IMPROVING STORES MANAGEMENT SYSTEM USING SIX-SIGMA METHODOLOGY

D.Balaji**,** M.Tech,
Quality Engineering and Management,
Dept.of Mechanical Engineering,
JNTUA College of Engineering, Anantapuramu,
AP, India.

Dr.R. Ganapathi, Professor,
Dept. of Mechanical Engineering,
Anurag Engineering College, Kodada,
Telangana, India.

Dr .R. Srinivas, Scientist/Engr –SF, SR &QAG,
National Remote Sensing center,
ISRO Dept. of Space, Govt. of India.
Hyderabad, Telangana, India.

Dr. B.Omprakash**,** Assistant Professor,
Dept. of Mechanical Engineering,
JNTUA College of Engineering, Anantapuramu,
AP, India.

Abstract: This paper depicts a project undertaken in the offices at ISRO, Hyderabad. The aim of the project is to simplify, improve, add value to Stores and Inventory management process (receipt cell, collection cell, inventory, accounting, and disposal). To achieve this Six Sigma methodology is proposed for implementation. This project involves the usage and application of the DMAIC (Define phase, measure phase, Analyze phase, Improve phase, control phase) methodology in a stores process and assesses its applicability. Through the elimination of problems identified and resolving issues using Six Sigma methodology, the processing time of stores and inventory is improvement.

Applying the six sigma concept in stores and inventory process we can improve the physical verification and detailed information of the materials, scrap consignments and surplus consignments and binning system. By using six-sigma DMAIC methodology the identification of the stores and inventory management problems can be measured and accordingly problem solution can be given. The root cause analysis can be done and solutions can be provided to improve and control.

Index Terms **– Six-Sigma, DMAIC, Stores and Inventory Process.**

I. INTRODUCTION

This project looks by a successful application of the Six Sigma improvement methodology within the stores department of NRSC, a part of ISRO, Hyderabad. NRSC has numbers of departments such as stores management, transport management, security management system, canteen management, civil department etc. In this project, stores management system has chosen for improvement, it provides the collection of materials, material storage, issue of material, disposal of materials. All types of materials are stored in the storage department. There are some defects in this system. By using the six-sigma methodology these defects or errors (requisition, storage, issues of materials, return of the materials, disposal of materials, inventory system, automation of the system, binning system) can be reduced. The main aim of this project is to get better the process efficiency, to decrease lead time of the process and also to improve the quality of the stores department.

SIX-SIGMA

Six-sigma looks to reduce waste and it defines a defect as anything that does not meet the customer's expectations. A Six Sigma company will produce no more than 3.4 defects for every million opportunities. Six-Sigma was introduced in the 1980's by an engineer for Motorola named Bill Smith.

ISRO-NRSC

Indian Space Research Organization (ISRO) formed in 1969. National Remote Sensing Agency (NRSA) was established as a registered society on 2nd September 1974. National Remote Sensing Centre (NRSC) at Hyderabad is answerable for remote sensing satellite data achievement and processing, data dissemination, aerial remote sensing and decision support for disaster organization.

II. CASE STUDY

A preliminary and survey analysis of the organization using a strategic procedure revealed some areas mostly in the stores management system. . In the stores department up to 800 goods or consignments materials are being received and they are issued to indentors or users per year. In the stores section there is a need for development in some areas. The present process requires extra time and also there is an increase in consignment cost.

III. APPLICATION OF SIX-SIGMA METHODOLOGY

This study implements a through DMAIC strategy to properly define the problem and uncover the areas in need improvement at some areas and the extent of the remedial actions. The DMAIC is a powerful six-sigma tools such as voice of

customer, project charter, histograms, house of quality and, process map provides analysis of the present situation and a place of remedial solutions that helped in generate significant price savings.

A.DEFINE PHASE

The aim of this chapter is to visibly understand and articulate the existing reality and the desired condition.

a. DEFINING THE PROBLEM

The main goals are obtained from direct communication through the management, shareholders, and employees. while mentioned earlier, it transpired from these communications with the workers and the organization that the major target of this project was to get better the material handling system (Binning System) and the custom clearance system plus the inventory management, disposal system in order to improve the overall process level and gain some major price savings. Few tools are being used to discover the problems in this stage. The summarized result from the employee feedback is shown below.

Fig 1. Employee Feedback

b. HOUSE OF QUALITY

It translates customer requirements, based on marketing research and benchmarking data, into an appropriate number of engineering targets to be met by a new process plan or new product design or new services plan. The below table shows what the customer requires and quality characteristics i.e. CTQ (critical to quality).

