A generic online action tracking platform for project management in industry

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Abstract

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Effective Project Management (PM) is essential to the success of projects in industry. It is reported that approximately 68% of all projects fail due to ineffective PM. A further 15% of projects are deemed to fail from the start, where 10.9% of the final project's cost is wasted. Only 58% of all businesses understand the importance of efficient PM. PM tools utilised for action tracking are widely used to improve efficiency; however, the current action tracking methods are not as efficient due to the activities being overlooked, not being dealt with in time, or having to be re-assessed.

Present action tracking platforms are designed for single-system use, which means that they only consider the current state of projects and cannot be adapted for future purposes, thus limiting their implementations. User interaction with the current PM tools is also inefficient, as the information displayed is not consistently updated or readily available. Effective PM methods are key to the success of projects, and the currently implemented methods are not as effective in aiding with PM. A need, therefore, exists to develop a platform for action tracking to assist with increasing the effectiveness of PM.

An in-depth literature study on the current methods used for PM in industry determined that a successful Action Tracking Platform needed to be generic, centralised, traceable, structured, scalable as well as having the ability to integrate its users. These requirements were used to evaluate the state of the art for PM. The literature review highlighted the importance of the development of a web-based action tracking platform implementing all the identified requirements. Web-based PM is one of the key underutilised platforms which can improve on communication, automation, and the standardising of processes. This created the foundation for the development of the method for the design of an Action Tracking Platform for use in industry.

An Action Tracking Platform was designed and developed to provide a centralised interface for PM teams to contribute to effective PM. The platform was developed to be scalable and to use generically-implemented classes to create a structured backend. This provided each PM team with a configurable PM tool to track the actions on their projects with their clients. The platform provided traceability amongst its users, and was developed to integrate all users to ensure that all personnel are aware of the current actions and their progress.

The platform was implemented for a multidisciplinary engineering company's PM teams, their clients, and their common projects. Successful implementations were achieved across three case study PM teams within the company. The platform yielded an 84.16% decrease in the average completion rates (days) of projects across each case study, thereby ensuring faster results and, consequently, increasing PM within the company. At the platform's inception, 38.08% of actions exceeded their planned completion rates. Following the evaluation period, actions were completed 17.33% faster than their planned completion rates.

The results proved that the platform implementation successfully met the objectives of the study and motivated users to more effectively manage their current actions and prioritise their successful completion. The platform's implementation successfully improved the PM of projects and their actions within the company and successfully illustrated the importance of effective PM within industry.

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Nomenclature

Abbreviations:

PM	Project Management
PMS	Project Management Systems
WPMS	Web-based Project Management Systems
ERD	Entity Relationship Diagram
KPI	Key Performance Indicator
SQL	Structured Query Language
CRUD	Create, Read, Update and Delete
SDLC	Software Development Life Cycle

Chapter 1

Introduction

1.1 Preamble

This section focuses on what Project Management (PM) comprises and what companies in industry do to successfully track their actions on projects. The importance of PM in industry and the current methods employed are introduced, as well as outlining the consequences that can occur as a result of poor PM.

After analysing the current methods that companies use to manage their actions on projects, the key focus points that were identified when looking at PM are introduced. The current literature will be evaluated against these key focus points to determine the state of the art.

These shortcomings and limitations will, therefore, define the problem statement. The need for the study will finally be outlined by determining the necessary objectives that the study would need to meet to be considered successful. The need for the study is identified through the shortcomings outlined in the state of the art.

1.2 Background

For projects in industry to succeed, it is essential to have effective and adequate ways to manage the active projects and the various actions required to complete them. In order to do this, PM teams need to undertake a successful PM strategy [1].

PM is important in ensuring that every process can be managed and organised as it occurs so that changes can be implemented efficiently within an organisation [1], [2]. In industry, companies meet their goals and targets by completing and undertaking projects that contribute to achieving their objectives. These projects often involve a multitude of people and a finite project length, due to deadlines and budgets. Project managers need to manage all these resources accordingly and act when necessary.

PM is defined as the technique that combines the expertise and the wisdom of a project manager with the proper tools and techniques to deliver a product that meets the requirements of the client [3], [4]. PM often involves the control of a single project only concerned with the direct inputs and outputs of that project, focussing on the scheduling, planning and tracking of the project [5]. PM principles are changing at a drastic rate due to business globalisation and advancements in technology and, as a result, many smaller companies are often left behind [3], [6].

With the recent shift in PM, organisations will be more focused on the work and process that goes into a project as well as the inter-team's collaboration [6]. This shift allows for distributed teams to work on distributed projects and achieve a higher success rate in project completion than what has ever been possible before [3], [6].

The move towards distributed PM means that organisations will rely more heavily on effective collaboration involving computer tools and methods [3]. Current PM techniques have become difficult to maintain and challenging to implement on projects that continuously scale in size whilst requiring more resources with time. This has seen the increasing demand for web-based PM[1] to bridge the gap in project collaboration [1], [2].

[1] Other names are also used to denote web-based PM, including PM System, Activity Monitoring, Project Web, Project Bank, Project Specific Website, Project Information Management System, and Virtual PM.

Projects that are undertaken by organisations become more complicated and expand along with the organisation, and this has, consequently, increased the level of complexity for PM [1]. The need has, therefore, arisen to incorporate better PM tools in businesses, which will help to control the widely dispersed projects that now have tighter schedules and higher quality standards than before [1].

The PM System (PMS) was a concept that was developed in the 1970s for smaller businesses, and now in the twenty-first century, with continuous improvements in technology, it can be applied to many fields within industry [1]. With the enhancement of management techniques and the improvements in communication technology, traditional management methods have become inadequate. Approximately 50% of a project manager's time is spent searching for the correct information [1]. This is an extreme loss in efficiency which can be improved through the use of the correct PM tools.

Ineffective Project Management

Covering all the aspects that PM entails is challenging, as there are always unexpected scenarios that appear throughout a project's life cycle [7]. With most deliverables in industry revolving around a service-orientated architecture, it is important to recognise problems even before they occur[2]. Ineffective PM can lead to severe financial loss throughout the life of a project and inconsistency in PM standards can greatly affect the goals of an organisation [7].

Up to 75% of a company's projects have the potential to fail because of problems resulting from ineffective PM [1]. To be a competing business in industry, these numbers need to be reduced and a company should focus on improving their PM skills. Managing a project often involves managing a multitude of people, and tasks can quickly start to spiral out of control if ineffective PM strategies are followed. The most common reasons that projects fail include [2], [3]:

- The project scope is not properly defined.
- The inability to accurately estimate time and effort for the project.
- Inefficient detailing of project plans.
- Failure to identify potential future risks.
- Project managers who lack the necessary experience to carry out the project.
- The lack of formal PM methodologies and strategies.
- The lack of healthy and constructive communication channels between teams, stakeholders, and customers.
- Failure to track new requirements and changes in the processes.

[2] A. Rongala. (2016). The Impact of Ineffective Project Management, [Online]. Available: `https://www.invensislearning.com/blog/the-impact-of-ineffective-project-management` (visited on 14/03/2020)

According to [6], approximately 9.9% of a project's total cost is wasted due to poor project performance as a result of poor PM techniques. Many organisations waste money on poor project performance as a result of [6]:

- organisations failing to bridge the gap between strategy, design and delivery,
- project leaders who fail to realise that strategy is delivered through projects, and
- not fully realising the importance of proper PM.

Organisations that misinterpreted the value of PM reported that an average of 50% of their projects failed outright; therefore, industries need to capitalise on effective PM and implement it correctly within their organisation [6].

Effective Project Management

Effective PM leads to many great benefits that can actively be seen in industry. It is reported that 93% of organisations recognise the value of PM and using standardised methods to track their actions on their projects as well as the value thereof [6]. Introducing a standardised PM technique can help mitigate risk and leads to better outcomes of the projects overall.

Fully understanding the benefits of effective PM is limited within industry, with only a reported 58% being able to fully comprehend the benefits within their organisation [6]. A further 71% of organisations report a greater improvement in agility across their organisation and are thus able to effectively adapt to changing project scopes [6].

80% of successful businesses report having an adequate PM strategy in place for their employees [6]. Project scope can successfully be controlled when organisations effectively manage their projects. Organisations that invest in proper PM experience greater success than their competitors [6].

The main aim of organisations is to achieve their goals and meet the objectives of their projects within the necessary constraints. Effective PM aims to optimise the allocation of resources amongst the relevant actions and meet the needs of a project within the client's boundaries [4].

The success of a project is vital and can be measured based on the following criteria [8]:

- **Time:** The project should be completed on schedule.
- **Cost:** The project should meet the requirements of the budget.
- **Quality:** A successful project should be delivered that meets its objectives.

Some of the outcomes that are intended to be met by an effective PM strategy include [7], [8]:

- Clear, realistic objectives.
- Strong detailed up-to-date plans.
- Good team communication and feedback.
- Proper user and client involvement.
- Effective management when a change in project scope occurs.

- Optimised resource allocation.

It should be noted that both the organisation and the client benefit from having an effective PM strategy in place [6], [8]. When projects are adequately monitored and controlled, this aids in mitigating the risks that are encountered during a project's life span.

This can, therefore, lead to a higher quality product overall. It allows for a team to properly manage their active, assigned projects and the actions that relate to them. Feedback can effectively be provided, and the organisation can more effectively prioritise their actions by setting clear objectives to meet their goals [3], [8].

1.3 Project Management in Industry

1.3.1 Introduction

There are currently various methods that organisations in industry employ to manage their active projects and the resulting actions. This section will discuss some of the current PM methods as well as newer methods which are still to be adopted by most organisations. This section will outline what each management technique entails, and give a brief overview of the method. This section is used to identify what industries look for in their PM tools and what is currently provided.

1.3.2 Logbooks

Personnel in industry often keep logbooks with them to track project progress. This can be a useful tool but is very limited for use in terms of the PM scope [9], [10] as they are mainly used as a personal management device and often do not incorporate the involvement or input of other people. While it is advised to keep a logbook for personal reference, it is not an adequate tool to maintain the state of projects and provide feedback within project teams [9], [10].

With advancements in technology, many people have moved away from the use of physical logbooks. Project members have started to incorporate the use of online logbooks for the collaborative sharing of knowledge within a project. A study was done on the use of online logbooks for final year undergraduate students to evaluate their performance [9].

The results revealed that, with online logbooks, significantly more students made real-time entries as projects changed and lecturers found it easier to give feedback through these platforms. It was also noted by the lecturers that the feedback recorded in the online logbooks was more structured and better maintained.

The research done in [9] is another key indicator of the advantages of using web-based platforms, as they are a more effective communication tool to convey information in a more structured manner. It also allows for faster feedback to be provided through a central interface and makes the data readily available for real-time reporting. Logbooks highlight the importance of having structure, and online logbooks emphasise the centralisation of data for the integration of all members of a common project [9], [10].

1.3.3 Project Audits and Performance Reports

Project audits are a useful means of managing a project's performance, as they can often indicate when a project is going off course[3]. They are mainly seen as beneficial to large organisations undertaking large projects, and usually only occur when the cost of not doing them outweighs the cost of doing them.

It is important to understand all the steps of a project and ensure that the correct methodology is applied by asking the right questions. A project audit can be a project on its own, and requires an experienced project manager to conduct the audit. It is advised that stronger management tools are also used alongside an audit, as this cannot be the only tool that determines the successful outcome of a project. Any flaws that are identified should promptly be handled, and if done properly, this can provide an organisation with many benefits[3], namely [7], [11]:

- Improved project performance.
- Increased customer satisfaction.
- Controlled project scope.
- Early problem identification.
- Identification of future improvements.

The main problem that arises with the project audit is the frequency of occurrence [7]. Project audits are only done later in a project's life cycle and do not provide immediate project updates. Project audits are time-consuming when all the data is not situated in a central location; therefore, project audits are usually done every month or at the end of a project. Once a project is audited it can be a challenging process to consolidate the information for use by the team or presentation to the client.

Performance reports are a key indicator of the progress of a project as well as an additional means of PM. They fall in line with the project audit to see whether a project is going according to plan and if any corrective measures need to be applied [11][4,5]. When developing these reports, it is important to be able to verify all the data and have a traceable means of where that data came from [11]. All the information reported should be traceable and provide the necessary accountability for the party [11].

Performance reports are defined as physical or electronic representations of work performance information, needed to generate decisions, actions, or awareness [12]. Performance reports are a means to control and monitor project work as well as management of the following processes [11], [12]:

- Teams
- Communication

[3] R. Martin, *Introducing Project Audits: Importance, Benefits and Preparation*, 2014. [Online]. Available: `https://info.obsglobal.com/blog/2014/03/introducing-project-audits-importance-benefits-and-preparation` (visited on 04/04/2020)

[4] F. Usmani, *Work Performance Reports in Project Management*, 2019. [Online]. Available: `https://pmstudycircle.com/2012/03/performance-report-in-project-management/` (visited on 04/04/2020)

[5] S. Karpatiya, *Performance Reporting in Project Management*, 2018. [Online]. Available: `https://medium.com/flowpot/performance-reporting-in-project-management-267de0e4532c` (visited on 04/04/2020)

- Risks
- Integrated change control

Performance reports are vital to increase the communication between the organisation and its clients, and are an easy tool to use to convey information [11]. Most importantly, the cost and budget of projects can easily be managed and reviewed against the project deadlines[4]. The main aim to increase the benefits of performance reporting is to generate them as frequently as possible; however, this is not always possible due to the time-consuming process it requires to create them as a result of the lack of centralised data [11].

1.3.4 Web-based Project Management

Utilising Web-based Project Management

Web-based PM is a means to create a virtual team. Virtual PM involves the communication of teams across distributed work locations [13], [14]. There can be teams communicating from remote locations, between cites, countries or time-zones, making face-to-face meetings almost impossible [3]. Meetings are, therefore, not always an option, and this contributes to why many teams choose to utilise the advantages of Virtual PM.

Having the ability for teams to communicate across regions is essential to organisations in this modern society. It allows for teams to be flexible and take advantage of distributed resources [13]. Since teams often work from distributed locations, they are reliant on using online communication techniques for collaboration on projects [13]. Virtual PM is used by teams to increase productivity, improve operational efficiency, reduce costs, and for talent acquisition [13].

Communication is an essential tool for building trust, providing feedback, and communicating context [1], [3]. The use of an online platform supports the improvement of team collaboration and can be used to drastically improve team performance [1], [3], [14]. Various forms of software are available for PM and one of the main driving factors for selection is the ease-of-use in managing the tool as the organisation grows [1], [3], [14].

For PM to be successful it must support the ability for projects to be flexible, promoting environments such as Virtual PM [1], [3]. Web-based PM provides the opportunity for projects to be easily scaled by allowing for the entire project scope to be centralised. If a team member updates the details of a project, it is available in real-time for all the members to see. This also provides the added benefit of data integrity, as anyone can immediately contribute to any of the changes [1], [3].

Web-based PM allows organisations to assign distinct roles and better control the management of all the active projects. All files and documents that are produced can be stored and backed up with ease, as well as allow for traceability within the PM environment. This allows organisations to easily recover and apply previous solutions to existing projects, which significantly reduces the overhead and clutter when managing projects [3].

The shift towards web-based PM has drastically increased in recent years [1]. It is reported that organisations are consistently moving to web-based PM to establish proper integration with their clients [1]. This can increase client satisfaction and is one of the advantages introduced by web-based PM. Using an online interface also increases the time the project manager has available to address more strategic issues [3].

The main outcomes from having effective web-based PM as identified in [15] are improved efficiency, enhanced productivity, and increased project profitability. A successfully implemented online platform should improve data flow and information as well as customise business solutions [15].

Web-based Project Management Tools

It is common for projects to fall behind schedule or go over budget, and without the proper PM techniques and detection, this can be demanding on the project manager. This "time versus information" dilemma initiated the concept of the Project Dashboard which covers the aspects of web-based PM [15]. A Project Dashboard aims to provide centralised, up-to-date information about all the currently active projects, maintaining their status, progress, and other vital information that is needed by the project manager [3], [4].

A Project Dashboard often involves the use of conditional formatting where all the projects are colour formatted according to pre-set conditions [3], where green indicates that a project is on-track, yellow indicates that a project is nearing its deadline, and red indicates that a project is over its expected deadline. This helps project managers to quickly identify and prioritise projects as the need arises.

Project Dashboards are used to reduce the time it takes a project manager to read through reports to determine the needs of the active projects [4]. Project Dashboards aim to simplify the information that is retained within the projects and provide a generic set of structured data [3], [5]. An example of what a basic Project Dashboard might look like can be seen in Figure 1.1.

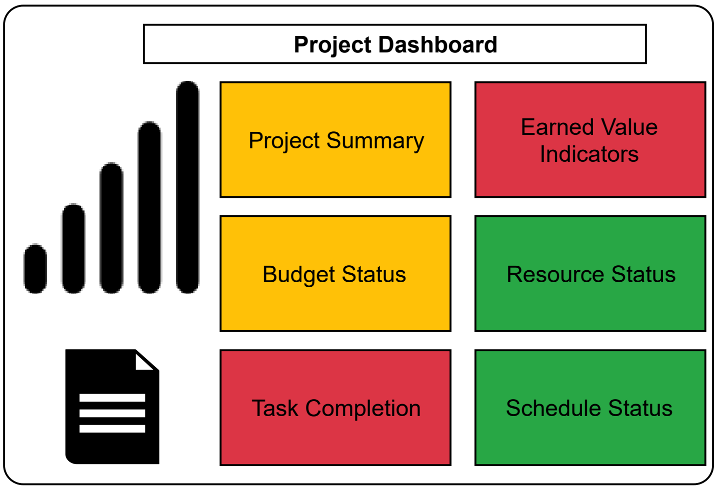


Figure 1.1: Illustration of the Basic Concept of a Project Dashboard.

Web-based PM is a new approach that organisations are utilising to adequately manage their projects and stay ahead of the competition [16]. Web-based PM aims to solve the current limitations that exist in PM processes by improving task and team communication, thereby aiding in project automation [16]. Some of the key advantages that have emerged when using web-based PM include [3], [5], [16]:

- Projects can be more effectively tracked by project managers.
- Simpler assignment of responsibilities to team members on projects.

- An organisation's clients can monitor a project's progress and thus increase client involvement, which increases client satisfaction.
- Organisations can lower their costs by improving the overall business management process and reducing resource wastage.
- Enhancing team collaboration to ensure a structured transfer of information.
- Improving traceability and the creation of audit logs by maintaining all project data in a central location.

An illustration of the basic functionality that is provided within web-based PM can be seen in Figure 1.2. When this is combined with the Project Dashboard from Figure 1.1 it can become a powerful tool for project managers if implemented correctly.

Active Projects

Start Date	Description	Team	Budget	Comments	Due Date
Action A					
Action B					
Action C					
Action D					

Figure 1.2: Illustration of a Basic PM Tool to Track Actions Relating to a Project.

Web-based PM aims to successfully integrate all the above-mentioned PM techniques into one central tool [17]. This can then be used by all the members of a project team at any time to provide real-time updates and feedback on the active projects [3], [4]. This allows for instant report generation and immediate up-to-date feedback on all the projects through the means of a Project Dashboard.

Web-based PM provides the ability to track all the actions of a project in a structured manner [5], [18] and provides traceability by logging all the data that is recorded and manipulated by anyone who has access to the tool. It also aims to consider the scalability of projects according to their size and integrate all those involved on a project with the current actions.

1.3.5 Summary

The section provides a summary of the discussed methods available for PM in industry. All the discussed methods have their own and advantages and disadvantage when it comes to monitoring and reporting on the progress of a project. Table 1.1 summarises the advantage and disadvantage of each method.

PM Method	Advantages	Disadvantages
Logbooks	1. Simple way to record quick project updates. 2. Increased availability to provide brief project summaries.	1. Lack of data centralisation. 2. Limited input from other team members. 3. Not adequate enough to maintain the state of projects.
Project Audits and Performance Reports	1. Improved project performance. 2. Increased customer satisfaction. 3. Controlled project scope. 4. Early problem identification. 5. Identification of future improvements. 6. Manage project risks. 7. Integrated change control.	1. Frequency of occurrence. 2. Time-consuming. 3. Lack of centralised data. 4. Challenging process to consolidate the information for use by the team. 5. Inability to adapt timely to project changes.
Web-based Project Management	1. Centralise all data and information. 2. Track statistics and provide traceability. 3. Provide real-time access to data. 4. Increased access to data. 5. Increase the speed of information delivery. 6. Improved reporting capabilities. 7. Collaborate with team members in real-time. 8. Provide instant feedback to the client. 9. Customisable to the user's needs. 10. Ability to track changes and a history of completed projects.	1. Increased upfront cost. 2. Higher learning-curve. 3. Security risks. 4. Limited offline functionality. 5. Can complicate smaller projects.

Table 1.1: Table Summarising the Advantage and Disadvantages of Each PM Method.

From Table 1.1 it can be seen that web-based PM provides the most advantages when managing projects and is one of the more underutilised platforms which can be greatly used to improve PM in teams. Web-based PM provides PM teams with the most flexibility in terms of managing their projects and being able to effectively report on their progress.

1.4 Project Management Platform Suggested Requirements

1.4.1 Introduction

After analysing the background of PM introduced in Section 1.2 and then analysing the methods used for PM in industry in Section 1.3, a set of suggested requirements for a PM platform can be identified. These suggested requirements utilise the information brought forward as well as the methods used to identify what constitutes a successful PM platform for use in industry, to further improve on PM effectiveness.

1.4.2 Discussion

When referring to Section 1.2 and what defines effective PM, it should be noted that the scope of projects is always changing and that different projects require different management strategies. This means that to effectively manage projects, the required platform needs to adapt to the changing project nature that exists in industry. This also emphasises the scalability of projects and the need to store enough project data over time.

It is important to have effective team communication throughout a project to effectively provide feedback. All project personnel need to communicate in a central location to ensure that everyone is updated with the latest project progress. Ineffective PM can be a result of the lack of integration between the project teams and their clients, and reducing the communication gap that exists is essential. The right PM method can, therefore, sufficiently reduce ineffective PM and is essential for use in industry.

When considering what methods are available for PM in industry from Section 1.3, it was seen that logbooks provided a structured way to manage projects but lack the ability to centralise data amongst team members as not everyone has the most updated copy. Online logbooks are, therefore, utilised to help improve data centralisation through real-time access. Logbooks illustrate the need for structured, centralised data in PM.

The project audits and performance reports highlighted the importance of having instant access to the most up-to-date data available. The reports also illustrate the importance of having traceable data to ensure that the most appropriate accountability measures are put in place. These reports are useful for integrating clients with the progress of the project team, but need to be provided on a more regular basis.

From Section 1.3, it was noted that web-based PM platforms provided the most versatility. Web-based PM allows personnel to utilise all the benefits available in the discussed PM methods. They highlight the effectiveness of having a centralised platform to communicate project information and provide a simpler means for handling project scalability. Through web-based PM, project teams can more effectively communicate and have access to structured project data.

1.4.3 Summary

Section 1.2 defined PM and what is needed to achieve effective PM. Sections 1.3 then identified some of the methods available for PM that are used in industry. Using this information, a set of suggested requirements can then be developed for what makes an effective PM platform. It was noted that the following features are important to organisations when using PM tools:

- Having a generic platform
- Centralisation of project data
- User and data traceability
- Structured PM
- Scalable platform and data
- Ability to integrate all users

These suggested requirements will be used as the identified focus points and to evaluate the state of the art for PM platforms.

1.5 Identified Focus Points

The following focus points were identified after the necessary research was done on what PM is and what some of the common methods available to handle PM are. These focus points were identified to develop a method to achieve success and apply improvements to the current state of the art for PM in industry. Appendix A.1 defines the focus points. Table 1.2 summarises the definitions for the key focus points as well as what will be discussed in Section 1.6

Focus Point	Definition	Evaluation Criteria
Generic	Only one class needs to be written and it can be reused to accommodate for multiple project structures and variable data types. This is used to reduce the redundancy, increase the simplicity of the code, and improve the software maintenance cycle after development by only having to maintain limited files across multiple platforms.	1. Did the study use a generic backend to accommodate multiple teams and handle multiple project structures with variable data types?

Focus Point	Definition	Evaluation Criteria
Centralised	Focusing on a central platform from where all the actions on a project can be managed. Feedback on tasks can instantly be provided and updated so as to be brought to the attention of upper management and colleagues with improved efficiency. Everyone has improved access to the current progress on all the project actions.	1. Was an interface provided to centralise all management activities to improve resource sharing and communication? 2. Could all personnel involved (project members, teams, and managers) in the project access the interface to either view or update the actions on a project?
Traceability	Emphasising the user activity monitoring and recording all the changes throughout all project actions. Allowing for easier accountability, tracking, creation of audit trails, and reusability of previously implemented solutions on projects.	1. Does the system keep track of changes in PM activities? 2. Does the system record who made the changes to the actions? 3. Does the system provide a history of the data recorded for future reference and audit purposes?
Structured	The system model follows a set structure with shared attributes that allow it to be reused and reapplied on further separate platforms, adding more value to it being generic. A structured system allows for easier implementation on different case studies and allows for uniform PM across an organisation.	1. Did the system provide a structured view to efficiently display project information and reduce clutter? 2. Was the implemented structure considered for use by more than a single project team and not only single-system oriented?

Focus Point	Definition	Evaluation Criteria
Scalable	When the organisation follows a structured PM approach, it makes it simpler to focus on the scalability of the system. New features and attributes can be added and expanded on for use on different projects, providing separate custom functionality, focusing on allowing changes in the business's PM structure to accommodate for organisational scalability, and the development of a modular platform to further improve scalability and maintenance.	1. Was the platform scalable in terms of long-term use and, therefore, extensive data storage? 2. Can the platform continue to meet the demands of the organisation's PM structure as it changes over time (modular and adaptive)? 3. Does the platform allow for change to the structure for use in different organisations and accommodate the use of different teams?
Integrated	The integration of the organisation, the clients and the platform. Ensuring effective collaboration on projects by having organisation-client integration. Reducing the pipeline of information transfer before reaching the client. Ensuring that all personnel are aware of the workflows taking place and that no one is out of touch with the project and no tasks are being overlooked.	1. Did the study emphasise the integration of the implemented platform with the organisation and its clients? 2. Did the study reduce the pipelined process of directing information to the client?

Table 1.2: Table Providing the Summarised Definitions for Each Key Focus Point and Their Evaluation Criteria.

1.6 State of the Art

1.6.1 Introduction

After the literature review was conducted in Sections 1.2 and 1.3 on the background of and what is defined in terms of the scope of PM in industry, the state of the art can be defined. It was seen that successful PM needs to incorporate the use of all the following criteria- generic, centralised, traceable, structured, scalable, and integrated- to be considered successful.

The state of the art of PM platforms and methods used are evaluated against these focus points to define the existing gap in literature. The current literature is reviewed across multiple industries where PM techniques have been applied and the implementations in each industry are evaluated.

1.6.2 General Industry Project Management

The importance of having effective communication methods in PM is discussed in [3], where a modular Web-based PM System (WPMS) was developed for small- to midsize-businesses. The platform aimed to encourage an increase in interactions between project members and to provide a centralised system where everyone can communicate and share information. The platform provided the users with a single predefined structure to manage all the actions that occur within the project teams.

In [3], this study focused on the importance of communication within project teams and having a centralised interface to share resources and information. The system, although, could not be properly scalable as it was a single-purpose system that used a set structure from the beginning which does not consider the scalability of its projects over an extended period. The system was designed to only be used to manage the projects of the company, and did not allow the client to view any of the active projects; therefore, not allowing the proper organisation-client integration.

This is where developing a generic Action Tracking Platform can be used to improve the scalability of projects. This will ensure that PM structures can be effectively modified as businesses restructure. This will also allow different project teams to use their own individual approaches to manage the projects allocated to their team, as every project manager has a different method.

The ability to manage projects once they surpass their completion date is also valuable to the clients of an organisation, and the maintenance and management of this process can be considered a project on its own [19]. A platform [20] was, therefore, developed for systems management to aid in maintaining the successful operation of existing systems. The platform helped users track the current actions and allowed engineers to quickly report on the current operation of equipment. The platform was able to record the running information of equipment as well as providing work-order management, job management, and spare parts management interfaces, which are all key aspects as identified in [19].

The platform in [20] successfully aided in the reduction of the workload that was required to improve system management and maintenance, thus confirming the conclusion derived in [19]. The platform was able to provide a structured view of the current operation of all the systems that were being monitored by the platform. The system was, however, not made available to everyone on the project, only to the upper management for quick system overview, and was, therefore, not focused on centralising all personnel.

The platform developed is a good example of structured management, and provides numerous tools to the user to manage all the different aspects of the project but lacks the implementation of a generic model to promote the reusability and scalability of its system to larger platforms.

1.6.3 Software Development Industry

Using a software tool to manage your software projects might seem unconventional and counter-intuitive; however, software projects can become extremely large and require extensive resources, with multiple people working on one system. This is where proper communication and centralisation is vital to ensure the output of effective working software projects. Software companies often employ some form of PM to control the flow of all actions and provide the team leader with a clear overview of what is occurring.

In [21], a Software Project Planning Associate was developed for a software company to assist the software project manager in structuring, planning, and organising projects and their project staff. It provided traceability to their clients on active projects and helped ensure that a project is within budget, on time, and are delivered according to customer requirements. The system described in [21] illustrated the importance and the effectiveness of using PM tools for project managers to track the actions of their development teams., but was only made available to the project manager. The system implemented was also single-purpose and would lack the necessary scalability over time.

A web-based project work management tool was developed in [22] to assist personnel in managing computer-aided designs. This tool allowed for the developers working on the project to structure their tasks for the computer-aided designs that needed to be made. The tool was made available online through a centralised interface to allow for improved team communication. The application that was made was a basic PM tool which provided little beyond the capability of visualising a project's actions. The design was also focussed on a single-purpose implementation and lacks any further application outside computer-aided designs.

In [23], a survey was done on Trello, analysing the current web-based PM system for use in monitoring software development projects. After analysing the platform it was noted that it provided a centralised interface, which allowed for users to view project data, but lacked the necessary means for communication on the platform. The platform provided a structured view to organise the tasks that needed to be completed on projects, but provided a limited means of traceability. The platform however did allow for users to configure it to their project needs, but limited users to that configuration thereafter.

PRINCE2 is a complex PM method which is used for collaborative and controlled processes and is generally not affordable for small-scale development. Therefore, in [24] a web-based approach was used to manage PRINCE2 using Trello to overcome this problem. The platform provided an easy-to-use, customisable approach to managing small-scale software development projects. This method allowed the team members to effectively use the PRINCE2 PM method and allow for the effective communication of all the project team members. The platform was mainly used by the PM team and not made available to any outside sources, therefore, only proving beneficial to those using it. The platform also provided a limited set of historic data on the projects and not all the project data could be recalled.

From [22]–[24], the platforms which were utilised, laid emphasis on using web-based technologies to manage projects as a means to centralise a project's data. The systems provided the users with a basic means to structured PM, but mainly considered single-purpose solutions. The platforms that were used also provided a limited means of traceability to maintain a database of past projects and, therefore, did not consider the scalability of these platforms for long-term use.

The agile software development approach is used by 80% of software development teams and digital tools are often used to increase PM success [25]. In [25], a DashVis platform was developed for use on a large collaborative touch display. This was intended to centralise all the work which the development teams were doing and allow for them to update the progress on the tasks that they are assigned to, in real-time. Although, the centralisation of the platform was limited and the project data could not be viewed outside the development environment The system was limited in the functionality that in provided and was solely used as a single-purpose implementation, providing no means of traceability and only maintained real-time project updates.

In [26], a web portal for PM in electronics design software development was used which attempted to bridge the gap on the current shortcomings with current PM web portals. The platform was designed to allow software developers to communicate with each other on a centralised interface and share project data in real-time. It allowed them to view the current tasks that they are assigned to and update their current status. The platform provided users with a basic fixed layout for software PM and allowed users to maintain a database of all their completed projects. The platform was successfully implemented and allowed the software developers to interact more effectively with their clients.

1.6.4 Medical Industry

A basic means of applying PM to successfully conduct nursing research was presented in [18], as it is often missing in the management of a research study. The authors attempted to illustrate how using proper PM software can be advantageous. There are many practical issues when it comes to sustaining clinical research, and this is often neglected in industry. The study introduced the nursing team to numerous PM tools that could be used to successfully conduct their research and encouraged them to take additional courses in PM.

The results in [18] illustrated that by applying basic PM techniques they were able to run their teams more efficiently, allowing them to yield higher-quality data for their studies. The conclusion of the study was that PM techniques should be considered and applied for future work across more sectors within the medical industry to increase the efficiency in the industry.

In the medical industry, access to proper patient care remains a concern where the use of information technology to solve patient management problems is still limited [27]. Timely access to information that is available to all users is highly valued and is an ongoing problem [28], [29]. Patient flow and providing the proper software management tools that can provide real-time support to patients is of key importance to hospital managers [27].

An organisational access display system was developed in [27] for use in an Australian medical care facility. The system provided a centralised interface to the hospital staff to monitor and record patient flow information and keep track of the emergency operating theatre bookings. The users of the system were provided with a dashboard to view the state of the hospital in real-time.

This helped reduce the amount of time staff spent searching for information, and plans were to make the system available throughout the hospital to integrate the staff as well as the patients. The system's long-term ability to scale to the changing needs of the organisation are still to be tested over time.

Maintaining projects as well as maintaining equipment also requires the proper centralisation of data to keep track of what equipment is being used and how long before it requires maintenance. The management of equipment and ensuring that all the equipment is operating successfully is especially important in the medical industry. In [30], a single-purpose, Computerised Preventive Maintenance Management System for the haematology department's equipment was developed. It was used to monitor the equipment and help provide staff with the necessary insight into its state.

The platform in [30] successfully helped to minimise downtime, improve the operating conditions of the equipment, and provide immediate access to reduce the number of incidents that occur. The system also provided the users with the necessary timeline for all the equipment maintenance that had occurred and is still to occur, and who oversaw it, thus providing the users with basic traceability features in case of failure or data recollection.

As shown in [30], proper PM is crucial in the medical industry where people's lives are at stake. These PM techniques were also applied in [31] to develop a systems architecture for Remote Patient Monitoring. The system was developed to provide high-quality health care to the elderly by monitoring their vital signs. The system was built off a generic architecture so that the structure could be modified to meet the specific stakeholder's needs and thus provide the necessary monitoring functionality on a per-client basis.

A centralised view was provided in [31] to all the stakeholders to effectively improve the type of health care provided to the patients so that their vitals can be monitored and any risks could be handled pre-emptively. The platform provided a place to store the patient's health files and have them easily accessible. The study also illustrated the importance of having a generic model so that it could be implemented and scaled for use across the whole healthcare sector and stated that platforms like these are unlikely to mature without a generic architecture.

Managing the health of patients is extremely important, and being able to communicate the needs of patients to hospital staff is crucial [32], [33]. A Project Dashboard was developed in [33] to facilitate the proper communication within the Hamilton Health Sciences network. The system allowed the staff at the hospital to view the most valuable information and reduce the complexity of managing projects. The dashboard provided data traceability for accountability purposes and was able to represent the volume of work to be completed, whilst providing an easy-to-use system.

The dashboard that was created in [33] illustrated the practicality of PM and how the centralisation of the correct data can improve the efficiency of an organisation. The Project Dashboard served only as a stand-alone solution and could not be applied to other hospitals. The system also provided limited data traceability as it maintained logs of the data which can be difficult to maintain over time and, therefore, also lacked the necessary scalability.

A Microsoft Excel visual management tool was designed in [34] for program planning, PM, and evaluation in paediatric health care. It provided a semi-structured view to increase the transparency and awareness of the work within the organisation but was limited in its ability to share valuable timely information, being an offline management tool. This tool would also require administrative support after completion of the project to provide improvements as user needs changed over time.

Being an offline tool [34], it already showed how simply implementing some form of PM can improve the operation of an organisation. It was, however, reported that users become frustrated due to its lack of maintainability, not displaying the required information, and not having it available at the correct times.

1.6.5 Construction Industry

Effective PM is needed and used for many applications in different industry environments. One such environment where PM can be successfully applied is in the construction industry. In [17] both studies focused on the application of web-based PM in the construction industry. WPMSs are used in the construction industry to improve the speed of communication between team members. It also allows for real-time access to updates on projects from remote locations. Some of the key factors for making web-based PM successful in the construction industry are discussed in [17].

Knowledge management is a critical factor for the success of projects in the construction industry. In [17], the platform *WEB-CONS* was developed and tested within a construction company for capturing, storing, sharing, and using project and corporate information. The main aim was to centralise resources and the knowledge gained from the projects that were implemented within the company. The platform focussed on the traceability of capturing project actions, which allowed it to create a knowledge base that could be referred to in the development of future projects and their actions.

The study in [17] revealed that web-based PM is crucial within the construction industry. It demonstrated that the simple and rapid sharing of documents is important to the success of a project. The systems allowed password-protected access to all the active projects that the company was working on. This allowed integration between the clients of the company and the company to see the active projects and get updates on what was occurring at any time.

It was noted that the feedback from the companies on the developed platform was improved, which made it less complicated for the project managers to manage the progress of their projects. The systems provided structured management to the companies, but the manipulation of the structure would require them to be reconfigured and no user changes on the data could be monitored.

A web-based Project Collaboration, Monitoring and Management System was developed in [35] to aid project managers with construction projects. It allowed for a central connection to take place between project managers and the team members to share project statuses and successfully collaborate. The platform also provided the clients of the organisation with project dashboards to monitor the project's progress. The platform developed followed a detailed structure to provide everyone involved with a tool to effectively communicate.

In [35], the author stated that most companies required a generic model to fulfil their requirements; however, the implementation they used would need to be a more specific software system to fulfil the company's requirements at the time. The immense, interconnected structure that was developed meant that the system would be very limited in terms of its scalability if the company ever decided to increase the systems which were monitored, thus limiting the platforms long-term use.

A different approach was taken in [36], where PM techniques were used to integrate public administrators and citizens. This allowed for the faults in the city to be easily reported on. The system allowed for simpler fault management, and allowed management to keep the community informed on the current progress in reparation of the faults. Some of the common urban problems which occur are street faults, potholes or broken streetlights, and using a web-based PM approach allowed for the centralisation of all the actions occurring and assisted project repair teams to easily identify faults for the timely repair thereof.

The system implemented in [36] illustrates the effectiveness of improved communication through the means of a centralised platform to integrate users. PMSs can effectively be used to manage construction projects as well as the faults that occur after completion. The management system was able to improve urban life, and, through further development, could be a useful tool for numerous cities by increasing the scalability of the platform. For now, the system can only be generalised to help other communities as it was not focused on being generic.

Construction companies need to frequently report on the progress of their projects, and this often involves using performance reports to evaluate the state of current projects [36]. The ability to make accurate and informed decisions is important to project management, and it can often be time-consuming to generate the necessary reports. Project Status Dashboards are often employed within industry to report reliable and accurate information regarding the state of a project more efficiently [37]. This alleviates the strain on the project manager and allows them to apply their focus to the more crucial tasks at hand.

A Project Status Dashboard was developed in [37] to aid in progress reporting within a construction company. The tool helped project managers to remain informed on all the actions that were occurring under them. Having a project dashboard helped the project managers to establish useful Key Performance Indicators (KPIs) to successfully benchmark the running of all operations and maintain consistency across their projects. The tool was intended for use by project managers to centralise the project progress, which allowed them to easily maintain the state of all projects and develop consistent reports.

The tool developed in [37] still needed to be implemented for use within the company but provided promising reasoning to how beneficial PM tools can be in industry. The company aimed to increase the date integrity on projects through the recording of all user manipulations. It also focussed on storing large data sets for the creation of KPIs and reporting on previous data.

PM tools allow the managers of projects to produce useful KPIs to benchmark their projects and effectively communicate reliable and consistent information to their teams. The research also suggested that the use of PMS should be adopted by all companies in the construction industry, as it could provide valuable cost and time savings.

1.6.6 Fishing and Maritime Industry

The fishing industry has an ongoing problem of not having accurate and consistent data, which can prove critical for fishing operations [38]. It is important to manage all the data that is gathered to effectively monitor sea activities and provide real-time reporting on the state of operations. In the fishing industry, it is often difficult to create logical links between the immense complexity of the data collected; therefore, using PM tools can effectively minimise the gap that exists in the collected data.

In [38], an electronic logbook was created to provide commercial fishing companies and the regulatory authorities with more effective reporting, better stock assessments, management decisions, and traceability amongst others. The software developed is an effective means of introducing PM in the fishing industry for traceability and the centralisation of data as well as integrating all the necessary personnel to ensure everyone is on the same level of awareness with the current actions.

Providing fishing industries with the proper tools to effectively manage ongoing actions could potentially transform the fishing industry. The results obtained in [38] illustrate the importance of PM to improve on the current operations in industry. Using the proper tools can also drastically improve the reliability of data in the fishing industry by improving data quality and integrity.

Another sector that requires the use of proper PM tools is the maritime industry. The maritime industry uses PM tools to manage the instrument workflow on cruise ships for the maintenance operations that occur. A need existed in cruise ship maintenance to ensure that all the instruments were properly managed. It also required the improvement of the collaboration of the different members of the maintenance staff [39].

This was solved in [39] through the implementation of a WPMS to manage workflow processes and tasks. This system allowed for a structured view of all the maintenance equipment and maintenance procedures that were occurring. The developed tool facilitated better communication between the staff and centralised all the information as well as providing a host of records for all the maintenance procedures that had taken place. The system implementation was relatively new, and the scalability of the system needed to be reviewed further. The platform structured the maintenance procedures and reduced the miscommunication between maintenance staff.

The studies done in [38], [39] illustrate the need for effective PM techniques in the fishing and maritime industry. It was shown how the fishing and maritime industry can benefit from using proper PM tools. Through the implementation of web-based PM platforms, users can better centralise management procedures. The studies successfully reduced the strain on the staff and provided them with the necessary tools to increase productivity and reduce overhead.

1.6.7 Agricultural Industry

The management of farming groups can be an extensive task, especially when considering that some groups consist of over 500 employees [40]. The implementation of software applications aims to facilitate farming activities to ensure adequate access to information. The use of WPMSs is key, as farming groups are often decentralised from one another and effective communication can be problematic.

