USE OF TOTAL QUALITY MANAGEMENT TOOLS TO IMPROVE RADIOMETRIC QUALITY OF OPTICAL REMOTE SENSING DATA PRODUCT

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ABSTRACT

The Total Quality Management (TQM) has been instrumental in development of organization through customer satisfaction. It is an organization-wide effort led by the top management to achieve continuous improvement through understanding the customer requirement.

The implementation of TQM principles commenced with manufacturing sector. Studies have shown that TQM can be successfully applied in service sector also. The gamut of applicability of TQM has also crossed the private sector and has been found to be effective in public sector.

However, the pertinence of management to the research field has been seen as counterproductive. Limited studies have demonstrated that TQM can complement the field of research and can make it more effective.

The vast geographical extent of a region and management of its natural resources for its optimized use for the benefit of population requires breakthrough technology like satellite based remote sensing. India’s remote sensing program has reached a maturity stage where the use of Remote Sensing Data Product (RSDP) by policy makers and decision makers can bring efficiency, transparency and fact-based decision-making. The 2011 report from CAG on underutilization of RSDP in India on one hand and increase in global players in the field of remote sensing on the other motivated this research to see the effectiveness of TQM tools in the field of remote sensing. The present research attempts to answer the following three questions:

1) Are TQM tools used in decision-making process regarding improvement of product quality?
2) What level of quantifiable improvement is achieved through use of these tools?
3) Can a TQM implementation model be developed for achieving continuous improvement?

The studies in management of space research has been largely limited to hardware, related to launch vehicles and sensors. The use of quality management system in improving the digital products generated through the data acquired by sensors is an unexplored domain. Hence, this study of investigating the use of TQM principles to improve the radiometric quality of remote sensing data product uses exploratory research. The remote sensing field is commanded by federal agency, a public sector organization, in India. The expertise in this field is concentrated in this organization and hence the two methods used in this study were: a) Case study method and b) Experience survey.
The four tools under Case Study were chosen, keeping in view the vital activities in remote sensing viz. understanding Application, software development, calibration of sensor and interoperability of sensor from various agencies. The House of Quality was developed to understand the translation of voice of customer to voice of engineer. The requirement of application scientists was translated to sensor design using quality function deployment function.

The digital nature of product and the enormous data required to be processed by data product generation team renders it impossible to carry out manual computation and makes it necessary to use computer software. The user also requires using third party software for analysis of this data and generating meaningful interpretation. The mistake proof design of software ensures smooth and flawless operation of software. The pokayoke design of software for vicarious calibration of optical sensor was second case study, which demonstrated that the mistake proofing of software can prevent inadvertent errors which can result in faulty calibration and poor radiometric quality.

The calibration of sensor is a very important activity for assured quality of data product throughout the life of remote sensing mission. The post-launch calibration activity requires information related to ground reflectance, atmospheric condition and modelling using standard radiative transfer algorithms. Design of experiment, the third TQM tool in the case study method, was used to identify and correct an anomalous ground measurement campaign. The step-wise identification of cause and effect through design of experiment salvaged the huge effort and resources without compromising on the calibration of sensor and in turn the radiometric quality of RSDP.

The operation and maintenance of remote sensing system is a very resource intensive activity by any country. The countries involved in launch and operation of remote sensing sensors work in collaborative manner to ensure availability of variety of datasets in more frequent manner. The use of multi-sensor data by the user requires that the data from different sources are inter-operable. The scatter diagram, the fourth tool used in the case study, helps in mapping the data from one sensor to the data of another contemporary sensor acquired under certain specific conditions. This simple tool helps the user either to use the data from similar sensors interchangeably or improve the radiometric quality of poorer sensor in reference to data from standard, calibrated sensor.

These four tools showed that TQM tools could improve the radiometric quality of RSDP and help the application scientists to derive meaningful outcome more efficiently.

The remote sensing field primarily has four components based on their role. The first and foremost being the Application scientists who are the end user of the data product generated. The design of sensor is based on the need of application scientists and forms the second component. Once the sensor is launched, the sensor records the solar reflected rays through opto-electronic components and transmits the same on ground. These are stored in computer. The Data Product generation system, a software system, corrects this data for various anomalies viz. Radiometric and Geometric, arising out of intervening atmosphere, earth rotation, sensor viewing angle etc and converts it into user-friendly Remote Sensing Data Product (RSDP). The output of this third segment goes to Quality Evaluation System before reaching the application scientist.