Table 1. Customer wants vs. Quality characteristics

Customer wants	Quality characteristics
• Cleaning of godown • required safety precautions • Increase man power • Required binning system • Required consignment transport equipment's	• Cleaning schedule and cleaning equipment's • Advance safety equipment's • Recruitment new men power • Process automation • Construct new storage buildings • Regular inspection

Theweight of quality appearances and their relative weight are calculated using the equation 1 and equation 2.

Weight of quality characteristic $=\sum_0^n$ relative weight of demand X relationship value   Eq.1

Relative weight of quality characteristic $=\dfrac{\text{weight of quality characterstic m1}}{\text{total weight of all characterstics}}$ Eq.2

Information availability got the highest relative weight as 8.6 followed by safety with relative 9.8. Therefore we decided to tackle with the information availability issue and then followed by other characteristics as per the relative weight from HOQ matrix as shown in below figure.

Fig.2 House of quality

B. MEASURE PHASE

The reason of the "Measure" phase in DMAIC is to collect data that describes the nature and scope of the problem. First, gathering of quantitative data and in the areas of inventory, custom clearance, stores, and disposal sections accuracy information, materials handling systems, and issues of materials, binning system, maintenance of godown, stock return, scrap consignments, surplus consignments. A few days' time and motion study was conducted in order to survey some sections and their daily activities. Results from the some days' time study showed that some sections were only being effectively.

a. PROJECT CHARTER

It provides a preliminary description of roles and responsibilities, outlines the project objectives, identifies the main stakeholders, and defines the authority of the project manager. It serves as a reference of authority for the future of the project

Table 2. Project charter

IMPROVEMENT OF STORES MANAGEMENT SYSTEM	
Problem Statement	**Business Case & Benefits**
From the stores department the following problems has been identified some of them inventory, disposal, safety measures, cleanliness. From the data gathered it is stated that only 85% performance is maintained. It is due to poor cleanliness, no proper Binnig system and no proper consignment storage. From the survey current performance is bad. If the same being continued there is a possibility of lose in profits.	The improvement in performance rate in stores division can be achieved by the development in process cycle time. The cleanliness in the section will get better the life period of the product, as the cleanliness of the department increase the Binning system has better performance. So that the required replenish products to the other departments can be easily transferred. In future the consignments would store at the free space so that the products are not damaged. This will increase the firm profits and reduces the wastage.
Goal Statement	**Timeline**
To increase the performance of the disposal and inventory section. And to reduce the process time of disposal consignment. To get better the quality of safety measures and to decrease the wastages. To improve the performance of the process from 85% to 93%	<table><tr><th>PHASE</th><th>PLANNED COMPLTION TIME</th><th>ACTUAL DATE</th></tr><tr><td>DEFINE</td><td>25-11-2017</td><td>28-11-2017</td></tr><tr><td>MEASURE</td><td>10-12-2017</td><td>15-12-2017</td></tr><tr><td>ANALYZE</td><td>25-12-2017</td><td>30-12-2017</td></tr><tr><td>IMPROVE</td><td>15-01-2018</td><td>18-01-2018</td></tr><tr><td>CONTROL</td><td>29-01-2018</td><td>15-02-2018</td></tr></table>
Scope - First/Last And In/Out	**Team Members**
In scope: Godown cleanliness, Process Steps, Time. **Out of Scope:** Automation, Proper Schedule.	<table><tr><th>POSITION</th><th>PERSON</th><th>TITLE</th></tr><tr><td>Head P&S</td><td>Raghuram.K</td><td>Project Sponsor</td></tr><tr><td>Senior PSO</td><td>Ramachandraiah. S</td><td>Process Owner</td></tr><tr><td>GH, SR&QAG</td><td>Dr. Saindranath jonna</td><td>Project Manager</td></tr><tr><td>Scientist-SF</td><td>Dr. Srinivas. R</td><td>Champion</td></tr><tr><td>Asst.Proff.</td><td>Dr. Om Prakash. B</td><td>Black belt</td></tr><tr><td>Student</td><td>Balaji.D</td><td>Team Leader</td></tr></table>

