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**Northumbria
University
NEWCASTLE**

Project Report

To develop an online meeting tool for a pharmaceutical
manufacturing facility.

James Singh

17000348

2020/2021

General Computing Project

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Abstract

Collaborative meetings provide a critical method of information transfer within industry. Within the manufacturing industry, companies will employ thousands of people working in many different areas of a complex facility; the need to share information with these employees goes beyond a simple email. The employees themselves witness important events that need to be recorded and communicated to peers from every department. In a digital world where remote working has become ever prominent, the client for this project, the Cramlington Manufacturing Facility, has fallen behind the times, opting for an in-person meeting approach as opposed to a digital platform. This project revolutionises this approach by designing, developing, and implementing an online digital meeting tool for use by the IT department within the facility. Creating a product that allows actions to be recorded and tracked, data to be filtered, and critical metrics to be analysed.

To aid the creation of the proposed system, relevant literature has been critically evaluated; identifying how meetings work, the need for a digital platform, and the currently available solutions. A detailed requirements capture exercise has been performed, obtaining primary research from the client, and identifying their needs. To accompany this, the project has implemented the Cramlington Manufacturing Facility's System Development Life Cycle methodology, providing a full set of documentation to detail the activities performed during each stage of the project.

Based on requirements set by the client, a fully comprehensive digital meeting application has been developed and implemented at the facility, meeting the needs of the company, receiving great feedback. The application provided the facility with newfound functionality capable of providing a greater, more comprehensive Tier Process experience than what is currently on offer. Further work beyond the project's scope is also discussed, with the potential of the product growing and developing into a complete tool for the entirety of the company.

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1. Introduction

1.1. Introduction

This project is a detailed investigation and discussion into the subject of collaborative meeting spaces throughout the industry. To support this investigation, a fully functioning, online collaborative meeting tool has been created for a pharmaceutical manufacturing facility.

1.2. Project Background

1.2.1. Introduction to “Big-Pharma”

Big-Pharma, as described by the Cambridge English Dictionary, is a collection of large pharmaceutical companies manufacturing and selling medical drugs. The client of this project is a globally recognised human health pharmaceutical manufacturing facility belonging to one of the largest pharmaceutical companies in the world and a member of Big-Pharma. Due to a confidentiality agreement, the client cannot be referred to by their actual name. This is because of the restrictions and regulations they have to adhere to. Therefore, for this project's duration, they are to be referred to by the pseudonym the Cramlington Manufacturing Facility (CMF).

The CMF, which specialises in research and development, human and animal health manufacturing, vaccines, biosimilars, and women's health, produces over 5 billion tablets per year with a diverse product portfolio, including diabetes and cardiovascular disease.

1.2.2. The Tier Process

Inside the manufacturing facility, such collaborative meeting spaces take place known as the Tier Process. The Tier Process is a method of funnelling critical information through the manufacturing site, getting the information to the right people. Each department within a business unit (e.g. IT, Packaging, Manufacturing) each hold a meeting where the participants go through a series of questions and sections relating to their business function. For example, some sections will include health and safety, planned downtime for systems, and ongoing issues; this is called Tier 1. Once the Tier 1 meetings have been completed, each department lead within that business function get together with the department lead and go through the same process, discussing the outcomes from the Tier 1 meeting; this is the Tier 2 meeting. For the Tier 3 meeting, each business function lead gathers together along with the plant manager to discuss the outcomes from the Tier 1 & 2 meetings across the facility. Figure 1 highlights this information transfer using the IT, Bulk Manufacturing and Packaging departments as an example.