Keeping in view the four components of remote sensing field as listed above and in addition, as all the four components originate from center in Ahmedabad, the experience survey targeted the experienced experts from all four components stationed in this center.
Prior to conducting experience survey, literature study was carried out to identify Critical Success Factors (CSF) of TQM implementation. The literature suggested that two types of study have been undertaken to characterize the CSFs of TQM in any organization. One category of research was based on using independent investigation of various organizations, which were following the TQM principles, to know the critical factors of TQM. The other set of studies was based on literature review and using Pareto analysis of all the reviewed literature to identify top CSFs. Eight CSFs, which were found in most of the literature, were chosen for carrying out experience survey. The questionnaire for the survey was designed to include and represent all the eight CSFs. The questions were phrased to epitomize the field of remote sensing.

The survey aimed to obtain the feedback of experienced respondent on the importance of various CSFs in improving the radiometric quality of RSDP. On the other hand, it intended to know if the CSFs are indeed being used in the field of remote sensing. These feedbacks are expected to fulfil the objective of this research and answer research question numbers 1 and 3.

The questionnaire was split into two parts. The first part consisted of filling the demographic information viz. Gender, Education, Experience, Component of RS field represented by respondent and Managerial status. The entering of name of the respondent was kept optional to give credibility of anonymity. One open question was also included in the first section of questionnaire, which allowed the respondent write his/her understanding about TQM.

The second part of the questionnaire was devised to capture the response about two aspects of the question. The first was about the Importance of the parameter in question in improving the Radiometric quality of RSDP on the scale of 1 to 7 with 1 being Most Important. The second, if the respondent believed that the aspect addressed in the question is indeed used in the field of Remote Sensing: the response was a five-point Likert scale viz. Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree.

The questions were sequenced randomly in order to intermingle the CSFs represented by them and not form any group. Also the number of questions corresponding to each CSF were arbitrary. In other words, the number of questions for any CSF did not necessarily reflect its importance in TQM.

Questionnaires were sent out on email to forty respondents equally representing the four sections of remote sensing component with atleast ten years of experience. However, to ensure the confidentiality, the respondents were also allowed to send the response in printed hard copy form.

The data analysis of the survey was carried out without using much of complex statistical calculations and using Excel in an intuitive manner. The data was analyzed to identify the trends and patterns with respect to the following:

- probe for any consistency in terms of CSFs across the four entities
- verify existence of any correlation between importance of CSF and agreement on its implementation in each element of remote sensing
- study the TQM CSFs in the field of remote sensing in integrated manner
- see if the above analysis manifests any TQM implementation model

A large average number in Importance scale of a CSF indicated lower importance of particular CSF in the activity. This means that the rating was inversely proportional to the
importance ranking. On the other hand, a larger number on Agreement scale implied greater agreement on the implementation of particular CSF. A detailed analysis on these two scales for all four constituent sections and an overall integrated activity was carried out.

The outcome of the data was intriguing. Following are the highlights of the findings from the data analyzed:

- The verdict on Important CSF was split between Benchmarking and Employee empowerment
- Supplier Quality management was considered the least importance in near-unanimous manner
- There was a strong correlation between importance of CSF and agreement of its being used in the field of remote sensing. This means that all constituents agreed that whatever is important is being applied.
- However, there seems to be a dis-agreement on the importance of particular CSF among four entities. Each constituent had its own important CSF. The Customer focus was in top three only for Quality and Application users and not for the Sensor or Product generation entity. Three of the four sections felt that Employee Involvement was important- in top position for Product Generation and Quality department.
- The role of Top Management did not appear in top three positions in any of the sections of remote sensing activity.

The observations indicate that although there is a correlation between importance of CSF and its implementation, there seems to be discord among various blocks of remote sensing activity about which factor is critical for the successful implementation of TQM.

The conclusions from case-study and experience survey as translated to answers of research question are as follows:

1) Are TQM tools used in decision-making process regarding improvement of product quality?
   Yes. The CSFs, which are felt important for a particular section in remote sensing, are undeniably being implemented

2) What level of quantifiable improvement is achieved through use of these tools?
   The case-study of four tools, especially the Design of Experiment and scatter diagram, indicate doubling of radiometric accuracy. Although a more comprehensive study to quantify the effectiveness can be undertaken, use of TQM tool show positive results in terms of reducing the inaccuracy to half.

3) Can a TQM implementation model be developed for achieving continuous improvement?
   The diversity in identification of important CSFs in various factions of remote sensing activity does point to the need to develop an organization-wide focused TQM model; it is also evident from this groundbreaking study that unlike in other sectors, the role of Top Management complements the Employee Involvement in the field of research.

This exploratory research has opened many possibilities of study related to critical success factors, especially with reference to the role of top leadership in research-driven activity.