

Design and Implementation of Lean Concepts in the HVAC Construction Industry

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Abstract — Construction Projects are always unique, and risks rise from several different sources. These situations bring new opportunities to improve critical areas in a project. As a Project Management approach, certain phases require documentation processes for the client, in which if the documents are filled wrong it will take more time to resubmit and this will cause more delay in the process. LEAN principles were applied to improve the submit process. A need of document standardization was identified to improve the submittal process, the Fillable PDF's tool was used to create the documents in an easy fill up PDF, also a series of Standard Operation Sheets were created for an easier comprehension of how to fill up the documents. After the standardization process, and the creation of the Standard Operation Sheets, the process was improved by 20% compared with the actual process.

Key Terms — Heating Ventilating and Air Conditioning (HVAC), Lean Principles, Project Management, Regulation Classification, Standardization, Time Reduction.

PROBLEM STATEMENT

As a construction company, Multi Air Services Engineers, Corp., has been providing construction services in the Heating, Ventilation and Air Conditioning (HVAC) Industry for about 35 years. With the acceleration in technology and new day to day challenges it is necessary a new structure to improve our system of communication with our stakeholders. This is to maintain the competitiveness in the market of a fast and reliable service system of management and communication.

Research Description

This study works with the Management of Construction Projects specified in the HVAC

installation in Federal Buildings. The Federal Construction System has a complicated structure of management in their construction projects. This structure includes Quality Inspectors, Construction Managers and Project Managers. The importance of this study is to improve the documents preparation phase in order to reduce the time frame between the delivery of the document and the return of the answer.

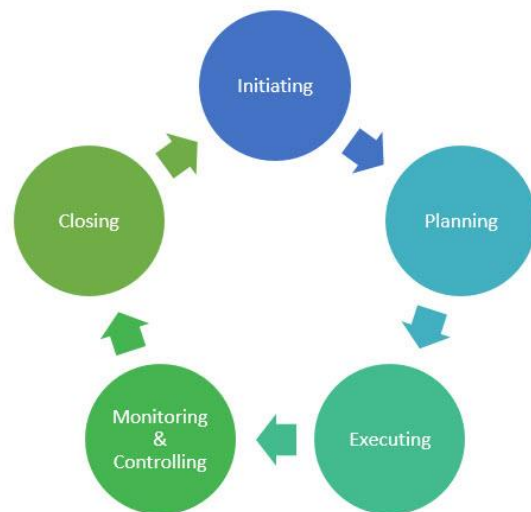


Figure 1
Project Management Methodology Steps

Research Objectives

To improve the efficiency in the Project Management using LEAN Methodologies to reduce time and cost in the Construction Projects. Decrease the cost in a 5% for the Control Stage in the Construction Projects.

Research Contributions

With these new improvements to the company, the time and cost of the projects will decrease, and the new Engineers will have a solid base to understand the new challenges of the HVAC Projects. In addition, the quality of the project will

be improved by the constant monitoring of the Project Progress, as well as the efficiency of the work performed in the field.

LITERATURE REVIEW

In every aspect of life, it will be necessary to manage projects as part of our jobs, and others, as daily life situations. As defined in A Guide to the Project Management Body of Knowledge (PMI, PMBOK® Guide, 2000), *a project is a temporary endeavor undertaken to create a unique product or service. This concept of temporary means that every project has a definite beginning and a definite end (Specific Time of Completion)* [1]. Unique means that the product or service is different in some distinguishing way from all other projects or services. Typically, most of the projects share most if not all the five characteristics below:

- 1) A start and a finish
- 2) A time frame of completion
- 3) An involvement of several people on an ad-hoc basis
- 4) A limited set of resources
- 5) A sequencing of activities and phases

Project Management is a specialized branch of management which has evolved in order to coordinate and control some of the complex activities of modern industry. The changing business environment of the twenty first century increases the range of activities coming under the periphery of project management techniques and the way projects are managed. Projects are open systems because they exist in an open environment and must respond to ever changing dynamics of situations requiring it to become much more adaptive than ever.

A good project management deals with three factors: time, cost and performance. Projects are successful if they are completed on time, within budget and comply with the performance requirements. They involve a toolkit of techniques, methodologies, and tools. These techniques provide the tools for managing different components involved in a project: planning and scheduling,

developing a product, managing financial and capital resources, and monitoring process.