b. Process map

Process mapping is the detailed display of steps, actions and operations that constitute a process. It's a clear design which identifies the steps, inputs and outputs, and other related details of a process by providing a step-by-step picture of the process.
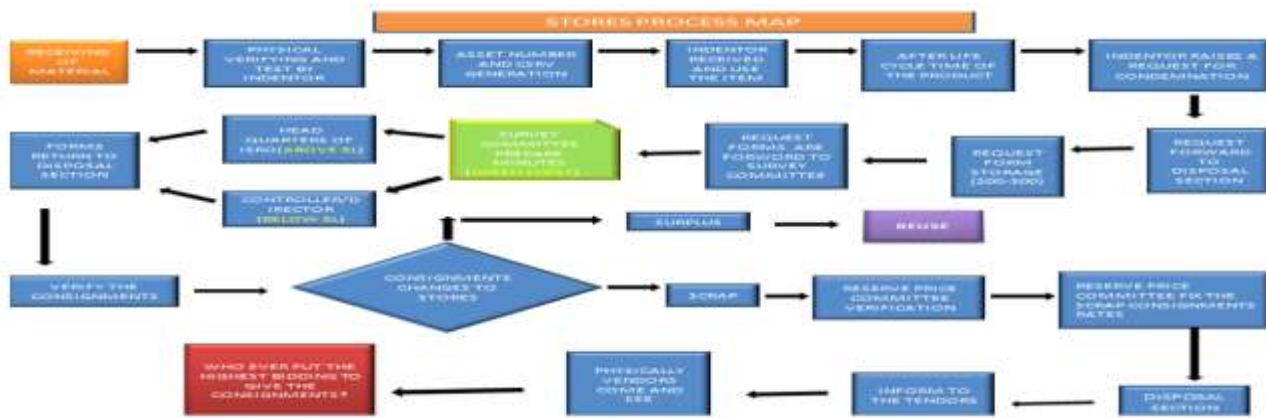

Fig. 3 Stores Process map

Process map visually shows the steps of work activity and the people who are involved in carrying out each step. The following process map shows the current NRSC Stores deportment overall process. This is step-by-step process of stores from receiving of the consignments or materials or goods to the process of selling the scrap consignments / materials / goods to vendors.

c.Value Stream Map

The figure below shows the stores value stream map. It is used to calculate the process time between the successive steps of the stores process.
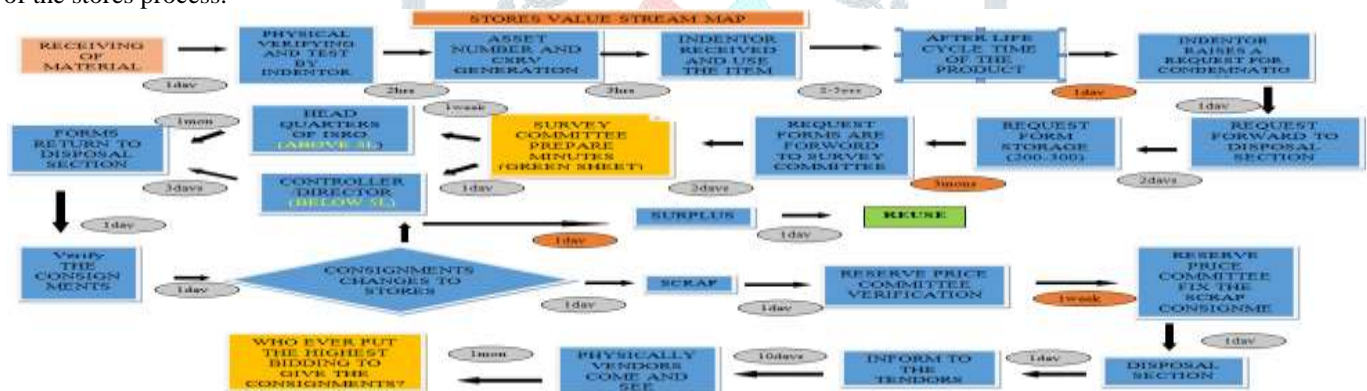

Fig 4: Value stream map

From this reviews the flow of process steps and the information from origin step to delivering it to the customers step can be known. In this process first we calculate the time of the each process. So by using the value stream mapping process cycle time can be reduced and also to improve the process efficiency.

d. SIGMA LEVEL CALCULATION

Six-Sigma is a statistical term used to measure the number of defects that are occurred during the process. In the stores department up to 800 goods or consignments materials are being received and they are issued to indentors or users per year (about 30-50 approximately every day), there were two different ways for each consignments to be processed incorrectly. Typically, most products or services have more than one opportunity of going wrong.

The data which is being collected from the previous phases is used for obtaining the following values.