A WPMS was implemented in [40] for the Gapoktan farming group in Indonesia. It served as the foundational development for implementing successful communication between farming groups by centralising all the current activities occurring within the group. The system provided a structured approach to managing farming activities in which the structure could be easily manipulated to suit the needs of each group. The system provided a quick overview of the current activities and their status, allowing for this data to be viewed across the groups.

The system in [40] provided a basic approach to platform scalability by allowing the structure to be manipulated, but this still required intervention from the development team to carry out. The developed software successfully met the needs of the Gapoktan group and illustrated great progress in their PM approaches. The implementation of the study showed great promise for the future implementation of PM software in the farming industry.

Large-scale scientific research teams in the agricultural industry need to communicate research across different areas and need the ease-of-access to information [41]. A modern PMS was proposed and developed to solve this problem in [41]. The system provided the teams with a project dashboard to share research, control the flow of the project, and allow effective real-time communication through web-based technology.

The system in [41] achieved the aim of efficient PM and proved the need for the extensive use of PMSs to improve organisational integration; however, it provided a limited single-purpose structure for the whole organisation. The system served to store data for traceability purposes and provided a set structure to log project information.

1.6.8 Railway Industry

The proper operation of trains and the correct dispatching can require major overhead in terms of the actions that need to be monitored. That is why platforms such as the Train Dispatching Command System (TDCS) are required to mitigate any risks, ensuring smooth operation for the client [42]. The railway industry can be extensively vast, with many interconnected networks. This, therefore, creates the need for effective PM of all the collected data.

In [42], a platform was developed and integrated with the TDCS to support the proper management and control of all the data to assist the control room operators. The TDCS is a complicated system that requires a lot of overhead from the management and maintenance staff, and it's possible that they might miss information due to the scattered system data of different formats. It is also essential that all the user actions and logs are kept as the railway industry relies on highly accurate data for accountability purposes.

The developed platform successfully highlighted the need for effective PM and helped to provide real-time analysis of all the current actions, which maintenance staff and management could have access to through a centralised interface. The platform was able to reduce the work pressure on the maintenance staff by providing a proper management interface and ensured the continuity of train dispatching. Due to the amount of data collected, the scalability was difficult to achieve and the platform was only focused around live data-viewing.

1.6.9 Mining Industry

The implementation done in [43] aimed to improve the cooling system performance on a mine through the centralisation of the correct data to the mining personnel. It can be viewed as a rudimentary means of introducing PM within the mining industry. A Data Information Knowledge Wisdom (DIKW) model was implemented to increase awareness of and improve the cooling duty on the mine. It indicated how a simple hierarchy of wisdom, that highlighted the key factors to monitor, was able to supply project managers with valuable context and understanding of a system's operation.

This study is a good indicator of how proper centralisation of the correct data, even through a report, is crucial to the effective PM of systems. Creating this reporting structure, based on the DIKW model, illustrated how providing the correct insight is critical in PM, and the implementation successfully saw a cooling improvement of 55% on the operation.

Using this study as a necessary introduction to PM illustrates how providing management with valuable information translates to improved system management. If providing centralised, valuable data can achieve such desirable results, it is, therefore, possible that implementing the correct system for PM and the viewing of centralised data can provide even further improvements.

1.6.10 State of the Art Summary

According to the evaluation criteria in Table 1.2, the current literature was analysed and reviewed, where ✗ indicates that a study did not meet any of the evaluation criteria and ✓ indicates that a study met the evaluation criteria. Out of the considered studies, Table 1.3 summarises the state of the art that was discussed.

Ref.	Generic	Centralised	Traceability	Structured	Scalability	Integrated
[3], [24], [30]	✗	✓	Partial	Partial	✗	✗
[17], [38], [41]	✗	✓	Partial	Partial	✗	✓
[18]	✗	✗	✗	✗	✗	✗
[20]	✗	✗	Partial	✓	✗	✗
[21]	✗	Partial	Partial	✓	✗	✗
[22]	✗	Partial	✗	Partial	✗	✗
[23]	✗	Partial	✗	Partial	✓	✗
[25]	✗	Partial	✗	Partial	✗	Partial
[26]	✗	✓	✗	Partial	✓	✓
[27]	✗	✓	✗	Partial	✗	Partial
[31]	✓	✓	✗	✓	✓	✓
[33]	✗	✓	Partial	✓	Partial	✓
[34]	✗	✗	✗	Partial	✗	✗
[35]	✗	✓	✗	✓	✗	✓
[36]	✗	✓	Partial	✓	✗	✓
[37]	✗	Partial	✓	Partial	✓	✗
[39]	✗	✓	✓	✓	✗	✓
[40]	✗	✓	✗	✓	Partial	✓
[42]	✗	✓	✓	✗	✗	✗

Table 1.3: Table Summarising the State of the Art for PM in Industry.

It can be noted from Table 1.3 that most of the implementations do not consider the need for generic platforms for PM. The current platforms are only concerned with single-purpose implementations and do not consider their long-term use; therefore, many of the platforms are not scalable and will require future maintenance to keep up with an organisation's changing business environment.

Almost all the literature discussed considers the centralisation of PM actions. This is a key factor in improving data flow amongst a team but fails to consistently incorporate the clients who they are providing these services to. These implementations did not incorporate the full purpose of platform traceability. Most of the platforms were only considered with maintaining a database of project actions, but no focus was put on tracking user manipulation of the data for data integrity purposes.

Structured PM is key for teams to effectively improve their PM methods. Several of the studies that were considered partially met the structured requirements, but only implemented a structure for single-purpose use that could not be manipulated across teams, thus making their implementations less effective with larger PM teams.

Client involvement, as seen from literature, is key to improving the success of projects. Only a small portion of the discussed literature developed a platform which helped PM teams to more effectively communicate with the client. These studies showed more effective management with their projects when compared to PM platforms without client involvement, as they were able to communicate project

A more detailed look at the state of the art is provided in the appendix through Tables A.1 and A.2

1.7 Problem Statement

PM is vital to record the progress of a business and all the project actions that are currently taking place. As derived from the state of the art, the current problem is that there are a lot of platform-specific PM tools for action tracking in industry. These platforms aim to solve their objectives through single-purpose implementations where the structure meets the needs of the business for a short period.

This limits the platforms that were designed, as they become outdated and cannot scale with the business by allowing alterations in the way projects are managed. A considerable number of platforms focus on a higher level of project information centralisation, where only upper management uses the platform to control their teams and this increases the overhead for communication within teams.

Present platforms for action tracking provide limited access to the whole team but fail to include the client in key PM decisions. The platforms lack the necessary integration needed between the PM teams and their clients. These platforms also fail to maintain the key component of traceability by recording who made the changes on projects to further ensure the accuracy and validity of project data and integrity.

A problem exists in industry where there are a lot of system-specific PM tools available but the user interaction with these tools is inefficient. The focus needs to be put on the implementation of a web-based platform for PM in industry. There is currently no solution available that covers the identified focus points discussed in Table 1.2. This can be seen from the analysis brought forward by the state of the art depicted in Table 1.3.

1.8 Objectives of the Study

This dissertation aims to provide a solution for the state of the art to address the problem statement from Section 1.7. This will improve the current PM techniques in industry and increase the efficiency of PM within teams. The objectives that this study aims to achieve are outlined in the following section.

Primary Objective:

1. Design and implement a generic online action tracking platform for project management in industry and evaluate the obtained results and their contribution to strengthening the research field.

Literature Objectives:

1. Investigate and define what is PM and how it is done in industry.
2. Investigate and define the key focus points that go into creating a successful Action Tracking Platform.
3. Evaluate the state of the art as defined by literature.

Empirical Objectives:

1. Develop and implement a successful Action Tracking Platform to:
   (a) Meet the needs set out in Table 1.2 that were not addressed in the state of the art (Table 1.3),
   (b) Verify the platform by ensuring that it met the requirements and specifications (Table 2.1).
2. Implement the platform in industry and validate it by using case studies to conclude on the improvements in PM for a company and its PM teams in industry.
3. Validate whether the implemented platform solved the gap in the state of the art.
4. Evaluate the obtained results and conclude on the platform implementation.
5. Communicate the findings of the research and how it contributes to strengthening the research area and the current gap within.

1.9 Overview of the Dissertation

This section gives a summary involving the overview of this dissertation. It outlines the focus points of each of the chapters and what they aim to achieve.

Chapter 1: *Introduction*

This chapter introduced what PM is and provides a background on how it is currently implemented in industry. It aims to provide background on the current methods that are used by industry to achieve PM and, therefore, highlights the key focus points that make a successful Action Tracking Platform. The current literature is then reviewed against the key focus points and a conclusion is drawn on the state of the art for action tracking and PM in industry.

Chapter 2: *Methodology*

This chapter provides the design science research highlighting the research paradigm for the study. The chapter then highlights the methodology for how the system will be developed. It analyses the requirements and specifications for such a platform, and thereby the development of a solution to meet them. Highlighted is the high-level overview for the platform designed which indicates the specification for the design of the platform. The Action Tracking Platform's design and how it operates is described and illustrated as well as being verified.

Chapter 3: *Results*

This chapter provides the results obtained after implementing the platform in the separate case studies. The implemented solution is validated to ensure that it solves the problem defined in Section 1.7 and meets the objectives of the study defined in Section 1.8. The obtained results are discussed, and a conclusion is drawn on what was achieved with the implementation of the platform.

Chapter 4: *Conclusion*

This chapter provides the necessary conclusion on the implemented Action Tracking Platform. It provides the summary for the work done by concluding the results obtained and identifying whether the platform was able to solve the problem. Limitations of the current platform and any recommendations for future work are also provided.

Chapter 2

Methodology

2.1 Preamble

This chapter focuses on the methodology for the design of an Action Tracking Platform as well as all the aspects that go into its development to ensure that it covers the state of the art identified in Section 1.6. This ensures that the need for the study identified in Section 1.7 will be met through its implementation.

Outlined are the requirements and specifications of the platform brought forward in Section 2.3. The fulfilment thereof and the platform overview is covered by the development of solution in Section 2.4.

The final development of the Action Tracking Platform is discussed in Section 2.5, highlighting the methodology for the implementation of all the software modules. The methodology that is followed is then verified in Section 2.6 to ensure that all the requirements are properly met.

2.2 Design Science Research

A new set of artefacts are to be designed and implemented to address the current problems that are present with the utilisation of online PM platforms. Current businesses undervalue the use of effective PM management methods and the online PM platforms that they use fail to address all of their needs and scale with the growth of the business. A literature review was conducted on the background of online PM platforms highlighting their use and what makes them effective. This identified six key focus points that determine the success of their application. The key identified focus points are generic, centralised, traceability structured, scalability, integrated.

The current state of art was then evaluated which highlighted the implementation of online PM tools in different industries and indicated their current shortcomings when comparing their designs with the key focus points. This identified the problem and the need for the study, as not all of these studies aligned with the key focus points and highlighted the shortcomings of their designs for which contributions to improvement can be made.

This, therefore, determines the need for the design of several artefacts which are to be improved on and implemented in an online PM tool. The design for the artefacts aim to collectively improve on current designs and make the necessary improvements to contribute to a more effect online PM platform. The design for the artefacts are discussed in this section and how they contribute to making a more effective PM tool for use in industry.

These artefacts will make up the design for an improved online PM platform, which will contribute to allowing PM teams to more effectively manage their projects and deliver improved results. This will, therefore, define a new practice for the design, implementation and use of online PM platforms and will be the focus point of this study.

2.3 Requirements and Specifications

Discussed in Table 2.1 are the requirements defined to create a successful Action Tracking Platform. The specifications of the platform that need to be followed to meet the requirements are outlined. The requirements and specifications are obtained from the PM platform framework in Section 1.4 as defined in Section 1.5. This will ensure the fulfilment of the problem statement in Section 1.7 as well as the objectives of the study defined in Section 1.8.

Requirement	**Specification**
Generic	A generic structure should be implemented allowing for multiple project structures.
Centralised	All management activities should be centralised through a single online interface. This should allow for all members involved in the project to effectively communicate and share information.
Traceability	Recording all the changes that occur on projects and their actions to maintain traceability and accountability on the platform.
Structured	Providing a structured way to manage projects and their actions whilst considering the structure of the application for multiple projects and teams.
Scalable	The platform should be easily maintained and allow for the scalability of projects and the structure of the platform to allow for ongoing future use.
Integrated	Integrating the project teams with the clients and ensuring that all personnel are aware of the ongoing projects and their actions.

Table 2.1: Requirements and Specifications.

2.4 Development of Solution

2.4.1 Introduction

This dissertation aims to follow the IEEE Std 1074-2006 for Developing a Software Project Life Cycle (SPLC) [44]. This will ensure that a proper solution is developed for the problem stated in Section 1.7, and that the platform developed is properly verified. Following this standard, the platform design and overview can be presented accordingly. This section aims to give a high-level overview of the platform and the reasons behind the methods applied for its implementation.

2.4.2 The Development Cycle

Based on the IEEE Std 1074-2006, the following activity grouping for the Software Project Life Cycle can be defined in Table 2.2[44].

Section	**Activity Groups**
Project Management	Project Initiation Project Planning Project Monitoring and Control
Pre-Development	Concept Exploration System Allocation Software Importation

Section	Activity Groups
Development	Software Requirements Design Implementation
Post-Development	Installation Operation and Support Maintenance Retirement
Support	Evaluation Software Configuration Management Documentation Development Training

Table 2.2: The Activity Grouping for the SPLC as Defined by IEEE Std 1074-2006.

Using this standard, a procedure can be applied to develop a successful Action Tracking Platform. The standard in Table 2.2 is then summarised and can be depicted by the Software Development Life Cycle (SDLC) as seen in Figure 2.1.

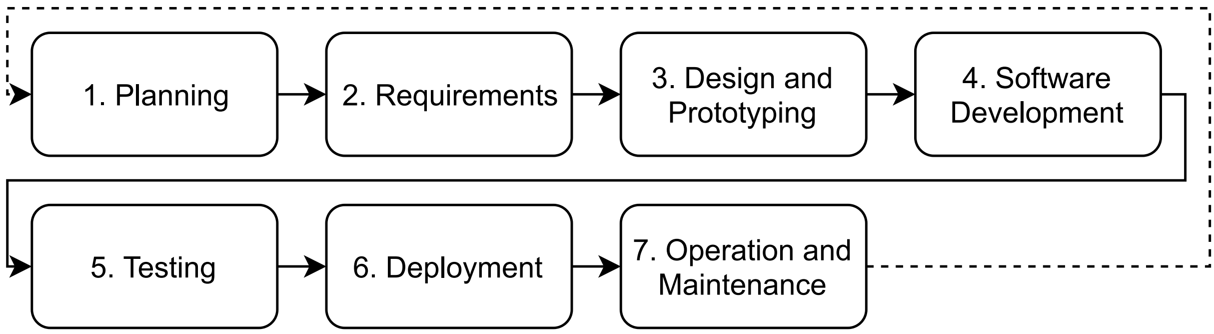


Figure 2.1: The Software Development Life Cycle [44].

This cycle illustrates the necessary steps that will be taken to develop the platform as well as how it will be maintained after development to meet the maintenance requirements. The SDLC and what it entails are described in Table 2.3.

#	Phase	Details
1.	**Planning**	The software tools that are available to develop such a platform will be analysed as well as understanding the existing infrastructure with which it needs to be integrated. This phase is used to understand the software environment that the platform will use, and initiate the start of the project (Section 2.4.3).
2.	**Requirements**	Determining the requirements and the specifications that the platform will need to meet: what features are important to the user, what features are currently missing from the state of the art, and what can be additionally provided and improved on (Section 2.3).

#	Phase	Details
3.	**Design and Prototyping**	Exploring various concepts and methods that can be used to develop the platform. Modelling the way the platform will be used through several iterative designs and prototypes (Section 2.4.3).
4.	**Software Development**	The development and implementation phase of the platform. Identifying what will be needed for the platform to meet the requirements and specifications (Section 2.5). Creating the first useable, deployed version for the PM teams so that feedback can be provided.
5.	**Testing**	Verifying that the software developed meets the requirements and the specifications (Section 2.3), and validating that an implemented platform will solve the problem (Section 1.7). Verifying that the platform fulfils the key focus points from the state of the art (Section 1.5).
6.	**Deployment**	Deploying the platform and making it available to the user to get feedback. Configuring the platform for use by the PM teams; thereafter, testing and making the necessary changes to optimise its use. Preparing the platform to run and operate in the specific environment of the PM teams and their projects. (Chapter 3).
7.	**Operation and Maintenance**	After the deployment phase, this phase allows the platform to be evaluated and properly configured for each of the PM teams. Providing the necessary training and support to all personal as well as documenting the use of the platform for easy access. Ensuring that the platform is properly maintained for future use and adapted as the needs of the user change (Chapter 3).

Table 2.3: The Phases of the SDLC and Their Descriptions.

This cycle in Figure 2.1 can be repeated to implement the platform for use by multiple PM teams in industry. This will allow all their actions to be tracked and ensure that the platform can be used for multiple project team structures. The cycle will ensure that a customisable, generic platform is created that is not limited to one use case and improves the PM structure within a PM team.

2.4.3 Platform Design and Overview

The environment for the Action Tracking Platform is designed according to Microsoft's `ASP.NET MVC`[1] Pattern. This allows the platform to exist online and be accessed from anywhere in the world. Figure 2.2 represents the basic principle behind Microsoft's `ASP.NET MVC` Pattern, and is the main method used for creating and configuring the Action Tracking Platforms to ensure the user can communicate and interact with the data.

[1] *ASP.NET MVC Pattern — .NET*. [Online]. Available: `https://dotnet.microsoft.com/apps/aspnet/mvc` (visited on 03/05/2020)

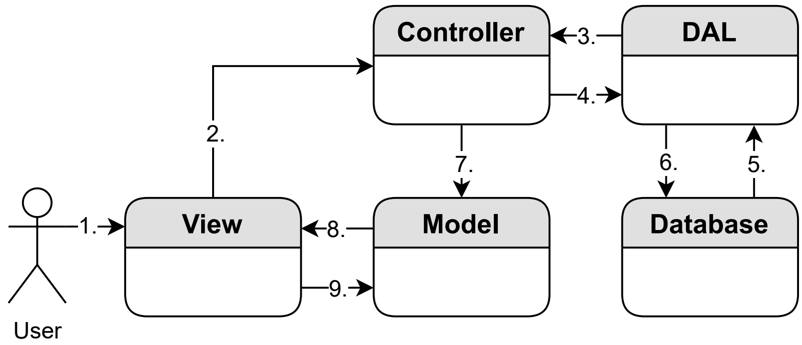


Figure 2.2: Action Tracking Platform Design Principle.

Where the Data Access Layer (DAL) is the step between the Controller and the database, the controller uses the DAL to retrieve data to update the model. Table 2.4 describes the numbers indicated in Figure 2.2.

#	Description
1.	`User` interacts with the `View`.
2.	`View` alerts the `Controller`.
3.	The `Controller` uses the `DAL` to read data from the `Database`.
4.	The `Controller` uses the `DAL` to update data in the `Database`.
5.	`DAL` reads data out of the `Database`.
6.	`DAL` updates data in the `Database`.
7.	`Controller` updates the `Model`.
8.	`Model` alerts the `View` that it has changed.
9.	`View` updates based on the `Model`.

Table 2.4: Table Defining the Numbers in Figure 2.2.

To fulfil the requirements defined in Table 1.2 as well as meeting the specifications for the requirements in Table 2.1, a variety of implementations were considered. It was determined that the main database used would need to be a `NoSQL` non-relational database[2]. This would be used to store all the actions and would help with overall performance[2].

By using the `NoSQL` data structure, the data can be easily manipulated over time and would mean that generic data structures can be stored in the same collection. This will assist in implementing a successful platform that will be easily maintainable and scalable as the projects grow. A `NoSQL` non-relational database would be used as the container to store all the recorded actions across the platforms.

A `NoSQL` non-relational database is chosen as it stores data in `JSON`[3]-like documents. This type of structure allows for maximum control over how data is stored and can easily be

[2] *Non-relational data and NoSQL - Azure Architecture Center — Microsoft Docs*. [Online]. Available: `https://docs.microsoft.com/en-us/azure/architecture/data-guide/big-data/non-relational-data` (visited on 24/09/2020)

[3] *JSON*. [Online]. Available: `https://www.json.org/json-en.html` (visited on 03/05/2020)

manipulated. JSON structures are fast and easy to use, the syntax is small and light weight[4] and it is an effective tool for sharing structured data of multiple forms.

JSON gives control over the structure of the data that is stored. It allows for many different generic structures to be created which can easily be saved in a NoSQL non-relational database in one collection. This allows the platform to have a generic structure that can effectively be manipulated by the user to suit the needs of the projects and their actions.

The design of the platform will encompass the development of methods to perform the necessary Create, Read, Update and Delete (CRUD) operations on the NoSQL non-relational database. These methods create the links between the PM team's tree structures (team project hierarchical structures) and the actions that are stored in the database.

The links will help structure the data and allow the correct actions to be retrieved on a per-platform basis. The links are relational and will be stored in an SQL[5] database. These links are made when actions are created on a node in the tree structure and the actions maintain the ID of the node that they are linked to in the grouping.

The actions that are created will be grouped according to the node that they are linked to on a PM team's tree structures, and this linking group is then stored in an SQL database. This will allow for numerous structure links and action groupings to be made to better fulfil the specifications of the platform. The type of link that will be needed is illustrated in Table 2.5.

Action Grouping	PM Team Structure
NoSQL Grouping ID	Node ID

Table 2.5: Linking Structure That Will Be Stored in the SQL Database.

These links will allow the actions to be grouped according to the specific node on a PM team's tree structure thus separating them by platform. The node ID from the PM team's tree structure, can then be used to search for the NoSQL Grouping ID. This will then retrieve all the actions in a group and ensure that all the actions can be linked to a node.

Using this setup for the configuration of tree structures allows for an Action Tracking tree structure to be created and, consequently, have a specific PM team's nodes linked to it. Figure 2.3 represents a PM team's tree structure and how groups of actions can be linked on a per-node basis.

4 *JSON - its advantages and disadvantages — JSON Web Service PHP*. [Online]. Available: https://ezeelive.com/json-advantages-disadvantages/ (visited on 03/05/2020)

5 *MySQL*. [Online]. Available: https://www.mysql.com/ (visited on 24/09/2020)

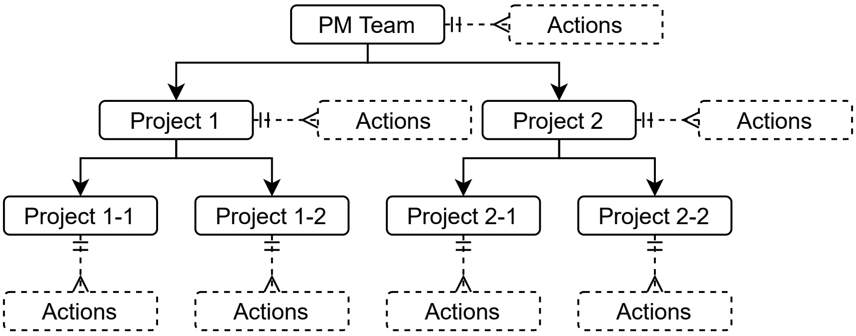


Figure 2.3: Action Tracking PM Team Tree Structure.

Every PM team can have their tree structure as outlined in Figure 2.3, and these tree structures will be specific to each platform. Every node on the tree structure can then have groups of actions linked to it which relate to that project. This will ensure that successful integration can be achieved with a PM team's already defined structure. It will be used as the method to group all the project actions and easily filter the data to the users.

Figure 2.4 illustrates a high-level overview of the proposed platform design that will be discussed in the following sections. Each component will be broken down and its contribution to the platform will be discussed.

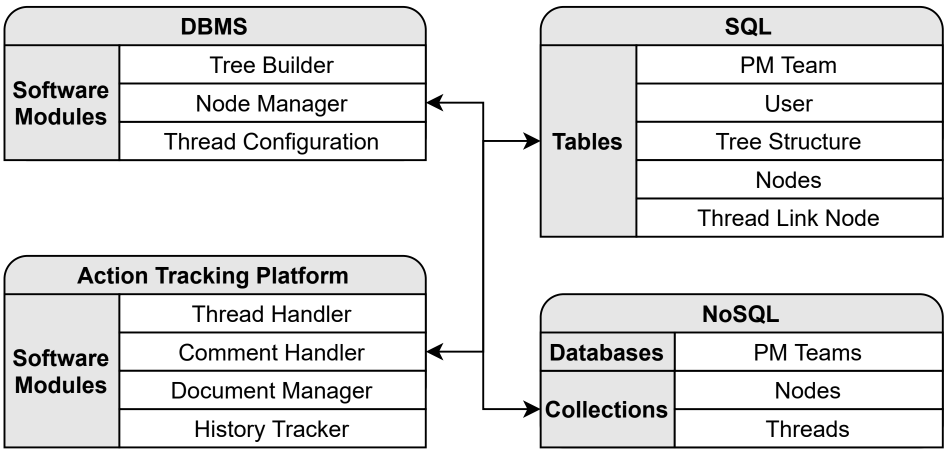


Figure 2.4: Diagram Indicating the Proposed Platform Overview.

2.5 Action Tracking Platform

2.5.1 Introduction

This section will cover the methodology behind the design of the Action Tracking Platform. After determining the development of a solution for the platform from Section 2.4, the software modules that meet the requirements and specifications from Section 2.3 can be identified. Table 2.6 illustrates the software modules that the Action Tracking Platform comprises as well as their reference in the methodology as seen in Figure 2.4.

Software Module	Requirement Met	Ref.
Thread Handler	Generic, Structured, Scalable	Section 2.5.4
Comment Handler	Centralised, Traceability, Integrated	Section 2.5.5

Software Module	Requirement Met	Ref.
Document Manager	Centralised, Traceability, Integrated	Section 2.5.6
History Tracker	Traceability	Section 2.5.7

Table 2.6: The Software Modules that the Action Tracking Platform Comprises.

The final design of the Action Tracking Platform will be illustrated and discussed as to where all the modules are integrated on the platform. This will then bring forward the methodology for the design of the entire platform as well as depicting its basic use cases. Each of the modules will be discussed in terms of their backend designs.

2.5.2 Action Tracking Platform Setup and Usage

The design is aimed to be as straight forward as possible and allow for several custom platforms to be created for different PM teams. The proposed steps that are involved in setting up an Action Tracking Platform for a PM team are described in Table 2.7

#	Step Description	Reference
1.	Create an Action Tracker tree structure based on the PM team's main structure.	Sections 2.4.3, 2.5.3
2.	Link the platform to a PM team and their tree structure.	Sections 2.4.3, 2.5.3
3.	Create new `NoSQL` groupings for each node on the tree structure.	Sections 2.4.3, 2.5.3
4.	Link all the created `NoSQL` groupings to each node on the tree structure.	Sections 2.4.3, 2.5.3
5.	Create a model for the PM team from the base model with any custom properties.	Section 2.4.3
6.	Configure a view for the PM teams based on the model that is created.	Section 2.5.3

Table 2.7: Table Defining the Proposed Setup Procedure for an Action Tracking Platform.

The basic use cases for most of the Action Tracking Platforms are illustrated in Figure 2.5.

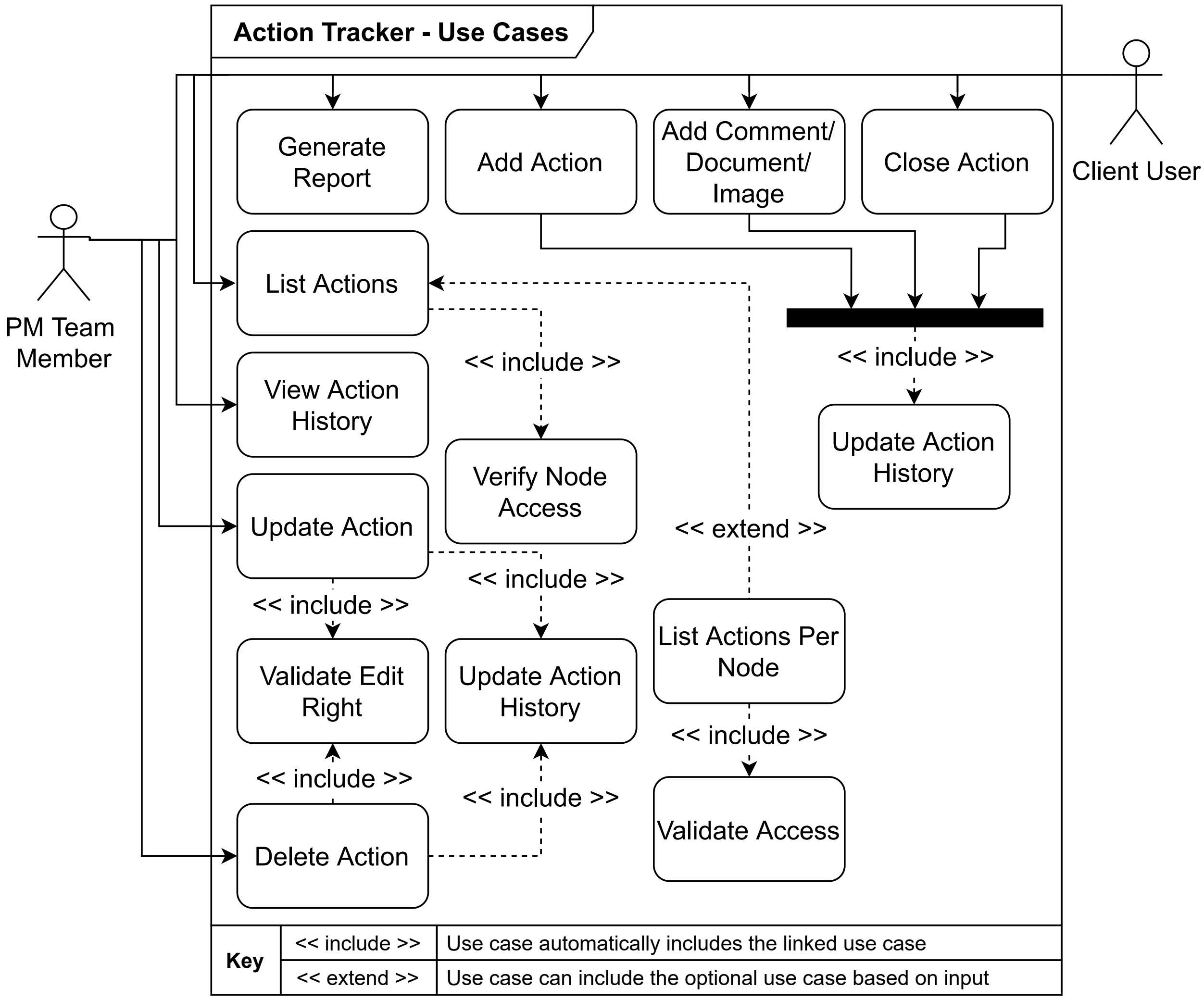


Figure 2.5: The Basic Use Cases on The Action Tracking Platform.

Figure 2.5 illustrates the basic use cases for how users will interact with the platform. Depicted is the basic functionality for an Action Tracking Platform and what interactions can be expected from a PM team member and the client.

2.5.3 Action Tracking Platform Model

One of the main requirements for the Action Tracking Platform is for it to be generic. This allows every PM team to use the platform their way to meet their needs. The model that the Action Tracking Platform uses also needs to provide a set structure across the PM teams.

This would allow for more structured tracking of actions across a PM team, thus contributing to better PM. The model needs to be easily modified on a per-team basis so that every platform is not based on the same structure. Having a generic model is important as not every PM team has the same structure and follows the same procedures for tracking their actions on projects as others.

Following the literature review that was done in Chapter 1, and analysing the way projects are managed, a base structure for all the actions can be determined. This structure is referred to as the Thread Document structure for development purposes. This structure is determined by analysing the implementations of similar platforms as well as looking at the needs of the PM team's current structure for tracking actions.

All the actions that are created across the PM teams will be stored in the `NoSQL` database. Each PM team has its database with its collections to properly structure the storage of data. The actions and the tags that they are linked to will be stored in each PM team's collections. Figure 2.6 illustrates the structure of the data storage in the `NoSQL` database

NoSQL	
Databases	PM Teams
Collections	Nodes
	Threads

Figure 2.6: NoSQL PM Team Collection Structure.

The `Node` collection will be used to store all the nodes that are linked to a tree structure for a specific Action Tracking Platform. A `Thread` collection will be added in the `NoSQL` database on a per-team basis and will be used to store all the actions from different Action Tracking Platforms on a per-team basis.

The structure would need to consider what is required from the user to track their actions as well as how the actions will be linked to a PM team. The base model of the Thread Document structure would, therefore, need to contain the necessary link that it has to a PM team. This will be done by storing the `NoSQL` Grouping ID that is associated with a node on a PM team's tree structure. This would ensure that actions maintain a reference to what node on a PM team's tree structure they are linked to.

Figure 2.7 illustrates the design for the model that will be used when creating an Action Tracking Platform for a PM team.

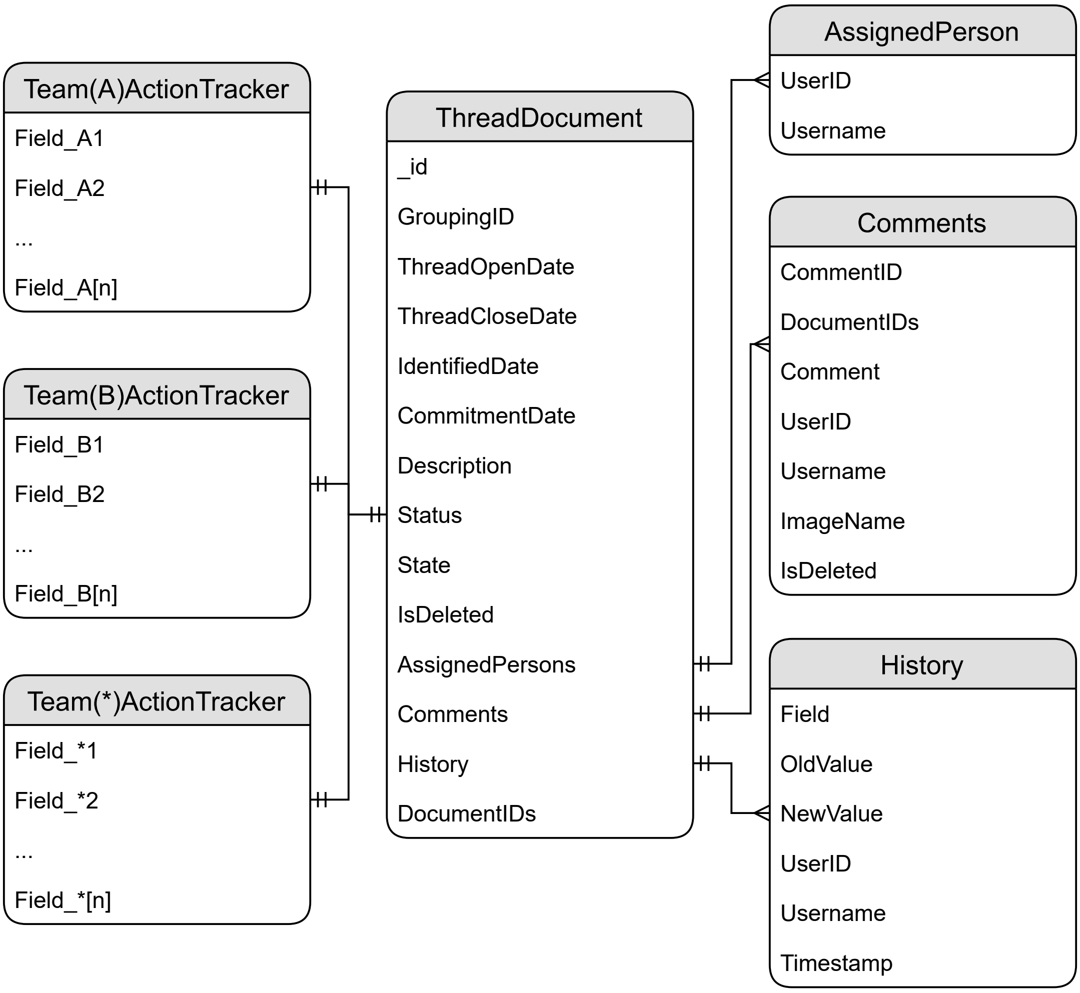


Figure 2.7: The Action Tracking Platform Model Structure Stored in a NoSQL Database.

This model illustrates the implementation of structured PM by having a set backend, but also implementing generic models that can be manipulated to fit the needs of the user. The model's design is discussed in the following sections.

Base Model

The initial design for the base structure of a Thread Document will be used as a starting point to store all the actions across the PM teams in the `NoSQL` database. The initial base structure is defined in Table 2.8.

Attribute	Description
_id	This is the primary key that the `NoSQL` database uses to identify and store all the documents.
Grouping ID	Contains reference to the `NoSQL` Grouping ID for linking actions to nodes on a PM team's tree structure.
Open Date	The date when the thread was created and stored on the platform.
Close Date	The date when the thread was marked as deleted and removed from the platform.
Identified Date	The user identification date of an action on a project.

Attribute	Description
Commitment Date	The planned user commitment date for completing an action on a project that can be set to null.
Description	The user description of what the action entails.
Status	Indicates whether the action has been completed or is still ongoing.
State	Indicates whether the action is on track concerning the current date and the planned commitment date.
Is Deleted	After an action is closed, it can be marked as deleted. Actions are never fully deleted on the platform for data integrity and to comply with the traceability requirements.

Table 2.8: The Initial Base Thread Document Structure for Storing Actions in the NoSQL Database.

The structure also requires that users be assigned to the actions, that any important documentation relating to the actions be linked, and those users can make any follow-up comments on the actions. For the documents to be linked to the actions, the storage of the `Document IDs` of each uploaded document is required, which ensures that any uploaded documentation can be linked to the actions and centralised for all users.

User Model

The addition of a new structure was required for users to be assigned. Table 2.9 defines the structure that is needed to store the assigned persons on an action.

Attribute	Description
User ID	The User ID of the assigned person.
Username	The username of the assigned person. Used for display purposes.

Table 2.9: Assigned Person Structure.

Comment Model

Comments on an action also required the addition of a new structure. Table 2.10 defines the structure that is needed to store the comments created on an action.

Attribute	Description
Comment ID	The Comment ID of the created comment.
Document IDs	The uploaded Document IDs.
Comment	The text of the comment.
User ID	The User ID of the person who created the comment.
Username	The username of the person who created the comment for display purposes.
Image Name	The name of the image (storage location) that is linked to the comment.

Attribute	Description
Is Deleted	When a comment is deleted on an action, it is marked as deleted. Comments are never permanently deleted on the platform for data integrity and to comply with the traceability requirements.

Table 2.10: Comment Structure.

History Model

To comply with the traceability requirements of the platform, there needed to be a way to maintain the history of all the actions. This is done by creating an additional `History` structure that each action would contain. Each action would store its own set of history models and maintain the changes that occurred to any attribute on itself. Table 2.11 defines the structure that is needed to store the history that is created on an action.

Attribute	Description
Field	Which attribute on the action was changed.
Old Value	The value that the attribute used to be before the change by the user.
New Value	The value that the attribute is after the change by the user.
User ID	The User ID of the person who made the change to the action attribute.
Username	The username of the person who made the change to the action attribute for display purposes.
Timestamp	The timestamp of when the change on the attribute occurred.

Table 2.11: History Structure.

This Thread Document creates a structured way for users to store their actions and unifies PM across the teams. Currently, this structure will form the base model that a PM team can use to ensure that better PM practices are applied. Using this Thread Document as a base starting structure, the platform would need to be designed so that PM teams can use this and create their models.

These models would then need to inherit from the base model and allow additional fields to be added on a per-platform basis. This would allow for the Action Tracking Platform to be generic and cater to the needs of each PM team.

This is done by making the Thread Document an `Interface`[6]. This would allow a Thread Document model to be created based on the interface and, thus inherit all of its attributes. The PM team models can then inherit from the Thread Document model, and a new singular structure can be created per Action Tracking Platform.

[6] *Interface - C# Reference — Microsoft Docs.* [Online]. Available: `https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/keywords/interface` (visited on 16/05/2020)

Using the interface would allow the model to not be bound by type, and the type can be determined for each PM team. This would allow for the proper handling of many Action Tracking Platform structures, and allow safe type conversion to handle many models with the use of only a single class.

If a new model is based on the Thread Document structure, this means that it can be handled and its data can be parsed correctly. This creates a powerful implementation, allowing the creation of different forms of Action Tracking structures to suit the needs of all its users and create a generic platform.

The implementation of this model ensures the proper tracking of a PM team's actions and provides them with a uniform means to efficient PM. The use of this model and how it is handled will be discussed in the following sections.

2.5.4 Thread Handler

The Thread Handler can be considered as one of the main modules that the Action Tracking Platform has. It allows the platform to be generically created and maintains all the actions in a central location. The implementation of the Thread Handler, combined with the way that data is handled and stored, would ensure the platform is properly scalable for future use.

This module controls all the CRUD procedures that are taking place by the user and interacts with the necessary databases. It controls the way the data is mapped to a specific model and where the data is stored. The module's functions are created generically to be able to handle any of the models that are created and that are in use across the platforms.

To handle the data on the platform, the functions need to be defined in two stages. This would ensure that the data gets mapped to the correct model at runtime and can be properly manipulated or readout of the database.

The CRUD functions all follow similar definitions in that two phases are involved when working with the data. For phase 1, when a platform is accessed depending on the Node ID, the correct `NoSQL` Grouping ID can be retrieved and the PM team structure can be determined (Table 2.5). This would ensure that throughout Phase 2 the data that is either being read from or written to the database is mapped to the correct Action Tracking model.

The only difference is that the read function has to retrieve the data and return it in a view to display it to the user. The CRUD functions serve to update the models that are already stored in the `NoSQL` database and need to know the structure to know what parameters to update. The updated models are then written back to the `NoSQL` database.

Figure 2.8 illustrates the flow of logic for the backend design of the Thread Handler module.