Because of the “Recession” the Construction Industry suffered small changes in the Project Management including new techniques or methods, and this brings the new challenges in the modern world.



Figure 2
Project Management Triangle

Construction Projects are always unique, and risks rise from several different sources. Also, the Construction Projects are essentially complex and dynamic, that involves multiple feedback processes. This includes a lot of participants (individuals and organizations) with different expectations and interests. This can create problems and confusion in the communication and control of the Project.

To understand some concepts, it is necessary to explain some important definitions about Air Conditioning. A Heating, Ventilating, and Air Conditioning System is a mechanical system that provides thermal comfort and air quality in indoor spaces. Types of HVAC systems include air conditioners, heat pumps, furnaces, boilers, rooftop units, chillers, and packaged systems. With this definition established, what makes an HVAC Project unique is that the personnel comfort and air quality of the building needs to be maintained in the space while the project is running. Many of the HVAC Projects these days are performed in buildings that are occupied with personnel, this makes the work more difficult and precise. The purpose is to not

interrupt the regular duties of the employees in the space and to finish the project as fast as possible, without compromising the quality of the work performed, as established in the American Society of Heating, Refrigerating and Air – Conditioning Engineers (ASHRAE). This society is in charge of the regulations for the test, design and practices in the installation and performance of HVAC Systems.

Because of the modern technology and new methodologies in the construction of HVAC System, a new method was needed to be implemented. In this case, the LEAN Methodology come across to reduce time and “waste” in the production lines. LEAN is a methodology established as the Toyota Production System (TPS) by Taiichi Ohno in 1949 and later identified as LEAN by James Womack in the 1990s. Lean is a comprehensive set of techniques that allows reducing and eliminating wastes. This system not only will make a company leaner, but consequently more flexible and more responsive by reducing waste, taking time out of processes, and creating better flow [2]. This concept brings different tools to improve the efficiency and reduce time. In the following paragraph these tools will be explained.

One of the most used tools in the 5S, are the following:

1. Sort (eliminate that which is not needed)
2. Set In Order (organize remaining items)
3. Shine (clean and inspect work area)
4. Standardize (write standards for above)
5. Sustain (regularly apply the standards)

Other tools are Value Stream Mapping, Poka-Yoke, Root Cause Analysis and others that work on different topics inside the LEAN methodology. These valuable tools are very important in the development of a project, because they help improve the efficiency of the workforce and reduce the time in and between the steps of a project.

METHODOLOGY

In this specific research, the 5S Methodology will be used to improve the project. A series of steps will be followed to comply with the goal of this

project. This 5S Methodology is divided in a series of different tools that work in different aspects of the project. First, a Standardized Work Tool will be implemented in the templates of the Transmittals, Request for Information (RFI's) and Incident Report Sheet. With this tool, a downtime study will be performed before and after of the implementation. This tool will present the opportunities in the process of documentation for improvement.

Also, a Standard Operation Sheet Tool will be implemented in the development of documents, to prevent typing errors in the future. The documents will be saved as “Fillable PDF's” to prevent typing errors in the creation of the documents.

A share folder will be created, to maintain all the templates, trainings and examples in one place, for the easy access for the Engineers. In this chapter, a Research Schedule will be presented with the plan proposed and the estimated due dates and time required to complete each activity.

RESULTS AND DISCUSSIONS

During the initial phase for the standardization of the templates that can be improved by this tool, the Transmittal Template, RFI's Template, Accident Report Template were standardized to Fillable PDF's documents. An evaluation process for each document was performed, the documents take from 2:00 mins to 3:00 mins to be filled up, the Project Section Manager was involved in the documents evaluation. The process was the following, the documents were transformed into Fillable PDF's and revised by the Project Section Manager and the Company President, any comments or issues were delivered for revision. When the documents were revised and accepted, the final product is released. This process was performed to have a Standard format in the all the documents that are submitted to the clients. Also, these new documents are easier to fill and to save as well. With this new format, the time of the filling process was reduced in 20%. The documents that were modified were the RFI's, the Transmittal Forms and the Accidental Report. Also, a Share Folder was created to have all the documents

available to the Engineers, with the Standard Operation Sheets as instructions. In the following pages the modified documents are presented. For Example in the Figure 3 below is the "Request for Information" document.