DEFECTS PER UNIT (DPU)
DPU= (no of defects observed ÷ no of units inspected)
DEFECTS PER OPPORTUNITY (DPO)
DPO = (no of defects observed on a unit ÷ no of opportunities on a unit)
     = D / (O*U)
D = total no of defects
D = 40
O = Opportunity for defects per unit

O = 700
U= Total no of units
U = 10
DPO   = 40 / (700*10)
         = .00571428542857
DPMO = 1000000*.00571428542857
         = 5714.285714285714
Defects (%)   = 5.71
Yield (%)   = 94.29 (approximately)
Process sigma = 3.08
Present six-sigma level value for the stores department is (5714.285714285714) which is calculated per one million opportunities. So it belongs to 3.08 process sigma.

C. ANALYZE PHASE

The target of the "Analyze" phase in DMAIC is to interpret the data or information in order to establish the cause-and-effect relationships that produce the flaws in the system.

Table 3. Problems in stores department and their possible solutions.

Problem Area	Problem	Cause	Possible Solutions For Improvement
Inventory	➢ Binning issue ➢ Safety precautions ➢ Line balancing ➢ Delivery time ➢ Scrap ➢ Request (space) form/template not sufficient. ➢ More no of requests through offline forms.	➢ Binning system adequate ➢ Misplaced inventory items ➢ Inefficient safety measures ➢ Lot of bugs in software. ➢ Employees were unaware of online requests	➢ Arrange mobile racking system ➢ Install fire safety equipment's ➢ Using UHF RFID readers for inventory management ➢ Request form modification. ➢ Online mode of request should be made mandate.
Disposal	➢ Cleaning ➢ Stocking ➢ No proper Disposal ➢ More no of requests through offline forms.	➢ Godown is unclean ➢ Inadequate material handling system ➢ Lack of man power ➢ No proper ventilation ➢ Employees unaware of online requests ➢ Software bugs.	➢ Regular cleaning should be done and maintaining of proper cleaning schedule. ➢ Recruitment of new employee. ➢ Should maintain proper ventilation.
Collection cell	➢ Custom clearance issues ➢ Payment issues	➢ Delay in clearance documents ➢ Lot of bugs in software. ➢ No proper submission of necessary documents	➢ Required quick and proper clearance documents. ➢ Improved approval of required documents ➢ Required the online billing system and instructions to be passed on for proper submission of all the documents
Receipt cell	➢ Human error in details entry. ➢ Format no. is missing.	➢ More manual data entry ➢ No proper filling of the documents	➢ Online application form should be made mandatory ➢ Improve the system optimization

This phase is meant to identify the root causes of the problems and the possible solutions for improvement process. A through data analyses is carried out to find out the many reasons of a problem. In the table a brief discussion is made on what are the problems that are encountered in stores department, causes of the problem and the possible solutions.

D. IMPROVE PHASE

Based on the identified root causes in the prior step, directly address the causes with an improvement. Brainstorm potential solutions, prioritize them based on customer requirements, make a selection, and test to see if the solution resolves the problem. The goal of improve phase to work on improvement solutions based on define, measure and analyze phase outputs. Improve phase compare before and after process status to develop and implement the process improvements. Once the problem causes are determined in the Analyze phase, the team finds, evaluates through testing, and selects new improvement solutions.

Fig.5web portal of stores management system

From the gathered information we decided to develop stores management system by automating all the process with the help of a new web portal.

IMPLEMENTATION

In the previous stages to define the problems, measure the problem and analyze the measured problems. The solutions for the identified problems are implemented in this stage. In this phase a valuable feedback or surveys or voice of customer were taken to create the new online request forms and new web portals for the stores management system. There is a slight improvement in all the processes by compare the previous data and newly implemented solution data.

SIX SIGMA CALCULATIONS AFTER IMPLEMENTING RECOMMENDED SOLUTIONS

DEFECTS PER UNIT (DPU)

DPU= (no of defects observed ÷no of units inspected)

DEFECTS PER OPPORTUNITY (DPO)

DPO = (no of defects observed on a unit ÷ no of opportunities on a unit)

$\qquad$ = D / (O*U)

D = total no of defects

D = 10

O = Opportunity for defects per unit

O = 700

U= Total no of units

U = 10

DPO $\quad$ = 10 / (700*10)

$\qquad$ = 0.0014285714285714

DPMO = 1000000*.0014285714285714

$\qquad$ = 142.8571428571429

Defects (%) $\quad$ = 1.428

Yield (%) $\quad$ = 98.57 (approximately)

Process sigma = 3.69

This calculation is made by analysing the feedback given by the employees after implementing the recommended measures. This value (142.8571428571429) is obtained after implementation of the six sigma methodology in stores management system six-sigma level which comes under defects per one million opportunities.