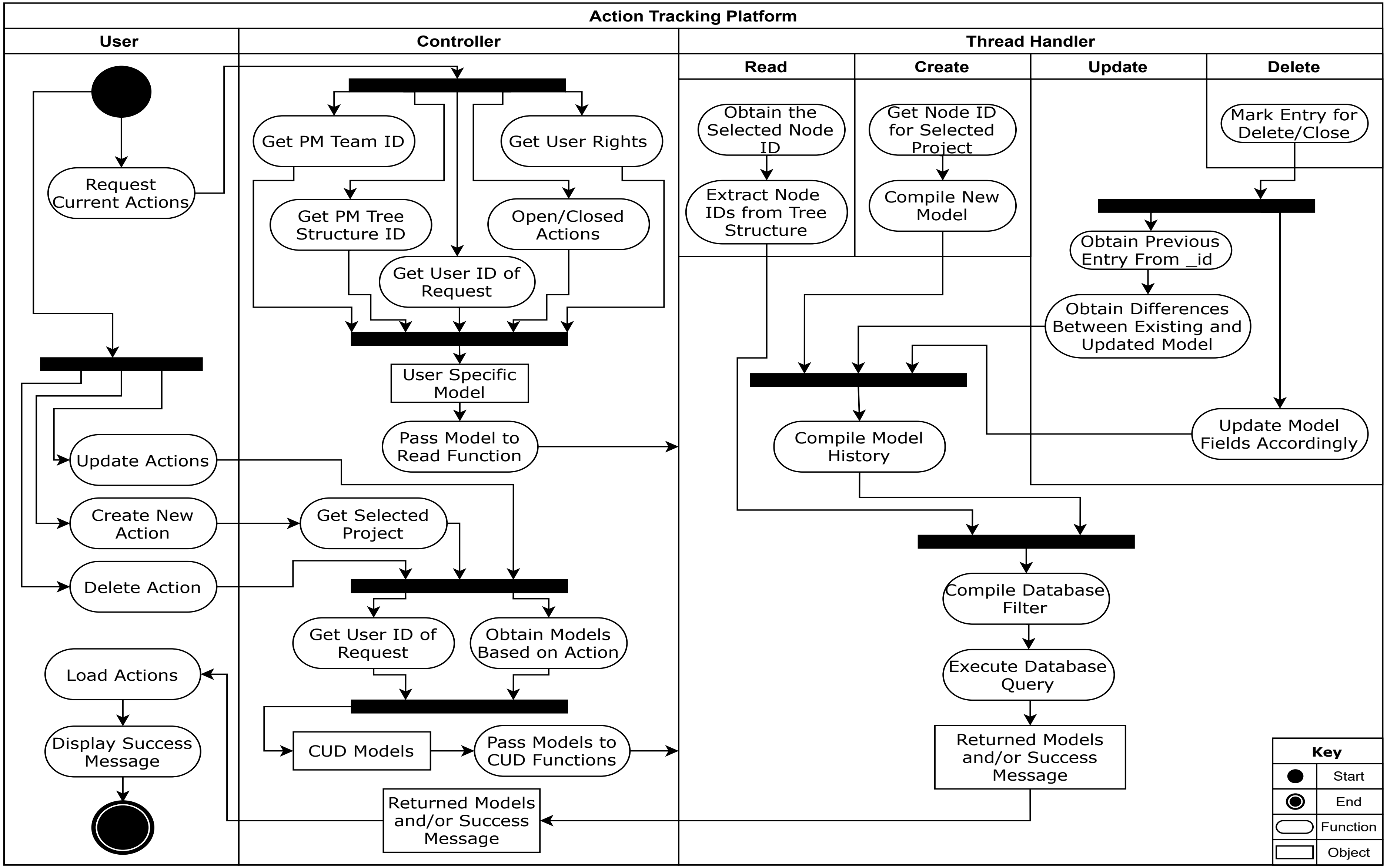


Figure 2.8: Swimlane Diagram Illustrating the Processes Involved for the Thread Handler Module.

2.5.5 Comment Handler

For every action that is created, it is possible to link comments to those actions. This is done so that users can update the progress of an action and allow it to be visible to all users. This would ensure that everyone is kept up to date with the progress on an action and provide further traceability on the platforms. Users can create comments and link any relevant documents or images. This creates a centralised means for communication across teams, and users can easily provide feedback on the actions that they are assigned to.

Backend

For every comment that is created, a new comment model is made with the relevant data and then linked to the list of comments that are on an action. The platform automatically records the timestamp of the comment as well as who created the comment. This is done for data integrity purposes and ensures that the proper traceability measures are put in place. Figure 2.9 illustrates the flow of logic for the backend design of the Comment Handler module.

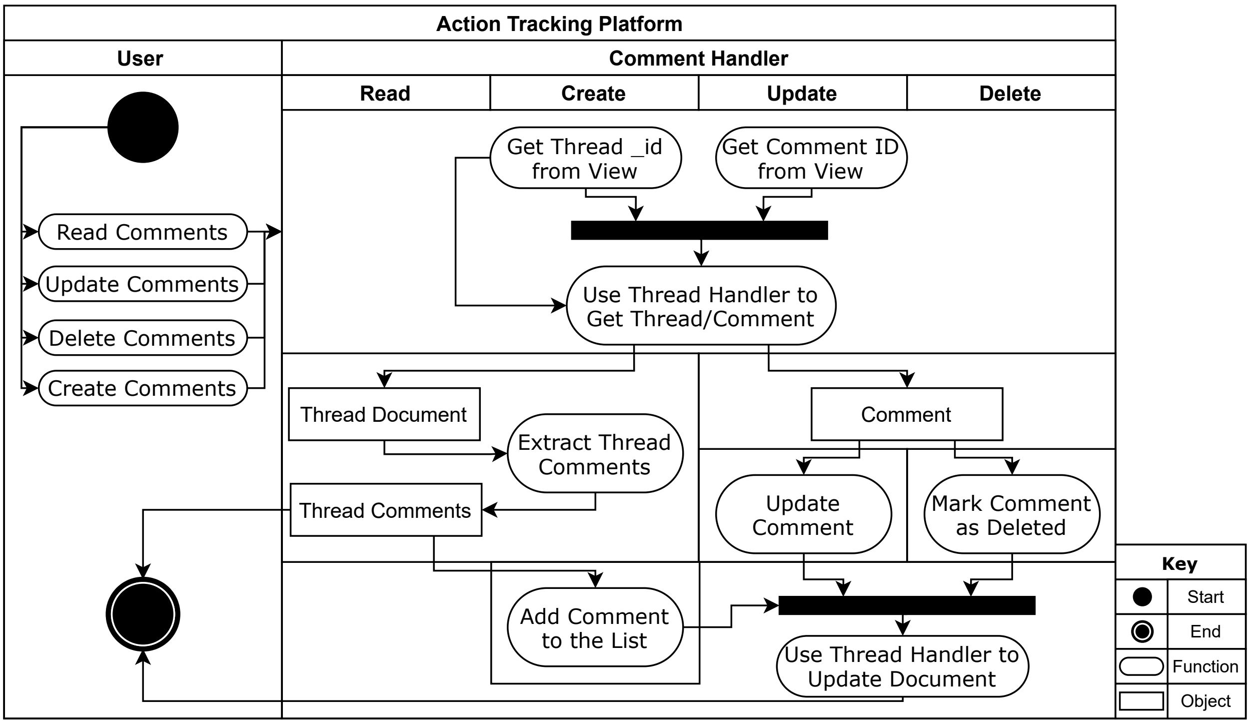


Figure 2.9: Swimlane Diagram Illustrating the Processes Involved for the Comment Handler Module.

2.5.6 Document Manager

The Action Tracking Platform also implements the use of a document manager to store documents. This allows documents to be linked to every action and its comments. It allows the platform to provide more value to the user by providing them with an interface to link and centralise any relevant documentation regarding an action.

This brings more structure to the documents that are being stored within the PM team and provide context behind the storage of a document. The document manager also provides traceability for the work that is being done on actions, as users can link relevant documentation and have it readily available. The design of the document manager aims to encompass the integrated, centralised, and traceable needs for the design of the platform by allowing the relevant documentation on projects to be maintained.

Backend

When a document is uploaded on the Action Tracking Platform, an entry would be created in the Document Manager. The Document ID of the uploaded document is then stored and linked directly to the action. Documents can either be uploaded directly to an action or linked with the comments of an action. Functions are created to read and to link the documents created to either an action or a comment. Figure 2.10 illustrates the flow of logic for the backend design of the Document Manager module.

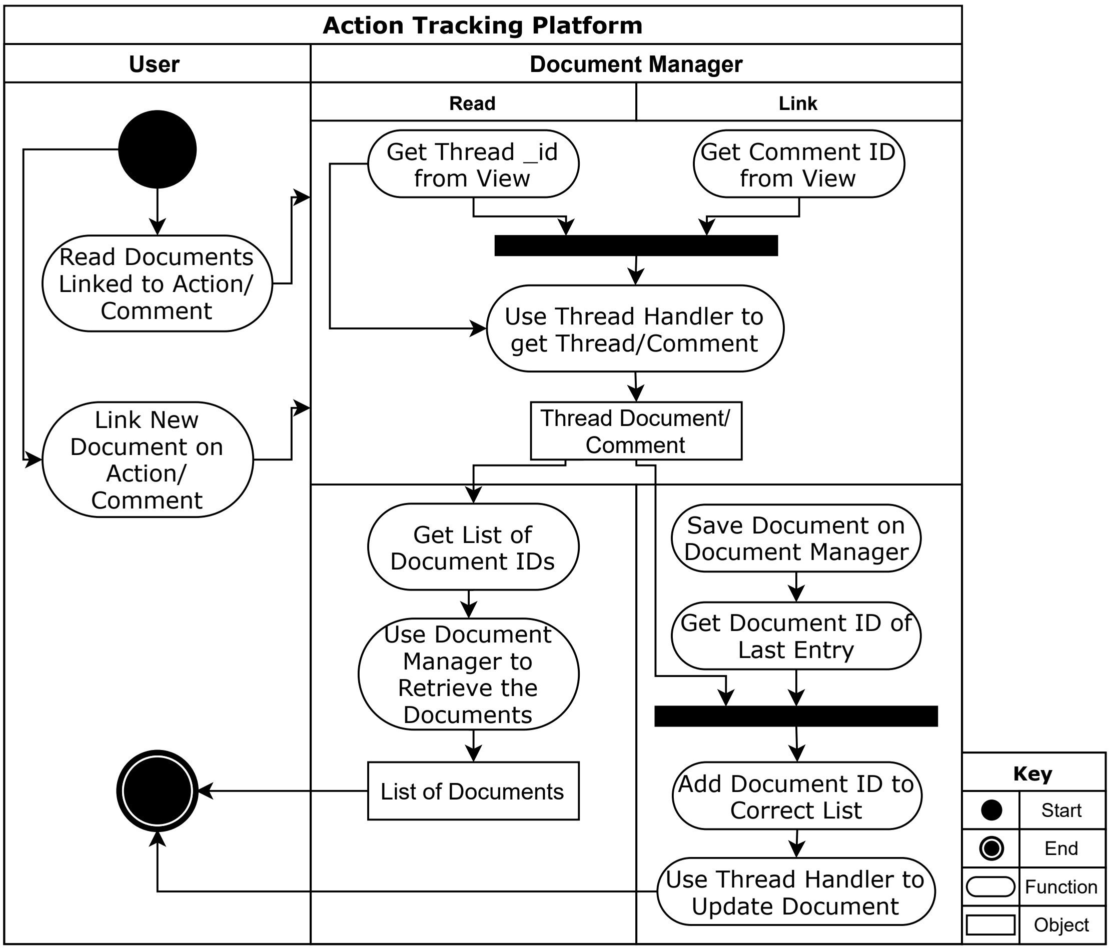


Figure 2.10: Swimlane Diagram Illustrating the Processes Involved for the Document Manager Module.

2.5.7 History Tracker

As one of the requirements from Section 2.3 and one of the fulfilments to meet the state of the art from Section 1.6, the platform must provide user traceability. This is where the development of the History Tracker is required.

The History Tracker ensures that every single update that a user makes is properly recorded and that the data integrity of all entries is maintained. Using the history helps of an action aid with user accountability as no update on any of the actions goes unnoticed and no incorrect data manipulations can occur.

Every action records the updates that occur to its fields within its list of history models. This data is only shown to the project managers and can be used to identify when changes took place and by whom. The History Tracker can be used to re-correct entries that are incorrectly updated or used to conduct project audits and track the user involvement with the actions that they are assigned to. It is a valuable tool to ensure that no data is incorrectly changed or deleted, and project managers can always rollback in case of an error.

None of the actions can be deleted and they are only marked as deleted in the database. This allows users to recall all the complete actions and view any of the changes on them. The implementation of the History Tracker helps contribute to successful PM, ensure the validity of any of the data entered, and provide the correct traceability amongst the users of the platform.

When an action is updated, the action is first passed to the History Tracker module before being written to the database. The existing document with the same ID would then be returned from the database. The existing document would then be compared with the updated document. Each field is analysed comparing the new value with the existing value.

If a change is detected, the existing and new value is added to a model along with the user that made the change and the timestamp of when the change occurred. The model is then added to the updated model's list of historical changes, and this new model is written to the database. This overwrites the previous entry but maintains a continuous list of all the changes that occur.

The typical format for the data being maintained in the history class is illustrated in Listing 1.

```
"Traceability"
{
    "Field"     : "Status",
    "OldValue"  : "False",
    "NewValue"  : "True",
    "UserID"    : 123,
    "Username"  : "Scott Hall",
    "Timestamp" : "2020-03-27T10:39:20.828Z"
}
```

Listing 1: Example of a Traceable Record Structure Entry.

It is noted in Listing 1 that the old value and the new value are recorded in case the data needs to be reverted; therefore, maintaining data integrity. The user who committed the change as well as when the change was committed is also maintained.

This helps provide the proper traceability and accountability amongst the users that utilise the PM platforms. The entry depicts how the Status field was changed, maintaining the user that changed it, the time it was changed, and what it changed to. This type of tracking accurately applies the definition of traceability.

2.6 Verification

2.6.1 Introduction

This section serves to verify that the methodology implemented correctly fulfils the requirements and specifications set out in Section 2.3 to comply with the evaluation criteria from the state of the art outlined in Section 1.6. The proper verification of the methodology will, therefore, ensure that the problem statement defined in Section 1.7 is correctly met with the final implementation of the platform.

2.6.2 Generic

The Action Tracking Platform is designed using a generic model as discussed in Section 2.5.3. This is done by creating a base class that contains reusable attributes concerning PM. The implementation of every Action Tracking Platform for a PM team can then extend this backend with their attributes. This, therefore, means that multiple different models for action tracking can be implemented, extending the usability of the platform.

A generic method to handle the multiple classes was implemented as discussed in Section 2.5.4, and the design was verified using integration tests. The integration tests would ensure that the Thread Handler can properly cast the correct models and handle different structures that may exist for each PM team. The tests are designed to verify the CRUD procedures of the Thread Handler to ensure that the platform can handle variable structures with different data types. The tests would also verify that these structures are correctly created in the `NoSQL` database.

The following testing procedure illustrated in Figure 2.11 is used to verify that the Thread Handler is implemented as a generic method.

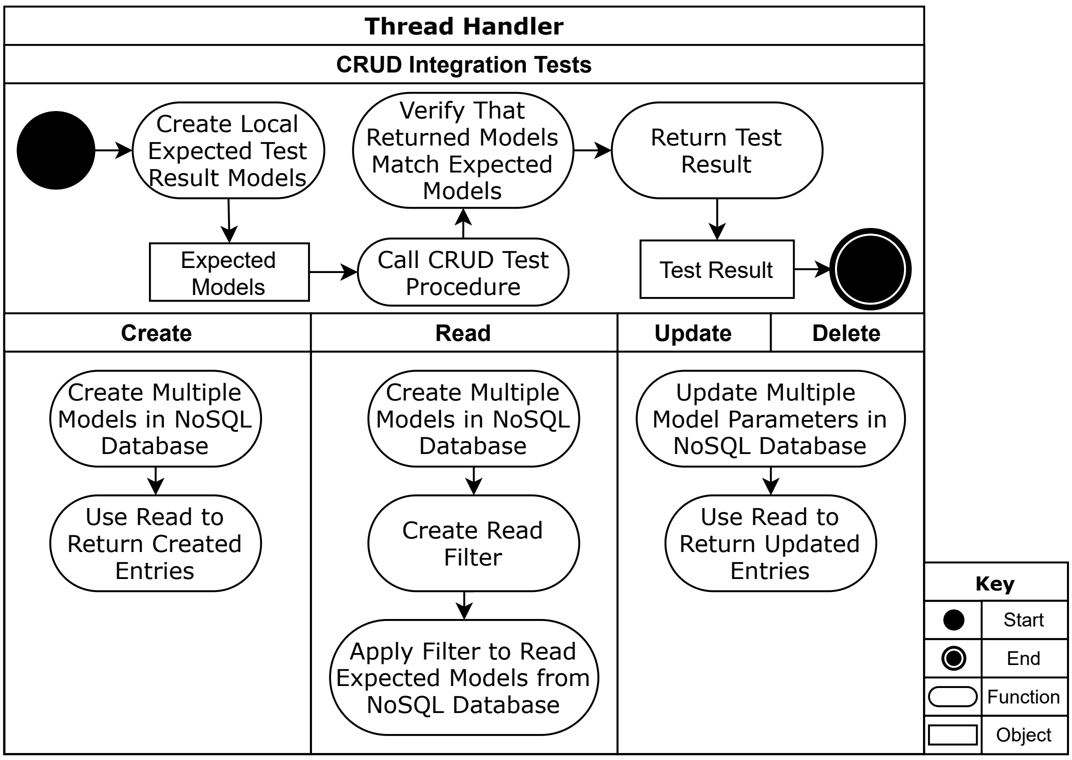


Figure 2.11: Integration Test Procedure Followed to Verify That the Action Tracking Platform is Generic.

The test procedure verified that CRUD methods can handle multiple different model structures and that the test conditions are met. The successful execution of all test procedures ensures that a generic backend is implemented. It verified that the Action Tracking Platform can handle multiple project structures with variable data types and that the correct methodology for the Thread Handler is followed.

2.6.3 Centralised

One of the main aims of the platform is to provide a centralised interface where all users can interact and maintain the user-awareness on all the responsibilities that they have. The platform is implemented using a web-based infrastructure as discussed in Section 2.4.3. This means that the platform can be accessed through any modern web-browser from all over the world.

The platform allows all the information on the current projects to be recorded on a centralised interface, and, through the correct login credentials, access can immediately be granted to anyone. This means that everyone can provide instant feedback on the actions that they are assigned to as well as view or update them.

Through the implementation of the Comment Handler and Document Manager software modules, as discussed in Sections 2.5.5 and 2.5.6, users can effectively share project resources. The resources for a project can all be maintained and accessed through a centralised interface, where users can make any comments relating to the tasks that they are assigned to.

The Comment Handler ensures a central place for effective communication between anyone involved in the projects. The centralisation of the platform through a web-browser increases the means of resource sharing. Project managers can manage their teams more efficiently through the centralisation of all actions within a team. This static verification of the methodology confirmed that the correct procedure is followed for the platform to meet the centralisation requirements.

2.6.4 Traceability

For the Action Tracking Platform to meet the traceability requirements, a History Tracker was designed as discussed in Section 2.5.7, which would ensure that all the changes are tracked in the PM activities. The module implemented can track any changes that occur on any of the attributes of the recorded actions as well as who made the changes and when. Every action is stored and its own set of changes is kept track of, and, using the History Tracker, they can be retrieved for display to the requesting user.

This helps contribute to the data integrity on the platform by ensuring that no data is incorrectly manipulated. It also means that if the data is manipulated on an action it can be restored. All the actions are maintained in the `NoSQL` database and none of the actions are deleted, but rather marked as deleted. This means that any data can be retrieved for audit purposes when requested in the future. All of this ensures that the proper traceability requirements of that platform are fulfilled.

The methodology of the History Tracker is verified by implementing integration tests to ensure that when updating a model, the correct set of changes are tracked and stored. The following testing procedure illustrated in Figure 2.12 is used to verify that the Action Tracking Platform met the correct traceability requirements through the implemented History

Tracker.

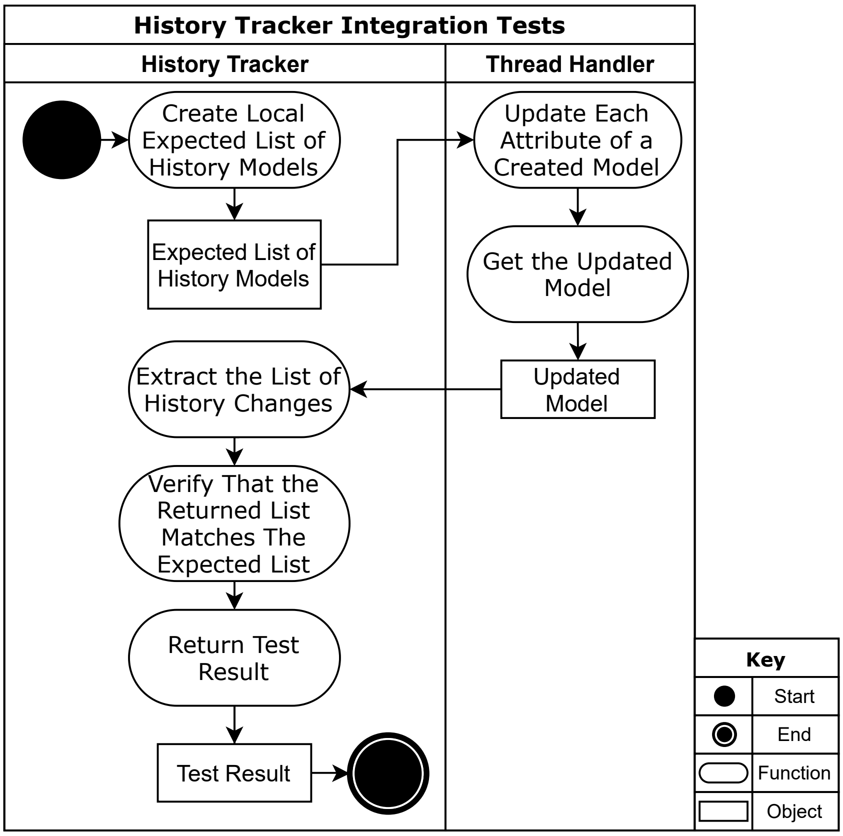


Figure 2.12: Integration Test Procedure Followed to Verify that the Action Tracking Platform Implements Traceability Through the History Tracker.

The implementation of the History Tracker verified that the correct traceability requirements of the platform are met. The integration test also verifies that the correct methodology is followed for the implementation.

2.6.5 Structured

The verification of the implementation of structured PM is illustrated through the design of the models that are used as discussed in Section 2.5.3. The implementation of the models verified that the platform would allow for structured PM across the PM teams. The base model would ensure that a uniform approach is followed across the PM teams. By allowing different platforms to extend and create more complex models from the base model, the base model illustrated that it can be used across multiple platforms.

Having the base model applied greater reusability of the platform, allowing multiple PM teams to implement their approach to PM whilst maintaining a set structure per platform. Section 2.5.2 describes the methodology for the platform and verifies the structured approach as illustrated in Figure 3.2.

The design of the interface ensures that project information is displayed efficiently to reduce the overhead that comes with PM. This static verification of the methodology confirmed that the correct procedure is followed for the platform to meet the structured requirements.

2.6.6 Scalable

The scalability of the Action Tracking Platform is one of the most important features, as projects can often increase in size as time goes on. Projects also experience scope creep, and as a result a lot of changes can be made. The platform is aimed for use by multiple PM teams, where the platforms can experience a lot of overhead. This means that the data that it stores will quickly grow throughout its life cycle.

As can be seen from the methodology, the platform is divided into different software modules. This is a key point that is brought forward from the literature review. Dividing the platform into separate modules ensures that it will be properly scalable and maintainable over time. The separation into modules also decreases the complexity and overall compile time of the platform. This methodology will ensure that it will be able to efficiently handle an increased user base and effectively scale with an increase in project data.

To comply with the scalability requirements of the platform, it was decided that the entries created should be stored in a `NoSQL` database. A `NoSQL` database is capable of transactional stores where performance is a concern, and can store data structures that evolve. The implementation of a `NoSQL` database ensures that vast amounts of data can be stored with varying structures and data types[7]. The data can also be retrieved in chunks and easily passed to the correct types, which ensures that a PM team's action tree structure can vary with time. A `NoSQL` database provides high performance, availability, and automatic scaling[4].

Using a `NoSQL` database means that the platform can be easily scalable for excessive data storage across multiple platforms. The implementation of the model discussed in Section 2.5.3 means that the platform can continue to meet the demands of a PM team's changing PM structure.

The changes in the PM structure can be correctly stored and easily modified on a `NoSQL` database. By combining the generic implementation of the methods with the possibility of storing different structures, it is verified that the platform will be properly scalable.

2.6.7 Integrated

One of the main focuses of the platform is that it can properly integrate the clients of the PM teams into all PM activities. This would ensure that the clients get the required feedback on their projects and that they are always kept updated with a project's status. In terms of proper PM, this is of great value to the PM teams and their clients and can greatly improve their business relationship.

As discussed in Section 2.4.3, the platform is made available online and accessible from anywhere in the world. This allows all users of the platform to obtain instant feedback on a project's actions. The platform design allows PM teams to interact with the active actions effectively as well as delegate responsibilities.

The Comment Handler discussed in Section 2.5.5 also allows communication to occur between the company and their clients by allowing them to provide instant feedback and updates. With the integration of the Document Manager, discussed in Section 2.5.6, it also allows the

[7] *What MongoDB is and What it Does Well.* [Online]. Available: `https://optimalbi.com/what-mongodb-is-and-what-it-does-well/` (visited on 30/05/2020)

sharing of important resources between the involved parties. This would lead to the pipeline of information conveyed between the company and the client being reduced.

The implementation of all these components allows the platform to properly integrate the company with its clients. It ensures that important information can be correctly conveyed to the client and that no one is out of touch with the ongoing projects. Feedback can also be quickly provided to the client and ensure that none of the actions goes overlooked as everything can easily be recorded. This static verification of the methodology confirmed that the correct procedure is followed for the platform to meet the integrated requirements.

2.6.8 Verification Summary

Table 2.12 summaries whether the requirements and specifications from Section 2.3 are properly met. This in turn verifies that the platform design is properly implemented and confirms that the correct methodology is followed.

Requirement	Methodology Ref.	Requirement Met
Generic	2.4.3, 2.5.3, 2.5.4	✓
Centralised	2.4.3, 2.5.5, 2.5.6	✓
Traceability	2.4.3, 2.5.5, 2.5.6, 2.5.7	✓
Structured	2.4.3, 2.5.3, 2.5.2	✓
Scalable	2.4.3, 2.5.3	✓
Integrated	2.4.3, 2.5.5, 2.5.6	✓

Table 2.12: Requirements and Specifications Verification Summary.

2.7 Conclusion

This chapter provided the necessary methodology for the design and implementation of an Action Tracking Platform for PM in industry. The requirements and specifications that needed to be met by the platform were outlined. This led to the development of the solution and outlined what procedures and software modules would be used, summarising a high-level overview of the platform design.

The platform was designed to provide a web-based platform to PM teams. The data for the platform was stored across the `SQL` and `NoSQL` databases, and the necessary software modules for interacting with these databases were designed. The tools needed to make the software modules that would be specifically implemented for the platform were discussed. Each software module's methodology is discussed as well as how it was used to create the Action Tracking Platform.

The methodology was verified to ensure that the user requirements and specifications were met, thereby fulfilling the state of the art. The methodology for the design and implementation of an Action Tracking Platform was successfully achieved.

Chapter 3

Results

3.1 Preamble

This chapter identifies the results that were obtained by implementing the Action Tracking Platform on different case studies in industry. These case studies involve the different PM teams within the company that aim to improve the client's energy usage needs and improve their overall operating efficiency. The platform aims to cater to the PM teams and the clients to improve on the current PM methods that are in place.

The PM teams must undertake several projects to meet the demands of the company's clients. The techniques currently employed become difficult to manage with increasing project scale and the number of active actions. This chapter will discuss the implementation of the Action Tracking Platforms and how it catered for each of the case studies.

Each of the platform results is presented based on the evaluation criteria and are then summarised, comparing the inception and presently recorded results. The effect the platform has on the PM performance improvement after the evaluation period is then evaluated and discussed.

This chapter aims to illustrate the fulfilment of the problem statement defined in Section 1.7 by meeting the objectives of the study from Section 1.8. The platform will be validated to ensure that the state of the art from Table 1.3 is fulfilled. The results obtained from the implementation will also be used to determine the fulfilment of the requirements and specifications from Section 2.3. The chapter will then conclude with the improvements noted through its implementation for use by the company and its PM teams.

3.2 Project Management Performance Evaluation

To evaluate the effect the Action Tracking Platform had on improving PM, the PM performance criteria needed to be determined. The necessary evaluation criteria were obtained through the analysis of literature and relating to monitoring the improvements on PM [45], [46]. Figure 3.1 summarises the set of criteria that will be used to evaluate each case study accordingly.

Each case study is evaluated according to the evaluation criteria to measure the impact on PM performance. The platform-specific results for the case studies are also discussed where applicable. These platform-specific results relate to the structure that the PM team used for tracking their actions and illustrate the additional benefit which is provided by the implementation of the platform.

The Quality of Service (QoS) improvements are discussed in the Appendix under Section A.7.4 by indicating the improvements the platform brings to PM for the company and its PM teams.

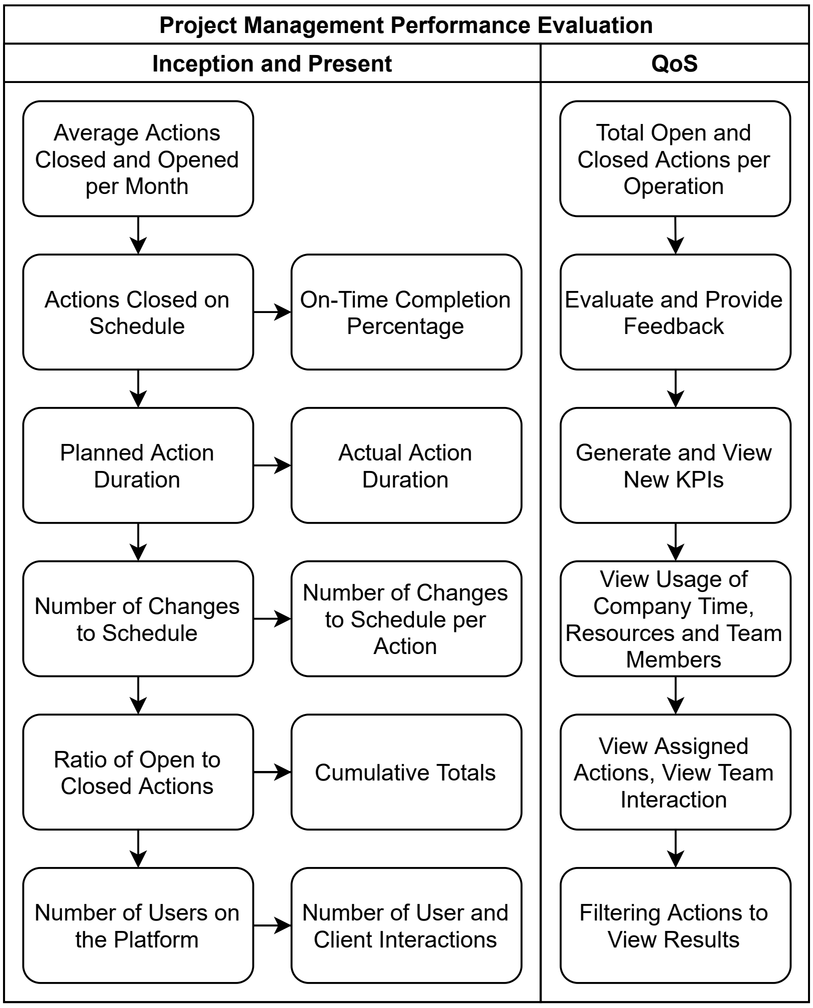


Figure 3.1: Project Management Performance Evaluation Criteria.

3.3 Platform Implementation

3.3.1 Introduction

The platform developed is for use by a multi-disciplinary engineering company and its PM teams, located in South Africa. The focus of the company is to increase efficiency in resources, logistics, energy, environment, health, and safety across top multinational mining and industrial companies.

The platform designed will be used to aid the company as well as its clients to successfully monitor all the projects that are being undertaken. It needs to ensure the successful monitoring of all actions of the PM teams assigned to each organisation across the company. The platform aims to further increase the efficiency of the company by ensuring that more adequate PM strategies are applied.

The software environment for the Action Tracking Platform was structured around Microsoft's `ASP.NET MVC` Pattern. It uses a combination of `C#`[1] and `JavaScript`[2] to develop

[1] *C# docs - get started, tutorials, reference. — Microsoft Docs.* [Online]. Available: `https://docs.microsoft.com/en-us/dotnet/csharp/` (visited on 03/05/2020)
[2] *JavaScript.* [Online]. Available: `https://www.javascript.com/` (visited on 03/05/2020)

`HTML` views. This then provides the web-based services needed for the Action Tracking Platform to allow it to be accessed from anywhere in the world and have all the data available in a central location. The case study company and its PM teams store their data across a combination of `MySQL`[3] and `MongoDB`[4] databases.

For the platform design, one of the main limitations is to integrate the platform with the existing infrastructure that the company had. This was needed to ensure that the use of the platform integrated seamlessly into what has already become a familiar environment for all employees.

The platform design had to consider the implications of the existing infrastructure and how to integrate the new platform into the company's software environment. The integration and the use the Action Tracking Platform has with the existing infrastructure of the company is described in the Appendix under Section A.3.

Each of the case study implementations followed the setup procedure as defined in Table 2.7. The results were then obtained after the users had used the platform for a certain evaluation period, defined from 1 January 2020 - 31 August 2020. Each Action Tracking Platform implementation is evaluated according to the PM performance impact it had at its inception (January 2020) and present (August 2020).

The case study platforms were all implemented using the same backend, where the PM team would indicate the additional model, according to Sections 2.4.3 and 2.5.3, that they would need to track their actions. This would, therefore, mean that each team had its structure for their Action Tracking Platform. The PM teams would also need to provide the tree structure, according to Figure 2.3, that they would like to use, which could be modified at any stage to adapt to project changes.

Each PM team could, therefore, have their individual Action Tracking Platform to meet the needs of their projects for the client. With each case study, it was possible to have more than one Action Tracking Platform. This would further divide the monitoring of actions across the teams, allowing for different structures based on the type of service delivered to the client. A centralised Action Tracking Platform could then be used to summarise all the actions across the individual projects.

3.3.2 Main Platform Interface

Using the setup procedure defined by Table 2.7, the layout for a platform would be created as illustrated in Figure 3.2. Figure 3.2 serves to visually illustrate the model for an Action Tracking platform and the concept for the platform's interface.

[3] *MySQL*. [Online]. Available: `https://www.mysql.com/` (visited on 03/05/2020)
[4] *MongoDB*. [Online]. Available: `https://www.mongodb.com/` (visited on 03/05/2020)

Figure 3.2: Illustration for the Basic Interface Design of an Action Tracking Platform.

#	Name	Description
1.	Tabs	An Action Tracking Platform consists of four tabs: The `Summary` tab (Section A.4.2), the `Open` and `Closed` tab, and the `Statistics` tab (Section A.4.2, A.4.3).
2.	Sub-header Toggle	Toggles the sub-headers from `12`.
3.	Reports	Would open the modal for the user to configure a report based on all the actions (Section A.4.1).
4.	Node Picker	This would allow the user to switch between the different nodes on the Action Tracker tree structure and view the actions linked to them (Section 2.4.3).
5.	Add	Allows a user to add new actions on the selected node.
6.	Save	Allows a user to save any updates or any new actions made on the platform.
7.	Reset	Resets any changes that the user may have made on the platform.
8.	Search	The user can search for any text that might match any of the actions that are loaded on the selected node.
9.	Grid columns	The columns that are created for the Action Tracking Platform based on the model used for a PM team. The model can be customised to add data of any format. In this case, the `Name` and the `Location` are added as extra fields.
10.	Selected Node Grid	The grid for the selected node and the actions directly linked to it. Clicking the header of the grid collapses the grid.
11.	Children Grids	Grids are also created for the first set of children on the selected node. Clicking the header of the grid collapses the grid. Clicking on the icon next to the header changes the selected node to that node.
12.	Sub-header Sections	Separates the actions under a header according to all the linked sub-children nodes. This provides better viewing and grouping for all the actions.
13.	Comments	Allows a user to add comments on an action (Section 2.5.5).
14.	Status	Indicates the status of an action to the user; red for when the action is more than seven days over its commitment date, orange for when an action is under seven days over its commitment date, and no colour for actions that are on track.
15.	Documents	Allows a user to link any documents that relate to the action (Section 2.5.6).
16.	Custom Context	Clicking this brings up the custom context menu, providing additional options on an action.
17.	Edit Node Link	Allows the user to edit on which node the action is currently linked.

#	Name	Description
18.	Close/Delete	Based on the tab, the action is either closed or marked as deleted.

Table 3.1: Table Defining the Numbers in Figure 3.2.

3.3.3 Comment Handler Interface

The interface is created as a separate view that would appear when viewing the comments linked to an action. Only the latest comment would appear in the grid of actions. This is done to reduce the clutter that would be created if all the comments are always shown and provide a smoother interaction with the platform. Figure 3.3 illustrates the section of the Action Tracking Platform grid that displays the comments.

Figure 3.3: Comment Section of the Action Tracking Platform Grid.

#	Name	Description
1.	Latest Comment	The latest comment on an action is always displayed in the grid.
2.	View	Clicking this allows a user to view all the comments linked to an action.

Table 3.2: Table Defining the Numbers in Figure 3.3.

Clicking on 1. in Figure 3.3 brings up the following comment modal seen in Figure 3.4

Figure 3.4: Comment Modal Containing the Grid with All the Comments Linked to an Action.

#	Name	Description
1.	Add Comment	The section defining where a user can add a new comment.
2.	Link Documentation	Allows a user to upload and link a document when creating a comment.
3.	Add Image	Allows a user to add an image when creating a comment.
4.	Previous Comments	The grid containing the previous comments made on an action (descending order).
5.	Timestamp	The timestamp of when the comment was made.
6.	User	The user who created the comment.
7.	View Documentation	Brings up the modal displaying the documentation linked to a comment (Discussed in Section 2.5.6).
8.	View Image	Fetches the image that is linked to the comment.
9.	Delete Comment	Deletes the selected comment by marking it as deleted in the database.

Table 3.3: Table Defining the Numbers in Figure 3.4.

3.3.4 Document Manager Interface

For every action created, documents can be linked directly to that action and directly to a comment on that action. Figure 3.5 illustrates the documentation button added to every action.

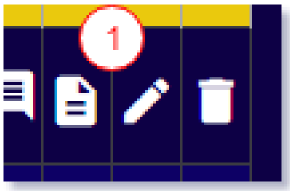


Figure 3.5: Documentation Button Added on Every Action.

#	Name	Description
1.	View	Clicking this allows a user to view all the documents linked to an action and its comments.

Table 3.4: Table Defining the Number in Figure 3.5.

Clicking on 1. in Figure 3.5 brings up the following modal seen in Figure 3.6. It is up to the user how many documents should be linked to an action.

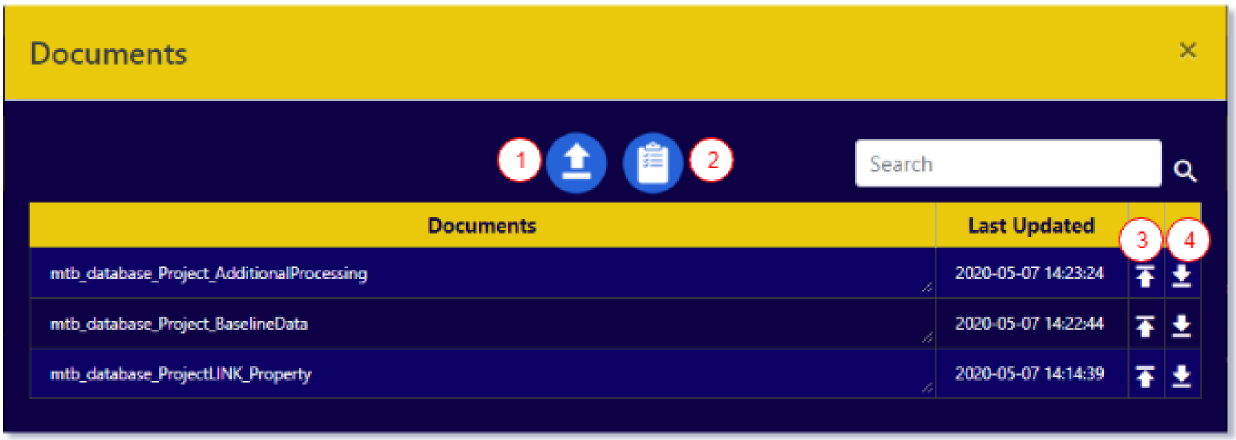


Figure 3.6: Document Grid Modal.

#	Name	Description
1.	Upload New Document	This allows a user to link more documents on an action (not linked to any of the comments).
2.	View Document Manager	Clicking this takes a user to the Document Manager where they can view more information on all the linked documents to an action and its comments.
3.	Upload New Version	Upload a new version of a document linked to an action or a comment.
4.	Download Latest Version	Download the latest version of the document linked to an action or a comment.

Table 3.5: Table Defining the Numbers in Figure 3.6.

When creating or updating comments for an action, documents can be linked to the comment. It is up to the user how many documents should be linked to a comment. Figure 3.7 illustrates the layout of the comments and how documents are added to each comment.