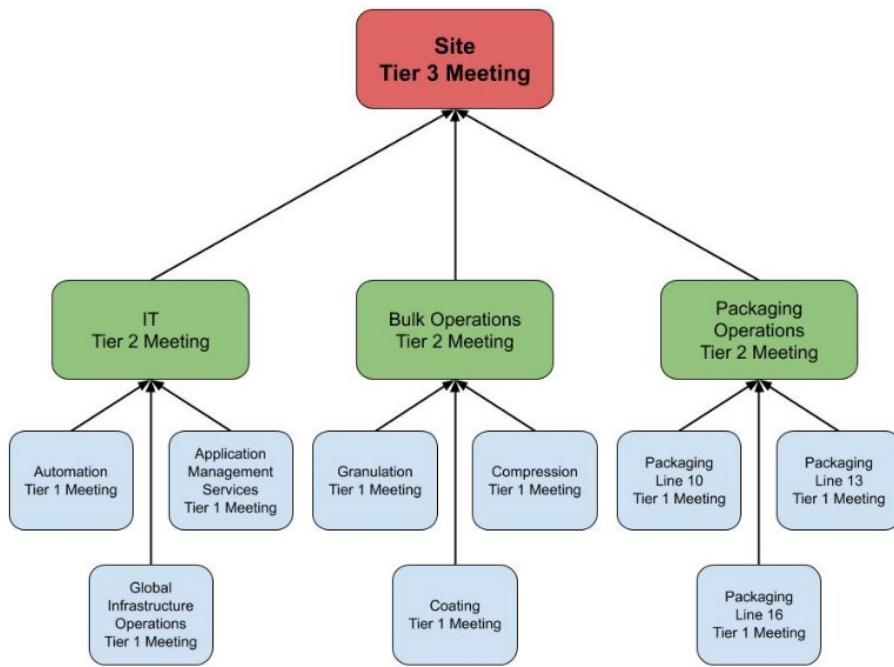


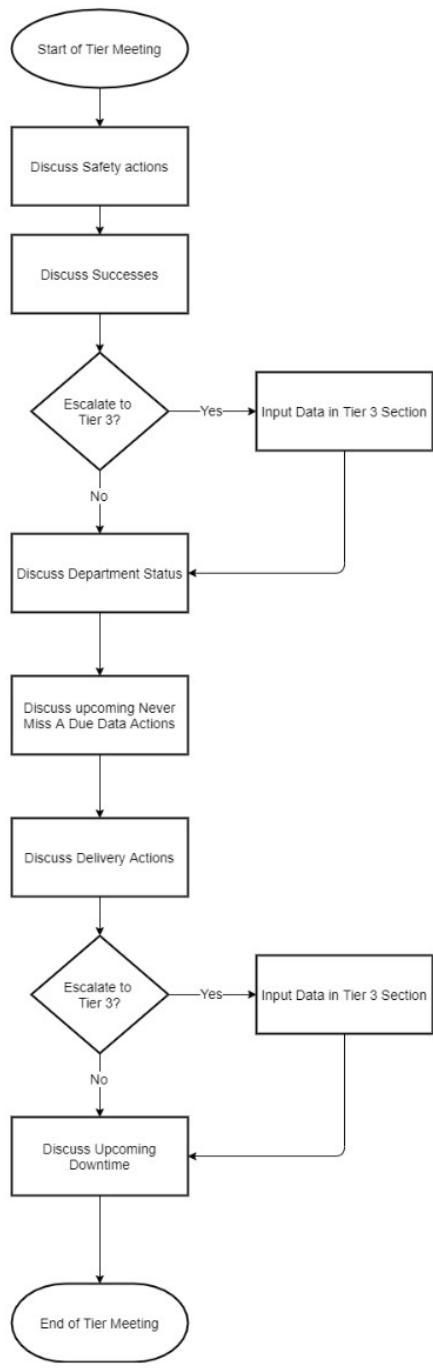
Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples. (Singh, 2020)

The manufacturing facility's collaboration spaces are centred around open spaces with an office environment, with lots of people walking past whilst the meetings are being held. Participants crowd around such areas, and upon the walls, a series of boards are hung up; these boards are used to mark the different sections of the meetings and, using a whiteboard marker, take notes on all matters. Figure 2 shows the boards that are used in the IT department for these activities.



Figure 2 – A visual representation of the Tier Board used at the CMF as examples. (Singh, 2020)

The Tier Board, shown in figure 2, appears quite complex to any first-time participant of a Tier Meeting when in reality, the process is straightforward and linear, with very few decisions being made. The process focuses more on discussions around what is happening in each area of the meeting. The process flow for a typical Tier Meeting is shown in figure 3 below.



