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Applying Lean Six Sigma Methodology to Improve Project Management in Telecom Companies

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Abstract

Purpose: This research paper aims to apply the Lean Six Sigma DMAIC methodology to improve the construction time of telecom towers. The study focuses on Almadar Aljadid Telecom Company, a Libyan telecom company, and aims to identify and prioritize the root causes of time delays in site rollout projects. The ultimate goal is to mitigate or eliminate these delays.

Study design/methodology/approach: The research employed a case study approach to comprehensively understand the subject under investigation. A total of 36 sites were selected and categorized based on site type and project area. The researchers used the Lean Six Sigma DMAIC methodology, which consists of five phases: Define, Measure, Analyze, Improve, and Control. The DMAIC cycle was used to identify and prioritize the root causes of time delays in site rollout projects.

Findings: The results show that there are many causes contributing to site rollout delay, these causes were prioritized to identify the most contributing causes to delay that need attention. The most contributing causes of delay were related to the contracting activity of the site rollout process.

Originality/value: This research paper contributes to the field of telecom tower construction by applying the Lean Six Sigma DMAIC methodology to improve construction time. The study provides insights into the root causes of time delays in site rollout projects and offers recommendations for mitigating or eliminating these delays.

Keywords: Lean Six Sigma, Telecom industry, DMAIC methodology, Time delays, Site Rollout Project.

1. Introduction

Telecom companies are widely undertaking network deployment projects to target emerging markets. Therefore, project management has become one of the basic competencies that telecom network operators have sought to excel in all operations, and it is a major success factor in implementing their projects, especially in developing countries. However, telecom operators face many challenges such as keeping existing subscribers satisfied to prevent them from switching to competitors (Lancaster, 2023).

These challenges require operators to expand their network coverage and capacity as quickly as possible to meet subscriber demands. Another challenge is the decline in revenues due to the aforementioned competition which requires telecom operators to carefully consider their investments in network deployment and expansion while paying attention to the role of project management in controlling both

capital and operational expenditures. Therefore, time and cost management are key skills for telecom services to launch projects that are constantly growing and evolving (Saragih et al., 2021)

In order to meet challenges in communications technical operations, project managers are forced to find new ways to improve performance, avoid delays, reduce costs, and meet the requirements and expectations of project investors and stakeholders. One potential solution to address such challenges is to integrate Lean Six Sigma into project management practices by adopting the DMAIC methodology to improve performance and to ensure an effective and accurate project outcome (Khanna, 2019).

In this paper, data were collected for 36 communication sites of Al-Madar Al-Jadeed Company. The objective was to apply the DMAIC (Define, Measure, Analyze, Improve, Control) methodology to identify the problems that led to delays in rolling out the project. The researchers aimed to analyze these project problems and explore possibilities for improving execution time.

2. Methodology

2.1. Project and Project Management

According to Project Management Institute (PMI), a project is a temporary endeavor undertaken to create a unique product, service, or result. It has a defined beginning and end in time, and therefore defined scope and resources.

Kuster et al. (2023) stated that the dimensions of any project can vary depending on the source, but some common dimensions include time, scope, budget, team, and quality. Other sources may include additional dimensions such as risk, communication, stakeholders, and resources. Fig. 1 shows a diagram of a project triangle, also known as a triple constraint or iron triangle.

Fig 1. diagram of project triangle [Eby, 2017]

Measuring project success is important to track progress. Recent research has identified multiple dimensions of project success, including:

- Project efficiency.
- Impact on the customer.
- Direct business and organizational success.
- Preparing for the future.

Project management is the process of planning, organizing, and managing resources to achieve specific goals within a defined timeframe and budget. It involves the use of specific knowledge, skills, tools, and techniques to deliver something of value to people (Irfan et al., 2021).