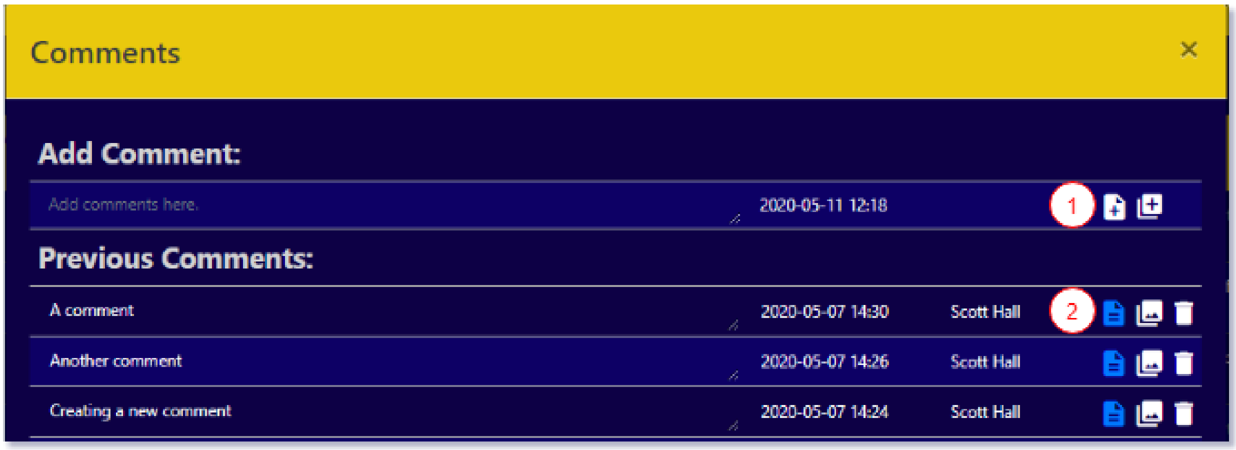


Figure 3.7: Comment Grid Modal.

#	Name	Description
1.	Add	Used to link a single document when creating a new comment.
2.	View	Used to view the existing documents linked to a comment.

Table 3.6: Table Defining the Numbers in Figure 3.7.

When updating the documents on a comment, the same modal is shown as in Figure 3.6, but it is specifically for the documents on that comment.

3.4 Case Studies

3.4.1 Introduction

This section covers the implementation of the Action Tracking Platform on the three case study PM teams. Each of the PM teams consisted out of different team members in which each PM team ranged in size from approximately 4 - 11 members. The structures that were used by the teams to track their actions and what their focus was when using the platform are discussed. The platform-specific results were also discussed along with each case study where applicable.

3.4.2 Case Study A

The platform developed for Case Study A was initially used for the PM team to track the compressed air leaks the team identified on the client's systems. This platform initially only served one purpose, but throughout the life cycle of the platform and increasing user interaction, the structure was altered. The final platform implementation currently serves to track all the actions for the projects that they have ongoing with the client, as well as tracking any internal team project actions the team needs to meet.

The platform implementation included splitting their tree structure according to the client-related projects as well as projects related to the team's internal structure. This way the team could view the KPIs, shown under the statistics tab (Sections A.4.3 and A.5), across their internal and client-related projects. This helps improve the management of the teams and their projects with the client.

The platform was made available to the company's PM team and the client personnel. This allowed for both the project team members and the clients to interact and share data. Feedback could be provided to the client instantly through the interface, reducing the need for face-to-face meetings. The client users were also limited to only the specific sites that they were in control of. This would reduce the clutter that they would see and allow them to focus on the actions related to their assigned operations, reducing the pipeline of information.

The clients could view the status of all the actions and be updated immediately by the PM team members. The platform provided the client with a log of all the actions that were taking place as well as future actions. Reported summaries of the work being done were sent to the client on-demand, and this reduced the effort required for generating these reports to provide feedback.

The access for the client users had to be requested along with what nodes on the tree structure they should be linked to. This ensures that proper access control is maintained on the structure amongst all users and that only the relevant data is displayed.

The implementation of the structure the team needed was determined through meetings and email interactions. The final implementation for the structure of the platform on Case Study A is illustrated in Figure 3.8.

Table 3.7 is illustrative of the additional fields that were added to the base `ThreadDocument` model (Figure 2.7) for the implementation of Case Study A.

Figure 3.8: Action Tracking Platform for Case Study A.

Attribute	Description
Annual Cost (R)	The annual cost that a client can incur if the action is not completed according to schedule as identified by the project manager.
Location	The location where the action for the project is taking place.
Name	A short descriptive name for the action that is used as headings in the reports.
Missed Opportunity (R)	For each day the project goes over the deadline, this is the additional cost that the client can face. It is the missed opportunity that could have been reduced through timely completion of the action (if a project takes one year to complete). If no annual cost was entered then this was not tracked.
Available Opportunity (R)	Indicates the available additional cost that can be saved if a project is completed ahead of schedule (if a project takes one year to complete).
Obstruction	Other actions that are preventing the completion of this action which need to be completed first.

Table 3.7: Case Study A Model.

The model implementation was focused on tracking the cost from the incomplete actions that the client would face if not completed on an annual basis. The completion of an action that was over the predefined commitment date was also considered. This was the missed opportunity that was pre-calculated by the platform for every day over the deadline if the action was not completed within a year. The missed opportunity was calculated as follows:

$$M_o = \frac{A_c}{D_y} * D_o \tag{3.1}$$

Where in Equation 3.1, M_o is the missed opportunity, A_c is the annual cost of the action, D_y is the number of days in the current year, and D_o is the number of days over the expected completion date.

Platform-Specific Results

This section highlights the platform-specific results that were recorded through the platform's implementation on Case Study A. Figure 3.9 illustrates the total cost-saving opportunities that were recorded by the teams using the platform.

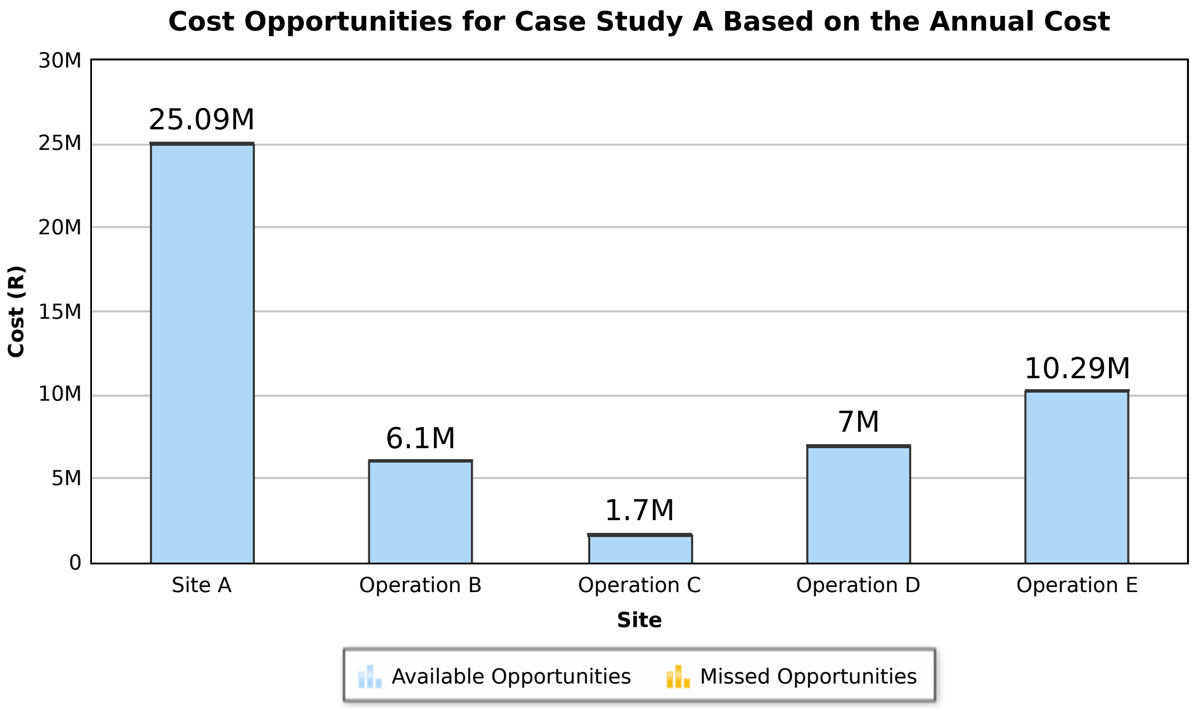


Figure 3.9: Cost Opportunities for Case Study A.

Figure 3.9 indicates that, as of 31 August 2020, the PM team of Case Study A successfully identified a cost-saving opportunity for the client of approximately R25 million through the actions which they completed and are aiming to complete. The current open actions are only missing out on a possible R5460 in cost-saving opportunities, as the actions are being completed according to schedule.

Figure 3.9 is indicative of the value that is added using the platform as these values are made directly available to the PM team as well as the client. The platform also indicates the operation which is currently producing the most cost-saving opportunities, and this can be directly linked to an under-performing operation or the operation with the most potential. This provides value to the PM team and the client on which of the operations the most focus should be put.

All users are made aware of the current actions and the value which they can add to the client when completed. Having the platform allows them to successfully report on the value that they can add to the client, as this data is made available to everyone for immediate access on the platform.

Figure 3.10 illustrates the reduction in the missed opportunities that occurred when completing actions within the scheduled period.

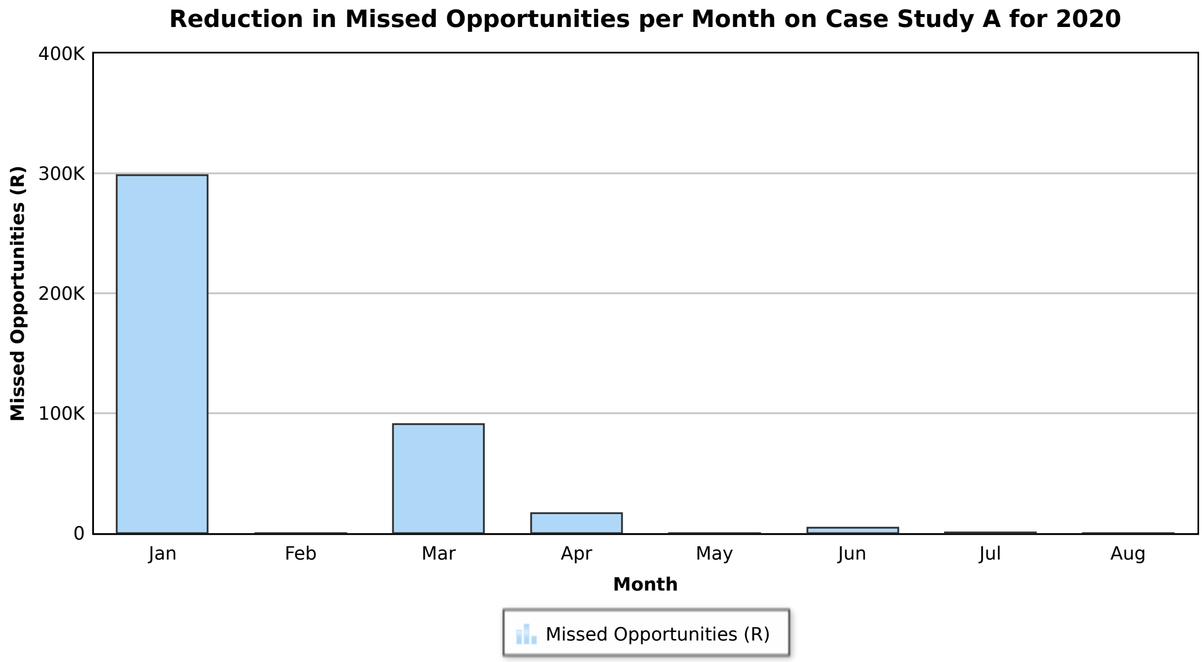


Figure 3.10: Reduction in the Missed Opportunities per Month for Case Study A.

The initial period indicates the missed opportunities that the team had, but throughout the period the value decreased as a result of the actions being completed on time (Figure 3.14), improved time management, and more effective PM techniques, with extended use of the platform by the PM team. Case Study A was able to successfully reduce the cost the client would face by completing their actions on time through the introduction of the platform.

3.4.3 Case Study B

The implementation of the platform on Case Study B was used by the PM team to track their internal actions for projects that needed to be completed for the client. This was used to track all the actions that needed to be completed, ensuring that they meet the requirements of their client and fulfil their contracts.

The platform was made available to the company's PM team and allowed them to view the KPIs that were shown on the statistics tab (Sections A.4.3 and A.5). This could help improve the management of the teams and their projects for the client.

The implementation of the structure that the team needed was determined through meetings and email interactions. The final implementation for the structure of the platform on Case Study B is illustrated in Figure 3.11.

Table 3.8 is illustrative of the additional fields that were added to the base `ThreadDocument` model (Figure 2.7) for the implementation of Case Study B.

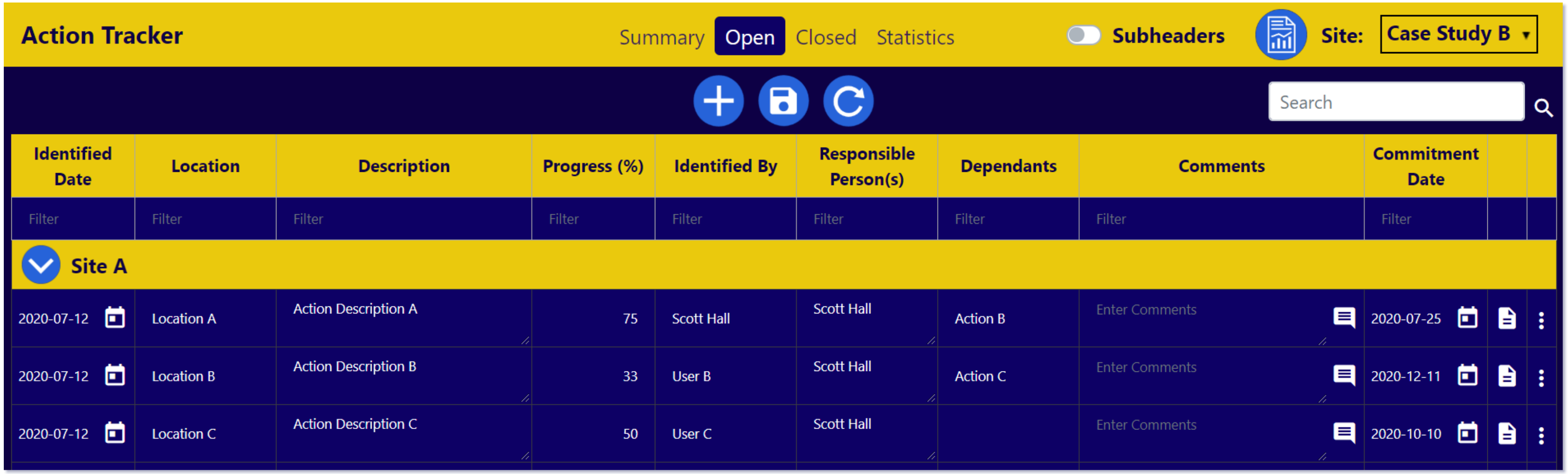


Figure 3.11: Action Tracking Platform for Case Study B.

Attribute	Description
Progress	The percentage of progress completion for the action.
Location	The location where the action for the project is taking place.
Dependents	What the completion of the action is dependent on.
Identified By	The team member that identified the action.

Table 3.8: Case Study B Model.

The model implementation was mainly centred around using the platform internally. It focused on tracking the actions that were identified by the team members and assigning the appropriate users. This would help organise the team and ensure that the correct actions are handled by the correct user.

The model would allow team members to structure their work, meet deadlines, and provide feedback on their actions to the client. The team was focused on tracking where each of the project's actions would need to take place and what they depended on to be completed. It was important to highlight the progress on the actions to ensure that the actions were being handled by the team.

3.4.4 Case Study C

The implementation of the platform on case study C was used by the PM team to track all the actions on the projects that were ongoing with the client. It would allow them to log their actions as well as the value that their completion would add to the client.

The platform was made available to the company's PM team assigned to the client and the client personnel. This allowed for both the PM team members and the clients to interact and share data. The team could view the KPIs, that were shown on the statistics tab (Sections A.4.3 and A.5), thus contributed to improving the management of the teams and their projects.

Feedback could be provided to the client instantly through the interface, reducing the need for face-to-face meetings. The client users were limited to only the specific sites that they were in control of. This would reduce the clutter and allow them to only focus on the actions related to their operation.

The clients could view the status of all the actions and be updated immediately by the PM team. The platform provided the client with a log of all the actions that were taking place as well as any future actions. Reported summaries of the work being done could be sent to the client immediately through the platform.

Access to the platform was granted to all personnel of the PM team, and the client access had to be requested, along with what nodes on the tree structure they should be linked to. This would ensure that proper access control to the data is maintained on the structure.

The implementation of the structure that the team needed was determined through meetings and email interactions. The final implementation for the structure of the platform on Case Study C is illustrated in Figure 3.12.

Table 3.9 is illustrative of the additional fields that were added to the base `ThreadDocument` model (Figure 2.7) for the implementation of Case Study C.

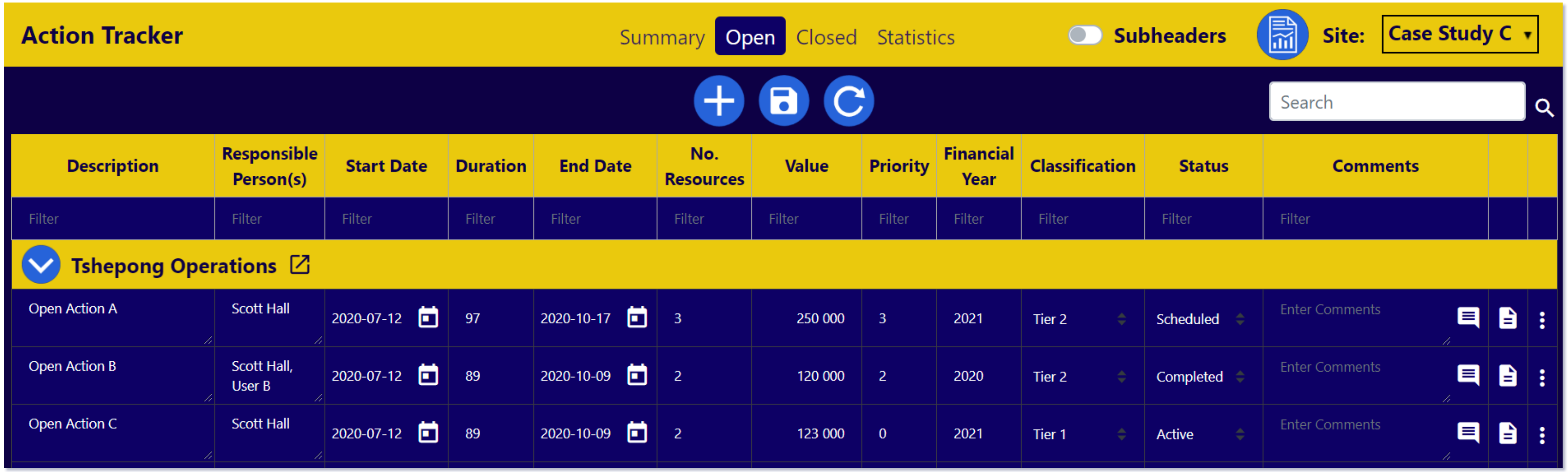


Figure 3.12: Action Tracking Platform for Case Study C.

Attribute	Description
Duration	The duration of the action in days, auto-calculated by filling in the start and the end date of an action.
Resources	The number of project personnel assigned to complete the action.
Value (R)	The value that is added for the client by the completion of the action.
Priority	Integer value indicating the priority of the action (1 = High, 2 = Medium, 3 = Low).
Financial Year	The financial year, according to the client, for which the value of the action contributes to.
Classification	Enumerator used to classify the action. The user can select between Tier 1, 2 and 3.
Progress	Enumerator indicating the progress on the action. The user can select between Active, Completed, Scheduled, Not Completed.

Table 3.9: Case Study C Model.

The model implementation was detailed and focused on tracking all aspects of a project's actions. The team was concerned with recording the value that a completed project would add to the client; tracking this data would allow them to report the total value that was delivered to the client at regular intervals or on-demand back to the client.

The value for the actions could be filtered down to the specific financial year to view the value added within a specific period. The actions required that the duration be pre-calculated as well as indicating the number of team members assigned to the action.

Clients could also interact with the platform to monitor the actions that are taking place and the value that is being added by the PM team. The client and PM teams could communicate and share resources through the platform, and actions could be prioritised and classified according to their importance. The progress on actions was recorded to indicate to the client how far along a project is.

Platform-Specific Results

This section highlights the platform-specific results that were recorded through the platform's implementation on Case Study C. Figure 3.13 indicates the total value that the team added to the client on completion of the tracked actions.

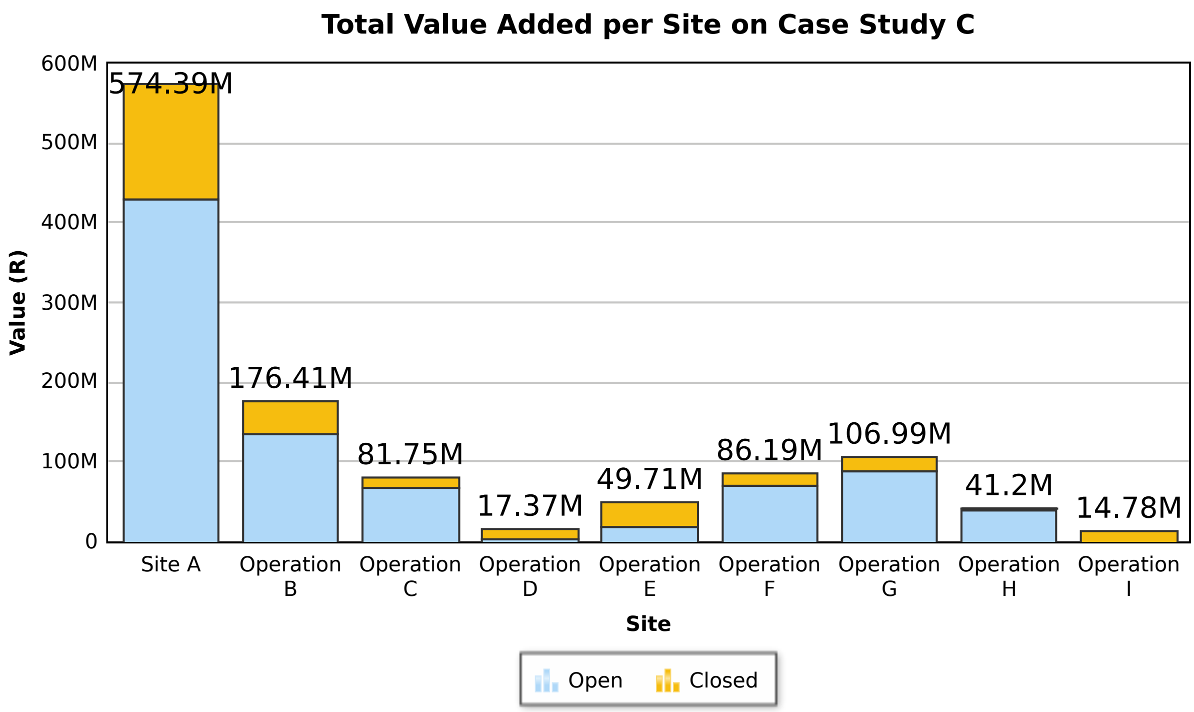


Figure 3.13: Value Added Recorded for Case Study C.

The team recorded a total of R574.39 million added within the evaluation period, where R149.74 million is a result of the closed actions and R424.65 M is as a result of the open actions that need to be completed.

The platform allowed the PM team to more effectively report to the client the value added from the actions they were implementing. This allowed the teams to effectively communicate this data to their clients and ensured its availability to the client at any time.

The PM teams could more effectively communicate with the client and more reliably validate the value they added, which contributed to maintaining client satisfaction in the actions they were completing.

3.5 Platform Implementation Results

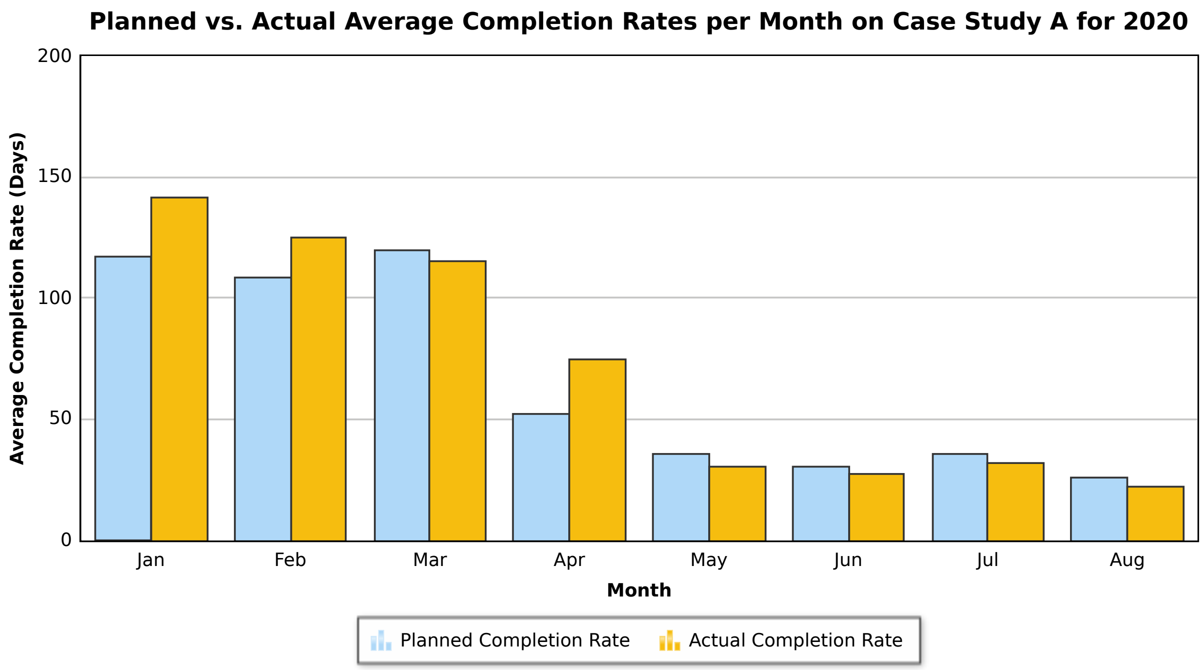
3.5.1 Introduction

The following section highlights the results obtained after implementing the Action Tracking Platform on the three case study PM teams, and illustrates the results obtained to evaluate the PM performance impact the platform had with its use by the PM teams.

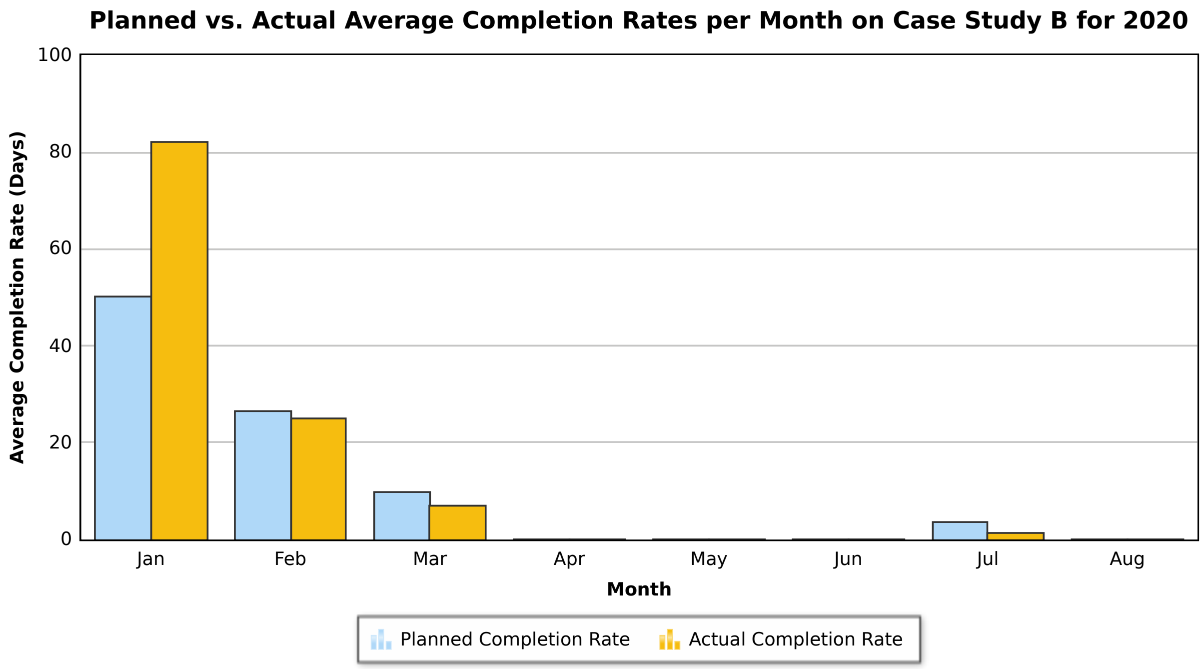
The results were recorded after the platform was operational for eight months (January - August 2020) across the case study PM teams. The results that were obtained and their contribution to effective PM are interpreted and discussed in Section 3.6.

3.5.2 Average Action Completion Rates

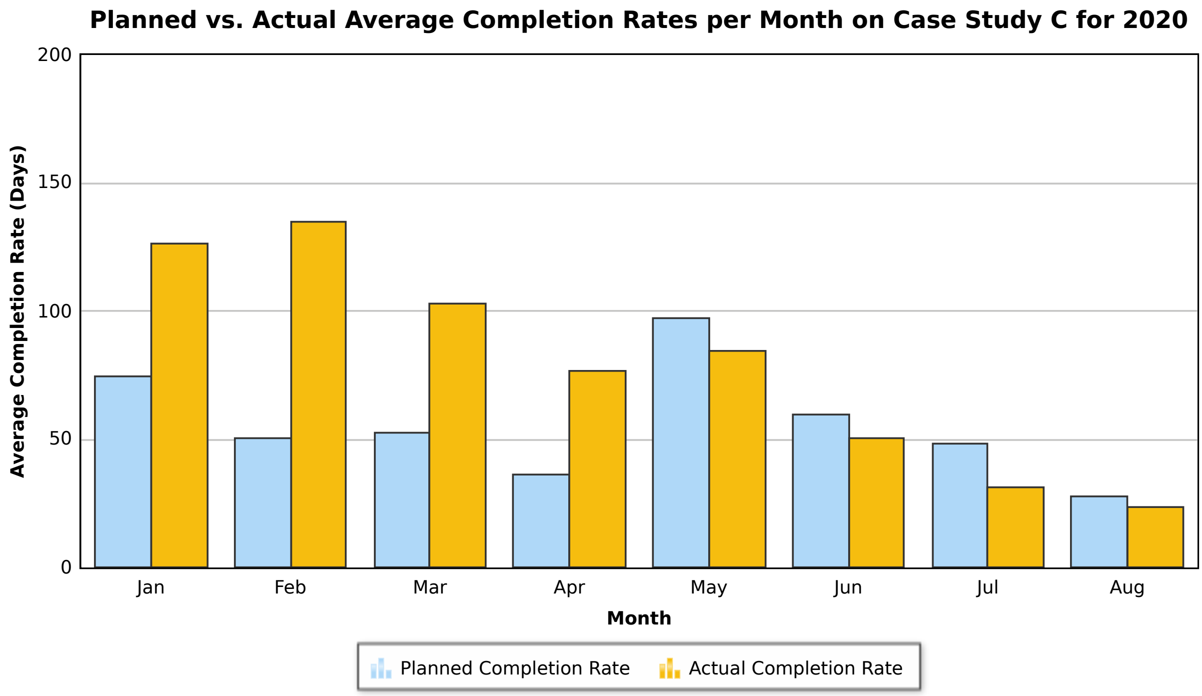
This reduction in the actual average completion rates across actions for each of the case studies can be compared with the planned average completion rates as illustrated by the case studies in Figure 3.14.



(3.14a) Case Study A.



(3.14b) Case Study B.



(3.14c) Case Study C.

Figure 3.14: Comparison Between the Planned and Actual Average Action Duration.

The actual completion rates of the case studies from Figure 3.14 were seen to steadily decrease every month through the implementation of the Action Tracking Platform. The platform implementation brought about a decrease in the delivery time of actions to the client and for presentation to the project manager. This illustrates the impact the platform had on improving PM within the company and how this can be effectively applied to industry.

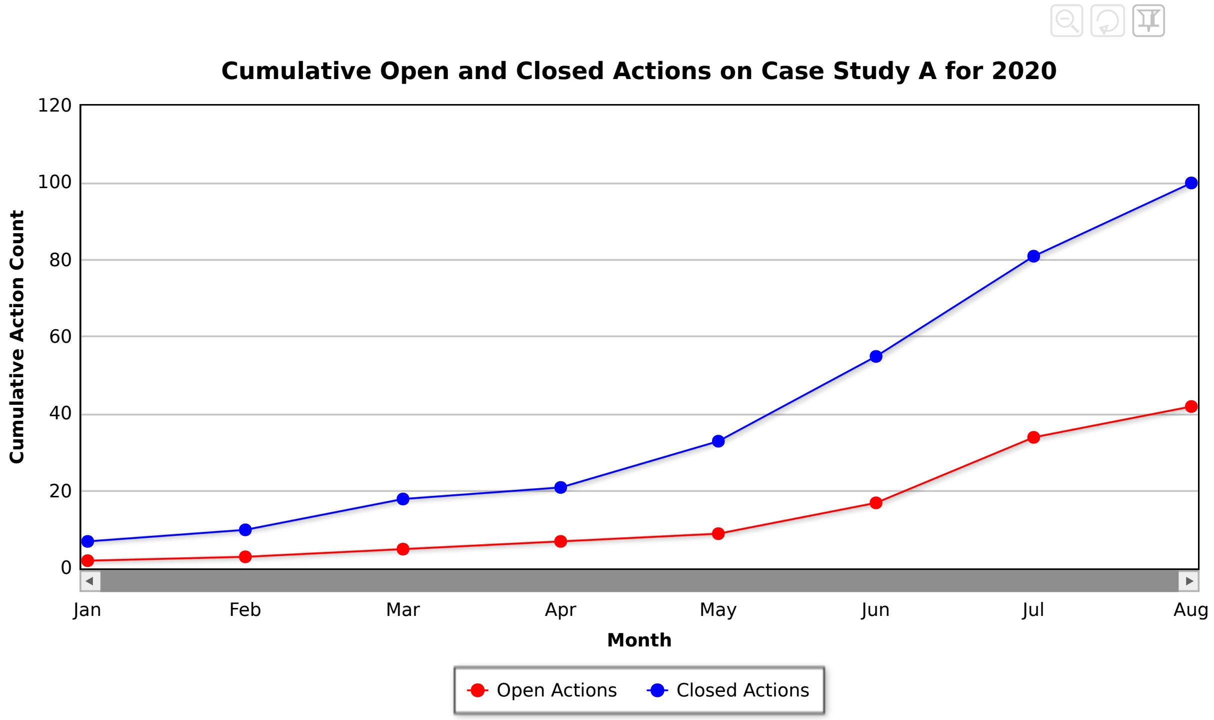
From the results of Case Study B, seen in Figure 3.14b, it must be noted how no actions were planned or completed from April - July 2020 due to the national lockdown that occurred in South Africa as a result of the `COVID-19` outbreak[5]. This impacted the operation of the client and meant that actions could not be properly completed by the PM teams. Case Study B, as of August 2020, was in the process of resuming normal operation, with minimal actions being completed.

From the results in Figure 3.14, it can be seen how the planned and actual completion rates of the actions decrease on a monthly period. The case studies were initially missing their planned completion rates and towards the end of the period, the actual completion rates were under the planned completion rates. Case Study A and C successfully illustrate a new baseline for the completion rate of actions. Case Study B was impacted due to `COVID-19`, as the client operation was impacted. Despite showing initially promising results, a new baseline for the completion of actions cannot be determined.

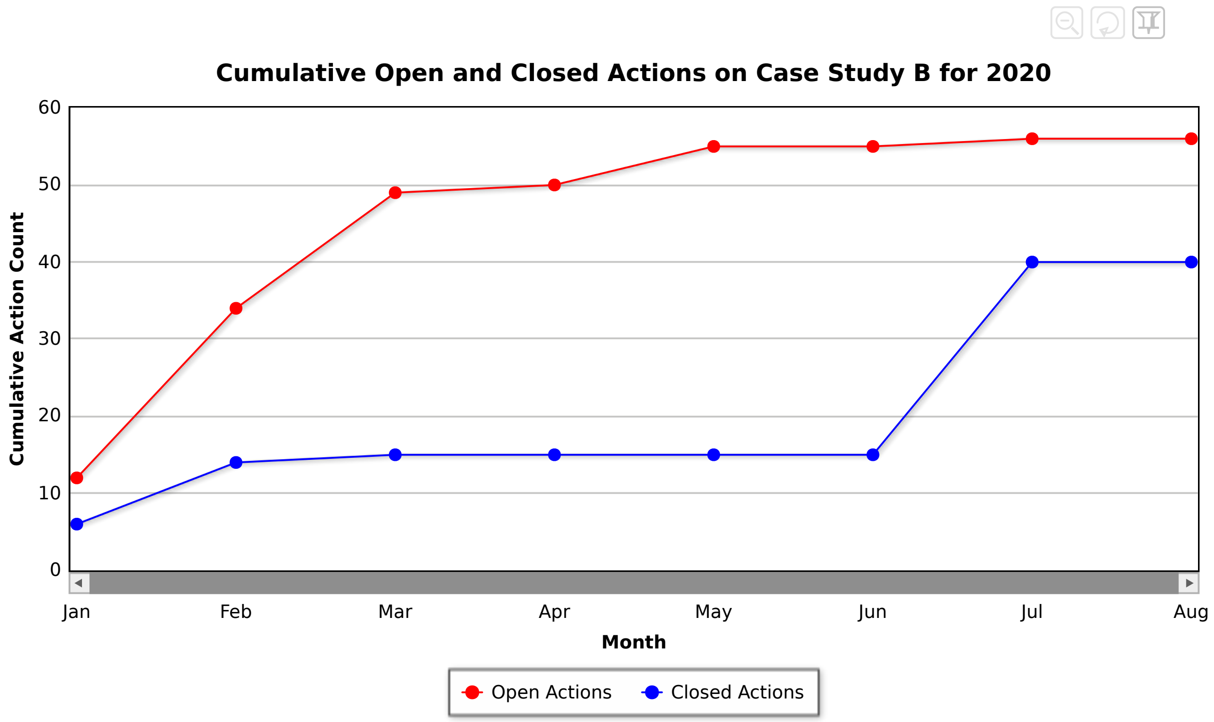
[5] *Regulations and Guidelines - Coronavirus COVID-19 — South African Government.* [Online]. Available: `https://www.gov.za/coronavirus/guidelines` (visited on 09/08/2020)

3.5.3 Number of Open and Closed Actions

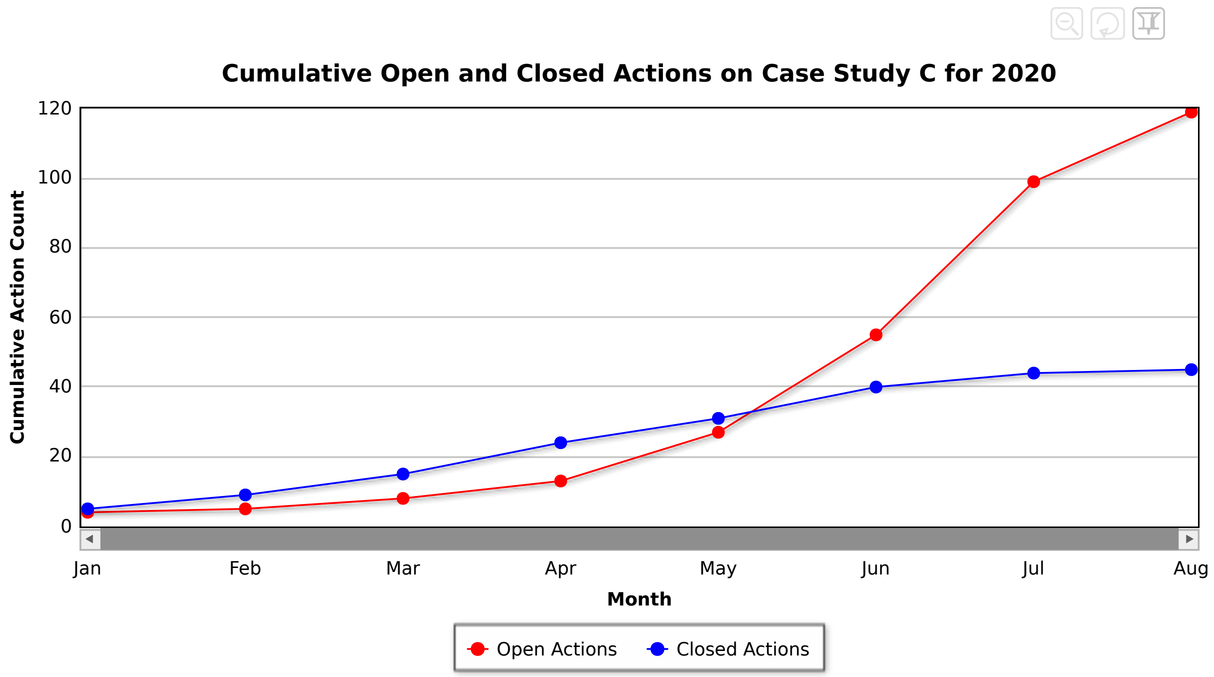
Figure 3.15 illustrates the cumulative number of open and closed actions on each case study.



(3.15a) Case Study A.



(3.15b) Case Study B.



(3.15c) Case Study C.

Figure 3.15: Cumulative Number of Open vs. Closed Actions Every Month.

From Figure 3.15 it can be noted how there was an increase in the number of actions that were tracked per month. This indicates that the need for the platform exists, and also indicates the user adoption of the platform across each of the case studies. Despite there being an increase in the number of actions created and completed, there was still a decrease in planned and actual completion rates of the actions.

This illustrates the impact the implementation of the platform had on the increase of effective PM within the company. More actions were being successfully delivered on time every month, and this allowed for more regular value to be shown to the client.