*Figure 3– A process flow demonstrating how a typical Tier Meeting takes place.
(Singh, 2021)*

1.2.3. Limitations

As shown in figure 2, the Tier Board sections are limited as to the amount of information that can be displayed at once, meaning previous meeting's information cannot be retained in this format. Although a comprehensive list of items for areas such as Delivery Operations, this list is very rarely fully used, meaning many blank areas across the Tier Board. These limitations mean that the boards take up approximately six feet of wall space in a small office area. Alongside this, there are often conversations that arise around other aspects of business that are not captured on the boards, meaning that information is often not captured or wrote down by a singular individual. This is not efficient.

1.2.4. Advantages

A major advantage of the Tier Process is the visibility it gives participants. During the meeting, it allows all notes to be visible. As a result, everyone can contribute to anything recorded, allowing transcriptions to be more accurate and have more input from the participants. This is highlighted by Hagner et al. (1996), who discuss that "*As recorders of the written meeting notes, facilitators reported that they wrote everything down. However, in reality, the fast pace of comments necessitated ongoing decisions about what to record and what to omit.*" This process limits the responsibility of the note taker, as all meeting participants are now responsible for what is recorded. During the meeting, the notes and recordings are visible, but people can refer to the meeting notes just by going up to the physical meeting space.

1.2.5. Improvements

This system does not cover some of the key statistics that need to be monitored by the IT team. An example of this would be that a server has just undergone a key change, meaning more workload is required from it; currently, there is no method of monitoring the performance of this server. The current set up is that a member of the team will get an email once it has reached a certain threshold, this could be identified sooner if there was a method of monitoring it regularly. This is one such example but the concept of being proactive versus reactive. Lee et al. (2004) discuss this approach with Networking, evaluating how it is more effective to have a prepared system for failures.

1.3. Aims and Objectives

Based on the project background, a clear problem case was identified. The following aims were created to resolve the issues identified with the problem case.

- To investigate and analyse the importance of how collaborative meetings bring information and issues to the relevant teams within a manufacturing environment.
- To develop a web-based meeting tool with digital data tracking and analytics for a pharmaceutical manufacturing facility.

From this, twelve different objectives were identified to support the completion of the aims and provide the detail for the subsequent report. These objectives can be seen below:

1. Perform a requirements capture for a new digital “Tier” system focusing on the IT department and their specific areas of need.
2. Conduct a Literature Review to analyse all relevant documentation.
3. Conduct research into how the current system is used and identify key features and areas for improvement.
4. Investigate and analyse existing collaborative meeting solutions.
5. Research and evaluate the most appropriate tools to develop the client-side and server-side parts of the tool, as well as the database used.
6. Create an entity relationship diagram and data dictionary for the database.
7. Use Human Computer Interaction and User Experience principles to design an appropriate user interface.
8. Develop a collaborative meeting tool that meets the requirements as set out in the requirements specification.
9. Conduct an appropriate level of testing both with and without user interaction to ensure the product is fit for purpose.
10. Develop a set of System Development Life Cycle documents in line with the CMF’s policy.
11. Complete an evaluation of the product.
12. Complete an evaluation of the project as a whole, including project management.

1.4. Subject of the Work Completed

1.4.1. Product Created

The product created for this project is a web-based meeting tool to support the Tier Process for the CMF’s IT department. Replacing the Tier Board, a virtual tool comprising seven comprehensive sections has been developed to encapsulate the current Tier Process whilst adding further functionality. This tool has been created to improve upon the current process used by the IT department, providing additional capabilities to analyse and discuss trends and metrics within the department. This report has been created to discuss the three distinct areas of activity to support the creation of the product. These areas are the Analysis, the Synthesis, and the Conclusions.

1.4.2. Analysis

The analysis chapters investigate what options are available to perform what is needed by the client. Due to the nature of the Tier Process, there is no current literature supporting the Tier Process itself, resulting in the need to investigate the wider field of collaborative meetings. This involves taking a detailed and critical view of the current literature surrounding the collaborative meeting process and the need for a digital tool. Trying to identify any current IT solutions available for use by the CMF took place, with the conclusions being that the only option was to create a dedicated bespoke tool.

Next, a thorough and meticulous requirements capture was executed. This involved interviewing representatives from the CMF to gather and formalise a set of requirements for the product. The tools and techniques that were to be used were then decided upon.