Project management methodologies are frameworks that guide project managers in planning, executing, and controlling projects. These methodologies provide a structured approach to managing projects,

ensuring that they are completed on time, within budget, and to the required quality standards. Some popular project management methodologies including traditional, agile, waterfall, and lean Six Sigma (Charvat, 2003)

Combining project management methodologies like Lean and Six Sigma can lead to improved efficiency, reduced waste, and increased customer satisfaction. Lean focuses on waste reduction, while Six Sigma emphasizes variation reduction. The principles of Lean and Six Sigma can be blended to create Lean Six Sigma, which is a fact-based, data-driven philosophy of improvement that values defect prevention over detection (Franchetti, 2015)

2.2. Mobile Phone Network

A mobile network is a telecommunications network that uses radio waves to route communications to and from users. It is composed of base stations that cover a delimited area or "cell." These cells provide radio coverage over a wide geographic area, enabling a large number of portable transceivers to communicate with each other and with fixed transceivers and telephones anywhere in the network (Rupprechtet al., 2017). The base station (cell sites) is a part of Mobile Network Architecture and is going to be the area of research study in this paper. Fig. 2 shows a schematic diagram of a base station or cell site.

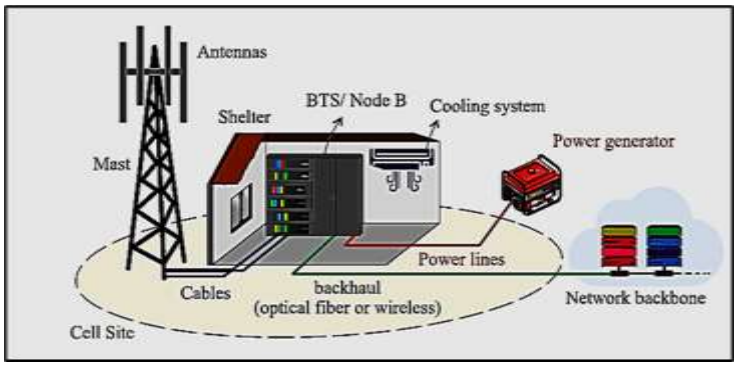

Fig 2. Schematic diagram of a cell site [Patwary, 2020]

Cellular base stations can be classified into two main categories based on their placement: greenfield and rooftop sites (Majeed and Hraba, 2017). Greenfield sites are built on open land, typically in rural areas where there is no existing infrastructure. They can be further classified into self-supporting towers, guyed towers, and monopoles. Rooftop sites, on the other hand, are installed on existing buildings or structures, commonly used in urban areas where space is limited for new infrastructure. Additionally. Fig. 3 shows the types of base stations currently used by Almadar Aljadid company.

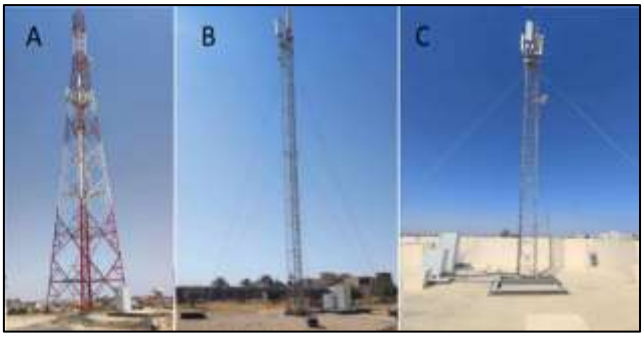

Fig 3. Types of sites used by Almadar Aljadid company.
(A-Greenfield self-support, B-Greenfield guyed mast, C-Rooftop)

2.3. Delay

In project management, a delay refers to an unplanned and unexpected deferment of a project due to an event or occurrence that impedes the project's commencement or continuation. Delays can cause companies to miss deadlines, exceed the actual allocated budget, and even derail projects. Some common causes of project delays include project scope changes, resource availability, inadequate planning, unrealistic deliverables, and external factors such as natural disasters or political instability (Nagata et al., 2017).