3.5.4 Combined Case Study Results

This section summarises the results obtained across all the case studies. The most important factors which are to be considered when evaluating the platform's effectiveness are highlighted.

For the tables depicted, `Inception` is abbreviated as `I` and `Present` is abbreviated as `P`. Inception is defined as the period where the platform is used for 1 month (January 2020) and Present after eight months of usage (August 2020). Figure 3.16 represents the planned and the actual completion rates across the platforms and summarises Figure 3.14. Table 3.10 also provides a lower-level breakdown of the results obtained for each case study.

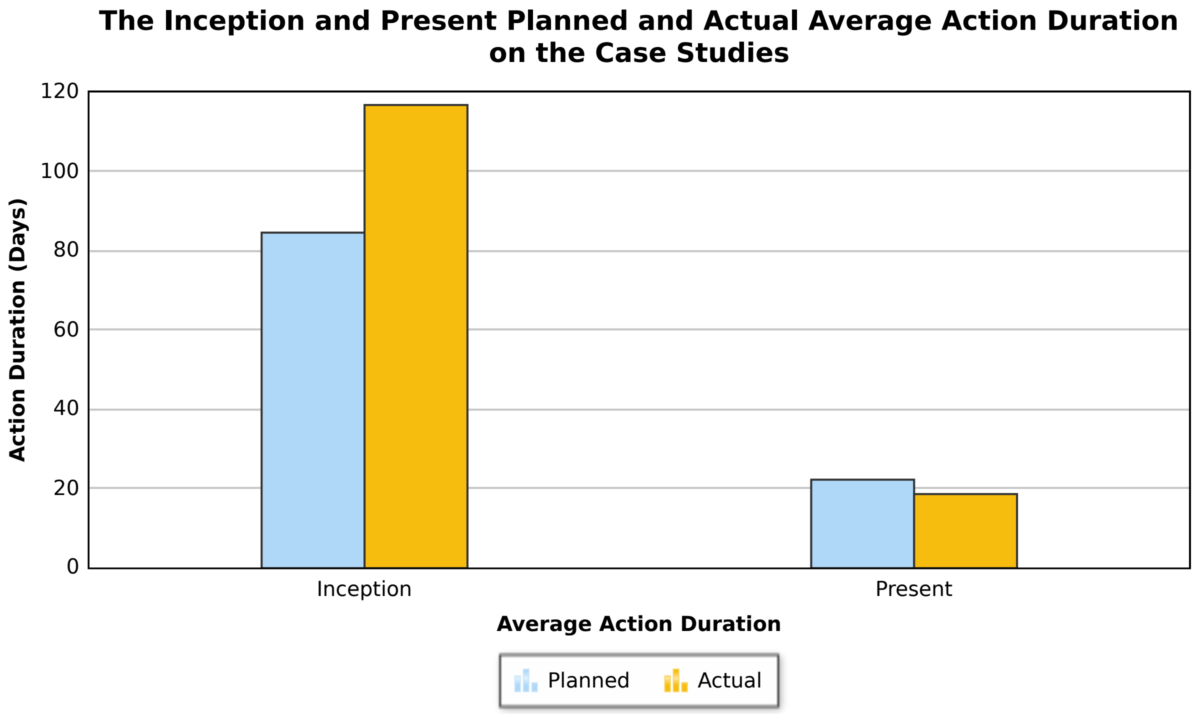


Figure 3.16: Planned vs. Actual Action Completion Rates Across the Case Studies.

	Case Study A		Case Study B		Case Study C	
Evaluation Metric	**I**	**P**	**I**	**P**	**I**	**P**
Planned Average Action Duration (Days)	119.81	31.73	50.17	4.30	83.92	31.14
Actual Average Action Duration (Days)	141.68	27.53	82.32	3.45	126.58	24.56
Percentage Change Between Planned and Actual (%)	18.25	-13.24	64.08	-19.77	50.83	-21.13

Table 3.10: Summary of the Planned and Actual Completion Rate and Their Percentage Differences in Each Case Study.

From Figures 3.14, 3.16, and Table 3.10, the case studies illustrated a decrease in the planned and actual average completion rates of all actions. The actual completion rates initially overshot their planned completion rates and then throughout the evaluation period, the differences between the actual and planned decreased.

The actual average action completion rates saw an overall 84.16% improvement in the delivery time of actions across the case studies. All the case studies illustrated a decrease between their planned and actual completion rates after the evaluation period, indicating an improvement in the effectiveness of PM by the teams.

At Inception, the actual completion rates were 38.08% over their planned completion rate, and at present, they are 17.33% under. Table 3.10 also depicts this improvement through a decrease across the case studies, which illustrates the percentage improvement of the planned compared with the actual average completion rates.

By the end of the evaluation period, Case Study A and C were completing their actions ahead of schedule on average, whilst Case Study B was still resuming normal operation and meeting the deadlines for the newly tracked actions. This indicates that the actions were being completed ahead of schedule.

A successful improvement in the PM of teams and their actions can be validated through these results. At present, the actions are meeting their deadlines and are often being completed ahead of schedule, which illustrates the impact the platform implementations had on PM effectiveness.

Figure 3.17 summarises the average number of actions open and closed every month across each of the cases studies. Table 3.11 also provides a lower-level breakdown of the results obtained.

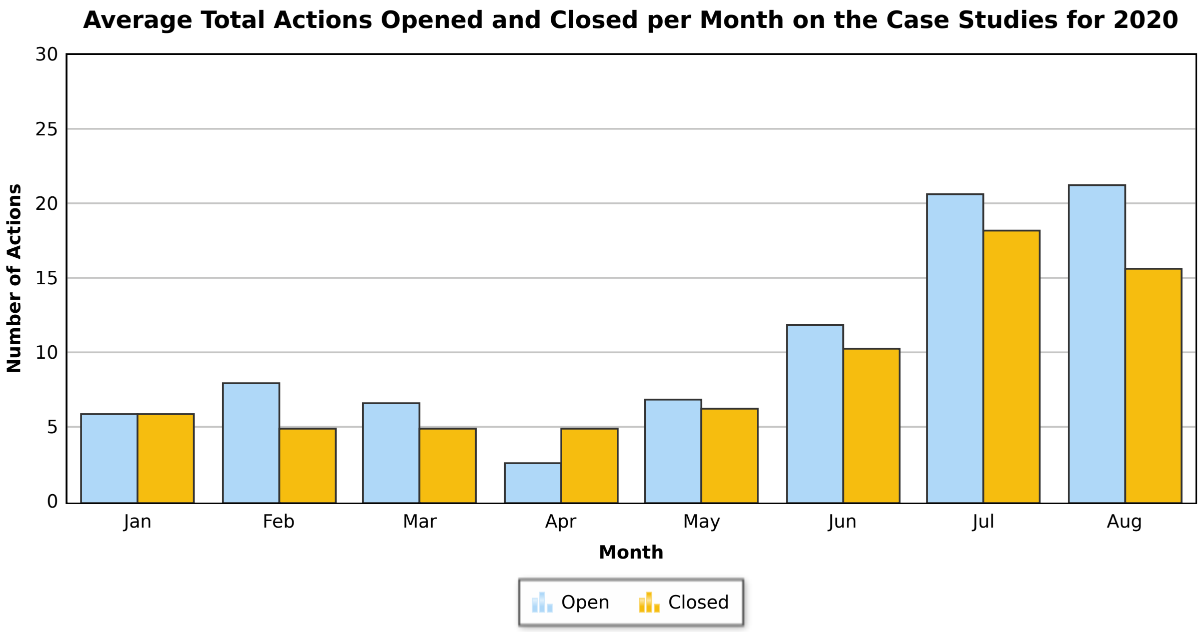


Figure 3.17: The Total Number of Open and Closed Actions per Month.

	Case Study A		Case Study B		Case Study C	
Evaluation Metric	**I**	**P**	**I**	**P**	**I**	**P**
Total Open Actions	2	53	12	56	4	131
Total Closed Actions	7	103	6	46	5	45
Average Actions Opened Per Month	2	5.57	12	7	4	16.38
Average Actions Closed Per Month	7	12.88	6	6.57	5	5.63
Ratio of Open to Closed Actions (%	28.57	51.46	200	121.74	80	291.11

Table 3.11: Total Open vs. Closed Actions and The Average Open and Closed Actions Per Month in Each Case Study.

The reduction in the planned and actual completion rate of actions is a result of the increase in the number of actions recorded on the platform. This decrease in completion rates is indicative of the actions potentially being broken down into smaller, more manageable tasks, as the total number of actions open and closed per month steadily increased, as noted in Figure 3.17 and Table 3.11.

The number of actions opened saw a 255.5% increase per month and the number of actions closed saw a 94.5% increase per month at the end of the evaluation period. This illustrates an increase in the effectiveness in the way the projects and their actions are managed by the PM teams using the platform.

Overall, the actions created have a smaller completion period and achieving project deadlines can be more effectively managed. The reduction in the planned and actual completion rates meant that more of the actions were being completed on schedule across the case studies.

The number of user interactions which occurred across all the platforms are also recorded. The initial user activity at inception and present on the platforms can be seen in Figure 3.18. Table 3.12 also depicts a lower-level breakdown of the user interactions across the case studies.

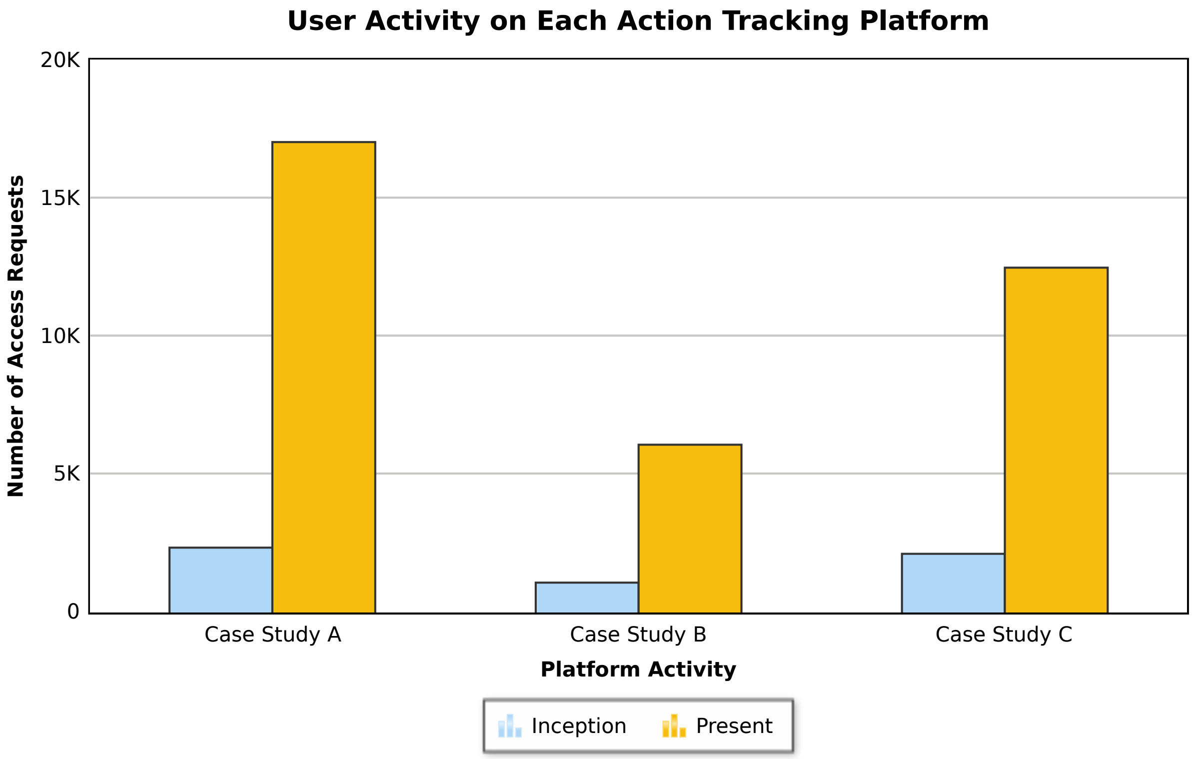


Figure 3.18: Inception and Present User Activity Across the Case Studies.

	Case Study A		Case Study B		Case Study C	
Evaluation Metric	**I**	**P**	**I**	**P**	**I**	**P**
Number of Users on the Platform	5	21	3	13	4	10
User Platform Access Count	2389	17044	1092	6124	2139	12506
Percentage of Client Access	9.43	14.13	4.17	5.06	9.25	16.02

Table 3.12: The User Interactions Across the Case Studies.

It can be noted, from Figure 3.18 and Table 3.12, that the users on the platform increased from 12 to 44 users, where users were averaging over 811 requests each, over the eight month period.

The increase in the actions being recorded can also be a result of the increase in the user adoption of the platform. More users were actively using the platform and actions could be more effectively handled by the team members. The workload of the actions could be more effectively distributed across the team members, as more users became actively involved.

From Table 3.12 it can be noted how the client users made up a significant portion of the requests on each platform. This illustrates the improvement in the integration of the client with the PM teams. A successful increase in client involvement on projects was noted through the platform's implementation.

The platform implementations led to more actions being completed on schedule. Figure 3.19 represents the number of overdue actions at inception and present, and Table 3.13 summarises these results across the case studies.

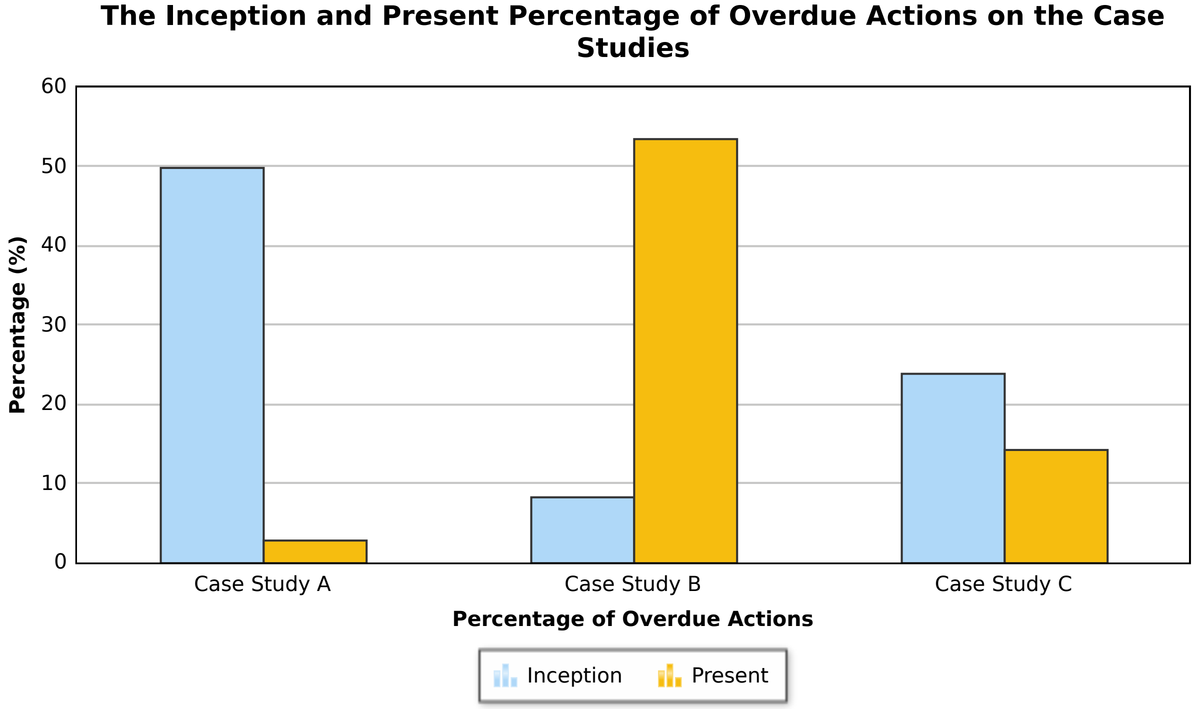


Figure 3.19: The Total Percentage of Overdue Actions at Inception and Present Across the Case Studies.

	I	P	I	P	I	P
Evaluation Metric	Case Study A		Case Study B		Case Study C	
Total Actions Closed on Schedule	2	27	3	5	1	19
Number of Changes to Schedule	4	250	10	104	8	301
Average Changes to Schedule Per Action	1.3	1.60	0.56	1.02	0.89	1.71
Percentage of Actions Overdue (%)	50	2.86	8.33	53.61	23.89	14.38

Table 3.13: Summary of the Increase in Efficiency of Closing Actions Across the Case Studies

It can be noted how both Case Study A and Case Study C saw a reduction in the total percentage of overdue actions. Case Study B encountered delays in their project schedules as a result of the impact `COVID-19` had on the client's operations. All the case studies maintained consistent changes to their schedules on a per-action basis.

From Table 3.13, Case Study A illustrated a decrease from 50% to 2.86% and Case Study C illustrated a decrease from 23.89% to 14.38%, whereas case Study B was severely impacted and saw an increase from 8.33% to 53.61%.

Overall, more actions were open and closed, seeing an increase in the number of actions closed on time and limited changes to the schedules of actions. These results highlight the improvement the teams had in managing their actions. This denotes the increase in the effectiveness of PM across teams.

3.6 Discussion

The results illustrated the improvement the PM teams had in managing their actions as they become familiar with the usage of the platform. The completion of actions ahead of schedule indicates the improvement in PM brought about by implementing the platform on the case studies. The improvement in PM can also be noted in Figure 3.19 where, for Case Study A and C, the percentage of overdue actions decreased significantly. Only Case Study B was negatively affected by project delays due to the national lockdown that occurred.

It was noted that the Action Tracking Platform allowed actions to be recorded and their progress to be updated on Case Study A and C, even through the lockdown period. This allowed the PM teams to indicate the value that they could continue to add to the clients. This further indicates the value that the platform can add, as face-to-face meetings were limited, but project progress could still be maintained and reported on by the teams.

Using an online platform, the work that the teams are delivering to the client can be reported on in a centralised location, allowing for an increase in feedback being provided to the clients. The clients can immediately see the impact that the company and its PM teams have on their operations. This allowed the teams to more effectively integrate with the clients and the work that they were doing for them.

Project progress can be more effectively reported to the client with more actions being completed and being created every month, as shown in Figure 3.17. The reduction in the average completion rates indicates the improvement in the effectiveness the team had when completing their actions. This indicates that an increase in PM effectiveness was noted, as actions were being more effectively handled.

It can be noted from Figure 3.14 that both the planned and actual average completion rates of actions decreased every month. At inception, the actual completion rates were overshooting their planned completion dates, then towards the end of the evaluation period, all the actions were meeting their planned completion rates. The platform allowed teams to more effectively structure their actions and handle their timely completion.

As can be seen from the Figures in 3.15 and Figure 3.17, all the case studies number of open and closed actions increased every month. This illustrates the need for the implementation of the platform and the effectiveness it brings to PM. The platform was also tested in terms of its scalability and was able to handle the increase in the number of users and actions being recorded.

The increase in the number of actions on platforms can be brought about by actions being subdivided, an increase in the number of actions which get tracked by users, an increase in the amount of work that is being done by the PM team as well as an increase in the number of users which are utilising the platform.

It can be seen from Figure 3.19 and Table 3.13 that, after the evaluation period, more actions were closed on schedule across the platforms, and the changes to the schedules across the actions decreased. When considering the ratio of open to closed actions, having the percentage less than 100% indicates the effectiveness the teams have with managing their workloads.

Having the ratio less than 100% indicates that the teams are successfully maintaining a high action-completion rate and ensures that no actions are overlooked for extended periods. Both Case Study A and B maintained high action-completion rates, where Case Study C was continuously opening more actions than what they were closing. Case Study C is illustrative of the PM improvement that can still occur, where Case Study A and B illustrate the improvement in PM through the implementation of the platform.

The number of users across the platforms increased throughout the evaluation period as can be seen in Figure 3.18. This increase in users led to more actions being effectively handled and distributed, where all the team personnel could be aware of the actions that were ongoing within the teams.

The number of client interactions also increased on all the platforms as shown in Table 3.12 and Figure 3.18, and illustrated the increase in client involvement on the projects. This successfully indicates the increase in the integration between the clients and the PM teams brought about by using the platform. Clients could immediately view the progress of all the projects and gain better insight into the value that was being added by the PM teams.

As the user adoption of the platform continued, the actions were seen to be completed either on schedule or ahead of schedule. This, therefore, led to the planned completion rate of actions being higher than their actual completion rates and, consequently, increased the delivery time of actions.

Overall, the platform helped the PM teams to better centralise their actions and allowed for more actions to be effectively recorded. All the actions could be tracked without a limit, where all the users could view what work has been assigned to them by the project manager.

Case Study A and C illustrated a significant improvement in the PM within their teams. From the results, Case Study B illustrated initially promising results, but their operation was impacted by the effects `COVID-19` had on the operation of their client and no actions could be properly completed.

The value that the Action Tracking Platform added in terms of effectively increasing PM in the company is noted through the metric results that were obtained. Table 3.14 summarises the improvement in PM brought about by the implementation of the platform. A more in-depth look at the data that was gathered can be seen by the Figures in the Appendix under Section A.7.

Project Management Improvement	Ref.
Decrease	
Completion rate of actions.	Figure 3.14
Number of actions overdue.	Figure 3.19 and Table 3.13
Number of changes that occurred to schedules on actions.	Table 3.13
Increase	
Number of actions that are completed ahead of schedule.	Figures 3.14, 3.16 and Table 3.10
Number of actions that are delivered in the PM teams.	Figures 3.15, 3.17 and Table 3.11
Number of users.	Figure 3.18 and Table 3.12
Number of clients involved in projects.	Figure 3.18 and Table 3.12

Table 3.14: Summary of Platform Implementation Improvements.

The results obtained from the implementation of the Action Tracking Platform illustrate the importance of having effective PM tools within industry. The implementation identified an increase in the effectiveness in the way the current projects and their actions are managed. The platform illustrated how, within industry, companies can greatly benefit from having proper action tracking platforms, which aligns with the literature identified in Chapter 1.

3.7 Validation

3.7.1 Introduction

This section serves to validate that the empirical objectives of the study as defined in Section 1.8 were met. The validation of the platform occurred at the closing of the development process and it serves to prove that the correct platform was implemented according to the requirements and specifications. This section uses the case studies from Section 3.4.2, 3.4.3, and 3.4.4 as well as the results obtained in Section 3.5 to successfully validate that the platform met the objectives defined in Section 1.8.

3.7.2 First Objective

The first empirical objective from Section 1.8 aims to fulfil the missing requirements that were not met by the state of the art as defined in Table 1.2. It also aims to validate that the requirements and specifications were met. The methodology for the implementation of the platform was verified in Section 2.6. This indicated that the correct methodology was used for the design of the platform.

After the platform was successfully implemented and made available to the user, it needed to validate that the state of the art was met. Table 3.15 indicates the validation that the platform fulfilled the state of the art evaluation criteria from 1.2 and met the specifications from Table 2.1.

Focus Point	**Validation**	**Crit. Met**	**Spec. Met**
Generic	The implementation of the platform on the different case studies illustrates the generic implementation of the platform. The platform structure was altered to suit the requirements of all the separate PM teams. The correct implementation of the design of the platform ensured that it could be easily used by multiple teams. The implementation of multiple platforms validates that it was implemented generically.	1. ✓	✓
Centralised	The platform was implemented on the company's existing infrastructure and made available to all the team members. The platform was web-based and made it accessible from anywhere in the world. It created a centralised platform where resources could be shared and communication could be improved. It was simpler for all project members to stay updated with the assigned task and improved the team's PM strategies.	1. ✓ 2. ✓	✓
Traceability	As verified in Section 2.6, the platform would keep logs of all the users and the activities taking place on the Action Tracking Platform. The implementation of the platform on the case studies illustrated that it was capable of successfully tracking all the user activity that occurred. This enforced user accountability and improved the data integrity of tracked actions, validated by the statistics tab and by the results obtained from Section 3.5, where the user interaction with the platform could be viewed. The implementation of the platform maintained all the created actions when they were closed and deleted. These actions could easily be reported on for audit purposes through the implementation of the document manager on the platform.	1. ✓ 2. ✓ 3. ✓	✓

Focus Point	Validation	Crit. Met	Spec. Met
Structured	The implementation of the platform on the case studies illustrates the different structures that could be used. This indicates that the platform was not single-system orientated and could be used for multiple PM teams. Each team could have their structure and this ensured that projects and their actions could be better managed. Having a universal structure that could be accessible throughout the teams improved the way projects were monitored and managed. Information could be displayed clearer and more efficiently, and this reduced the clutter that would occur without having structure. The platform is, therefore, validated to utilise a structured PM.	1. ✓ 2. ✓	✓
Scalable	The platform was used across multiple teams with increasing amounts of data. The correct verification of the scalability requirements from Section 2.6 ensured that the platform would be scalable for long-term use and excessive data storage. The implementation of Case Study A validates how the platform structure can be altered to fit the needs of the PM team. The separate case studies validate the scalability across multiple teams and organisations.	1. ✓ 2. ✓ 3. ✓	✓
Integrated	Case Study A and C were both made available to the client that the project team is assigned to. The platform illustrated the successful integration between the company and its clients to improve the pipeline process of communicating information. Actions could also be linked to each node on the client's structure. The results validated the improved interactions with the company and its clients and showed improved communication and resource sharing.	1. ✓ 2. ✓	✓

Table 3.15: Table Validating that the Final Platform was Implemented Correctly.

3.7.3 Second Objective

The second empirical objective from Section 1.8 aims to validate that the platform was implemented in industry and brought improvements to PM. This objective was validated through the implementation of the case studies. The platforms were implemented in industry for use by a company and its PM teams.

The results that were obtained showed significant improvements in PM across the company within the teams that used the platform. The platform improved on the previously implemented solutions the teams had in place to track the actions that needed to be handled.

handled. The platform allowed teams to interact more productively on the projects they had and achieve more effective results throughout the use of the platform.

3.7.4 Third Objective

The third empirical objective from Section 1.8 aims to validate that the problem statement defined in Section 1.7 was resolved. This would ensure that the need for the study is fulfilled. A platform was created that was not system-/organisation-specific and allowed for the implementation of multiple structures across teams.

The platform can scale with the needs of the business, as the correct methodology was followed to ensure this. The platform covered the six aspects identified by the state of the art in Table 1.2 and fulfilled the requirements and specifications of the user from Section 2.3.

The implemented platform and the results obtained, therefore, validate that the problem statement was resolved, thereby meeting the need for the study. A generic online Action Tracking Platform for PM in industry was developed and implemented.

3.7.5 Fourth Objective

The fourth empirical objective from Section 1.8 aims to evaluate the results obtained and validate that the implementation of the platform was correct. This objective was met through the results obtained in each of the case studies. Sections 3.5 and 3.6 also highlights and evaluates the results obtained.

Validating that the requirements were met in turn validates that the implementation of the platform was correct. The platform yielded positive results from the user and validated the correct implementation. The platform provided an improvement in the PM performance across the company and within its project teams.

3.8 Conclusion

This chapter described the necessary PM performance evaluation criteria that was used to evaluate the implementation of the Action Tracking Platform on the case studies. The different platform implementations and their structure for the case studies were described. The platform-specific results based on the structure of the actions recorded were also described where applicable.

The platform implementation results for each of the case studies were provided and then summarised across the case studies at the inception of the platform (January 2020) and present (August 2020). Each of the case study results that were obtained were then discussed and evaluated according to the observed PM performance benefits.

Overall, the platform saw an increase in the number of PM team users and client users on the platform. The implementation of the Action Tracking Platforms successfully yielded an increase in the PM performance when evaluating each team according to the evaluation criteria. The platform successfully contributed to more effective PM techniques being used across the company.

Chapter 4

Conclusion

4.1 Summary of Work

Effective Project Management (PM) is essential to the success of projects in industry. It is reported that approximately 68% of all projects in industry fail due to ineffective PM. A further 15% of projects are deemed to fail from the start, where 10.9% of the final project's cost is wasted. Only 58% of all businesses in industry understand the importance of efficient PM. PM tools utilised for action tracking are widely used to improve efficiency; however, the current action tracking methods are not as efficient due to the activities being overlooked, not being dealt with in time, or having to be re-assessed.

Present action tracking platforms are designed for single-system use, which means that they only consider the current state of projects and cannot be adapted for future purposes, thus limiting their implementations. User interaction with the current PM tools is also inefficient, as the information displayed is not consistently updated or readily available. Effective PM methods are key to the success of projects in industry, and the currently implemented methods are not as effective in aiding with PM. A need, therefore, exists to develop a platform for action tracking to assist with increasing the effectiveness of PM in industry.

An in-depth literature study on the current methods used for PM in industry determined that a successful Action Tracking Platform needed to be generic, centralised, traceable, structured, scalable as well as having the ability to integrate its users. These requirements were used to evaluate the state of the art for PM in industry. The literature review highlighted the importance of the development of a web-based action tracking platform implementing all the identified requirements. Web-based PM is one of the key underutilised platforms in industry which can improve on communication, automation, and the standardising of processes. This created the foundation for the development of the method for the design of an Action Tracking Platform for use in industry.

The platform should be accessible and useable by all project personnel and clients of the organisation. The platform will need to be generic to cater for different teams' structures, whilst also not limiting the teams to a single structure for a definite period. The platform should allow for structured PM across an organisation that caters for the scalability within industry. It should also provide the necessary traceability amongst all the users of the platform to ensure project accuracy and integrity. This will help the PM teams in industry to more efficiently manage their projects and actions. This created the foundation for the development of the method used for the design of an Action Tracking Platform for use in industry.

A method was designed for the development of the platform that would meet the requirements and specifications as denoted in the literature. The method ensured that the implemented platform would meet the objectives of the study and fulfil the gap that exists in the state of the art. The development of the method was verified to ensure that when implemented, it would fulfil the identified focus points for effective PM.

A platform was implemented for use by a multi-disciplinary engineering company and its PM teams to increase PM effectiveness across the company. It was designed and implemented based on Microsoft's `ASP .NET MVC` Pattern using a combination of `C#`, `JavaScript` and `HTML`, where the data was stored across `SQL` and `NoSQL` databases.

The platform was generically implemented to meet the needs of the different PM teams and contributed to limiting the future maintenance required. The platform successfully structured the way project actions are managed across the company's PM teams. The platform made it possible to centralise all the data, thus contributing to decreasing the pipeline of information transfer to the company's clients.

The platform allowed for timely feedback on projects for use within the company or for presentation to the clients. All the transactions on the platform were recorded and a database of actions was maintained contributing to improved data integrity, traceability, and accessibility. The choice of the databases used and the way the platform was designed ensured that it would be properly scalable for prolonged use by all the teams whilst maintaining performance.

The platform was implemented for a multidisciplinary engineering company's PM teams, their clients, and the projects that connect them. Successful implementation was achieved across three case study PM teams within the company. The platform yielded an 84.16% decrease in the average completion rates (days) of projects across each case study; therefore, achieving faster results and increasing PM within the company. At the platform's inception, 38.08% of actions exceeded their planned completion rates. After the evaluation period, actions were completed 17.33% faster than their planned completion rates.

After a set evaluation period (eight months), the results were obtained and evaluated against the necessary metrics used to evaluate PM performance. The value that the Action Tracking Platform added in terms of effectively increasing PM in the company was noted through the metric results that were obtained.

The implementation of the platform led to a decrease in the completion rate of actions, the number of actions overdue, and the number of changes that occurred to the schedules on actions, whereas there was an increase in the number of actions that were completed ahead of schedule and that were delivered on time within the PM teams. An increase was also seen in the number of users throughout the use of the platform, where an increase in the client involvement on projects occurred.

The results proved that the platform implementation successfully met the objectives of the study and motivated users to more effectively manage their current actions and prioritise their successful completion. The platform's implementation successfully improved the PM of projects and their actions within the company and successfully illustrated the importance of effective PM within industry.

The platform's implementation concluded the findings in literature and illustrated the importance of having an effective PM method. It was directly seen from the results how having a method for PM teams to track their actions on projects contributed to their timely completion and more efficient management thereof. This study contributed to communicating the importance of having effective PM and successfully contributed to the field of online PM. It was noted how the use of an online platform for PM teams can increase the effectiveness of completing projects on time.

This research contributed to the importance of effective PM and how organisations can greatly benefit from having a central, online platform to communicate the actions on projects across team members. It was also noted how reducing the communication gap between the PM teams and the client can greatly improve the success of a project and reduce the need for unnecessary face-to-face meetings. The PM teams were able to more effectively communicate amongst each other and ensure that everyone remains updated with project progress.

The final implemented platform met the objectives of the study and successfully met the requirements and specifications by solving the problem statement. A generic online Action Tracking Platform for PM in industry was successfully designed and implemented. Its design was successfully verified, and the implementation was validated for use in industry through its implementation on three case study PM teams, thus proving the need for effective PM in industry.

4.2 Limitations

The implementation of this platform incurred several limitations, and some of these limitations can impact the effectiveness of the platform and its sustainable usage. The limitations that the platform faced are discussed under the following sections.

4.2.1 Existing Infrastructure

The main bottleneck for performance improvements was dependent on the computing performance of the server the company used for its online platforms. Depending on the user interaction with other platforms and the Action Tracking Platform simultaneously, this could affect the platform's performance.

The implementation on the company's existing infrastructure also meant that it was bound by their software environment. This meant that its development had to follow set standards and that it had to interact with the existing software modules.

4.2.2 User Input & Usage

One of the main limitations is that the platform is only as good as the user and their input. The platform aimed at improving the PM performance of the company, but it was reliant on the user to input accurate and timely data. The effectiveness of the platform was dependent on how well the user understood the platform and how they made use of it. If the user entered invalid data, they would get invalid data out (GIGO[1]).

The platform would also only continue to exist and maintain its usefulness so long as the user interacts with it. If the users remain dedicated and switches over to using the platform to track their actions, it can operate effectively. Case Study B was an example of where the platform usage went down due to the impact `COVID-19` had on the client operation and as such its effectiveness was temporarily impacted.

4.2.3 Maintenance

It was noted that throughout the life cycle of the platform, scope creep would occur with the requirements. The users of the platforms were constantly manipulating the structure used to track their actions. The maintenance time for these requests was significantly reduced through the generic implementation of the platform, as each structure that a platform was based on could be easily manipulated, but it was a time-consuming process for these changes to be applied. The impacts on the existing data needed to be considered as well as how it would affect other users.

[1] *GIGO — Meaning in the Cambridge English Dictionary*. [Online]. Available: `https://dictionary.cambridge.org/dictionary/english/gigo` (visited on 05/07/2020)

Users were also requesting different features that were required by the platform and the implementation of these features was time-consuming. The platform will continue to require consistent maintenance in the future to provide newer features and continuously improve performance.

4.3 Recommendations for Future Work

4.3.1 Introduction

After the implementation of the platform and gaining first-hand experience into how the projects are managed in industry, recommendations for future work were noted. These recommendations are what PM teams can use to better visualise their actions and further improve on effective PM.

4.3.2 Project Workflows

Project workflows can be added to help teams better visualise their actions and see what tasks they are assigned to[2]. These workflows will help teams to better organise their actions on a higher level and be more useable in team meetings. Figure 4.1 illustrates a basic example of a project workflow.

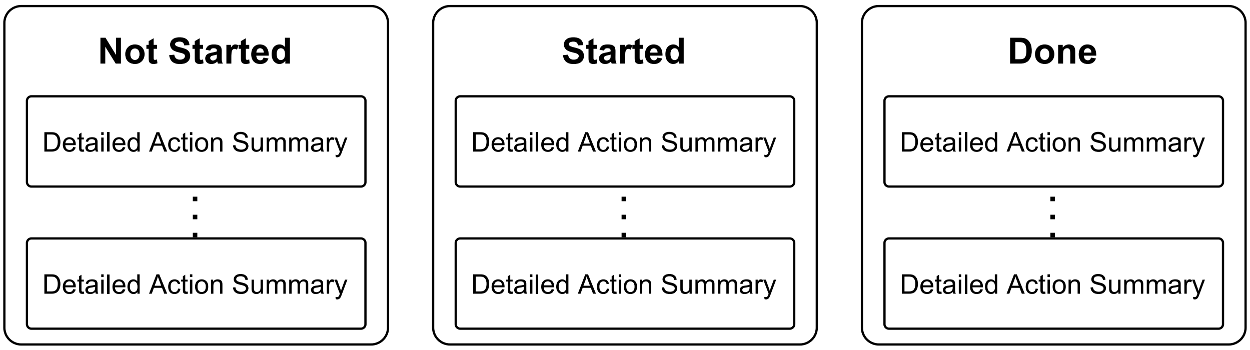


Figure 4.1: Illustration of a Basic Project Workflow.

As can be seen from the workflow, actions can be more effectively grouped under categories and they can be visually interacted with. Users can use this to visually see the flow of work and the backlog of actions that need to be done. A detailed action summary is also provided which highlights the most important points on that action. Users can view their assignments and gain better insight into their workload.

4.3.3 Action Linking and Sub-actions

It is recommended that a way of linking actions to one another be implemented to further aid in the visualisation of projects. This was noted as not all projects take a single action to be completed.

[2] *3 Steps to Designing a Powerful Project Workflow - ProjectManager.com*. [Online]. Available: `https://www.projectmanager.com/training/define-workflow-process` (visited on 12/10/2020)

Actions can be linked to one another and this can help further sub-divide the work at hand. This will create a better hierarchy for the presentation of the work that needs to be done by the team.

Critical paths can be analysed and expected completion dates for projects can be better presented to project managers. Figure 4.2 is a basic illustration of a hierarchy for the connected actions and their critical path [47].

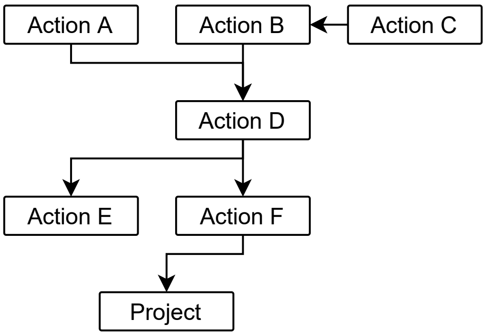


Figure 4.2: Project Hierarchy and Critical Path.

This hierarchy will help teams to visualise the critical path of their projects and provide more accurate expected completion dates. If one of the deadlines is updated in the hierarchy then this can automatically update the project's deadline and further improve PM within teams. This will significantly help reduce the overhead when managing projects and their actions.

4.3.4 Gantt Charts

Another visualisation tool that can improve the efficiency in teams is the implementation of Gantt charts[3]. These charts can help teams gain a better overview of the actions that are to be completed as well as how their schedules are looking. Figure 4.3 illustrates a basic example of a Gantt chart for action visualisation.

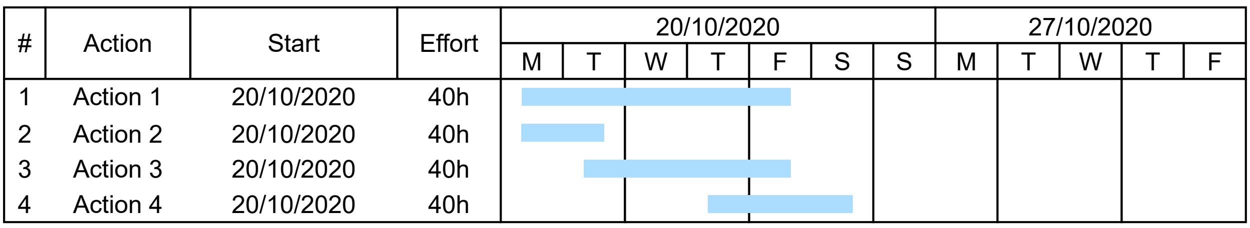


Figure 4.3: Project Gantt Chart.

This chart will help teams to better visualise the project deadlines and handle conflicting deadlines more effectively, as a new action's schedule may often not be able to overlap with an existing action's and cause overall delays in the projects.

The implementation of project workflows and Gantt charts will create transparency within teams. All team members will be aware of one another's responsibilities and understand how to progress forward with the workflows.

[3] *What is Gantt chart? - Definition, Benefits & Tools.* [Online]. Available: `https://www.proofhub.com/articles/gantt-charts` (visited on 12/10/2020)

4.3.5 Reporting and Emailing

Providing the ability for the user to have reports automatically generated on a scheduled period and then having the ability to automatically email them to the correct users will allow users to more effectively monitor a project's progress and maintain reported summaries of the projects.

Emails for project deadlines can also be generated and sent to the relevant personnel. This will help users to effectively manage a project's progress and ensure the timely completion thereof. Clients can also more effectively be made aware of the progress on projects by receiving periodic, summarised reports.

Emails can also be configured for user assignment so that users are continuously aware of the tasks that they are assigned to. This will ensure that no user is out-of-touch with the work that needs to be done by them. Users can then be immediately notified of new actions or any action updates made to their assignment.

4.3.6 Summary of Future Recommendations

Implementing these recommendations will help teams improve on their transparency, efficiency, communication and collaboration[2, 3]. Table 4.1 summaries the discussed improvements which can be considered for future implementations.

#	Future Recommendations
Project Workflows	
1.	The definition of project workflows. Allowing users to visually interact with their assignment on actions and view upcoming actions linked to them or other team members.
Action Linking and Sub-actions	
2.	Further subdivision of actions to create a better-connected hierarchy of actions that can be linked to one another.
3.	The identification of a project's critical path by analysing its dependants and providing a better perspective on the scope of a project.
4.	Automatically adjusting project schedules when changes are made to any dependant actions.
Gantt Charts	
5.	Offer improved visualisation tools like Gantt charts.
Reporting and Emailing	
6.	Generating emailed reminders and alerts when tasks are due or past deadlines.
7.	Automatic report generation and emailing to assigned users.

Table 4.1: Summary of Recommendations for Future Work.

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Appendix A

Further Contributing Information

A.1 Identified Focus Points

The necessary research was conducted on how PM is done and what contributes to a successful platform. The following section provides further details on the key focus points that were identified; what these key focus points entail and what they focus on is described. These points are used in Section 1.6 to evaluate the state of the art as defined by the literature. Section 1.5 was used to provide a summary of these focus points.

Generic

Generic programming entails not defining the underlying type for a class to increase the usefulness of its application in software. Generic programming enables the representation of data structures in different forms, while still being able to use and interpret them [48]. It allows for shared functions to be reused on multiple classes, which helps to reduce the software overhead needed to handle multiple different input types or structures.