After implementations of the process there is a very good improvement in the process performance level and sigma level increased by 0.61.

Fig. 6 Employee feedback before and after implementing six-sigma

E. CONTROL PHASE

The purpose of the last phase "Control" of a full DMAIC procedure is to make sure that the gains made throughout the other phases of the procedure are preserved (sustained), until and unless new knowledge and data show that there is an even better way to operate the process. For this study, in order to make sure that the improvements/gains can be sustained, the following actions were recommended and must be taken: Random cycle counts and location audits shall be conducted often to make sure that the physical count and location are in accordance with the records.

Table 4. Implemented solutions

Provide regular status report on the overall stores	The value of regular status reports is absorbed. Few sudden inspections were conduct. Regularly communicating with the employees (about the information of stores). The communicating the information that will be most helpful to them , the true status of the project, including accomplishment, issues, risks, scope changes, and so on. The status reports should convey information that is useful in the decision-making process.
Issues and risks	Maintain a complete tracking log for all issues and risks, including the all types of problems in the stores department.
Change plan	If there are any changes in stores department we plan and develop the solutions, which established the process to be used to manage and control. Change requests must be formally submitted in writing and include estimates of effort, time and cost required to implement the change.
Perform quality	Monitor, control and performance goals to ensure that the required results established in the performance plan are delivered.

IV. CONCLUSION:

The help of six-sigma, the efficiency and level of performance is improved in stores management system. In order to improve the process, enhance process capability and increase product quality six-sigma is implemented. By implementation of six sigma it is succeeded in identifying the critical factors that affected the process by series of analysis. In order to improve the quality in stores management system DMAIC has been used. This methodology was followed for improvement in one of the offices of ISRO Hyd. The analytical study has been undertaken for identifying and rectifying the drawbacks in stores inventory, stores disposal and custom clearance.

Based on the data collected from stores, it is calculated sigma level by analysing the feedback from employees and have found very good improvement in process performance level and sigma level increased by 0.61 i.e. 3.08 to 3.69 which means process success rate (yield %) increased from **94.29%** to **98.57%.** In the analysis phase the root cause for problems are identified and possible solutions for improvement are given. It is found that due to lack of automation and use of manual methods for data logging has reduced the efficiency. Hence it is ensured that the process needs to be automated and alert generations are required for better performance. Hence the process time reduced drastically and the time saving is possible.

V.ACKNOWLEDGEMENT

REFERENCES:

1. George, M. (2002-3). Lean Six Sigma: Combining Six Sigma Quality with Lean Speed, McGraw-Hill.
2. Coleman, S. (2008). Six Sigma: an opportunity for statistics and for statisticians.Significance, Vol. 5, Issue 2, pp. 94-96.
3. Tshibangu, W. M. Anselm and Berlinski, Stephen (2012).Productivity Improvement through Facility Layout Redesign: A Lean Six-Sigma Case Study.]
4. Pande, P.S., Neuman, R.P. & Cavanagh, R.R. (2000). The Six Sigma Way: How GE, Motorola and Other Top Companies are Honing Their Performance. New York (NY – USA): McGraw-Hill.
5. Alexandra Tenera, Luis Carneiro Pinto, A Lean Six Sigma (LSS) project management improvement model, Procedia - Social and Behavioral Sciences 119 912 – 920 2014.
6. Cherrafi A, Elfezazi S, Chiarini A, Mokhlis A, Benhida K, The integration of lean manufacturing, Six Sigma and sustainability: A literature, Journal of Cleaner Production 2016.
7. Manzouri, M.; Ab-Rahman, M.N.; Zain, C.R.C.M.; Jamsari, E.A. Increasing Production and Eliminating Waste through Lean Tools and Techniques for Halal Food Companies. Sustainability,6, 9179-9204, 2014.
8. Ross Raifsmider& Dave Kurt (2004). Lean Six Sigma in higher Education, Xerox Corporation Sean P. Goffnett (2004). "Understanding Six Sigma: Implication for Industry and Education", Journal of Industrial Technology, Vol. 20, No. 4, Sep-Dec 2004.
9. ArashSahin (2008). Design for Six Sigma (DFSS): lessons learned from world-class companies", International Journal of Six Sigma and Competitive Advantage, Vol.4,No.1, 2008 iSix-Sigma- as six-Sigma-magazine.
10. George, M. (2002-3). Lean Six Sigma: Combining Six Sigma Quality with Lean Speed, McGraw-Hill. Heizer, J. and Render, B. (2013). Principles of Operations Management, 9th Edition, Prentice Hall.