In construction projects, delays can be classified into different types, which are important in determining their impact and potential compensation. They can be classified into four categories, which are critical or non-critical delays, excusable or non-excusable delays, compensable or non-compensable delays, and concurrent or non-concurrent delays. Understanding these classifications is important in determining the impact of delays on a construction project and in deciding whether compensation is due to the contractor (Tawfek and Bera, 2013).

There are ways to mitigate the effects of construction delays. Some of these ways are anticipating potential delays, identifying causes of delays, developing a contingency plan, improving communication among stakeholders, using technology, and managing risk. By taking these measures, it is possible to mitigate the effects of construction delays and ensure project success (Aziz et al., 2022)

2.4. Lean Six Sigma DMAIC Methodology

Lean Six Sigma is a methodology that combines the principles of Lean and Six Sigma to improve processes and eliminate waste. Lean methodology was established by Japanese automaker Toyota in the 1940s, while Six Sigma was designed by Motorola engineer, Bill Smith, in the 1980s as a standard to measure productivity. The goal of Lean Six Sigma is to improve quality, reduce costs, and increase customer satisfaction. It strives to eliminate the waste of physical resources, time, effort, and talent while assuring quality in production and organizational processes. Simply put, Lean Six Sigma teaches that any use of resources that doesn't create value for the end customer is considered a waste and should be eliminated (Stern, 2019).

The principles of Lean Six Sigma can be applied to a wide range of industries, including manufacturing, healthcare, finance, and service industries to improve efficiency, reduce costs, and enhance profits. The DMAIC process is a key component of Lean Six Sigma, which involves five phases: Define, Measure, Analyze, Improve, and Control. Successful implementation of Lean Six Sigma requires management support, employee engagement, and a commitment to continuous improvement (Stern, 2016).

Lean principles are a set of guidelines that help organizations improve efficiency and eliminate waste. According to Rovira (2020), the five Lean principles that are commonly used are:

- Defining value: Value is defined from the standpoint of the end customer. It is important to understand what the customer wants and needs in order to provide value.
- Mapping the value stream: This involves identifying all the steps in the value stream and eliminating any steps that do not add value.
- Creating flow: This principle involves creating a smooth and continuous flow of work processes, without interruptions or delays.
- Using a pull system: This principle involves producing only what is needed, when it is needed, and in the amount that is needed. This helps to avoid overproduction and waste.
- Pursuing perfection: This principle involves striving for continuous improvement and always finding ways to get a little better each and every day. The company should be a learning organization and alw-

ays find ways to improve.

A crucial step in any Six Sigma project is to determine the exact requirements of the customer and define defects or problems in terms of critical to quality (CTQ) parameters. This involves understanding what the customer expects from the product or service and identifying the key factors that are critical to their satisfaction. Six Sigma projects can focus on improving the areas that have the greatest impact on customer satisfaction. This leads to the development of products and services that meet or exceed customer expectations and ultimately drive business success (Singh et al., 2021)

The integration of Six Sigma and lean management is a topic that has been explored by several researchers. Salah et al. (2019) proposed a new detailed description for integrating Six Sigma and lean to provide an improved approach for continuous improvement as shown in Fig. 4. By linking the 5 lean principles to the 5 DMAIC phases, organizations can apply a structured approach to continuous improvement that focuses on reducing waste, improving flow, and increasing customer value.

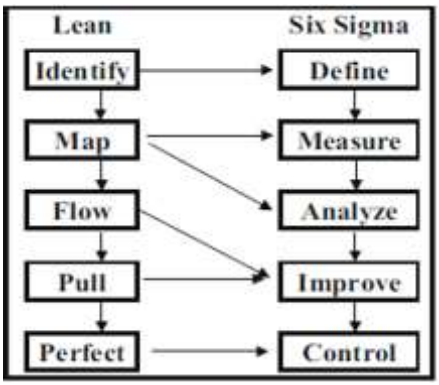

Fig 4. Lean and Six Sigma phases relationship [Salah et al, 2019]