1.4.3. Synthesis

The synthesis chapters look at how the product was created to meet the requirements. This section begins with the design approach used for the project, detailing the supporting documents created and the rationale behind each one. The process used for this project is based upon the CMF's principles and methods. The implementation of this design is then covered, with supporting figures evidencing how each piece of functionality was completed. Finally, the testing of the product was detailed, following the approach as taken by the CMF, whereby the test cases were drawn from the requirements capture, which took place within the analysis.

1.4.4. Evaluation

To conclude this report, a detailed and critical evaluation of the project has been completed. This looks at the product itself and the strengths and weaknesses shown, whilst also obtaining final feedback from the client and their opinions on the project's outcome. As well as looking at the product, a comprehensive evaluation of the project process was completed, ensuring to detail how the project management influenced the final result and what skills and lessons were learnt. Finally, the report concludes with an overview of the aims and objectives, describing how these were met, before detailing further work that falls outside this project's scope.

Analysis Chapters

2. Literature Review

2.1. Introduction

The following chapter will provide an in-depth view and critical analysis of literature relevant to creating and implementing a digital collaborative meeting tool. This will aid the understanding and challenges surrounding this problem whilst providing feedback and inspiration for developing the resulting tool. There is no current literature describing or evaluating the Tier Process used at the CMF; therefore, a general review of the surrounding topics occurs. The key topics covered in this chapter include general meetings, meetings using technology and remote working.

Evaluating other methodologies, from other industries, in a critical manner will establish the basis for the requirements capture and draw comparisons between what is needed in different fields, allowing the evolution of such meetings within the pharmaceutical manufacturing facility.

2.2. Meetings

Throughout many industries across the world, meetings are held day-in, day-out, in the same conference rooms, with one person leading the meeting and talking to the rest of the participants. A meeting has two key aspects: the purpose of the meeting and the objectives of the meeting. The purpose is the reason the meeting is being held, whereas the objectives are the outcomes required to be achieved by the meeting (Meeting Planning Know How, 2020). Every meeting has both a purpose and objectives. Achieving these in the most efficient method whilst maintaining happiness and well-being inside the organisation is how productive the meeting participants are (business.com, 2020).

2.2.1. Collaborative Meetings

More often than not, such meetings are not as productive as they could be, with more industries moving towards a collaborative style of meeting, which as described by Heerwagen et al. (2004), is perceived as a tool for increased organisational effectiveness and can be defined as "*working together*". Heerwagen et al. (2004) also go on to say, "*effective collaboration entails both individual-focused tasks and interactive group work.*", highlighting the need for environments and technologies that will support collaborative work to be conducted.

Meeting spaces and technologies should facilitate the transitions between individual and group focused tasks. More often than not, this is not always the case; as Richter et al. (2001) discuss, "*often informal, the information generated during these discussions often does not get recorded informal documentation. However, this information is later useful for providing additional context, details, and decisions surrounding a project*", highlighting the need for further advancement to record

meeting information. Distractions from new technology can often harm the group's productivity due to inquisitive nature, investigating the new technology and getting off track.

2.2.2. Collaborative Ideation

One such concept focuses on productivity and the creative ability of the participants in collaborative ideation. *Collaborative ideation* is a process that allows ethnographic insights from a group of participants (Gama, 2018). Working together to solve problems and generate new and exciting ideas is much more useful than one person working alone to achieve this; different backgrounds, experiences, and lifestyles can create a much more innovative solution to the problem (Siangliulue et al., 2015). This thought process establishes a method used within many different industries to become a more efficient, social, and innovative enterprise. Couple collaborative ideation through a medium of data captures, such as recording technology and architecture for collaborative interaction and problem-solving, is created.

2.2.3. Distributed Cognition and Cognitive Artifacts

Distributed cognition is the awareness of details and tasks that no individual is responsible for (Hutchins, 1995). An example of distributed cognition that Hutchins (1995) uses is how things are distributed around a workspace; no one person holds all organisational knowledge. It requires a team of people to develop the organisation's full picture. This concept establishes collaboration and problem solving as a team, meaning that participants have a significant role to play in these scenarios. In these situations, a medium must transfer the team's critical knowledge and information to the correct destination to achieve the goal. This process is usually in a collaborative meeting, with all relevant stakeholders identified and congregated.

