain the improvements identified and implemented. Therefore, the objective of control phase is to establish measures to standardise, monitor and integrate the changes within the existing framework. A control plan is suggested in order to maintain the improvements.

Considering the fact that information management is a combination of human involvement and information technology, the systems utilised for the process have to be carefully designed. As identified earlier, lack of standardisation is also a cause of variations; therefore SOP should be put in place for all the processes and made applicable to one and all. Strict discipline and adherence to these SOP's has to be ensured by the supervisors.

In order to put a control measure to the identified causes, targets should be decided for each of the "X" at a strategic level and management must define the control limits with a point of view of improving the Sigma quality level of the operations. These control limits generated from the process can be used to generate attribute-control charts to understand the variation in the process and take counter measures. Following measures would be monitored:

- total errors; and
- percentage of records audited.

The control plan indicated should be documented within the quality system of the organisation such as ISO being followed by organisation currently.

Anticipated benefits from the improvements.

Strategic non-tangible benefits:

(1) Better control of information.
(2) Availability of correct and timely information.
(3) Central data collection point at control centre will enable real-time access to site information around the clock.
(4) Reliable and accurate management reporting and monitoring of KPI's.
(5) Overall, a better control of the operations and resource utilisation. Duplication of activities will be avoided, hence reduction in manpower.

S. no.	Recommendation	Average rating
1	Centralise information flow	7.8
5	Systematising or automating the information flow	5.4
3	Reduction in nodes	3.8
2	Communication system integration	3.4
4	Standardisation and consolidation of forms	1.8
6	Work force scheduling	1.8

Table III. Ratings for prioritising improvement recommendations

(6) Above all it builds customer confidence within the company and enhances customer satisfaction, resulting repeat orders and better customer retention.
(7) Provides a competitive edge in the market place.

As the anticipated benefits listed above is non-tangible in nature and few more can be added to the list as the project progresses, it is important to understand the preferred benefits from the team and management perspective. In order to determine the preferred benefits process of ranking was undertaken. The outcome of the ranking is shown in Table III.

It is clear from Table IV that reliable and accurate management information leading to generating KPI's takes the top rank of the anticipated benefit list followed by customer satisfaction and better control of information. Of the seven benefits the top four draw focus on improvement of CIM system.

Financial benefits. Further to the aforementioned intangible benefits as a result of recommendations provided, cost of quality for the operation can be reduced resulting in hard cash savings. The anticipated savings from the suggested implementations based upon the pilot depot amounted to £120K per year. The projected savings are indicated for one business unit within the group but considering the similarity in operations comparable potential is expected in other three business units. Considering the whole group, the expected savings are anticipated in the range of £350-£480K per year.

The company was revisited in June 2008 to estimate the benefits realised from the project. It was reported that the control plan suggested for sustaining the gains from the project was adhered across the business unit, resulting in the savings of over £400K till June 2008.

Managerial implications and lessons learned

The case study found that top-level management had general awareness of Six Sigma and was committed in deploying the strategy across the organisation. The understanding of Six Sigma at the middle management level was not reflected from the findings and thus need a serious thought to develop good knowledge base within the organisation as a whole, for successful deployment of Six Sigma across the organisation.

Training plays a vital role in implementation of any new system. With regard to this project it is important that emphasis should be laid on creating awareness of the proposed system to all users and the importance of each entry should be realised by all involved.

S. no.	Anticipated benefit	Ranking
4	Reliable and accurate management reporting (KPI)	1
6	Customer satisfaction	2
1	Better control of information	3
2	Availability of correct and timely information	4
7	Competitive edge in market place	5
3	Centralised information handling	6
5	Better control of operations and resource utilisation	7

Table IV. Ranking of anticipated benefits

These factors help in institutionalising the improvement process. In order to ensure effectiveness of the training, a skill matrix must be prepared for all the involved and training needs should be identified accordingly. The skill set should be reviewed on regular basis to determine the awareness level and prepare the training calendar accordingly. Since the project requires involvement of the ground-level staff, the management should keep the staff motivated through sustained communication and education.