The proposed integrated model for LSS uses the holistic DMAIC structure, which is a five-phase method for addressing existing process problems. The phases of the model are as follows:

- Define: This is where the understanding is formed for what is of value to the customer.
- Measure: This is a phase of measuring and analyzing, as data is collected to see how the baseline looks like and the improvement ideas start to arise, causing the analysis to start.
- Analyze: This phase involves analyzing the data collected in the Measure phase to identify the key drivers of the problem and develop a hypothesis for improvement.
- Improve: This is where the process is adjusted to improve the value flow using the future-state VSM exercise as an example and to introduce the pulling concept.
- Control: This phase is where the process is perfected by introducing the procedures to ensure Continuous Improvement in the future. The integration of Lean brings the Measure and Analysis phases closer to each other.

In this paper, the Lean Six Sigma DMAIC process will be utilized. Lean concepts and tools will be combined with the DMAIC methodology in a way that makes it focus on minimizing waste and non-added value activities.

3. Applying The Methodology

The study aims to achieve its objectives by following the lean Six Sigma method, which involves five steps: Define, Measure, Analysis, Improve, and Control (DMAIC). The data collection methods used in

the study were carefully selected to ensure that the data collected was accurate and relevant to the research problem. The case study was carried out in Almadar Aljadid Telecommunication Company, a subsidiary of Libyan Post Telecommunication and Information Technology Company. The data collection methods used in the research include observations, database, and e-mails. Interviews were also conducted with Site rollout project staff and Project managers.

In this study, a total of 36 sites were selected and categorized based on site type into: Roof Top sites (RT), Greenfield guyed mast sites (GF GM), and Greenfield Self-Support sites (GF SS). The sites were also categorized based on project area into: MRND, GTB, LTE.PH2.OP1 and LTE.PH2.OP2. The results of applying the Lean Six Sigma methodology to address the causes of delay in rollout projects will be presented. The tools and techniques used in the study will be described.

3.1. Define Phase

Firstly, a process flow chart was created as shown in Fig. 5, a work breakdown structure was created as shown in Table 1 to illustrate the activities of the site rollout project and the planned time for each of these activities for each site type. specific criteria were established to identify significant delays in the site rollout project as shown in Table 2. Tools used here align with the lean principle of eliminating waste, embracing continuous improvement, and improving customer satisfaction.

Table 1. Work Breakdown (WBS) Structure of the Site Rollout Project

Activity	Activity Description	Planned time RT (Days)	Planned time GF GM (Days)	Planned time GF SS (Days)
A	Site Survey Report	10	10	10
B	Technical survey radio Wireless	4	4	4
C	Technical survey civil & power	4	4	4
D	provide and review documents & sign the contract	15	15	15
E	Test report by outsourcing company	5	5	5
F	Construction of concrete bases	10	30	35
G	Installation of tower	3	4	8
H	Site plan by GECOL	3	3	3
I	Implementation of the GECOL Plan	4	6	6
J	Implementation of Power Works	2	3	3
K	Installation of telecom equipment	3	4	5
L	Site commissioning	2	2	2
Total		**65**	**90**	**100**

Table 2. Criteria to define delay acceptance in site rollout projects.

Delay time	Delay Acceptance
4 days or less above planned time	Accepted
more than 4 days above planned time	Not Accepted

3.2. Measure Phase

The measure phase of the study involved data collection and cause identification. Data related to the actual time of site rollout were collected, and the percentage of delay was calculated. A summary of the data is presented in Table 3. A list of the causes that influenced the delay of the site rollout project is listed in Table 4. This aligns with the lean principle of identifying and measuring waste to eliminate it.