One method of a collaborative meeting environment being more effective and productive is by using cognitive artifacts. These artifacts are the method of transferring information from a team of people into a readable and reusable format, and the idea of cognitive artifacts stems from Distributed Cognition (Hutchins, 1995). Carroll and Norman (1991) talk about cognitive artifacts and define them as "*an artificial device designed to maintain, display, or operate upon the information to serve a representational function*". Cognitive artifacts are classed as endogenous, meaning that they are constructed by the users in-house to support their work or exogenous, created elsewhere and then introduced into that work environment (Jones and Nemeth, 2005). Examples of such cognitive artifacts include audio or video recordings, books, notepads, and other printed material (Norman, 1992).

Cognitive artifacts are a vital concept when investigating collaborative meeting spaces. Often these artifacts can be influenced by the different methods of collaborative ideation. These cognitive artifacts are interfaces between people and their interactions with essential information and processes. Cognitive artifacts differ depending on the organisation and evolve throughout time and experience (Nemeth

et al., 2006). They are embedded within organisations today, each having its own interpretation, using different concepts of distributed cognition and different mediums as their artifacts.

2.3. Collaborative Meeting Spaces Throughout Industry

Many different industries use the concept of collaborative meeting spaces, with Hua et al. (2010) discussing how "*effective collaboration has become increasingly critical for organizational performance and agility*". This highlights the need to become flexible and adaptable for a business to grow; collaborating with team members is one such way a company can generate new and improving ideas and solutions.

2.3.1. Hospital Handovers

An industry where collaborative meeting spaces are becoming more utilised is hospitals and healthcare in general. Randell et al. (2010) discuss how shift handovers in hospitals transfer that information between one team and another. Vinu and Kane (2016) define handovers as "*the transfer of professional responsibility and accountability for some or all aspects of care for a patient, or a group of patients, to another person or professional group on a temporary or permanent basis*". Kohn et al. (2000) discuss how lack or breakdown of communication is one of the most prominent causes of unanticipated patient problems.

Randell et al. demonstrate how whiteboards during handover, similar to the CMF, display information about patients, available beds, and awareness of admissions and discharges. This provides visibility and knowledge for anyone coming on shift. Couple this with informal, verbal communication; it clarifies all the patients' status on the ward.

Vinu and Kane (2016) expand on this idea of handovers by conducting a study into the use of technology within the handover process. They piloted a computerised version of the handover process within a hospital, and the results they found showed that "*The use of the computerised structured format provides a prompt for critical information and helps to ensure that information is not overlooked*". This system meant that processes were followed more closely, and information was transferred to the different teams more efficiently and, most importantly, accurately.

2.3.2. Honda's Waigaya

Honda is a Japanese motor company and is one of the world's leading manufacturers of automotive and marine vehicles, industrial and home use power tools, and aircraft (Honda.co.uk, 2020). Honda motor company was founded in 1948 by Soichiro Honda and his business partner Takeo Fujisawa, creating their first motorcycle for commercial use in 1949 (Honda.co.uk, 2020). Today they are one of the world's most successful motor companies, having sold over 100 million cars worldwide and building a reputation of being a reliable and dependable vehicle brand (Honda.co.uk, 2020).

Honda has a unique process for its meetings within each department, from manufacturing and maintenance to sales and marketing. They operate with spontaneous, open meetings to solve problems and gain access to insights and opinions across the corporate spectrum (Sahu, K., 2019). These meetings are called Waigaya, which is not a word in any language but instead coined by Takeo Fujisawa, Honda co-founder. "*It is the noise of heated discussion and the free flow of ideas; it represents a battleground of subjective and objective opinions, of chaotic communication, open disagreement, and inharmonious decision making*" (Rothfeder, 2014). These meetings can vary between three and twenty people and can be a half-hour meeting on a problem or a series of meetings that lasts months looking at a new upgrade or significant project. The rules for Waigaya are as follows (Rothfeder, 2014):

- Everybody is equal in Waigaya—there are no bad ideas except those that are not aired.
- All ideas must be disputed and rejected until they are either proven valid or vanquished.
- When a person shares an idea, they do not own it anymore—it belongs to Honda, and the group can do with it what it will.
- At the end of Waigaya, decisions and responsibilities are generated—a precise list of who is to do what next and by when.