Culture is another major contributor towards ensuring that the improvement is sustained for long time. The management has to instil within the team a sense of ownership and responsibility for the actions they do, to ensure that the information provided is correct in entirety. In order to improve the effectiveness of communication and information across organisation, management need to develop this culture at the field level to enhance reliability of information at source.

The study provided an appreciation of the Six Sigma methodology, roles and responsibilities that helped to carry out the research. The case study approach enabled application of DMAIC methodology in a real-world situation and provided opportunity to correlate the theoretical knowledge gained through the literature review with the practical application in the concerned organisation. The case study also facilitated factual primary data collection for the research and the survey instrument enabled to narrow the scope of root causes to identify the vital few from the trivial many.

The lessons learned from the case study need to be propagated and transferred to different business units across the organisation. An understanding of quality and process thinking at different levels will help to establish continuous process measurement and improvement systems. Considering the lack of data-driven approach towards decision making across the organisation, it is important to train the management at all levels in Six Sigma since a data-driven methodology helps in making effective and better informed decisions. Embracing Six Sigma across the organisation and effective use of Six Sigma tools and techniques for problem solving will develop the organisation into a Six Sigma organisation.

As stated by Antony (2004a), successful implementation of Six Sigma within an organisation depends upon the consideration for critical success factors (CSFs) of Six Sigma. In this regard following CSFs of Six Sigma were identified in the organisation that were instrumental in carrying out the project:

(1) top management commitment and involvement;
(2) leadership;
(3) linking Six Sigma to business strategy;
(4) education and training;
(5) understanding of Six Sigma methodology;
(6) organisational infrastructure; and
(7) awareness of quality tools.

Lack of consideration for these basic CSFs of Six Sigma within organisation would have resulted in failure of the Six Sigma project. With regard to the project undertaken it is also worth mentioning that along with the CSFs, the clarity of aims and objectives prior to starting a Six Sigma project contributes to successful implementation.

Limitations and directions for future research

Jankowics (2005) acknowledges that limitations of any research must be recognised and any data collected should be examined in a critical fashion. Throughout this research following limitations have been realised:

- Paucity of literature on the application of Six Sigma within CIM arena, presenting huge scope for future research.
- Owing to paucity of literature no competitor data could be accessed for research to benchmark against. In future such a research can be conducted across the CIM systems of different companies.
- The research would have benefited from the use of longitudinal study, allowing full deployment of DMAIC methodology through implementation of recommendations.

Conclusion

Six Sigma is a disciplined, data-driven approach that is applicable to all arenas starting from manufacturing to transaction and enhances process efficiency by identifying and eliminating the defects. The paper presents case study from a leading infrastructure support company where Six Sigma methodology was employed to address the concern within the CIM system of the organisation. The structured Six Sigma approach facilitated to identify the root causes of the problem and tools like brainstorming, Pareto analysis, cause and effect analysis, etc. helped to prioritise the issues and find effective solutions to the problems.

In conclusion from the study conducted it is evident that a systematic and conscious effort to influence and control the flow of information will lead to efficient processes and improve the overall effectiveness of CIM system within the organisation. By developing the control centre into a one point contact for all the core businesses of the group focus can be laid on real-time data access in a controlled manner. This will enhance the effectiveness of the group with timely updates on the completion of tasks in real time and highlight concerns, if any at work-sites so that necessary action can be taken to rectify the situation as and when required. This will facilitate generation of timely management reports of the business for the senior management at all times. The financial savings generated from the project as reported by the Six Sigma Project Champion in June 2008 was over £400K. Overall an effective CIM will definitely provide a competitive edge to the group as a whole.

As a next phase of this research, the organisation can conduct an extensive empirical research across different business units to understand the impact of ineffectiveness in the CIM system within each unit and evaluate impact across the organisation. Investigate the mode and effectiveness of suggested CIM improvements and incorporate them in the continuous performance initiative for the organisation.

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Appendix

Data Management and Communications Questionnaire

The purpose of the questionnaire is to study the data management, communication flow and measurement effectiveness of Business Units within the organisation

Name: ______________________ Position & Unit : ______________________

Notes for understanding of the questionnaire

Information being referred is with regard to your business unit
Communication networks refer to modes of communicating back and forth, ie. if system based approach is adopted at one end, the same should be at the other end.