Table 3. Summary of actual time and delay of site rollout projects

Site Type	Count of Sites	Planned Time (Days)	Actual time (Days)	Avg. Delay %	Count of Major Causes	Count of Accepted Causes
R.T	12	65	98.25	51.15	65	12
G.F G.M	12	90	114.58	27.31	42	26
G.F S.S	12	100	146.92	46.92	70	24
Total	**36**			**41.8**	**177**	**62**

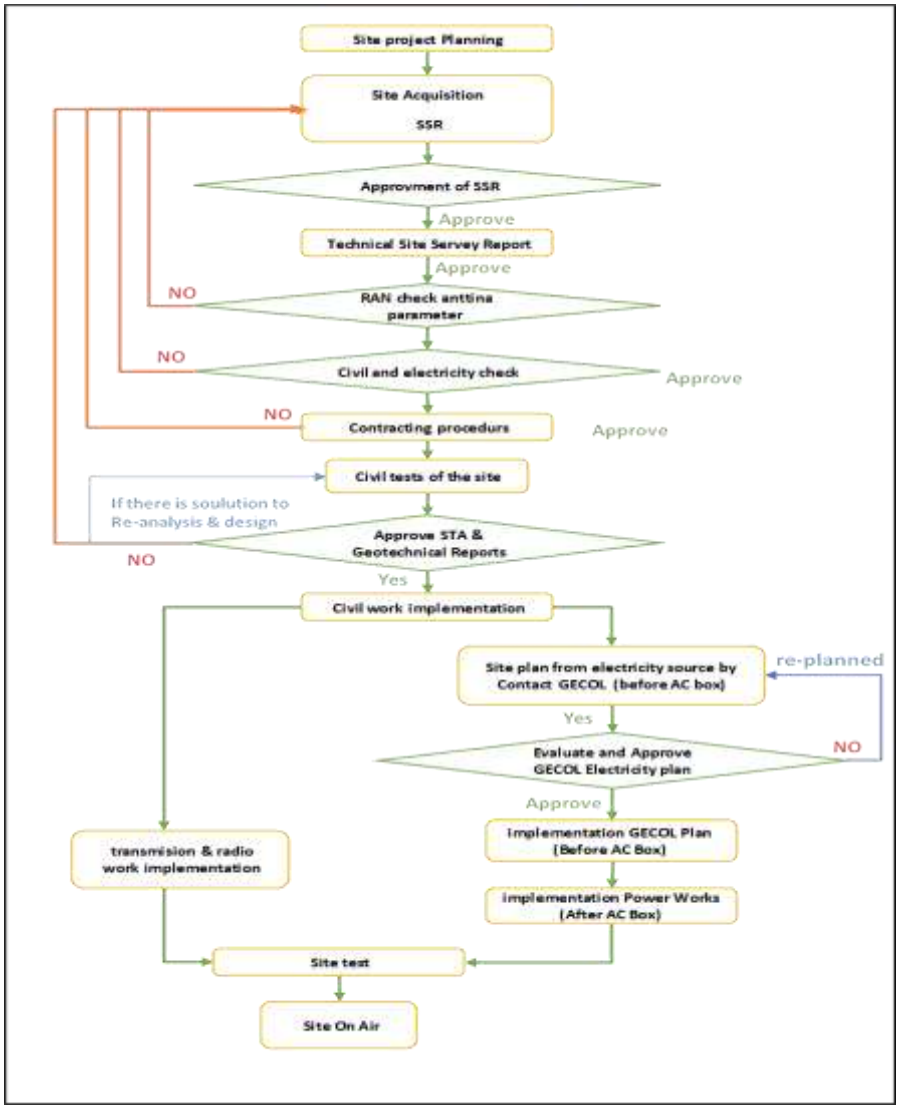

Fig 5. Site Rollout Process Flow Chart of Almadar Aljadid Company

Table 4. List of the causes that influence site rollout project delay

Causes ID	Description	Causes ID	Description
A1	Rent value (Low value)	**G2**	Quality of work
A2	Corona pandemic	**G3**	Corporate assignment procedures
A3	Fear of radiation	**G4**	Security issues (war zone)
A4	Owners absent from home	**G5**	No towers available
A5	Limited resources in this stage	**G6**	Owner postponed the work
B1	Limited resources in this stage	**G7**	Delay in tower acceptance
B2	Independence of the staff to project	**G8**	Bad weather
B3	Poor Communication with other departments	**G9**	Grounding System issue
B4	Change network plan	**H1**	Document procedures by GECOL
B5	Random building	**H2**	Delay in planning by GECOL
C1	Building's structure is unsuitable	**I1**	Corporate assignment procedures
C2	Site needs leveling (high cost)	**I2**	Delay from the executing company
D1	Delay in providing documents	**I3**	Interference of neighbors in works
D2	Delay from governmental institutions	**I4**	Security issues (Theft)
D3	Delay for legal department	**J1**	Corporate assignment procedures
D4	Delay from client to sign contract	**J2**	Security issues (war zone)
D5	Cancel due to no documents	**K1**	Quality of work
E1	Corporate assignment procedures	**K2**	Corporate assignment procedures
E2	Delay in testing procedures	**K3**	Limited resources in this stage
F1	Delay from the executing company	**K4**	Security issues (war zone)