Listing 2 depicts the typical declaration of a generic class in the *C#* language environment[1].

```
// Declare the generic class.
public class GenericList<T>
{
    public void Add(T input) { }
}
class TestGenericList
{
    private class ExampleClass { }
    static void Main()
    {
        // Declare a list of type int.
        GenericList<int> list1 = new GenericList<int>();
        list1.Add(1);

        // Declare a list of type string.
        GenericList<string> list2 = new GenericList<string>();
        list2.Add("");

        // Declare a list of type ExampleClass.
        GenericList<ExampleClass> list3 = new GenericList<ExampleClass>();
        list3.Add(new ExampleClass());
    }
}
```

Listing 2: Example of the Declaration of a Generic Class[1].

The main advantages of generically implemented classes include[1]:

- The ability to generate code optimised for any collection.
- Maximising code reusability, type safety, and performance.

[1] M. Wenzel, B. Wagner and N. Schonning, *Generics - C# Programming Guide — Microsoft Docs*, 2020. [Online]. Available: `https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/generics/` (visited on 22/03/2020)

- Writing a single class that can be used without incurring runtime casts or boxing operations.
- Reducing code duplication [49].
- Increasing the scalability of the system with time.

The implementation of generic classes for PM dashboards to track project actions have many advantages. It allows for multiple different structures to be defined for different teams on the platform; therefore, allowing each team to get their value out of using the platform. Only one class needs to be written and it can be reused across multiple different Action Tracking Platforms. This is used to reduce the redundancy, increase the simplicity, and improve the software maintenance cycle after development of code. Generic programming will allow developers to only have to maintain limited files across multiple platforms.

Centralised

For the management of projects to be successful, the members of a team need to be able to communicate with each other and not be limited by distance [50]. Teams need to be able to collaborate and communicate effectively to improve the visibility of a project's progress for the project manager and everyone involved. For PM teams to prove the value of the actual project's performance, clients often request to view updates to plans [50]. The ability for PM teams to provide this visibility on their projects and their continued updates provides great value to the clients. This adds more value to the PM team's projects and the services that are being provided to their clients.

It is important to realise that in today's connected world, high-valued knowledge drives the current business evolution[2]. Centralisation of all the current workflows of a project creates a work-pipeline. This can be effectively used to evaluate the skills of the team members and becomes an essential tool for the PM team. It allows them to monitor workflow performance to adequately generate performance reports.

Centralisation focuses on a central platform where all activities can be monitored throughout. Feedback on tasks can be instantly provided and brought to the attention of upper management and colleagues, with improved efficiency. This in turn ensures that everyone has easy access to the current progress on all the project actions. Figure A.1 illustrates an example of the advantage of having centralised management against decentralised management.

[2] J. Lund, *How Digital Transformation is Driving Customer Experience*, 2020. [Online]. Available: `https://www.superoffice.com/blog/digital-transformation/` (visited on 18/04/2020)

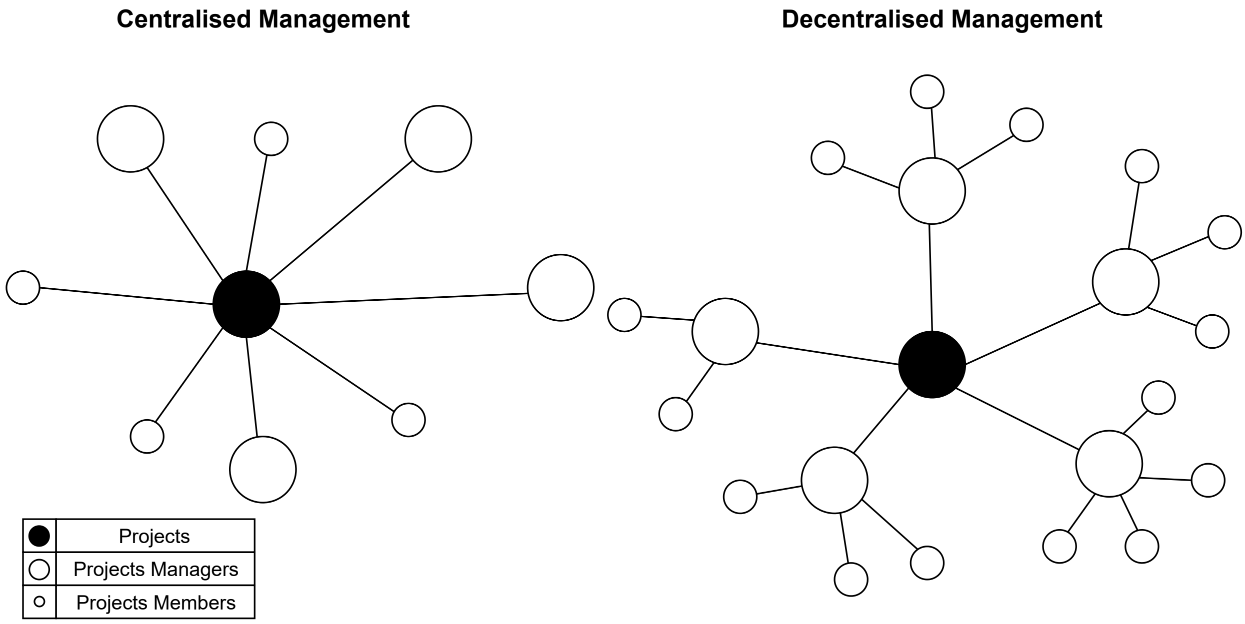

Figure A.1: Centralised Compared to Decentralised PM.

From Figure A.1 it can be noted how, with centralised PM, every project member has access to view all the current projects. All teams have access to a central view of all the active workflows, where everyone can understand their responsibilities and view the progress of all tasks, whereas in the decentralised PM approach, each member of a team must first interact with the project manager before gaining knowledge about the project. There is no direct link between the different teams making it difficult to have effective communication amongst all the project members, which is important in the PM approach [51].

The correct implementation of centralisation ensures that all members involved in the active actions can receive real-time information. This allows the project members to view the central repository containing all the active actions. Having this type of centralisation allows for simpler report generation and avoids generating reports that contain any unnecessary data that is not already known by the client. Teams can be correctly mobilised by interacting through a centralised monitoring interface to create a virtual team. It allows them to leverage skills that were once underutilised due to the limitations of working without a centralised interface.

The centralisation of PM within PM teams brings about the following advantages[3]:

- **Supports overall business strategy:** All the projects contribute to the overall business goal and not just individual teams.
- **Optimise resource usage:** Efficiently assigning the correct people to work/handle a project.
- **Prioritisation on value to the PM team:** The ability to prioritise the correct projects. Emphasising doing the highest priority projects that bring the most benefit to a business, now.
- **Streamlining workflows:** All members can view their work and the tasks they are

[3] B. Johnson, *Centralized Project Management Focuses on Strategy*. [Online]. Available: `https://cloudcoach.com/focus-on-strategy-over-projects-the-growth-of-ppm/` (visited on 26/03/2020)

assigned to in one central location, reducing the time and energy wasted on multiple different projects.

- **Improved reporting:** It becomes easier to report on a project's progress when they are all managed in a central location. Centralised projects improve visibility and reporting for all the projects within a PM team.

Traceability

Traceability, as defined in terms of the scope of PM, focuses on keeping a log of changes on all the active projects. This helps ensure accountability to all the changes that are taking place within a project's scope; therefore, maintaining integrity within the data. This form of logging helps keep track of the changes to any of the attributes on a project and helps to maintain an audit trail [52], [53]. This helps project managers to easily keep track of who made the changes and correct invalid data as well as communicating with those who made the changes.

Another advantage of traceability is the use of the audit logs to maintain the history on all the projects. This can be used as a guide to address future scenarios that may lead to similar project scope. Traceability emphasises the user activity and recording all the changes across a project's actions.

Traceability to the origin of a change is important and useful in situations where the correctness of data is essential. It is often required when many users are manipulating and working on the same shared data source [52]–[54]. Care should be taken to prevent data loss and this is, therefore, why it is important to maintain an audit trail containing details about all the critical and non-critical events [54].

Businesses are increasingly dependent on confidentiality, integrity, and availability when it comes to technology and the data that it handles [54]. According to [54], for a system to be considered safe, it must first meet the following criteria:

- **Authenticity:** Meeting the conditions of non-repudiation and legality.
- **Privacy:** Ensuring that the data stored is only maintainable by its owners and that the information is not disclosed to others.
- **Audit:** The different stages of an entry's life cycle, including the type of process, the persons involved, and the time when an action took place.

These criteria fall under the need for accuracy of data. It illustrates the essential need for traceability amongst the data and the user which interacts with the data, especially for effective PM.

Structured

Many PM implementations require the use of a structured approach when managing their project actions. This involves improving the clarity, quality, and development time needed to develop a software program [55]. The implementation of a structured program makes use of structured control flow and block structures. If a structured approach is not taken, a program can often develop into *spaghetti code* which becomes very difficult to maintain [55][56].

It is important in PM for a PM team to have a structured and controlled approach to managing their projects. This relates to how they manage their projects and the software they use to do it. The software applications often form the foundation for the approach that a PM team uses to manage its projects. It is, therefore, important to use a structured software application when monitoring a project and all of the actions involved [57] to produce a uniform PM strategy.

An example of a simple structure that PM teams can use for tracking a project and its related actions is illustrated in Listing 3.

```json
{
    "StartDate" : "2020-04-09",
    "EndDate" : "2020-09-09",
    "IdentifiedDate" : "2020-04-09",
    "ResolvedDate" : null,
    "CommitmentDate" : "2020-12-09",
    "Description" : "Project Management Entry",
    "Grouping" : "Systems",
    "Status" : "Ongoing",
    "Progress" : "55%",
    "Assigned Persons" : "Scott Hall, John Doe",
    "Comments" : [
        {
            "Comment" : "Closing Comment",
            "Timestamp" : "2020-04-09",
            "User" : "Scott Hall"
        },
        {
            "Comment" : "Opening Comment",
            "Timestamp" : "2020-04-09",
            "User" : "Scott Hall"
        }
    ]
}
```

Listing 3: JSON Example on a Simple Action Tracking Structure for Use in Industry.

The structure in Listing 3 is a basic representation of what PM teams can use to record project actions. It considers the most common information that would need to be seen when tracking actions by the management teams. It allows for a shared structure that can potentially be utilised as a backend for multiple teams working towards a common goal. This will help to standardise PM across a PM team. Utilising this structure as a starting point and manipulating it for a proper display to the user will allow PM teams to gain key insight into all the current projects.

The main key factors that are to be considered when focusing on structured PM and the software platform that will be used to achieve this are [57]:

- **Software development process:** What is the approach that is needed to develop a successful PM tool?
- **Software used:** Does it allow for structured team management and allow for activities to be managed in a structured manner according to the team's philosophies?

- **Team project management:** Can the team be managed under a structured approach or is the team currently using a structured way to manage their projects?

These factors all contribute to having structured PM and the development of a structured software management tool to be used by the teams. This structure helps PM teams use one agreed-upon management approach for all the teams in an organisation and is highly beneficial to the PM team [57].

Scalable

Scalability is needed in good PM software. This is often because most of the projects in industry have the potential to scale over time. This is as a result of companies often following an agile development approach. This means that projects generally scale in size after every meeting and as the projects progress through their lifespan. Project scope creep is inevitable in any project, which is why it is vital that a company's PM software needs to scale with it. Some of the examples of project growth include an increase in projects, users, reports, meetings, and clients[4].

Scalability can be defined as the ability to handle an increased workload whilst still maintaining performance [58]. A system needs to be properly scalable as more teams begin to use the platform. Teams will often apply the software management tool to benefit their needs, thereby increasing the platform utilisation for different demands and outputs. Some of the factors that need to be considered when implementing a scalable system are:

- **User interface:** Taking into consideration the amount of information which needs to be presented to the user.
- **Capacity limits:** How many entries a system can handle.
- **Algorithmic performance:** Ensuring that no unnecessary computation tasks are performed.

A trade-off often must be considered between the functionality of a system and the scalability of it; therefore, to provide a properly scalable system, it may be worth considering splitting up the functionality of the system to maintain the performance and improve the scalability in the long term [58]. With the correct amount of scalability applied to a PM tool, users with projects of various sizes can track their actions and mitigate their risks.

Integrated

It can be noted how including the client in the involvement on the active projects can successfully improve customer satisfaction [50], which places great emphasis on how important it is to integrate a PM team with its clients. It allows for both parties to be aware of the current workflows and everyone is updated with the actions taking place, as provided by the PM team.

Pipeline management can be improved through proper resource management, where knowledge can be effectively shared in real-time to increase project performance. Integration

[4] S. Pogue, *How to Determine If a Project Management Tool Can Scale — Workzone*, 2019. [Online]. Available: `https://www.workzone.com/blog/how-to-determine-if-a-project-management-tool-can-scale/` (visited on 28/03/2020)

between the PM team and the clients can help the clients recognise the professional services they are receiving from a PM team.

Integration focuses on the inter-team collaboration that occurs between a PM team and its clients. Effective collaboration is a key focus point in industry when it comes to PM. In [59] it can be seen how having the proper means for user collaboration can be an effective tool in improving the accuracy of the data that is placed into a system. The proper integration of users that are contributing to a team can have a great effect on the success or failure of a project.

Having successful PM team-client integration also reduces the clutter that occurs when managing projects. With everyone being able to gain access to the necessary steps that are occurring within a project, teams can effectively reduce the amount of duplication that occurs and improve on the delivery of a project [59].

Figure A.2 represents the aim of what integration tries to accomplish between a PM team and its clients. It allows all members to be aware of the project's ongoing status and creates the missing link between the PM team and its clients to effectively share Data, Information, Knowledge, and Wisdom (DIKW).

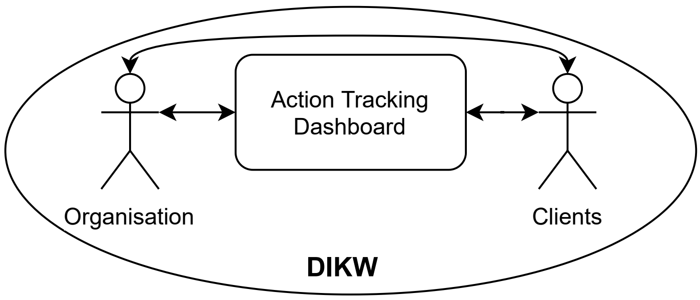

Figure A.2: The Integration of the Organisation and its Clients Within the Same DIKW Circle.

Integration between an organisation and its clients can help improve the quality of the delivered products or services [60]. Collaboration between PM teams and their clients is considered an important tool for businesses in industry. It allows for the innovations of services delivered that alone would not be possible. More specifically, having an online environment where users can integrate and collaborate provides a unique opportunity to share resources and knowledge amongst one another. Cross-team integration on a project is highly encouraged for effective management to deliver a product of even higher quality [60].

Some of the advantages of effective PM team and client integration include [61]:

- **Increased productivity:** Efficiently distributing tasks amongst team members and all involved in the project, whilst keeping the client informed.
- **Improved problem-solving:** Solving problems together can lead to solutions that are achieved quicker and with better results.
- **Improved communication:** PM teams can communicate effectively with their clients, even across remote locations when using an online platform, reducing the side-tracking of projects.

- **Lowered overhead:** PM teams and clients no longer need to be in the same place, thus reducing the need for meetings that consume valuable time.
- **Improved human resources:** Improved collaboration leads to improved relationships between the PM team and its clients, thus contributing to client retention.

A.2 State of the Art

This section serves as a more detailed overview of Table 1.3 of the state of the art and uses Table 1.2 to illustrate whether the studies met the evaluation criteria. A more detailed look into the state of the art is provided herein Table A.1.

Ref.	Generic	Centralised	Traceability	Structured	Scalability	Integrated
[3]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[17]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓
[18]	1. ✗	1. ✗ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[20]	1. ✗	1. ✗ 2. ✗	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[21]	1. ✗	1. ✓ 2. ✗	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[22]	1. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[23]	1. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✓ 2. ✓ 3. ✓	1. ✗ 2. ✗

Ref.	Generic	Centralised	Traceability	Structured	Scalability	Integrated
[24]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[25]	1. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✓
[26]	1. ✗	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✓ 2. ✓ 3. ✓	1. ✓ 2. ✓
[27]	1. ✗	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗
[30]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[31]	1. ✓	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓	1. ✓ 2. ✓ 3. ✓	1. ✓ 2. ✓
[33]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✓	1. ✓ 2. ✓ 3. ✗	1. ✓ 2. ✓
[34]	1. ✗	1. ✗ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[35]	1. ✗	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓

Ref.	Generic	Centralised	Traceability	Structured	Scalability	Integrated
[36]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓
[37]	1. ✗	1. ✓ 2. ✗	1. ✓ 2. ✓ 3. ✓	1. ✓ 2. ✗	1. ✓ 2. ✓ 3. ✓	1. ✗ 2. ✗
[38]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓
[39]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✓ 3. ✓	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓
[40]	1. ✗	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓	1. ✓ 2. ✓ 3. ✗	1. ✓ 2. ✓
[41]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✗ 3. ✓	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✓
[42]	1. ✗	1. ✓ 2. ✓	1. ✓ 2. ✓ 3. ✓	1. ✗ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗
[43]	1. ✗	1. ✓ 2. ✓	1. ✗ 2. ✗ 3. ✗	1. ✓ 2. ✗	1. ✗ 2. ✗ 3. ✗	1. ✗ 2. ✗

Table A.1: Table Illustrating the More Detailed View of the Criteria the Studies Met When Compared with Table 1.2.

Ref.	Comments
[3]	Centralised PM and tracking in small businesses, but was not scalable for larger projects.

Ref.	Comments
[17]	Provided a fixed single-purpose PM structure for construction projects.
[18]	Served as a study that promoted the effectiveness of using PM within the medical industry.
[20]	Only used as a backend monitoring system when needed.
[21]	Used by the project manager to manage their teams, access not provided to everyone.
[22]	Tool provided to assist in managing computer-aided design projects and help track their progress.
[23]	Web-based platform to assist in managing the progress of software projects.
[24]	Web-based platform in order to more effectively manage the complexity of small-scale development projects for PRINCE2.
[25]	Web-based platform designed to operate on a large touch display to provide a centralised interface that developers can use to update project progress.
[26]	A web portal for PM in electronics design software development to bridge the gap in the current web portal software.
[27]	Provided a simple structure to view patient flow in the hospital, but was only made available to some staff members. Only concerned with the now.
[30]	A basic structure was provided that was only used by the maintenance staff.
[31]	Successfully implemented the use of a generic backend, but was not focused on user traceability.
[33]	A centralised monitoring dashboard that provided a structured view of the current operations for all staff. Providing limited scalability within the organisation.
[34]	Basic implementation of PM in Microsoft Excel, with limited future capability as needs change.
[35]	A highly interconnected structure that would make long-term use and maintenance impractical.
[36]	System successfully centralised projects, but required further work for the implementation in other cities.
[37]	Dashboard for use by project managers to record current project progress.
[38]	Provided a basic, structured approach to managing fishing industry activities.
[39]	Improved equipment management and reduced work stress.
[40]	The system illustrated limited means for scalability by providing a structure to suit each farming group's needs.
[41]	PMS used to share research across geographical locations and integrate PM teams.
[42]	System-specific implementation to be integrated with the existing Train Dispatching Command System.
[43]	Used offline reporting to monitor equipment status.

Table A.2: Table Providing Comments on each Reviewed Study.

A.3 Existing Infrastructure

The Action Tracking Platform that was implemented for the company needed to integrate with their existing infrastructure to be made readily available. Integrating the platform with their infrastructure would allow all the employees as well as the company's clients to interact with it. The integration would also ensure a smoother transition into user adoption as users are already familiar with the existing infrastructure as well as reducing the time for the development of the platform.

The company uses relational databases to control the user access to their platforms, maintain the PM team tree structures and maintain the links between other database platforms. This section will describe the existing infrastructure that the company has and how the Action Tracking Platform will build upon this infrastructure.

A.3.1 PM Team Structures

A PM team's structure and what operations make up a PM team are maintained by the company in the `MySQL` database. The structures represent the layout for each of the client's operations and how they are linked to each other. Figure A.3 illustrates the tables that are used by the company to store the PM Team's tree structures in the database.

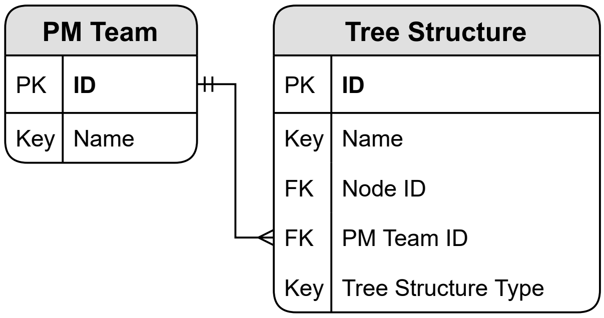

Figure A.3: ERD Illustrating the Data Storage of a PM Team's Tree Structures.

Maintaining this type of configuration allows PM teams to have multiple tree structures. This allows a PM team's action tracking tree structure to have multiple definitions, which ensures the integrity of the tree structures created and allows the data of PM teams to be linked to different tree structures for specific project instances, allowing the Action Tracking Platform to have a direct relation to the PM team.

The created tree structures can then utilise the operations linked to a PM team's structure. Figure A.4 illustrates the tables that are used by the company to store the created tree structures and the nodes which are linked to them.

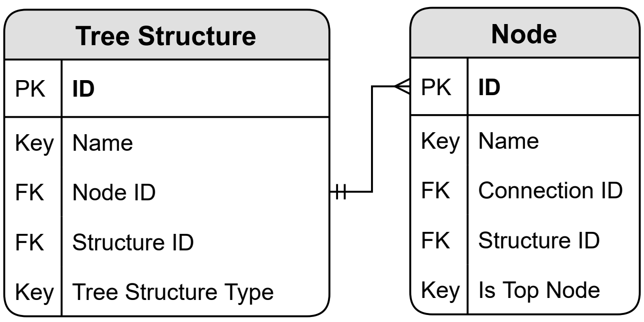

Figure A.4: ERD Illustrating the Linking of Nodes to a Structure and Node Connections to a Tree Structure.

The `Nodes` of a PM team are linked to their `Tree Structure`. The `Tree Structures` of a

PM team can then be based on the organisations by storing what `Nodes` are specific to that `Tree Structure`. This allows for greater flexibility and control over the `Tree Structures` created as they will not fall out of sync with the Action Tracking Tree Structure.

Using this setup for the configuration of tree structures allows an action tracking tree structure to be created and have a specific PM team's nodes linked to it. Figure A.5 represents a PM team's structure and how groups of actions can be linked on a per-node basis.

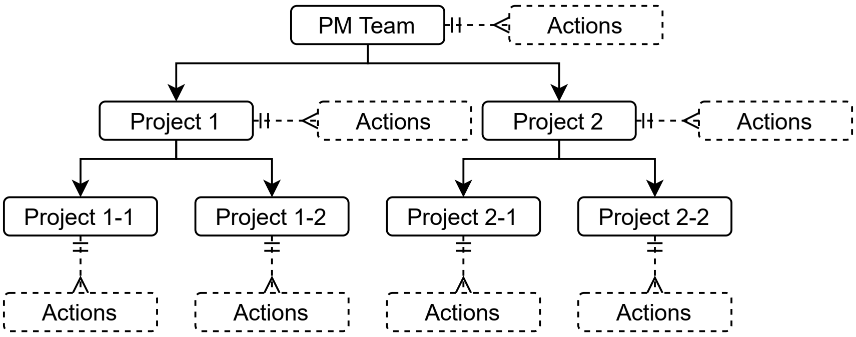

Figure A.5: Action Tracking PM Team Tree Structure.

Every PM team can have their tree structure as seen in Figure A.5, and these tree structures will be specific to each platform. Every node on the tree structure can then have groups of actions linked to it which relate to that project. This will ensure that successful integration can be achieved with a PM team's already defined structure. It will be used as the method to group all the project actions and easily filter the data to the users.

A.3.2 Dashboard Views

To display the views that the company makes for its clients, the company would need a means of properly grouping them with the data they want to display. The grouping of these views would ensure that the menus that are created are easy to use and display the correct data under the correct categories. Figure A.6 illustrates the tables in the `MySQL` database that are used to properly manage their systems and how they can then display them to their clients.

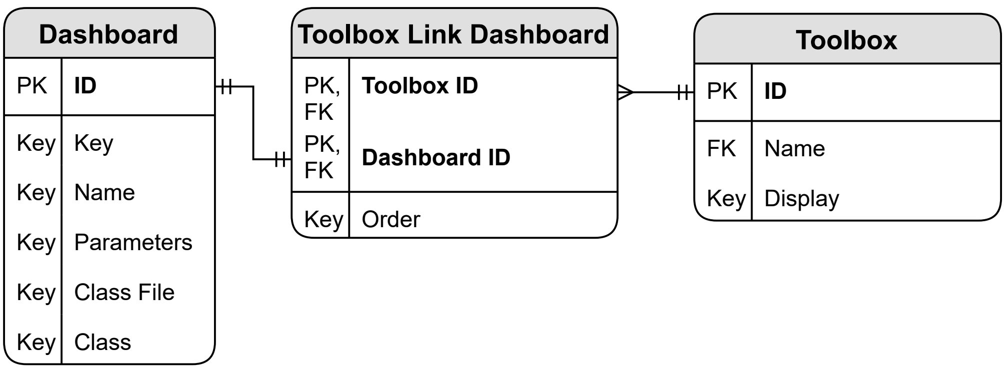

Figure A.6: ERD Illustrating the Link Between Dashboard and Toolboxes.

A `Toolbox`- and `Dashboard`-linking structure is already implemented to handle this. The `Toolboxes` are what is directly displayed to the client when they log in, and several `Dashboards` can be linked to them to group the data accordingly. When clicking on a `Toolbox`, it loads the first (`Order`) `Dashboard` linked to it. The `Dashboard` then uses the appropriate controller file (`Class File`) and method (`Class`) which then loads the correct data for display within the `Dashboard`.

This structure will be used to create an `Action Tracker Toolbox` which an `Action Tracker Dashboard` can then be linked to. This will ensure that the data that is created in an Action Tracking Platform will be properly integrated and displayed on their main systems. Loading this Toolbox/Dashboard will then utilise the Action Tracking Platform and load the appropriate data for the PM team that the user is linked to.

A.3.3 Document Management

The company also provides its teams and clients with the ability to store any documents online. This is all done through the created Document Manager dashboard. Users of the dashboard can upload documents and link them directly to the created document tree structure.

This provides a proper means for storing any documents that relate to any of the work done on specific operations. The current structure for how the documents are stored is maintained in the `MySQL` database. Figure A.7 illustrates the table in the `MySQL` database that is used to store a PM team's documents.

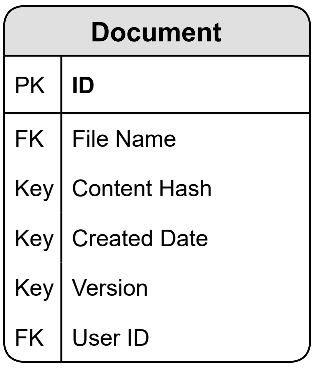

Figure A.7: ERD Illustrating the Document Storage.

The documents are currently assigned to the node on a PM team's structure and are mainly used as a storage device with insufficient information about the context of the documents and why it is linked there.

The Document Manager that the company has will be integrated with the Action Tracking Platform. This will allow documents to be directly linked to any of the actions created and provide more meaning to the documentation that is stored and in turn the actions that are created.

A.4 Additional Software Modules

This section covers the additional software modules that were developed for the state of the art. They fall-out of the state of the art specifications but serve as an additional beneficial feature provided by the Action Tracking Platforms.

A.4.1 Report Handler

It is important to provide the user with the ability to report on their actions and the actions of the teams. The Report Handler was created to generate PDF documents containing summaries of the actions filtered according to user specification.

Backend

When clicking the report generator button, the user can select to filter the action by their open/closed status, their open and close date, whether the comments should be included, and whether the images on the comments should be included. Figure A.8 illustrates the flow of logic for the backend design of the Report Handler module.

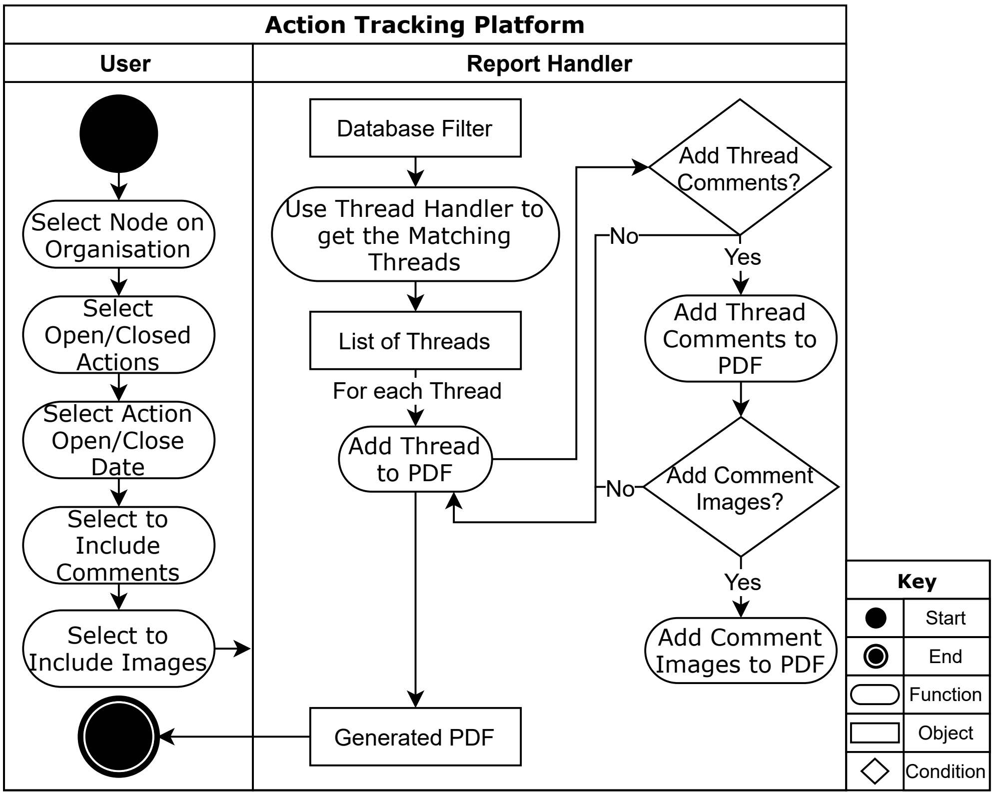

Figure A.8: Swimlane Diagram Illustrating the Processes Involved for the Report Handler Module.

Front-end

When the user clicks on the Generate Report button it allows them to configure the content they want in the report. Figure A.9 illustrates the design of the modal that the user sees when selecting to generate a report.

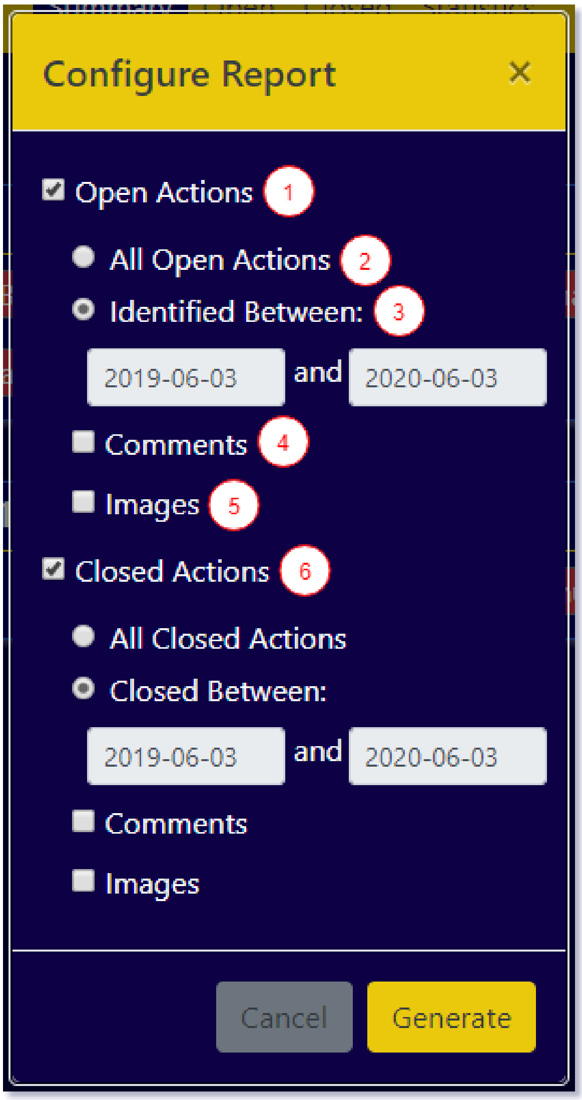

Figure A.9: Report Handler Configuration Modal.

#	Name	Description
1.	Open Actions	Select to include the open actions with the desired configuration.
2.	All Open	Select to include all the open actions.
3.	Date Range	Select the identified date range for the open actions (the closed date is used for the closed actions).
4.	Comments	Select to include the comments in the report.
5.	Images	Select to include the comment images in the report.
6.	Closed Actions	The user can select this to configure the closed actions in the report with a similar configuration to the open actions.

Table A.3: Table Defining the Numbers in Figure A.9.

A.4.2 Card Handler

The Card Handler covers two aspects when displaying data to the user and is used to provide a high overview of immediately relevant statistics on a PM team's Action Tracking Platform. It identifies what is considered to be Key Performance Indicators (KPIs) when referring to PM [12], [45].

These KPIs were determined by analysing what are some of the most important statistics to display to the user to aid in successful PM[5,6,7]. The cards that were created were set up across two tabs; the Dashboard Cards were allocated to the Statistics Tab along with the Charts, whilst the Overview Cards were allocated to the Summary Tab of the Action Tracking Platform.

Dashboard Cards

The Dashboard Cards calculate a generic set of KPIs based on the Action Tracking Platform for display to the User. Figure A.10 illustrates the five dashboard cards that the user can view under the Statistics Tab.

Figure A.10: The Front-end Display of the Dashboard Cards to the User.

Card	Description
Actions	Indicates the general statistics of how many actions have been opened and closed since the inception of the Action Tracking Platform. Provides the teams with a breakdown of the work that is at hand.

[5] *Choosing the Right Charts for Your Dashboard.* [Online]. Available: `https://blog.kubicle.com/choosing-the-right-charts-for-your-dashboard/` (visited on 23/05/2020)

[6] *The 25 Most Important Project Management KPIs.* [Online]. Available: `https://www.clearpointstrategy.com/25-important-project-management-kpis/` (visited on 23/05/2020)

[7] *Top Project Management Dashboard Examples & Templates.* [Online]. Available: `https://www.datapine.com/blog/project-management-dashboards-examples-and-templates/` (visited on 23/05/2020)

Card	Description
Completion Rate	Indicates how long it takes on average to complete a tracked action, as well as the number of new actions created that month. The completion rate is calculated using the total number of closed actions and the average difference between the identified dates and the thread closed dates of the actions. A team does not want to be opening too many new actions if their completion rates are too high.
Overdue Actions	Gives a general breakdown of how many of the open actions are currently overdue. Split between the actions that are under seven days overdue and over seven days overdue. Keeping these numbers low would be suggested and can aid teams in prioritising the current open tasks.
Time Management	Illustrates the overall time management of a team by indicating how many of the actions are closed on schedule and how many are closed off schedule when comparing the planned commitment dates with the actual thread close date. This can give the team a better overview of how well they plan their commitment dates. It can ensure they do not fall behind on their targets by readjusting their commitment dates for future actions.
Commitment Dates	Based on the commitment dates of all the open actions, this card indicates the number of days left for the nearest and the furthest actions commitment date. It can be indicative of the period that the team has set for themselves on all their open actions and ensure that they are always on track.

Table A.4: Table Defining the Dashboard Cards from Figure A.10.

Overview Cards

The Overview Cards were designed to give a high-level indication of a PM team's Action Tracking Platform. It would display a breakdown of the selected node on a PM team's tree structure and indicate how many open actions are linked to the selected node and its first two levels of children.

It also provided the user with an easier means of navigating their open actions. Users could click on the cards and navigate to the actions under that card or a section within a card. Every section within a card also displayed the highest action state for the actions linked under that node's section.

This view was presented to users when logging into the Action Tracking Platform and provided an informative overview of where the focus should be put. Users could see where actions are taking place and what node within a PM team's structure has the most work to do as well as which node on a structure is the furthest behind. Figure A.11 illustrates an example view for the overview cards that are generated for a PM team.

Figure A.11: The Front-end Display of the Overview Cards to the User.

#	Name	Description
1.	Selected Node	Illustrates the total number of actions that exist on the selected node. When clicked, it loads all the open actions for that node.
2.	Child Card	Illustrates the cards that are created for the selected node's first set of children. Indicates the number of actions linked to itself and its children. When clicked, it loads all the open actions for that node.
3.	Child Section	Illustrates the child section for the header of the current card. Indicates the number of actions linked to itself and its children. When clicked, it goes one node deeper and loads the next set of cards.
4.	Grandchild Section	Illustrates the sections for the grandchild nodes of the selected node placed under each card of the child node. When clicked, it loads all the open actions for that node.

Table A.5: Table Defining the Numbers in Figure A.11.

When 3 in Figure A.11 is clicked and there are no further children nodes linked to that node the card in Figure A.12 is created.

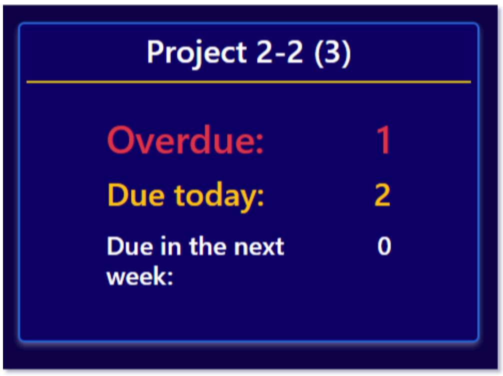

Figure A.12: Breakdown of the Current Actions on a Node and their Commitment Dates.

It gives a breakdown of the current actions linked to that node and indicates how many actions are overdue, due today, and due within the next week. This simply provides the user with an overview of the time management needed for the tasks on that node.

Algorithm 1 illustrates the pseudocode of the procedures that were used to develop the cards.

Algorithm 1 Creating the Overview Card containing all Their Sections.

```
function GetOverviewCards(StructNodeID, TreeStructureID)

    ThreadTagIDs ← Get ThreadTagIDs from StructNodeID and TreeStructureID
    ThreadDocs ← Use ThreadHandler to get Threads linked to ThreadTagIDs
    StructNode ← Create tree structure from StructNodeID and TreeStructureID
    Cards ← empty list

    for each ChildNode ∈ StructNode children do                ▷ Create each card
        Sections ← empty list
        for each GrandChildNode ∈ Chilnode children do         ▷ Create Section in Card
            GrandThreadTagIDs ← Get GrandThreadTagIDs from GrandStructNodeID
and TreeStructureID
            GrandThreadDocs ← Filter ThreadDocs according to GrandThreadTagIDs

            Section ←
                [
                    Name ← GrandChildNode and GrandThreadDocs Count
                    StructNodeID ← GrandChildNodeID
                    Class ← Assign highest Action State in GrandThreadDocs
                ]
            Add Section to Sections
        end for

        Card ←
            [
                Header ← GrandChildNode and GrandThreadDocs Count
                StructNodeID ← GrandChildNodeID
                Sections ← Sections
            ]
        Add Card to Cards
    end for
    return Cards
end function
```

A.4.3 Chart Handler

The Chart Handler also fell under the Statistics Tab of the Action Tracking Platform. These charts were displayed below the Dashboard Cards and served the same purpose of providing a high-level overview of the data stored on the Action Tracking Platform and provided a graphical way to analyse the current performance of a team and considered the most important statistical information to display.

The graphs were generic and were displayed on every PM team's Action Tracking Platform. The choice of the charts that were used aimed to increase the effectiveness of the view[5,6,7]. It was decided that a total of seven charts would be displayed to the user.

Description	Reference
Actions Stacked Bar Chart	
The graph used to compare the number of open actions against the closed actions. Helps the teams realise the work that they have done and what work there is still to do.	Figure A.13
Average Completion Rate Bar Chart	
Illustrates the average completion of the actions on the selected node and its first set of children. Gives a useful breakdown of the operations which are performing better and how the resources should be allocated.	Figure A.14
Average Completion Rate Per Month Bar Chart	
Illustrates the average completion rate for all the actions as the months go by. Fluctuation in this graph is not desirable and it is best to keep the completion rates low per month or consider breaking up the actions into smaller tasks.	Figure A.15
Status Pie Chart	
Summarises the current action states for all the open actions based on their commitment dates. Gives a good indication of the team's performance and how they handle their actions.	Figure A.16
Cumulative Line Chart	
The cumulative totals for the number of actions open and closed on a monthly based. It would be advisable to keep the closed and open actions on the same level or lower, as a team does not want to be creating any new actions if they are not keeping up with the current ones.	Figure A.17
Assigned Actions Bar Chart	
Illustrates the number of assigned actions that a user has. Can be used to indicate the amount of work that a user must do and allows them to adjust their work rate accordingly	Figure A.18
User Interaction Bar Chart	
Indicates the user's interaction with the platform and which of the users update the Action Tracking Platform the most in their teams. Gives an indication of the work rate if used correctly.	Figure A.19

Table A.6: Table Defining the Type of Charts that were Used for the Action Tracking Platform.