Supplier and customer refer to internal as well as external eg. Information from site is an internal supplier to X and the Senior Management is internal customer to receive the information
Please leave any ambiguous query unfilled

Please read through the following queries and provide your valuable feedback.

		not at all	some extent	moderate extent	larger extent	greater extent
1	The same information is recorded in more than one file / format (Duplication)					
2	The same information is stored in separate systems for different application areas (Form of Hard copies and system Doc.)					
3	Inconsistencies occur because separate copies of data are updated at different times (eg. Delayed information from site)					
4	Data storage requirements could be reduced by eliminating duplicate data in separate applications/ocation					
5	Definition of key data elements (e.g. customer id, call type or shift times etc.) are standardized					
6	All function areas of business unit use the same logical scheme to represent information (inconsistency)					
7	All function areas of the business unit use the same document format standard in sharing information (eg. Types of forms used in particular unit)					
8	Operating personnel can access authorized data through communication networks (eg. Application or web based access at site)					

(*continued*)

9 Operating personnel can exchange their ideas and document through communication networks (eg. Mail system or getting authorization online)

Please describe your preferred method: ____________________

10 Departments can share data and applications on the communication networks (eg. Finance department gets relevant infromation timely)

11 Senior management can access all business specific information from their workstations (eg. Automated KPI's or MIS reports as required)

12 Through communication networks, management can distribute the latest business information within the business unit

13 The business unit and its main customers are linked by communication networks (eg. Contractors, reported authorities, extranet)

14 The business unit and its main suppliers are linked by communication networks (eg. Infor from sites)

15 The business unit and field staff persons are linked by communication networks

16 Corporate headquarters and the business unit are linked by communication networks (Depots and branche offices)

17 Through communication networks, senior management can distribute latest information to the business unit's suppliers (contractors etc.)

18 Corporate data can be seamlessly accessed from remote locations

19 Processes are checked continuously to prevent defects in products/services

20 Processes are controlled to ensure their correctness

21 Emphasis is on eliminating the root causes of processes in the business

22 Processes in the business are designed to be defect-free to eliminate unexpected human errors

23 Processes are evaluated continually for improvement

24 Process improvement standards are raised periodically

25 Redesign in processes are implemented after thorough testing

Note: S. no. 1, 2 & 3 have reverse polarity
S. no. 1 - 7 refer to data management issues
S. no. 8 - 18 refer to communication systems being used
S. no. 19 - 25 refer to measurement issues for processes

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Professor Jiju Antony, Director of the Centre for Research in Six Sigma and Process Improvement (CRISSPE) and Director of Knowledge Exchange within Strathclyde Institute for Operations Management in his ten year research career, has published more than 200 refereed journals and conference papers and six textbooks in the area of reliability engineering, design of experiments, Taguchi methods, Six Sigma, total quality management and statistical process control. He successfully launched the first *International Journal of Lean Six Sigma* in April 2010. Professor Antony has been invited several times as a keynote speaker to national conferences on Six Sigma in China, South Africa, The Netherlands, India, Greece, New Zealand, South Africa and Poland. He has also chaired the First, Second and Third International Conferences on Six Sigma and First and Second International Workshops on Design for Six Sigma. The recent work of Professor Antony includes collaborations with organisations such as Thales Optronics Ltd, Scottish Power, Rolls-Royce, Tata Motors, Bosch, Nokia, GE Domestic Appliances, Scottish Widows, 3M, Land Rover, GE Power Systems, NHS Ayr and Aaran, Kwit Fit Financial Services, Clydesdale Bank, etc. in the development of Six Sigma, Lean and Continuous Improvement programmes within these organisations. He is on the Editorial Board of over eight international journals and a regular reviewer of five leading international journals in quality, operations and production management. He has been recently elected to the International Academy of Quality, the first in Scotland and third in the UK to be elected to the Academy. He is a fellow of the Chartered Quality Institute, UK, a fellow of the Institute of Operations Management, UK, a fellow of the Royal Statistical Society and a Certified Lean Six Sigma Black Belt. Jiju Antony is the corresponding author and can be contacted at: jiju.antony@strath.ac.uk

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