This concept, although it allows free-flowing conversation, can also be distracting at the same time. Waigaya, with its increased productivity, also can be a waste of time and resources, causing disruption and, as a result, is counterproductive. To outsiders, this concept appears to be a waste of time and effort as to "*most companies and most observers Waigaya is an odd idea, seemingly too free-form to be productive and to lack a strong enough leadership component to produce real results*" (Rothfeder, 2014).

Although this process seems like a waste of time and resources to others, Honda doubles down on this concept, believing it has several benefits to the company and its employees. Honda's first significant benefit is increased productivity from their staff as they can freely express their emotions and ideas in a judgment-free manner, meaning all issues can be resolved then and there rather than not being exposed until tensions are high. The free form meeting structure influences more ideas to be brought to the team, providing a more creative and more outstanding problem-solving capabilities. Every team wishes to achieve this when working collaboratively, and Honda's Waigaya allows this to take place expressively. Finally, a significant benefit of this meeting structure, which can often be problematic when working collaboratively, is that everyone is involved, no matter the employee's rank or the difference in ethnographic background. This is a significant benefit to any company, allowing participants to feel that their opinion is as valued as anyone else's, even if that person is much higher in rank. This togetherness created a collaborative environment and looking at Waigaya as a whole; Honda has created a system that

promotes collaboration amongst the entire team, networking together rather than working in individual silos.

2.3.3. Teaching

Although teaching is not thought of primarily as a collaborative meeting method, it is, in fact, a method of communicating information between the teacher and the students. The majority of learning throughout the world in the present day is conducted via face-to-face classroom interactions. It is a place for "*focused engagement where students understand the goals and feel safe getting involved*" (Cooper and Garner, 2012). In effect, this is a face-to-face meeting between teachers and students where interaction on both parts is required; this may not be in the traditional form but still provides an interface for communication.

Some of the most common teaching practices include good communication skills between teacher and students, engaging with the students and using peer learning (Educatorstechnology, 2020). All of these practices are similar to those required in meetings; any concepts of distributed cognition will be similar to what a meeting would require. Cognitive artifacts used in teaching might vary based on teaching style, but the concept remains the same. Specialised artifacts would be vastly different from those used in meetings.

2.4. The Shift to Remote Working

2.4.1. COVID-19

In late 2019, the WHO (World Health Organisation) learned of a new respiratory virus, SARS-CoV-2 (COVID-19). Originating in Wuhan, China, symptoms of the novel coronavirus included fever and a dry cough. In March 2020, COVID-19 was categorised as a global pandemic and had spread globally (World Health Organisation, 2020), causing significant lockdowns; thus, working from home becoming essential for many industries.

2.4.2. Impact to the Manufacturing Industry

Despite the necessity to transition to home working, many industries struggled with this, trying to complete work in the same way they did before COVID-19. Industries were not prepared to implement this way of working (Wang et al., 2020). Pharmaphorum deepdive discuss this in an interview with Natalie Yeadon, the managing director of Impetus Digital, a company specialising in collaboration experiences with life sciences companies (Impetus Digital, 2020). In the interview, Yeadon states, "*Companies are still bringing everybody together and gathering insights the same way they would in an in-person meeting, but now it is just through a virtual platform*" (Pharmaphorum Media Ltd, 2020).

In many other manufacturing industries, "*including Airbus, BMW, Boeing, Ford, GM, and Volkswagen are shutting down factories and lowering manufacturing capacities*" (Wuest et al., 2020). The inflexibility of the manufacturing industries has shown that

production was halted or greatly slowed, including all communications. Wuest et al. (2020) discuss how several different manufacturing industries have been affected by the results of COVID-19, with automotive, pharmaceuticals, aircraft, defence, and household paper products industries, in particular, highlighted. Depending on the industry, the impact differs. However, one aspect that is not discussed is the impact on support functions for these industries. Functions such as in-person, hands-on, IT and automation support has been replaced by remote working to reduce the risk to workers.