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REQUEST FOR INFORMATION

PROJECT NAME: _____ RFI No.: _____
 PROJECT No.: _____ DATE: _____
 CONTRACTOR: _____ SUBMITTED BY: _____
 Project Manager's Name: _____ Email replies to: _____

AREA / ITEM OF CONCERN:

REASON FOR REQUEST:
 INSUFFICIENT DATA
 DRAWING / SPEC. CONFLICT
 ALTERNATE PROPOSAL
 OTHER: _____

ACTION REQUESTED:
 CLARIFICATION
 DIRECTION
 APPROVAL

REFERENCE: _____ DRAWING No.: _____ REPLY DUE: _____
 TASK: _____ REV No.: _____
 PARAGRAPH No.: _____ SPECIFICATION: _____

A. INFORMATION REQUIRED: _____

B. CONTRACTORS RECOMMENDATION: _____

C. RESPONSE
 PROCESS WITH RECOMMENDATION
 PROCEED WITH FOLLOWING INSTRUCTIONS

BY: _____ DATE: _____

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Figure 3
RFI after Standardization

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TRANSMITTAL FORM

Transmittal Number: _____

Project Name: _____
 Project No.: _____
 To: _____
 From: _____
 Subcontractor/Supplier: _____
 Manufacturer: _____

Submittal Title: _____
 Revision No.: _____
 Submittal No.: _____ DATE: _____ SUBMITTED BY: _____

Spec. Section No. _____ Spec. Title _____
 Drawing No. & Detail Reference: _____

A. TRANSMITTAL DESCRIPTION: _____

B. TRANSMITTAL DISTRIBUTION RECORD: _____

BY: _____ DATE: _____

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Figure 4
Transmittal Form after Standardization

In Figure 4, the Transmittal Form is presented, which is one of the most important forms to fill in the projects, this form always is attached with any submittal or document that will be delivered to the client. With these Fillable PDF the time and errors were greatly decreased.

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Accident/Incident Report No. _____

Personal details:
 Name: _____ Date of report: _____
 Occupation: _____

Accident/incident details:
 Date: _____ Time: _____ a.m. Date reported: _____

Location: _____

Witness: _____

Reported to whom: _____

Full accident/incident details – what happened, or in the case of a near miss, what could have happened:

Injury – Nature of injury:

Contusion/crush Burn Dislocation Amputation
 Laceration/open wound Superficial injury Foreign body Internal injury
 Concussion Sprain/strain Fracture Dermatitis

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Figure 5
Accidental Report Form after Standardization

Location of Injury:

Head/face Eye Internal organs
 Hand/fingers Shoulder/arms Trunk (other than back)
 Hip/leg Foot/toes Back
 Other (state) _____

Results of accident:
 Lost time injury: **No** No. of days: _____ days Workers' compensation: **No**

Treatment received:
 First aid Doctor Hospital

Damage to equipment/buildings/vehicles etc:
 What was damaged? _____
 Extent of damage: _____
 Contributing factors: _____

Corrective actions:
 Immediate actions: _____
 What controls can be put in place to prevent this from happening again? _____
 Recommendations for action: _____
 Who is to implement these controls/corrective actions? _____
 Date by which action is to be taken: _____

Signatures
 Supervisor _____ Date _____
 Employee _____ Date _____

Figure 6
Accidental Report Form after Standardization

Figure 5 represents the new format for the first page of the Accidental Report Document, showing an easier way to describe and to write the issues of any accident. The Figure 6 below represent the second page of the Accidental Report, that identifies where the employee receive the injuries and where he was treated.