A.5 Action Tracker Chart Handler

This section illustrates the charts that were created by the Chart Handler as described in Section A.4.3

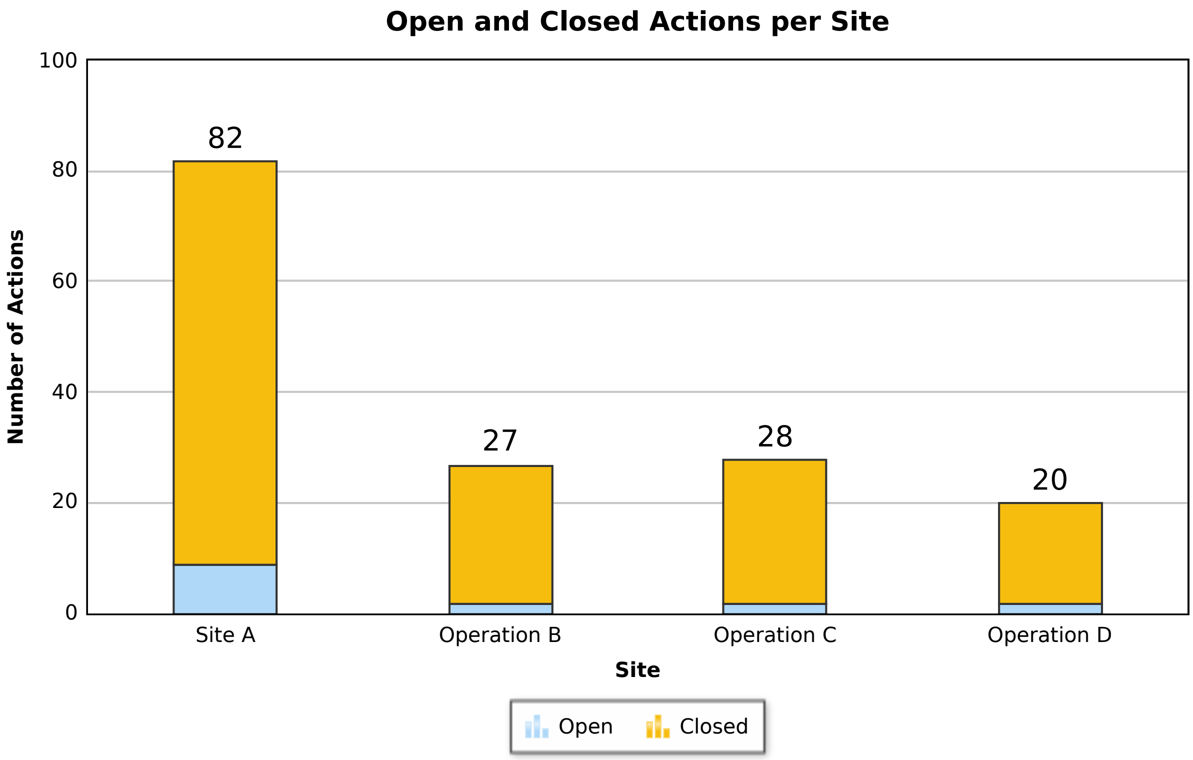

Figure A.13: Stacked Bar Chart Illustrating the Number of Open and Closed Actions on a Site.

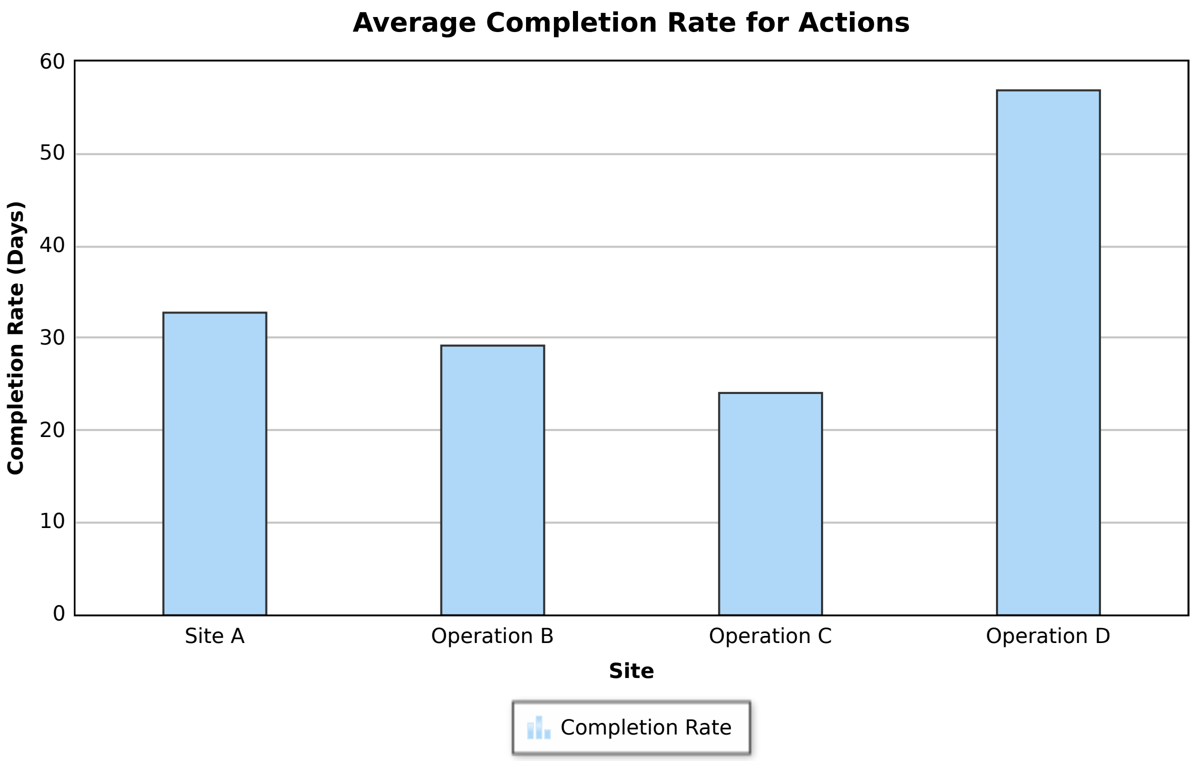

Figure A.14: Bar Chart Illustrating the Average Completion Rate of Action Per Site.

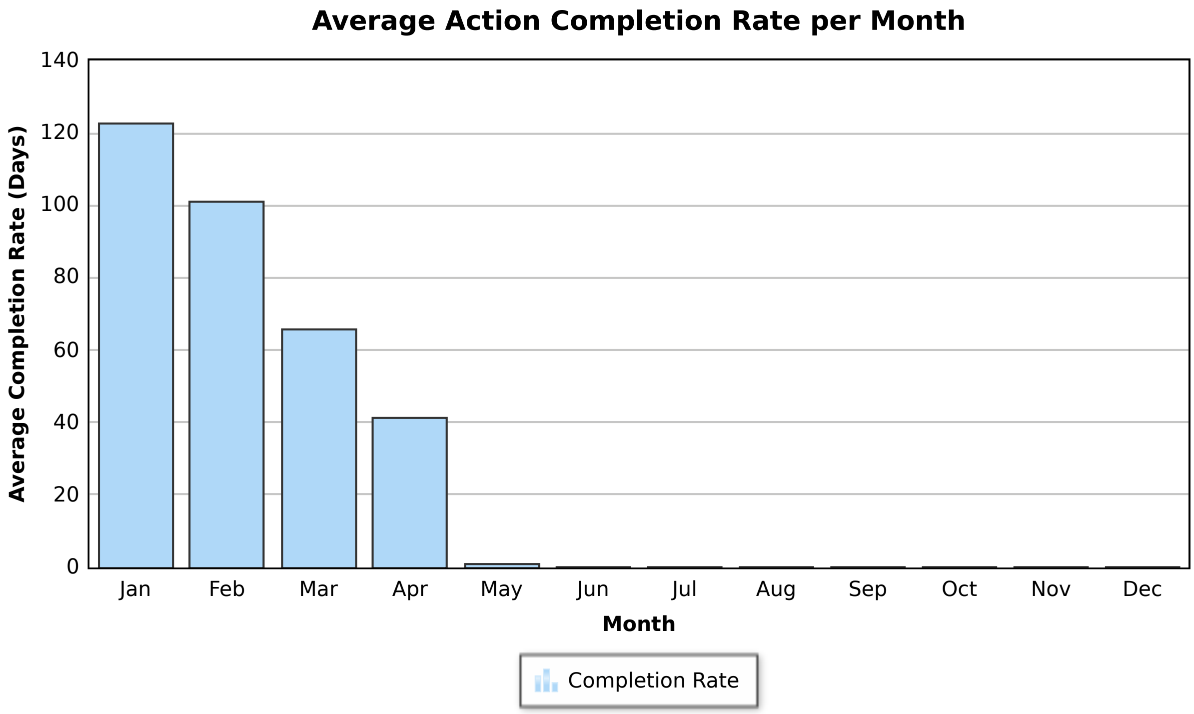

Figure A.15: Bar Chart Illustrating the Average Completion Per Month of that Calendar Year.

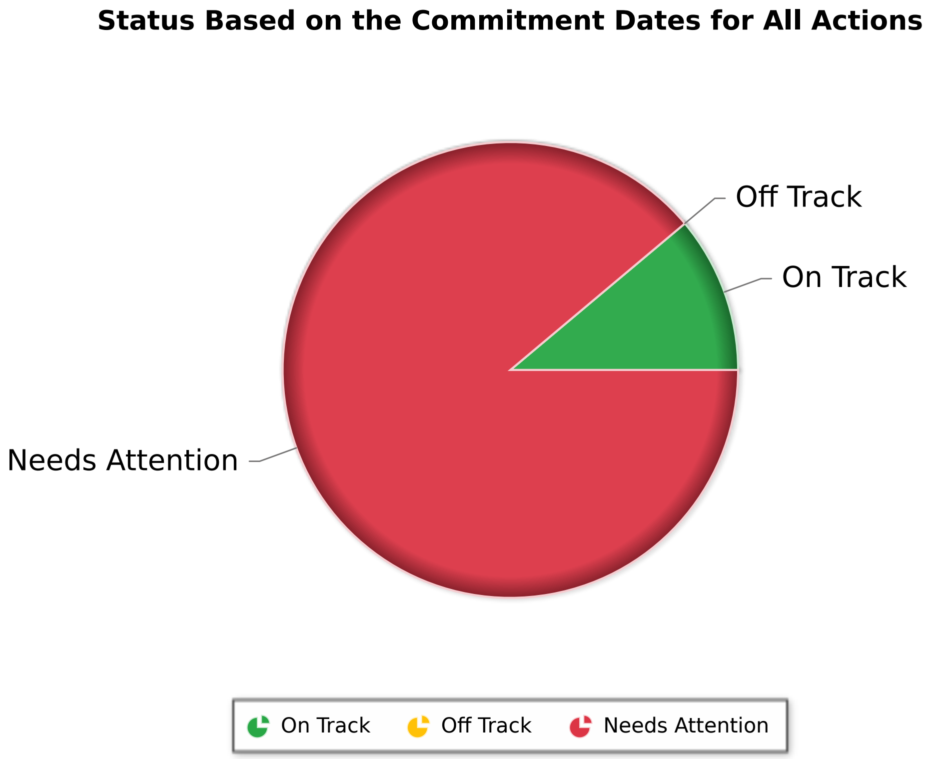

Figure A.16: Pie Chart Illustrating the Action States of the Open Actions.

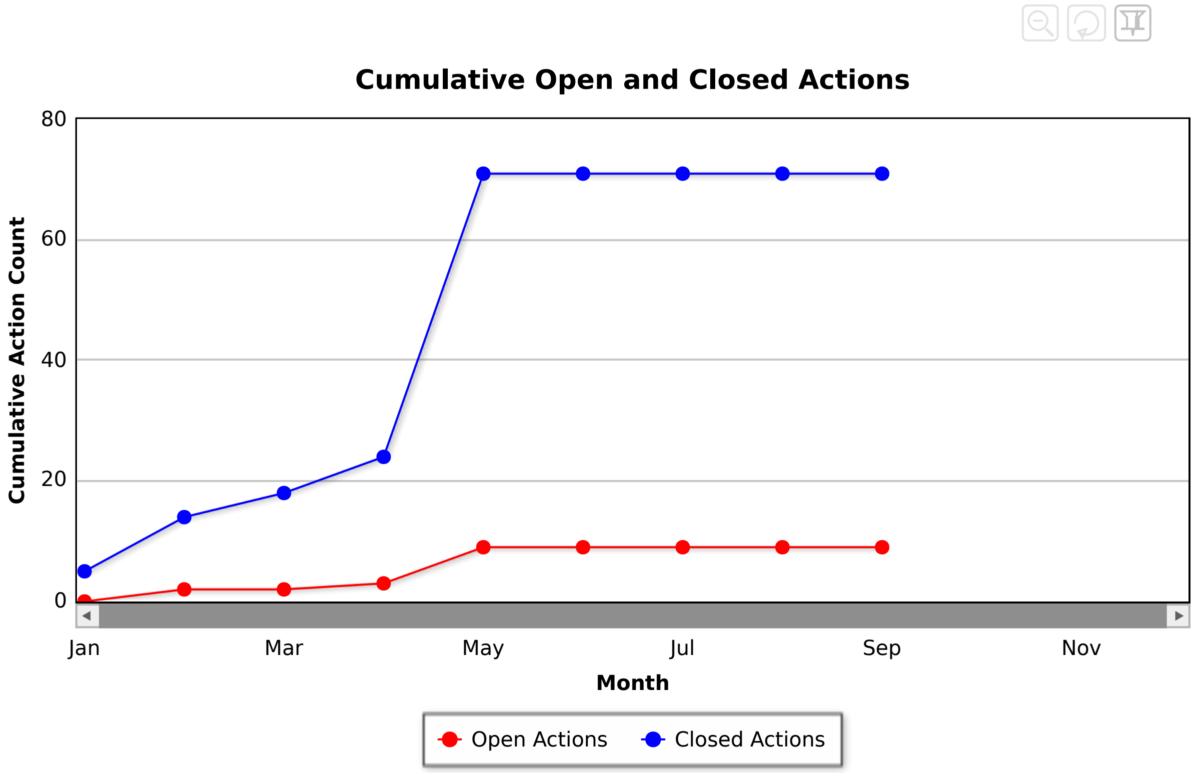

Figure A.17: Line Graph Illustrating the Cumulative Number of Open and Closed Actions.

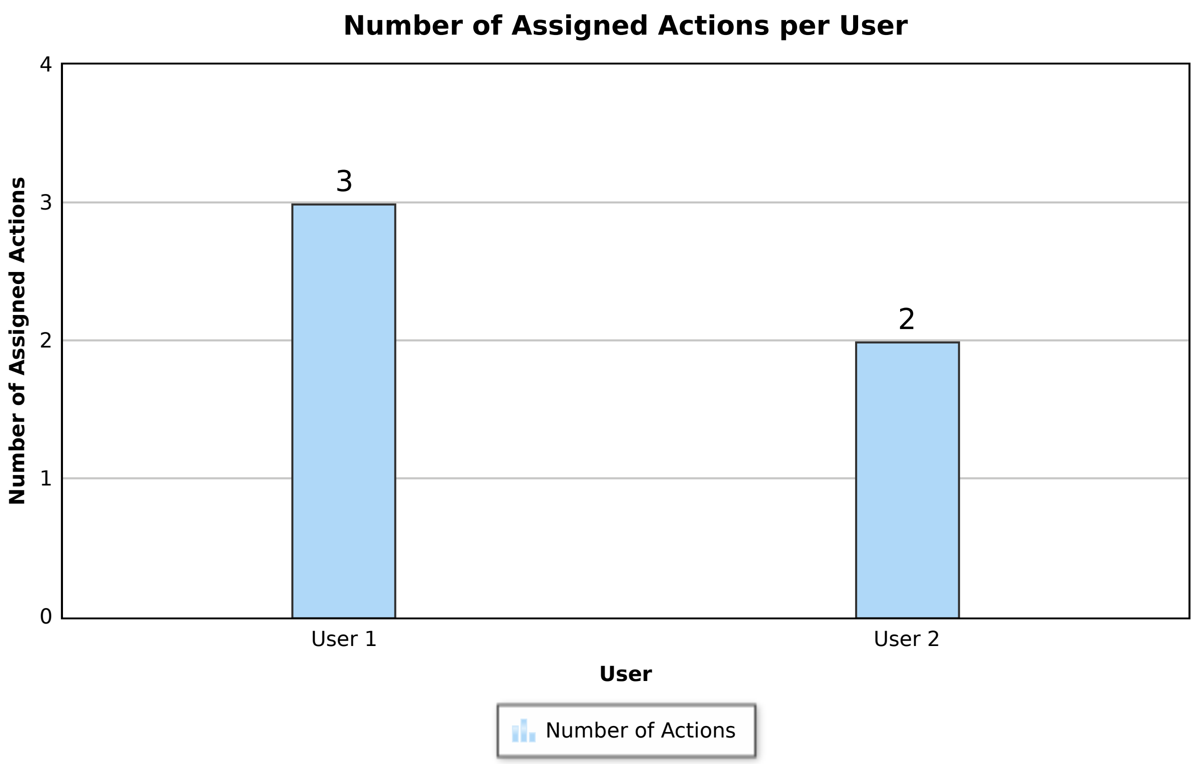

Figure A.18: Bar Chart Illustrating the Number of Assigned Actions Per User.

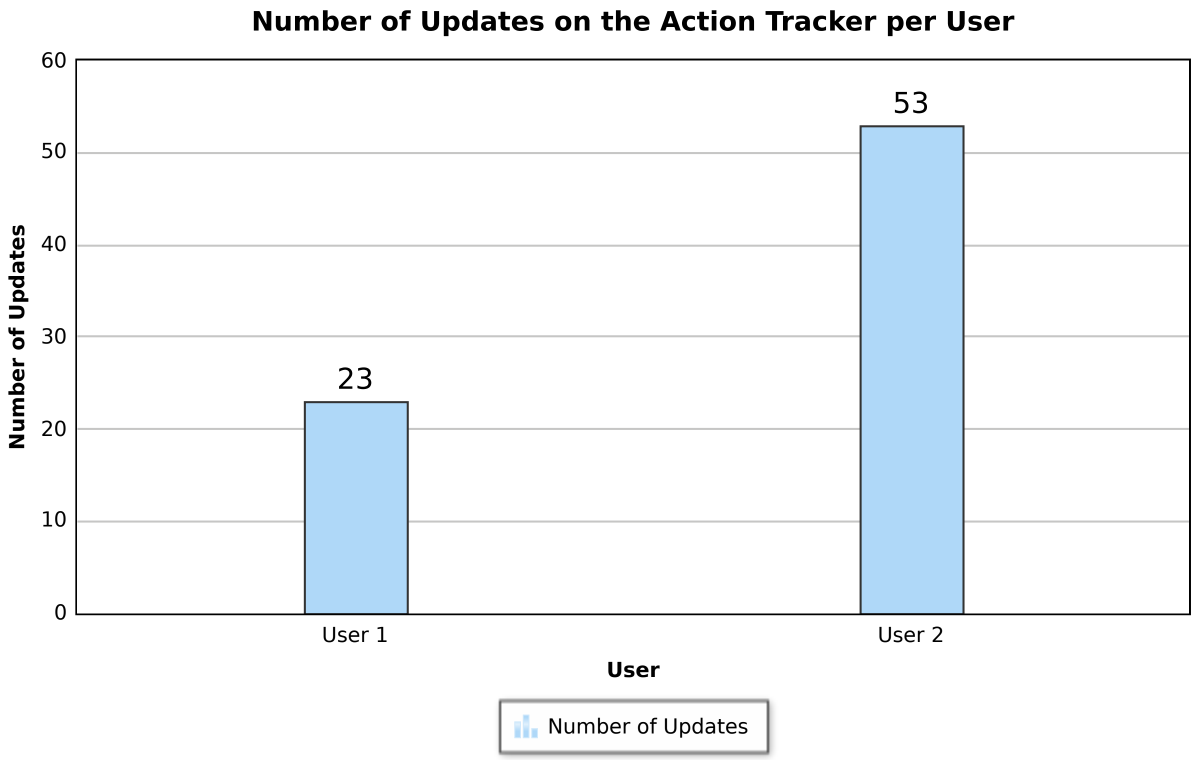

Figure A.19: Bar Chart Illustrating the Number of Updates that a User Has Made on the Action Tracking Platform.

A.6 Action Tracking Platform Implementations

This section illustrates the different platform structures and their interfaces that were implemented on each of the case studies.

A.6.1 Case Study A

Figure A.20: Action Tracking Platform for Case Study A.

A.6.2 Case Study B

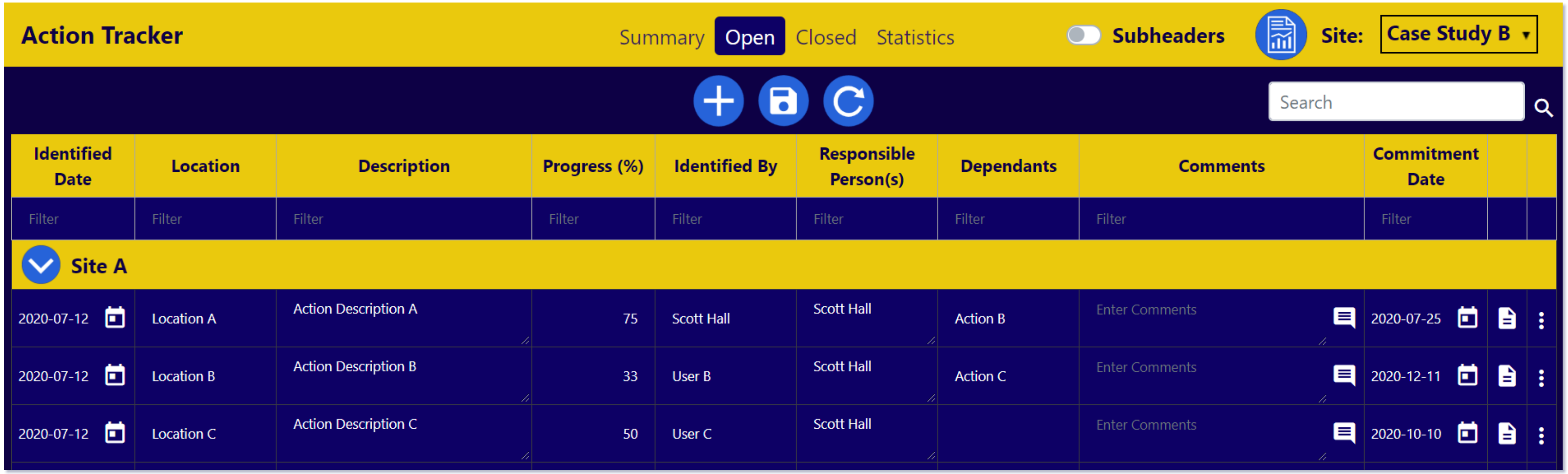

Figure A.21: Action Tracking Platform for Case Study B.

A.6.3 Case Study C

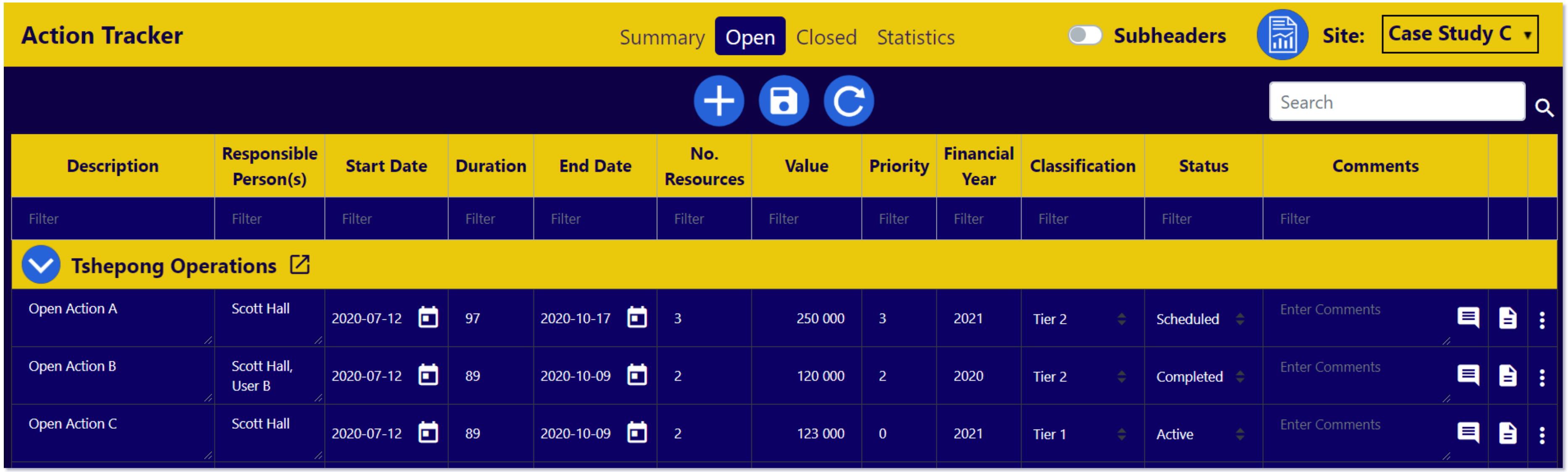

Figure A.22: Action Tracking Platform for Case Study C.

A.7 Additional Data Gathered Through the Platform

This section illustrates the additional data that was gathered and provided on each of the case studies through the implementation of the Action Tracking Platform. This data was accessible to all users of the platform under the statistics tab.

A.7.1 Case Study A

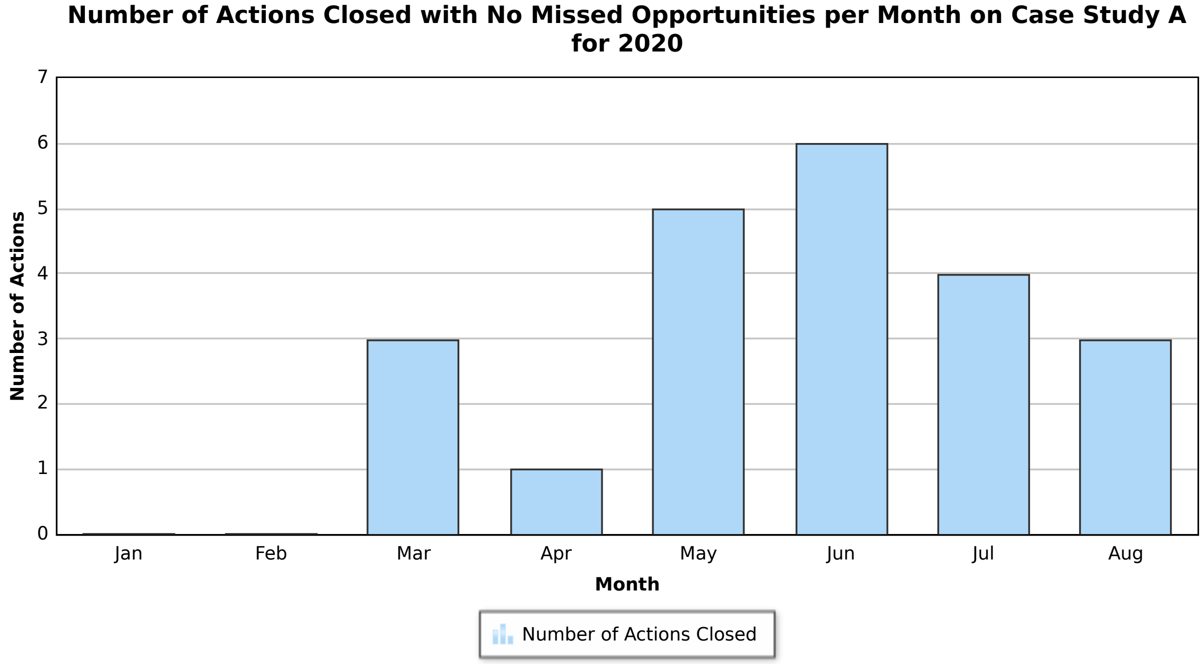

Figure A.23: Actions Closed with No Missed Opportunities per Month.

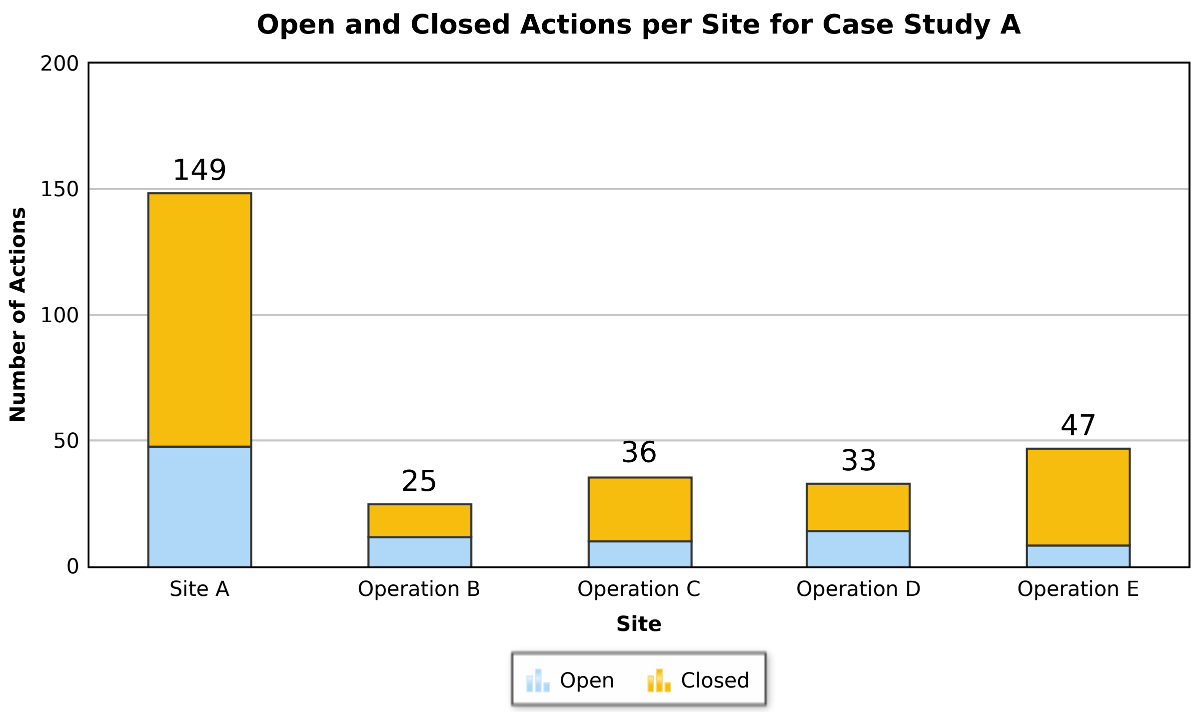

Figure A.24: Open and Closed Actions per Site.

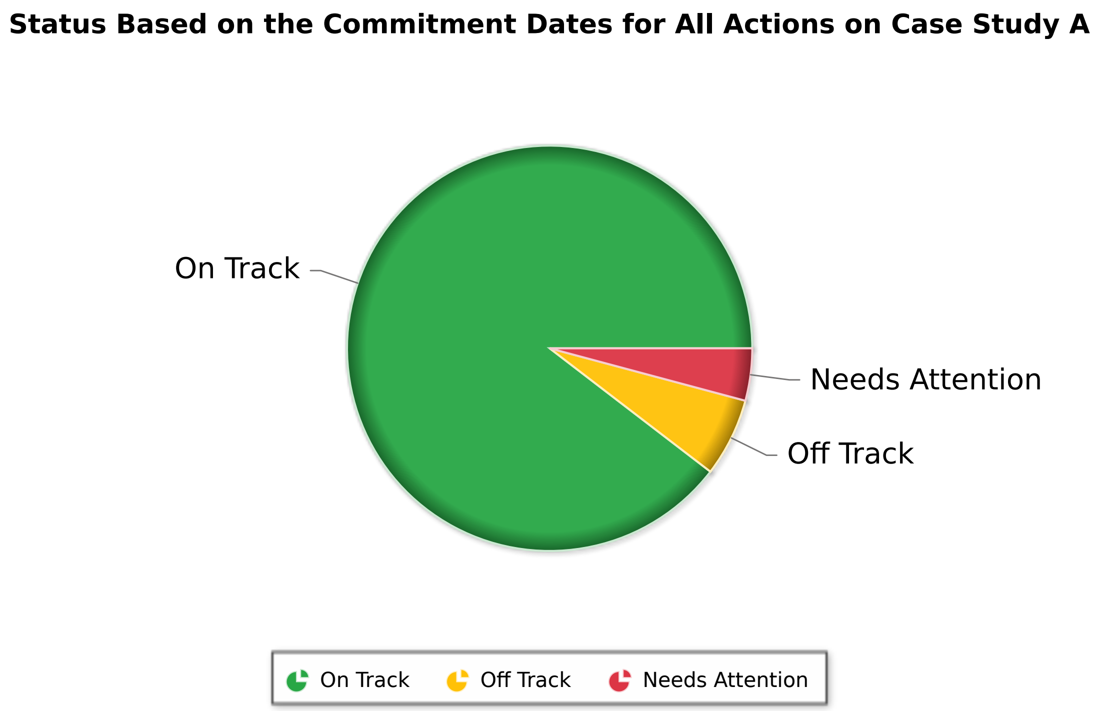

Figure A.25: Status Based on the Commitment Dates for All Actions.

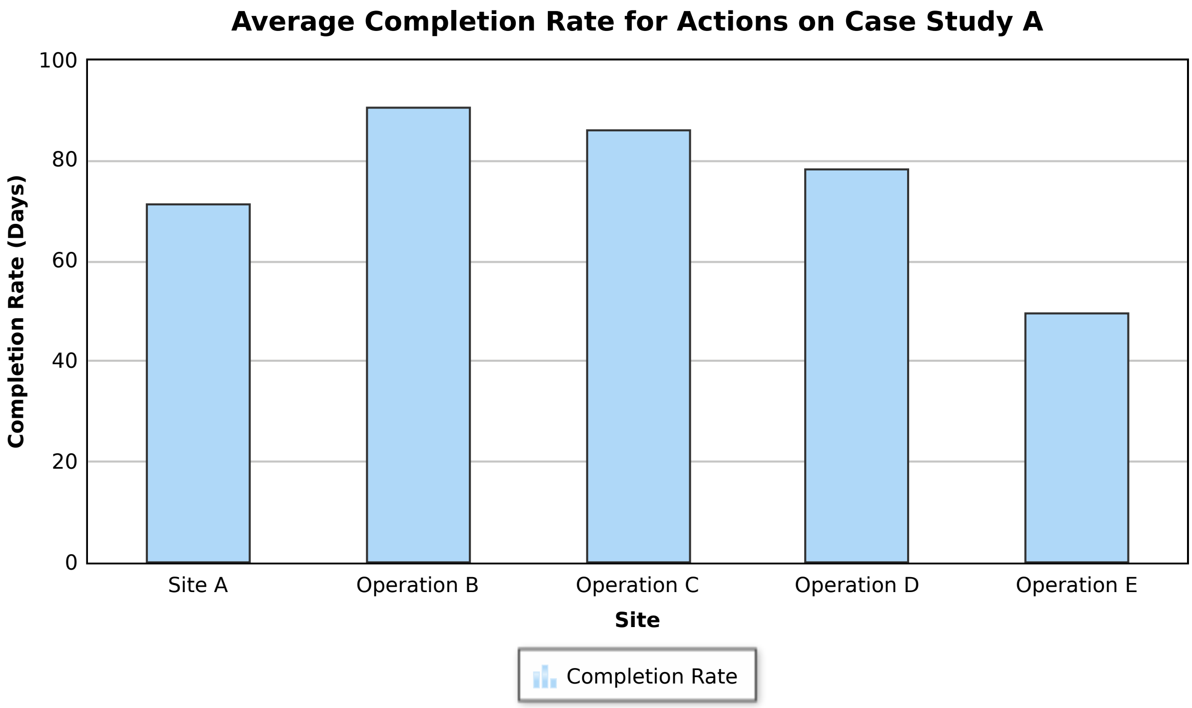

Figure A.26: Average Completion Rate for All Actions Across All Operations.

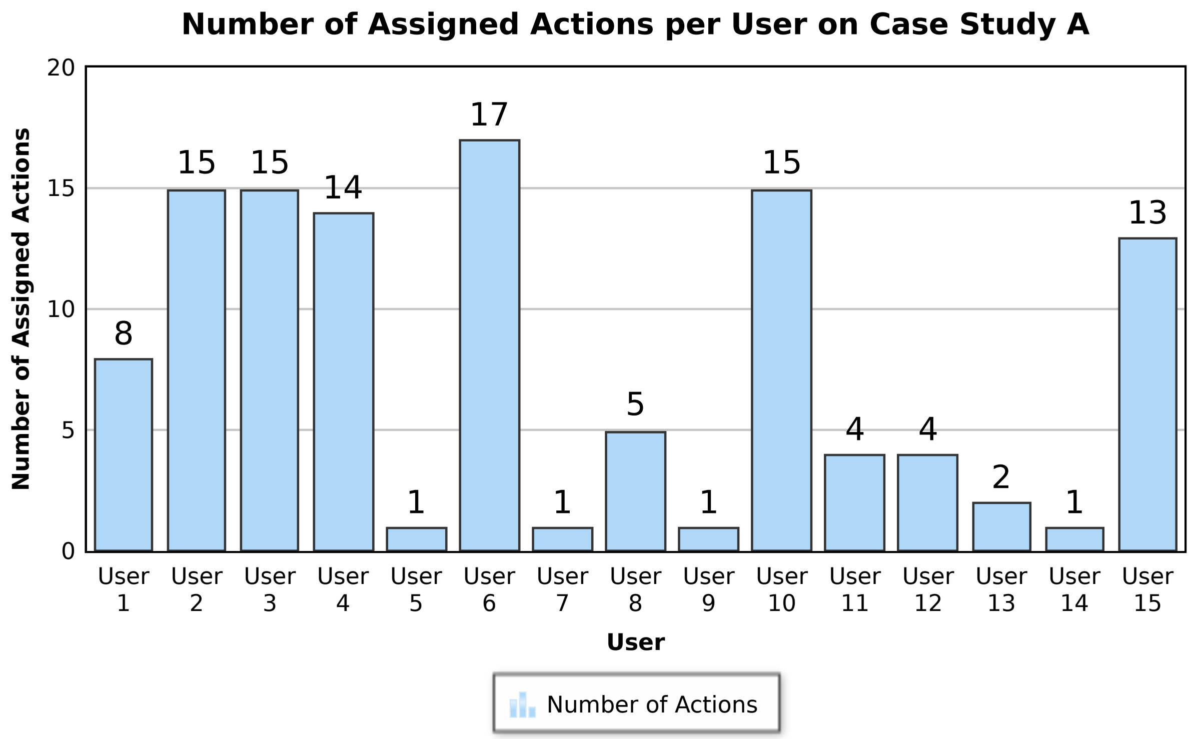

Figure A.27: Number of Assigned Actions per User.

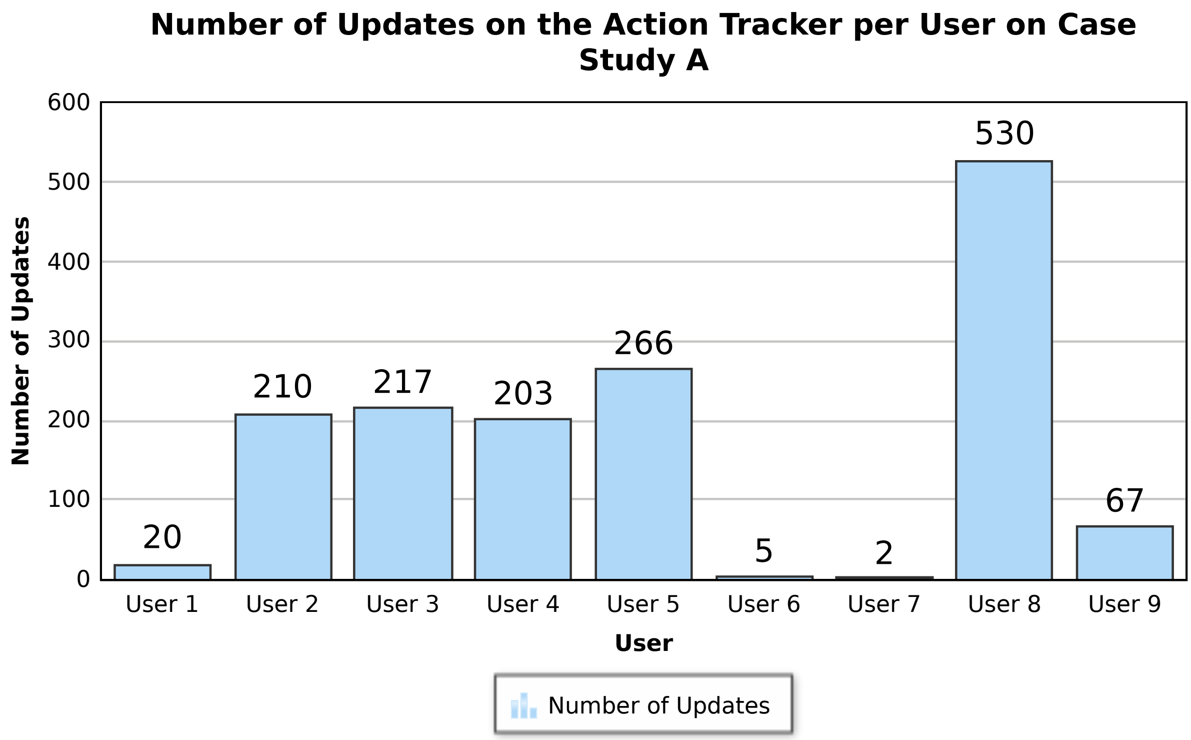

Figure A.28: Number of Updates on the Platform per User.