F2	Quality of work	**K5**	Bad weather
F3	Corporate assignment procedures	**K6**	Material not ready in the warehouse
F4	Security issues (war zone)	**L1**	Poor communication
F5	Rocky lands take too much time	**L2**	The lack of electricity on site
F6	Corona pandemic	**L3**	Site uplink is not ready
G1	Delay from the executing company	**L4**	Fiber connectivity with Hatif Libya

3.3. Analyze Phase

The analysis phase involves the following steps, which were carried out for each site type separately

- Identification and Prioritization of root causes: The identified root causes were prioritized based on their significance and impact on the project.
- Graphical representation: Various graphical tools, such as bar charts, Pareto charts, and cause and effect diagrams, were used to analyze and represent the data.

The tools used in this phase aligns with the lean principle of analyzing processes to identify inefficiencies and visual management. A cause-and-effect diagram was prepared as shown in Fig. 6. The potential causes

are mentioned in the diagram within their categories. A Pareto chart was created to prioritize the major causes that affect delays in rollout projects for all sites. as shown in Fig. 7. Most of delay causes are related to contracting activity (D). The top 3 causes were (D1, D3, B3), the description of these causes is listed in Table 4.

3.4. Improve Phase

The following improvement steps should be taken in consideration to mitigate the major causes of delay:

- A radio and M.W engineer with administrative skills was assigned to act as a liaison between different departments, facilitating improved communication and collaboration.
- A flexible work system with contract and relationship employees was implemented to enhance communication with owners and strengthen working relationships.