Standard Operation Sheet Request for Information (RFI)		
No. #	Procedure	Explanation
1	General Information	This part is filled with the general information of the Project and person that is preparing the document.
2	Information to be Requested Specifications Information	This part is filled with the information provided by the Specifications of the client. The checkbox are selected with the information that we need for the project.
3	Information Required Contractor's Recommendation	In this part the contractor fill the box with the information required for clarification and if is the case a Contractor recommendation (equipment, new design etc.)
4	Client Response	In this part the client select one of the boxes. The document need to be returned with the client's instructions. (is only filled by the Client)

The screenshot shows the RFI form with four numbered callouts: 1 points to the 'PROJECT NAME' field, 2 points to the 'REQUESTED INFORMATION' checkboxes, 3 points to the 'CONTRACTOR'S RECOMMENDATION' text area, and 4 points to the 'CLIENT RESPONSE' section.

Figure 7
Standard Operation Sheet for RFI

In Figure 7 above is a Standard Operation Sheet for the RFI that explains how the document need to be filled. Also, in Figure 8 below is the Standard Operation Sheet for Transmittal Form that present how to fill up the document for the submit process.

Standard Operation Sheet Transmittal Form		
No. #	Procedure	Explanation
1	General Information	This part is filled with the general information of the Project, the client and person that is preparing the document.
2	Submittal Specifications Information	This part is filled with the information of the Submittal to be delivered and the details provided by the Specifications of the client.
3	Transmittal Description and Distribution Record	In this part the contractor fill the box with the information required for clarification and if is the case a Contractor recommendation (equipment, new design etc.)

The screenshot shows the Transmittal Form with three numbered callouts: 1 points to the 'PROJECT NAME' field, 2 points to the 'SUBMITTAL SPECIFICATIONS' section, and 3 points to the 'CONTRACTOR'S RECOMMENDATION' text area.

Figure 8
Standard Operation Sheet for Transmittal

Standard Operation Sheet Accidental Report Form		
No. #	Procedure	Explanation
1	Personal Details	This part is filled with the information of the injured person.
2	Accident Details	This part is filled with the information about the location and time where the accident occur.
3	Full Accident Details	This part is filled with the detailed description of the accident and what type of injury the employee suffer.

The screenshot shows the Accidental Report Form with three numbered callouts: 1 points to the 'PERSONAL DETAILS' section, 2 points to the 'ACCIDENT DETAILS' section, and 3 points to the 'FULL ACCIDENT DETAILS' section.

Figure 9
Standard Operation Sheet for Transmittal

Standard Operation Sheet Accidental Report Form		
No. #	Procedure	Explanation
4	Location of injury and Result of Accident	This part is filled with the location where the employee was injured and the result of the accident in terms of lay off for the employee.
5	Treatment Received and Damage to Equipment	This part is filled if any vehicle, building or equipment receive any damaged and where the employee was attended.
6	Corrective Action	This part is filled with the corrective actions taken after the accident.

The screenshot shows the Accidental Report Form with three numbered callouts: 4 points to the 'LOCATION OF INJURY' section, 5 points to the 'TREATMENT RECEIVED' section, and 6 points to the 'DAMAGE TO EQUIPMENT' section.

Figure 10
Standard Operation Sheet for Transmittal

The Figure 9 and 10 shows the Standard Operation Sheet for the Accidental Report Form, this form is one of the most extensive to fill up, with these Fillable PDF's there is an easier way to document any accident during work. Information

CONCLUSIONS

During this design project the process of document preparation was studied for improvement. This process has some inefficiencies in terms of preparation of the documents. During this study Lean principles were applied to propose valuable improvements to the process with the objective of comply with the client's due date. Using the 5S Methodology an improvement was made in the document preparation phase; a standardization tool was used to develop Fillable PDF's for an easier way to prepare the required forms. Also, a Standard Operation Sheet for each document were created in order to know how to fill the blank spaces, for future engineers use. The time was considerably reduced by 20% from 2:00 mins to 1:30 mins, and from 3:00 mins to 2:24 mins per form. With these improvements a data base can be created for future audits and reference to other projects.

The next step for this Project is to create a series of training videos in the Share Folder for future use for the new Engineers that will be entering in the company, this will reduce the training time for these new employees.

REFERENCES

- [1] A Guide to the Project Management Body of Knowledge (PMBOK® Guide), Project Management Institute, Inc, 2017.
- [2] L. Wilson, *How to Implement Lean Manufacturing, Second Edition. Lean Manufacturing and the Toyota Production System*, Chapter 1, McGraw-Hill Professional, Access Engineering, 2015.