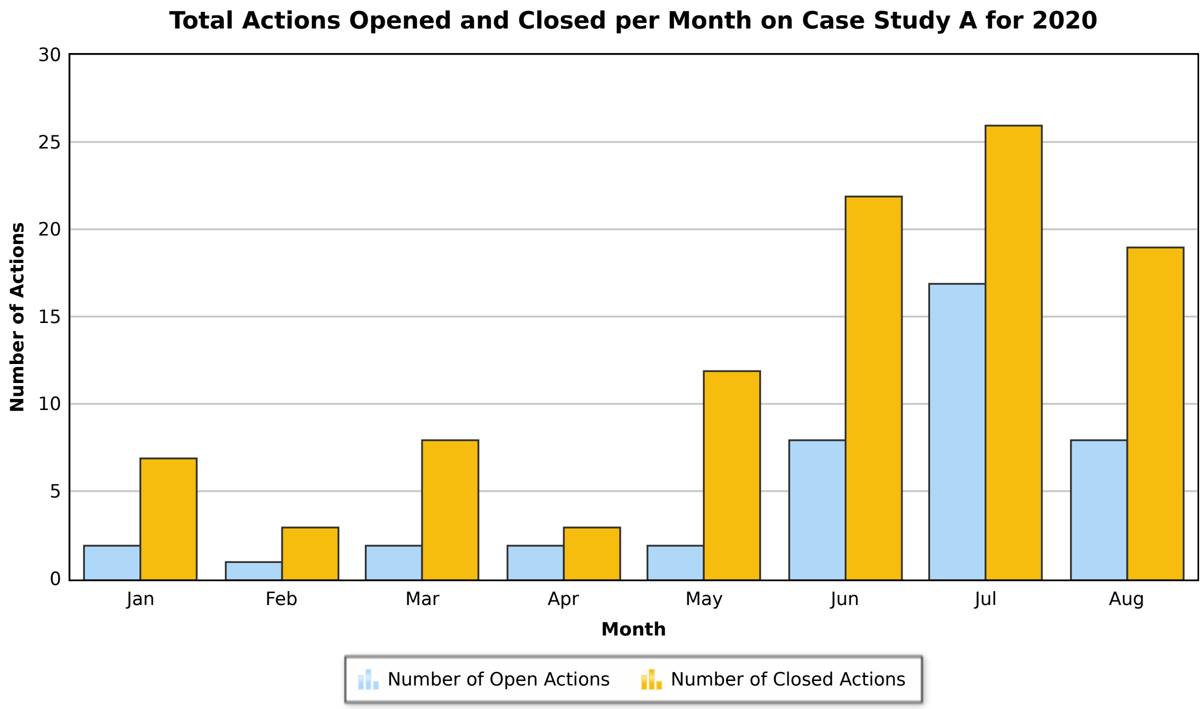

Figure A.29: Total Actions Opened and Closed per Month.

A.7.2 Case Study B

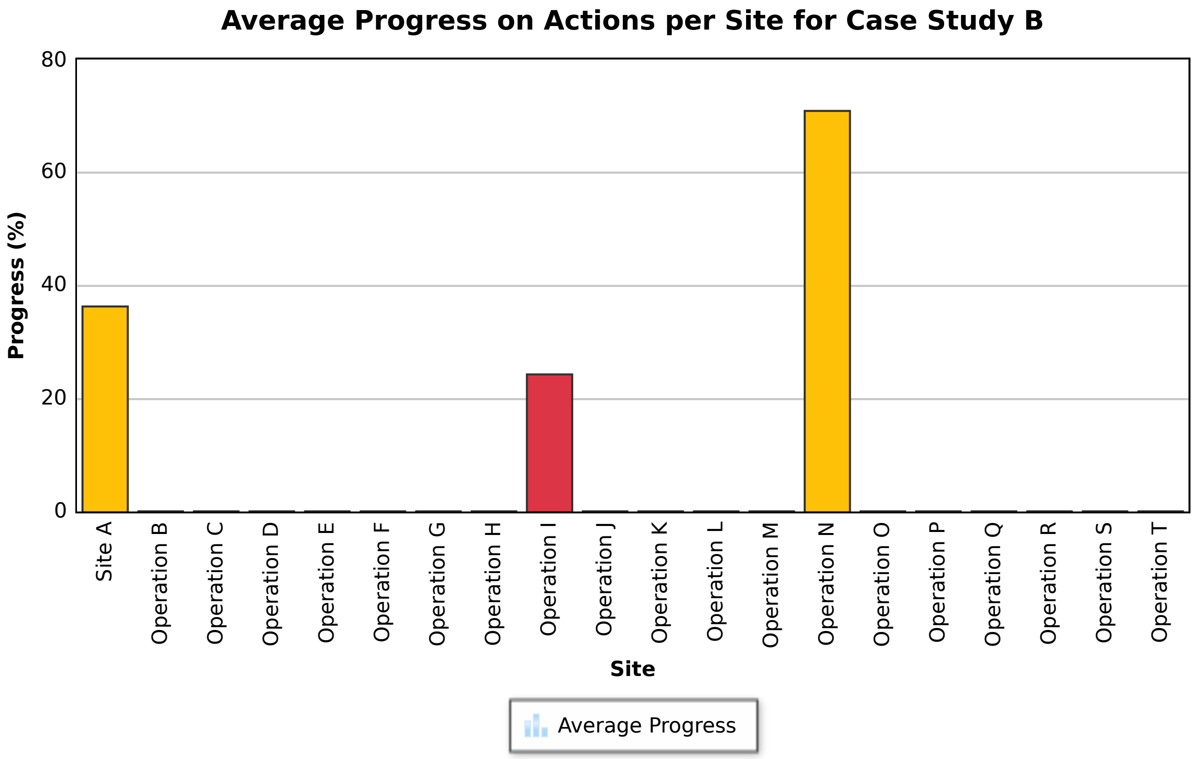

Figure A.30: Average Progress on All the Actions per Site.

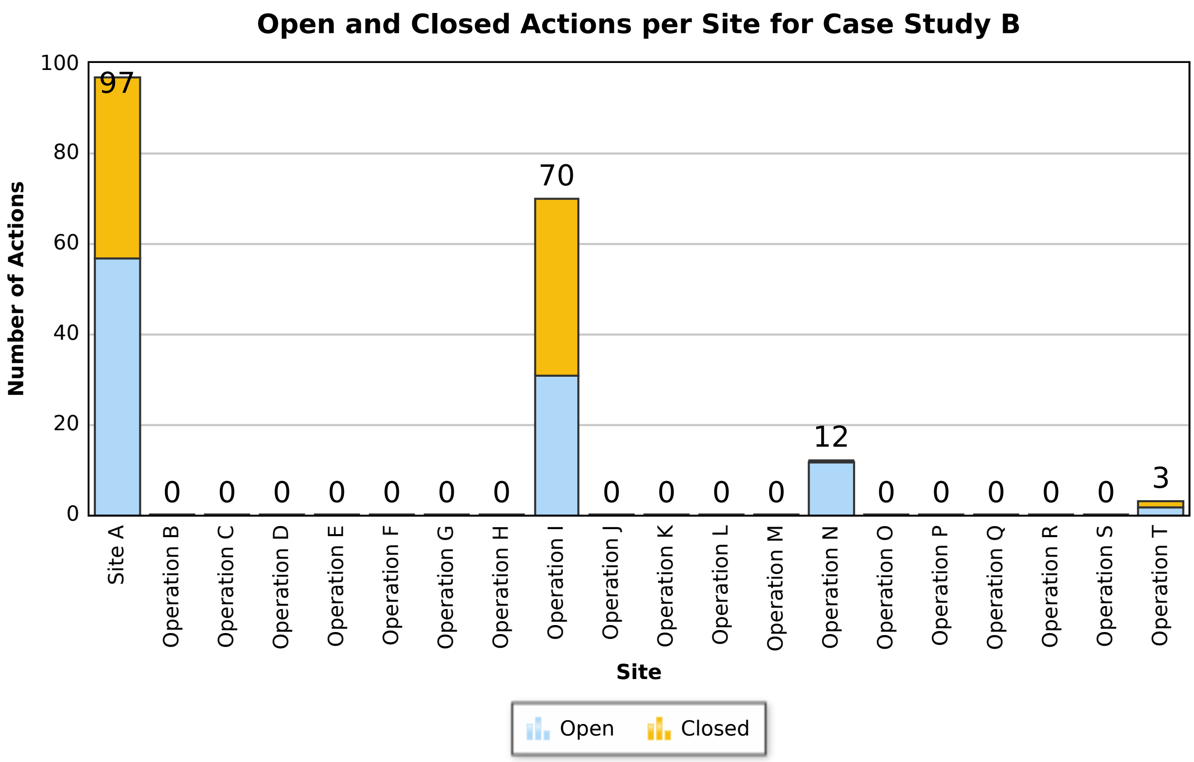

Figure A.31: Open and Closed Actions per Site.

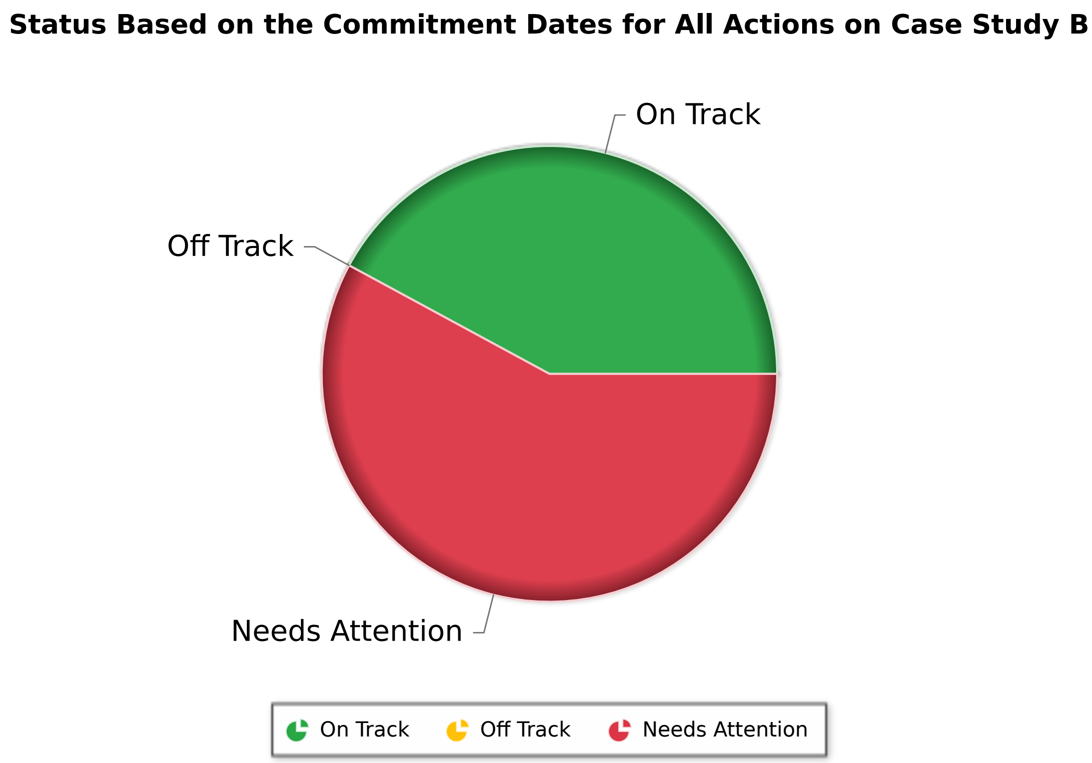

Figure A.32: Status Based on the Commitment Dates for All Actions.

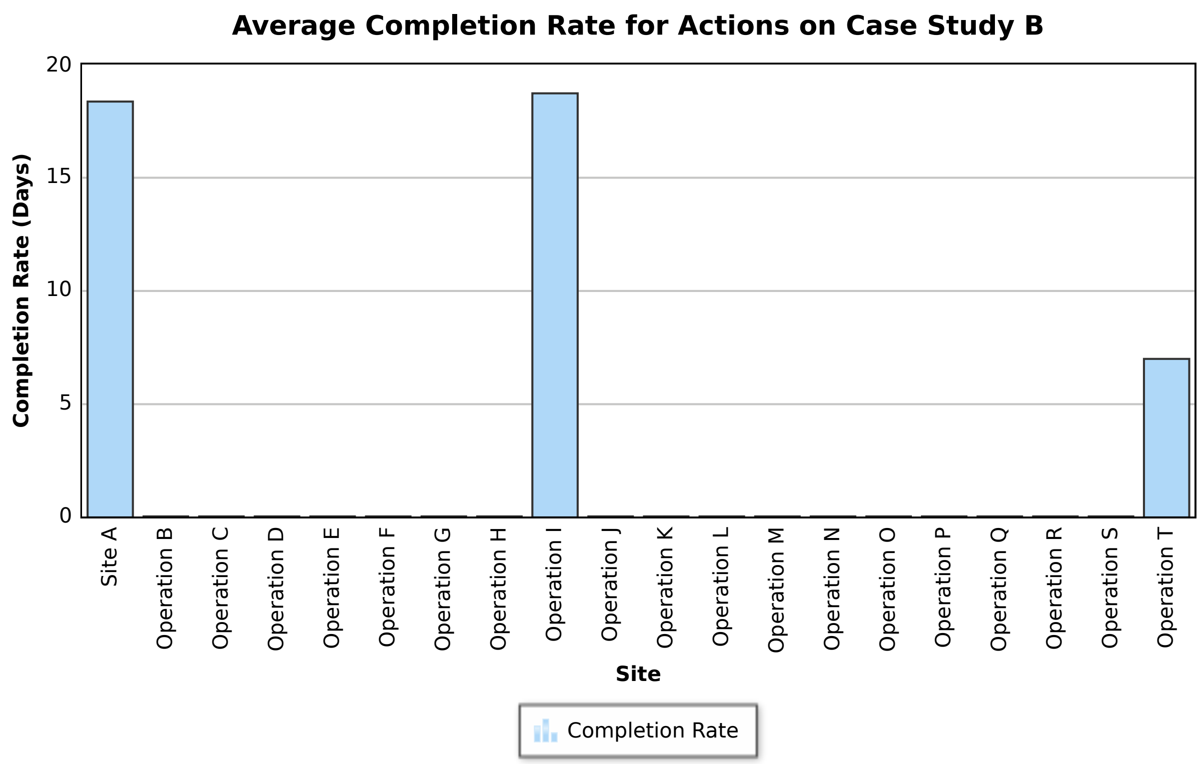

Figure A.33: Average Completion Rate for All Actions Across All Operations.

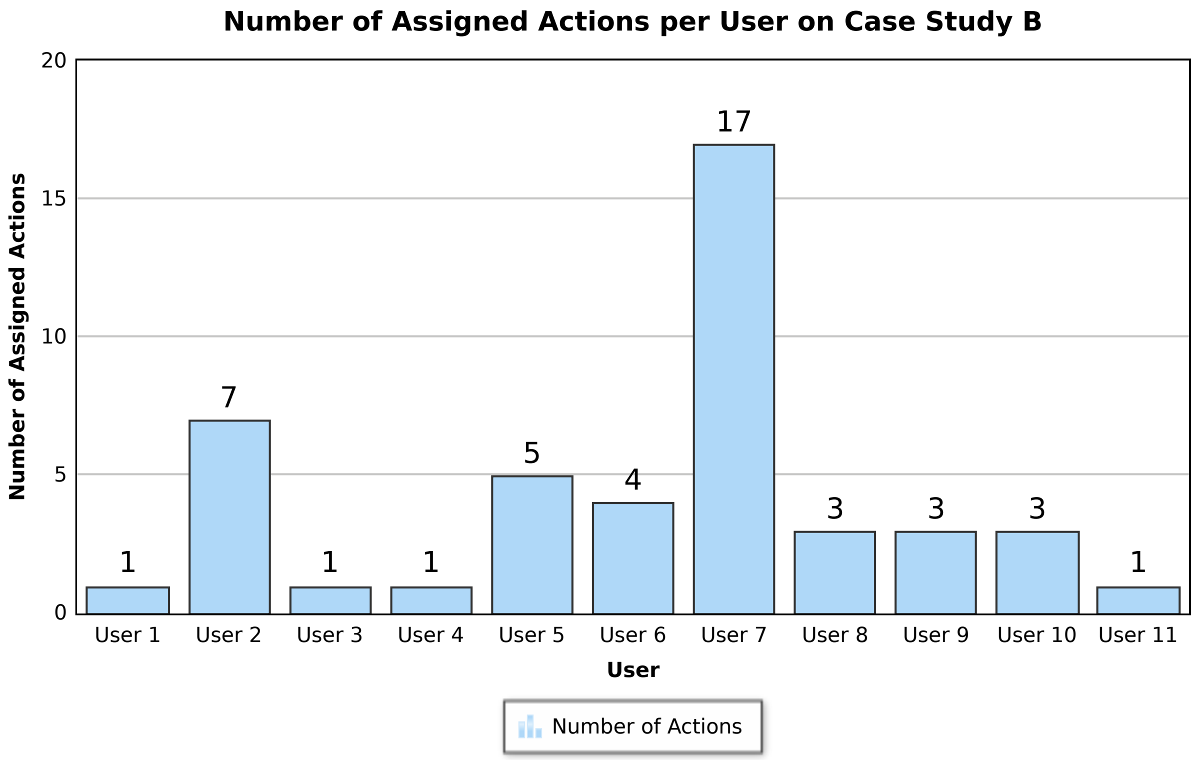

Figure A.34: Number of Assigned Actions per User.

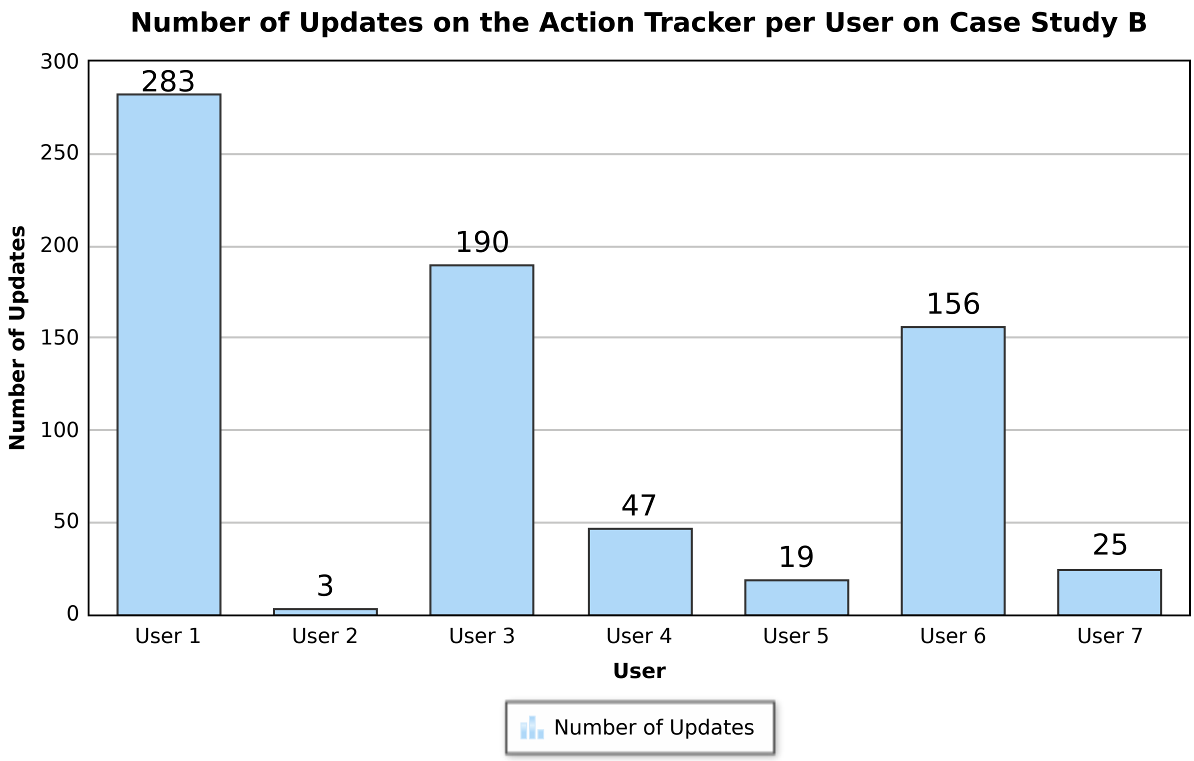

Figure A.35: Number of Updates on the Platform per User.

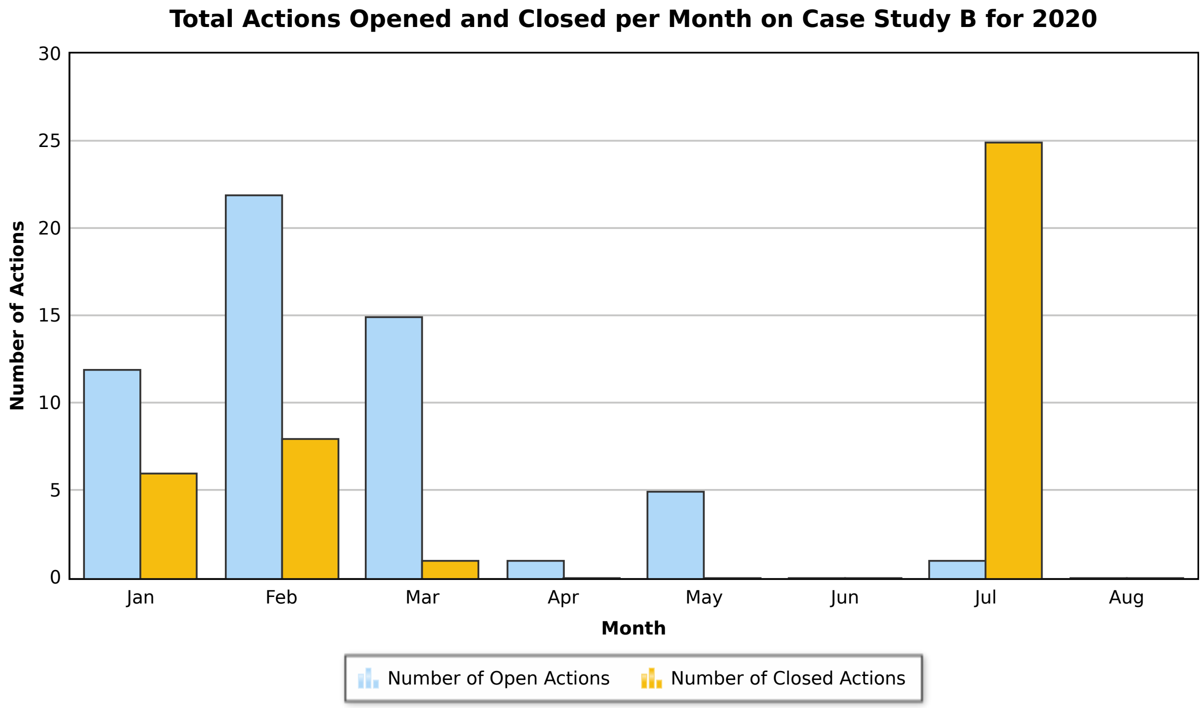

Figure A.36: Total Actions Opened and Closed per Month.

A.7.3 Case Study C

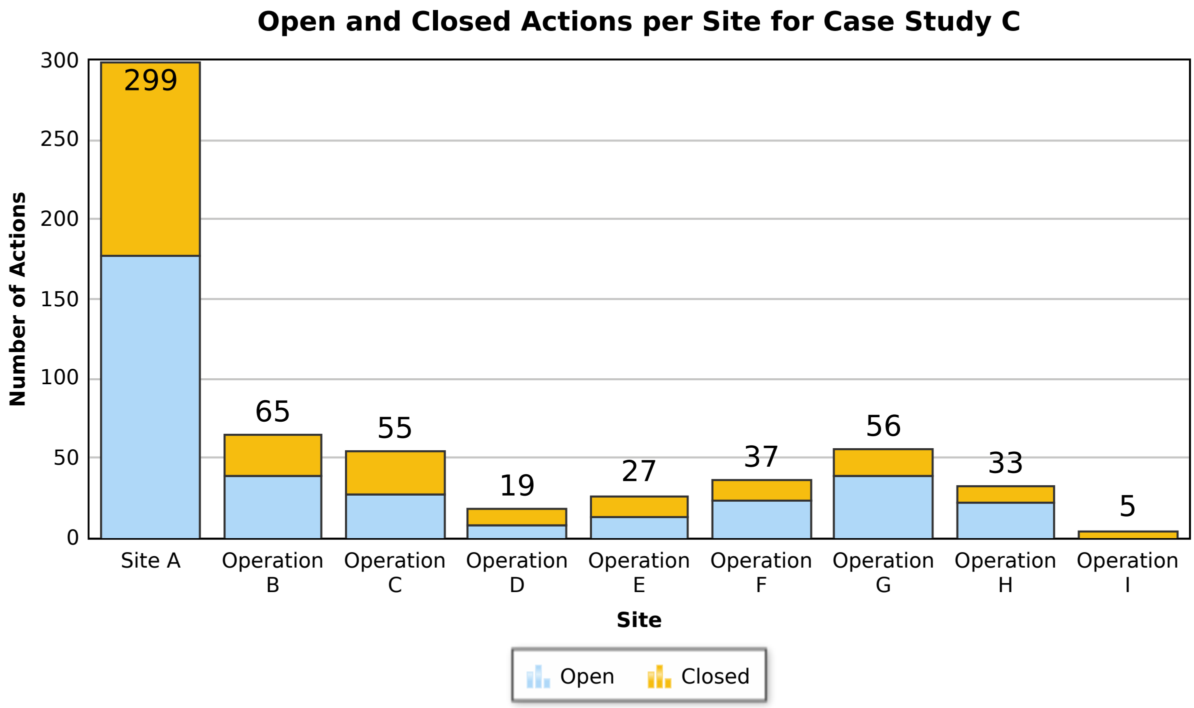

Figure A.37: Open and Closed Actions per Site.

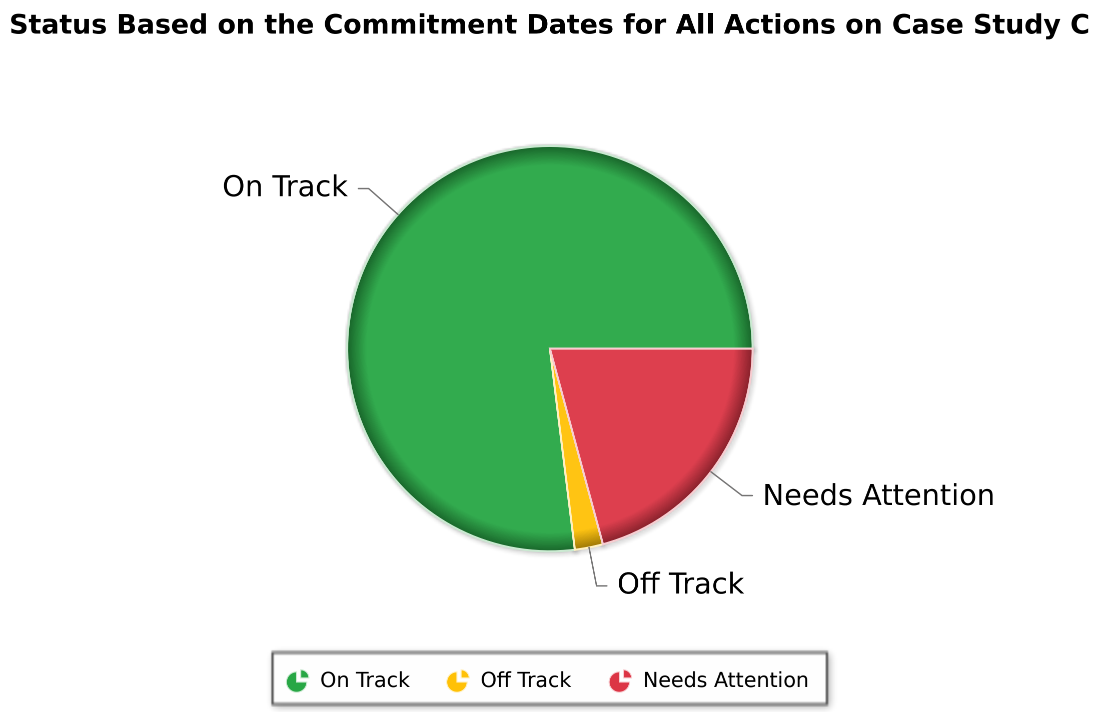

Figure A.38: Status based on the Commitment Dates for All Actions.

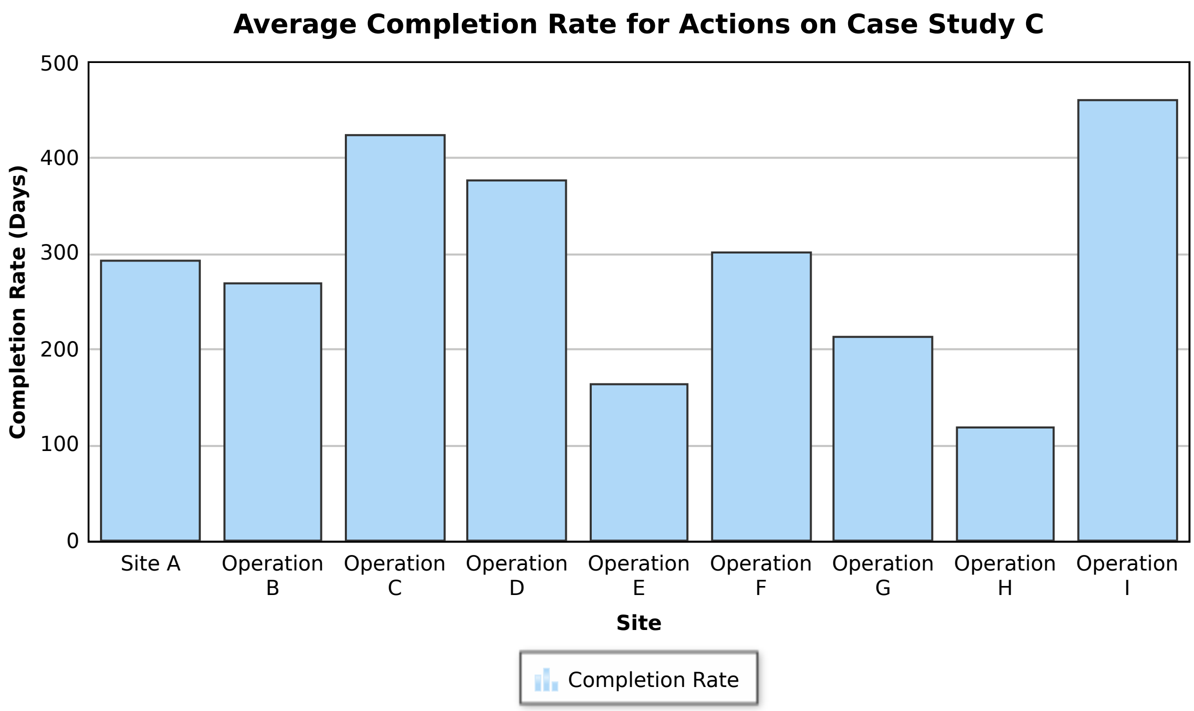

Figure A.39: Average Completion Rate for All Actions Across All Operations.

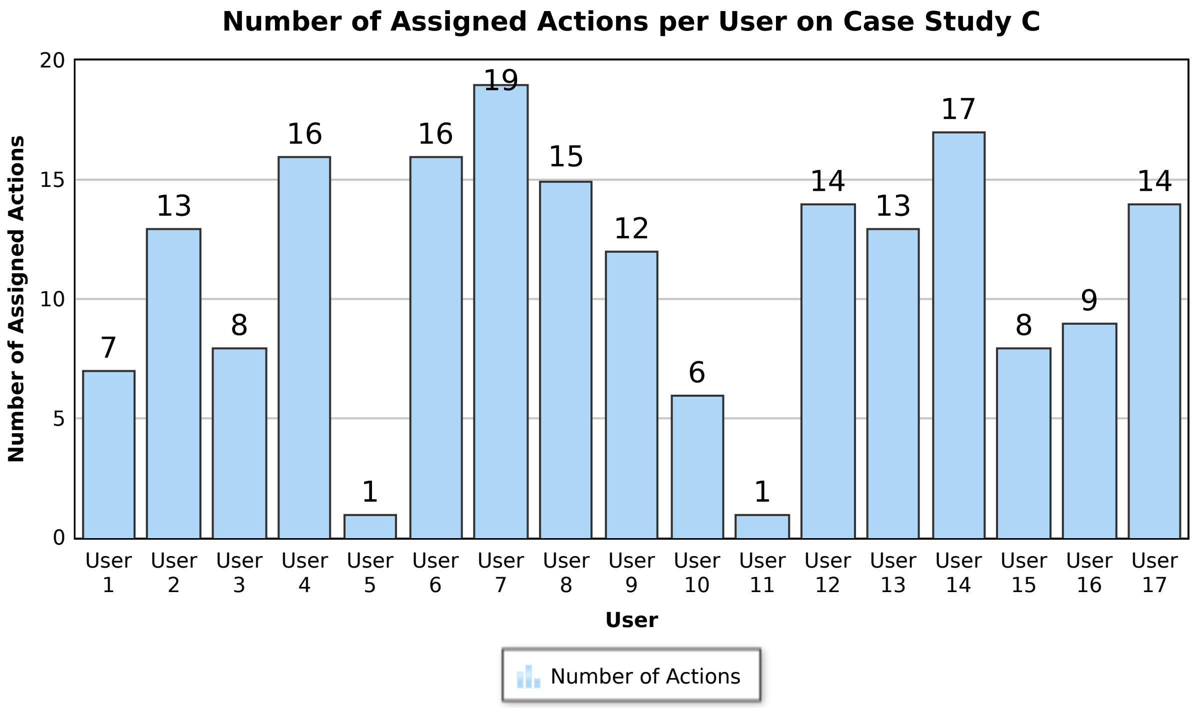

Figure A.40: Number of Assigned Actions per User.

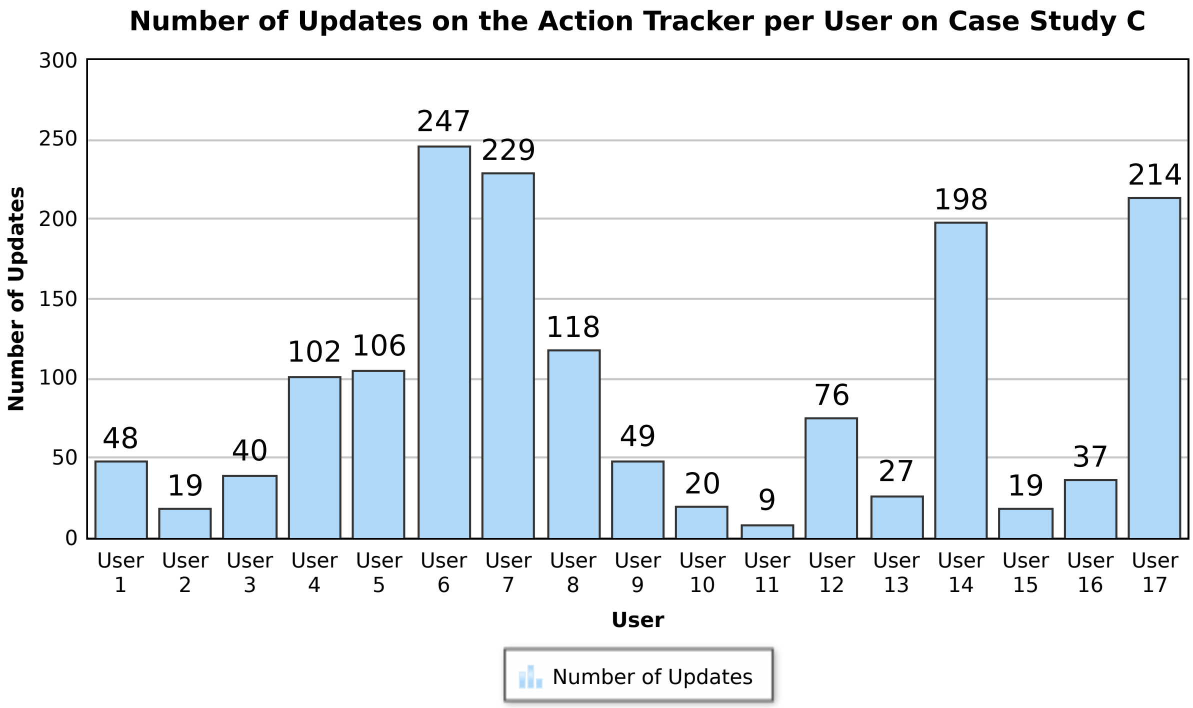

Figure A.41: Number of Updates on the Platform per User.

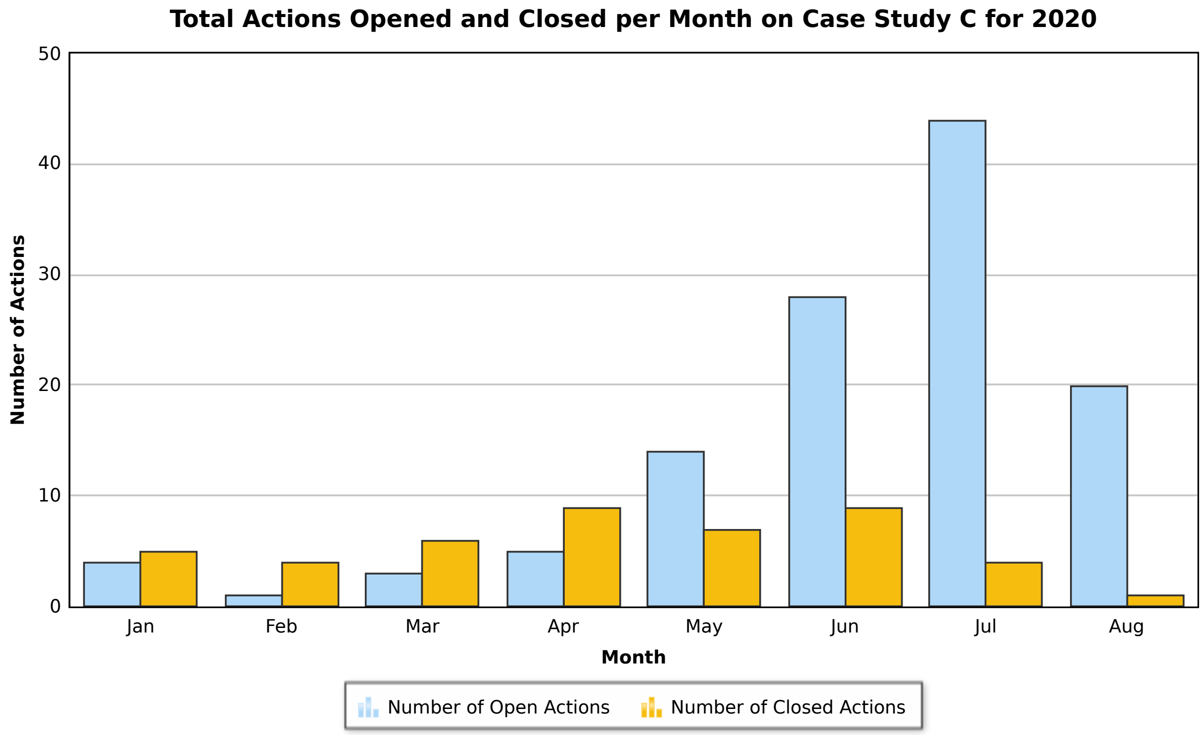

Figure A.42: Total Actions Opened and Closed per Month.

A.7.4 QoS Improvements

The Action Tracking Platform added numerous Quality of Service (QoS) improvements for the company and how it undertakes PM. All the case study implementations obtained the same QoS improvements. The platform allowed the users to gain quick insights into all the current projects and their actions.

The creation of a centralised platform allowed the entire team to interact more effectively. Team members could use the platform to provide timely feedback on their tasks and keep their project managers updated. Interaction with the client was also made possible by allowing them to interact with the teams and share resources. Users could link the necessary documentation to the actions to provide the necessary feedback to all users and improve the distribution of knowledge.

The platform also allowed the generation of reports according to the user's specification. These reports could provide immediate summaries of the work at hand to the project manager which could then be sent out to the client on-demand or used within team meetings. The reports are a valuable tool for generating summaries of all the actions that are taking place. They can be used as indicators to the client of the work that they are receiving from the company and its PM teams.

Teams can use the statistics tab to keep track of all their deadlines and gain better insight into the actions on the platform. Figure A.13 indicates the work that has been completed and all the actions still taking place. This will allow the project managers and the clients to see the value added in terms of the actions taking place. Users can then view those actions and see where the most work is being done. This will ensure that the clients will always be aware that projects are being handled by the company and indicating their ongoing work.

Figures A.14 and A.15 illustrate to the user the average completion rates of the actions across all the sites and give a monthly breakdown. This can be used by the project managers to view the operations which take the longest to complete and investigate further into their operation and how they are tracked. The monthly overview can indicate the performance of the team, where decreasing the completion rate can be used to measure a team's PM improvement.

Through Figures A.16 and A.17, users can obtain a quick overview of the status of the actions to summarise the workflow. Team members can prioritise the actions that are off-track and ensure that their commitment dates are either adjusted or that the actions get completed. In Figure A.17 it would be advisable to keep the difference between the open and the closed actions negligible. Users do not want to track more actions if none are being closed and can be indicative of the work rate and prioritisation skills of the team.

Project managers can get a good indication of the workflow and which members are assigned to which tasks. This would benefit the managers by ensuring that there is an even distribution of project actions. Figures A.18 and A.19 can give managers a good indication of the distribution of work and ensure that everyone has a job to do. It is also possible to view the interactions on the platform to illustrate the active users.

Users were able to filter the entries and view the actions that they were assigned to. This would ensure that no team member is left behind and that the team member is aware of the actions that they must complete. The platform ensures that no actions were overlooked as all actions are tracked and a log of all the closed actions are maintained. The data for the closed actions are a good way to provide feedback to the client on the work that is done and can be presented on a scheduled basis or on-demand.

A structured way of managing projects and the PM teams is brought to the company. It unifies the way projects are managed across the company and improves the way PM is done. The platform improves on the outdated techniques that the company used to manage projects and ensures a standard approach to managing projects. This consistency makes it easier to manage different teams as they all utilise a similar implementation of the platform that is familiar to all users.

The history of all the actions provides accountability and is a good way to impress the clients with the value of the company's services. It is important to provide regular feedback to the client and this is what the platform aimed to achieve. The data can always be made available to the client at any time. This increase in the availability of the data will maintain client satisfaction.

The platform allows the PM teams to view KPIs on the tracked actions that were not made available before. The platform helps provide valuable insight into the actions that a team tracks. The company can use the KPIs to adjust the PM teams to more effectively manage company time and resources.