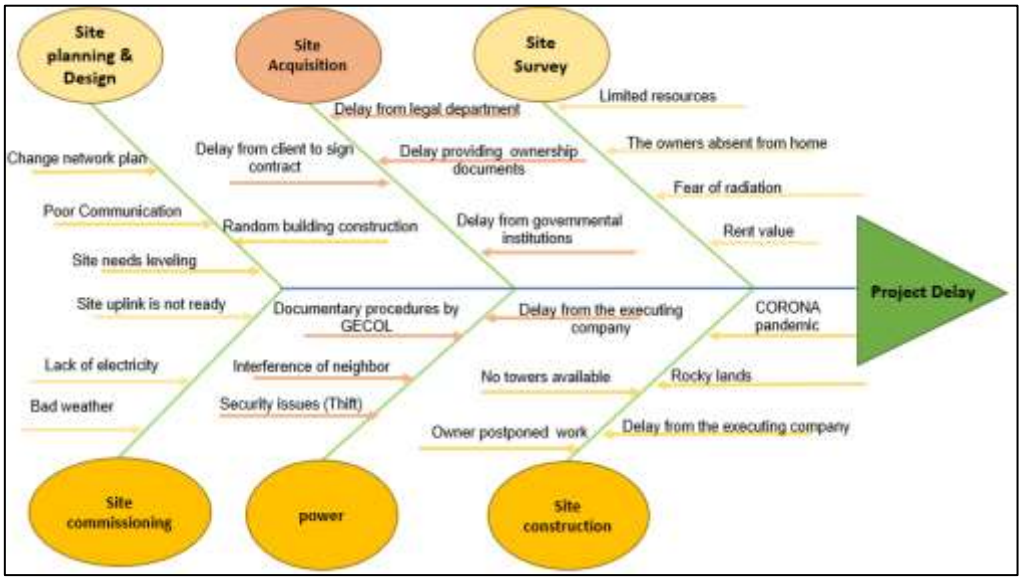

Fig 6. Cause and Effect Diagram for delay in site rollout projects

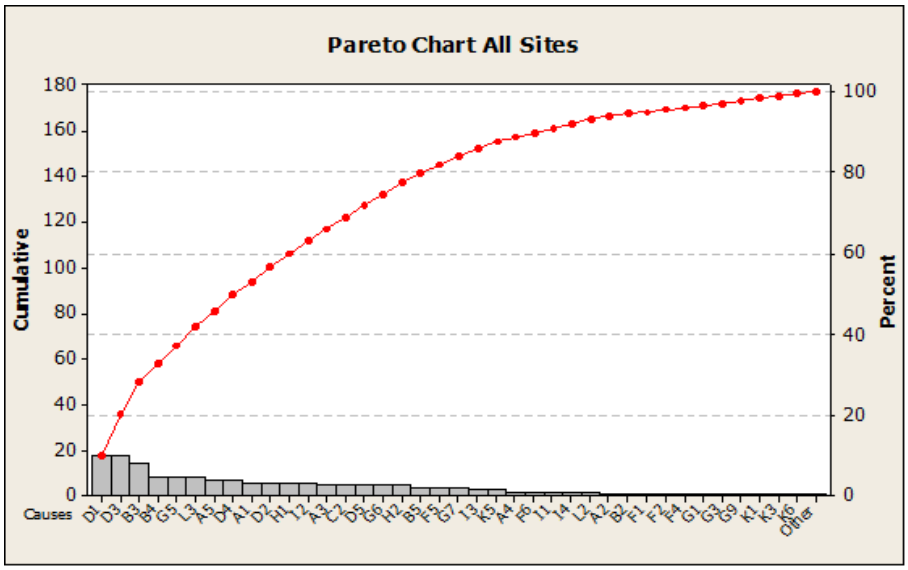

Fig 7. Pareto Chart for site rollout project major causes

- Effective communication and collaboration between the project team and the network planning department were ensured through scheduled meetings and the provision of progress reports.Schedule regular meetings between the project team and the network planning department. During these meetings, discuss the progress of the project and provide reports on radio and microwave technologies from the NOC (network operations center).
- Supervisors' efficiency was improved through training courses that contributed to finding innovative solutions to problems during project implementation.
- The value of rents according to geographical areas and the importance of the location was increased, providing additional services to the owners to obtain a positive result.
- Enough human resources were provided to expedite the work, allowing dedicated professionals to focus solely on completing tasks promptly and professionally.
- The existing joint committee work with GECOL was improved by clearly defining the scope of the joint committee's powers and responsibilities, establishing effective communication channels, and using digital tools and technologies to collect, analyze, and present data. Additionally, a hotline with GECOL was established to address any issues that arose.

These improvement steps were converted into implemented solutions after interviews with working groups and were implemented in the pilot study. The pilot study consists of 3 sites, one of each type, the pilot study analyzes the effectiveness of the implemented improvement suggestions. Table 5 shows general information about these sites. The working group of this pilot study consist of project managers and site project team, roles and responsibilities were assigned to each member to ensure better communication.

Table 5. General Information about Pilot sites

No	Site ID	Site Type	Site Area
1	NTR418	LTE.FH2.OP2	RT
2	NTR603	LTE.FH2.OP2	GF GM
3	NTR576	LTE.FH2.OP2	GF SS

The results of the pilot sites show that the delay percentages of the 3 sites; NTR418, NTR603 and NTR576 were found to be 1.5%, 5.6%, and 3% respectively. It was observed that no major activity contributed to the delay. Tables 6 and 7 show the contributed activities and causes of delay for each site.

Table 6. Contributing Activities to delay in pilot sites

Site ID	Delay %	Contributing Activity	Activity Description
NTR418	1.5	A	Site Survey Report
NTR603	5.6	A	Site Survey Report
		G	Installation of tower
NTR576	3	A	Site Survey Report

Table 7. Contributing Causes to delay in pilot site

Site ID	Cause ID	Cause Description
NTR418	A4	The owners are not present in the homes in the morning period
NTR603	A1	Rent value (Low value) for roof top site or Green field site
	A4	The owners are not present in the homes in the morning period
	G1	Delay from the executing company
	G7	Delay in tower acceptance
	G8	bad weather
NTR576	A3	Owners and neighbors refused to install the site due to fear of radiation

These improvement steps align with the lean principle of continuous improvement and eliminating delay.

3.5. Control Phase

The Control phase of DMAIC is critical to ensuring that the improvements made during the Improve phase are sustained over time.

A Standard Operating Procedure (SOP)was created to ensure that the improvements made during the pilot study are sustained over time and that the process continues to deliver the desired results. The SOP can serve as a reference for the project team and other stakeholders, ensuring that everyone is on the same page and that tasks are performed consistently and efficiently. The SOP includes the following steps:

1. Collect data on the delay percentages and causes of delay for the sites involved in the pilot study on a regular basis.
2. Analyze the data to identify any deviations from the improved state, for example (emergence of new causes or increase in delay percentage).
3. Develop response plans to address any deviations from the improved state.
4. Implement response plans to address any deviations from the improved state.
5. Continuously monitor and analyze the delay percentages and accepted causes count of delay for the sites involved in the pilot study to ensure that the improvements are maintained and that any deviations from the improved state are identified and addressed.
6. Document the results of the pilot study and the control measures implemented.
7. Communicate the results of the pilot study and the control measures implemented to relevant stakeholders.
8. Review the results of the pilot study and the control measures implemented on a regular basis to ensure that the process continues to deliver the desired results.

Lean principles are integrated with the suggested steps to enhance the sustainability of the improvements made during the DMAIC process.

4. Conclusion and future work

In this paper, a case study has been presented showing the implementation of Lean Six Sigma methodology in a Libyan telecom company. Lean Six Sigma approach DMAIC is applicable in telecom cell site construction. By integrating Lean principles within the DMAIC process, project managers were able to identify and address causes of delay. The DMAIC process was used to identify the root causes of the problem and develop solutions to address them.

The results show that there are many causes contributing to site rollout delay, these causes were prioritized

using Pareto charts to identify the most contributing causes to delay that need attention. Most of the causes are related to the activity D (provide and review the ownership documents & sign the contract). The results of this study were compared to another study conducted by Abudaia (2020) on a Libyan mobile phone company and similarities were found, the most contributing causes in both studies are related to contracting activities.

A pilot study was conducted on three sites to validate the effectiveness of the improvement suggestions developed during the DMAIC process. The results of the pilot study showed a significant improvement in the delay percentage and the count of causes contributing to delay. These findings demonstrate the effectiveness of the DMAIC methodology in identifying and addressing the root causes of delay in site rollout projects. The pilot study results were used to inform the full-scale implementation of the improvements, and the DMAIC methodology was continued to the Control phase to ensure the sustainability of the improvements.

To enhance the theoretical and technical knowledge of project management methodologies and increase awareness and involvement in Lean Six Sigma implementation, a comprehensive training program should be implemented for managers and team members involved in site rollout projects.

Coordination among other telecom companies in the country is necessary to establish a database center using available technologies like GIS. GIS mapping can help telecom providers enhance network planning, deployment, maintenance, operations, and even sales and marketing.

5. Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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