2.4.3. Online Teaching

One of the many effects of COVID-19 was that teaching in many different education levels had to cease or transition to an online platform. Online teaching uses the internet and connected technologies to develop and deliver educational purposes (Fry, 2001). Hrastinski (2008) speaks about the two different types of online teaching: asynchronous and synchronous.

Asynchronous teaching is the creation of material and then posting that material to a platform so that participants can view the content at a time that is convenient to them, allowing time for family, work, and other commitments (Hrastinski, 2008). On the other hand, synchronous is content that is delivered live, usually via video conferencing software. One such platform that allows both is Blackboard. Blackboard is a learning management tool allowing teachers to post content and assignments for students whilst also providing a synchronous distanced learning solution through "Blackboard Collaborate" (Blackboard.com, 2020).

This concept allows students to work both individually and collaboratively as part of a larger group, promoting greater productivity due to various learning methods. A drawback to this setup is that the teacher has to understand the technology used as they have to support the students digitally and with the content they are delivering. This has the potential to cause issues, meaning valuable time is lost when delivering content and can also lead to a disruptive "classroom" (Hogle, 2017). Another disadvantage of moving to an online solution is that opportunities for engagement may not be as forthcoming. In a traditional classroom, learners will respond in different ways, not always verbally. They may smile, nod, sigh or look disinterested. Online, this is not always apparent, and therefore, the teacher needs to create opportunities for this engagement and feedback. This will ensure that learners participate and get the most out of the lessons possible (Hogle, 2017).

2.5. Technologies to Support Remote Working and Collaborative Meetings

Digital Collaborative Meeting Spaces bring together the key concepts previously discussed, cognitive artifacts, collaborative ideation, and remote working, to create a solution. Advanced Collaboration Environments is a concept that puts this into practice. This concept is to bring together the right people, the right technology, and

the right data at the right time to achieve a common goal or solve a common problem. (Corrie et al., 2003).

2.5.1. Digital Sticky Notes

One commonly used solution in many different industries and environments is the use of "Digital Sticky Notes". Jensen et al. (2018) conducted a study comparing digital and physical sticky notes using NoteCreator and NoteCanvas. From this study, Jensen et al. took away some key findings, the first being that digital sticky notes have greater longevity. Participants discussed how with sticky paper notes, they cannot be left as they will either get damaged or lost. Likewise, they are not durable and can often fall off the surface they are stuck to. Another finding from the study was that the digital notes were more comfortable to sort due to the software's easy drag and drop features. This also meant better visibility of the notes, allowing for more organisation and ultimately more productivity. One drawback that the study found was a decline in productivity and involvement with the overall group activity.

2.5.2. Microsoft Teams and Whiteboard

Over the past few years, collaboration tools such as Microsoft Teams and Microsoft Whiteboard have become more prominent in the industry. As stated on Microsoft.com (2020), "*Stay connected and organized. Accomplish more together across work, school, and life with Microsoft Teams*", this shows that they have developed a platform that is intended to be used by people who want to collaborate. As well as their call, meet and chat functions, they also want to use it as a collaboration tool. The way Microsoft promotes collaboration is through the sharing of files to stay organized, video in meetings and working together, at the same time, on the same document (Microsoft.com, 2020). On top of this, they allow the use of tools such as Microsoft Whiteboard inside the Teams meetings to drag and drop images, sticky notes, and other media and sketch and write on the board (support.microsoft.com, 2020).

2.5.3. Bespoke Meeting Software

Many companies require meeting software, and whilst generic software like Teams exist, this sometimes does not meet a business's requirements. This is where bespoke software comes into play. As defined by Oxford Learner Dictionary (2020), Bespoke is "*made specially, according to the needs of an individual customer*". Certain industries may need specific items only by creating something that fits their exact specifications. Meetings differ from company to company, and one solution does not fit all.

Ekodono et al. (2014) developed an online meeting application for a software development company with some of the features of the application, including meeting rooms dedicated for specific teams, separate projects inside these meeting rooms, task creation and completion, file attachments and a chat function (figure 4, Ekodono et al., 2014).

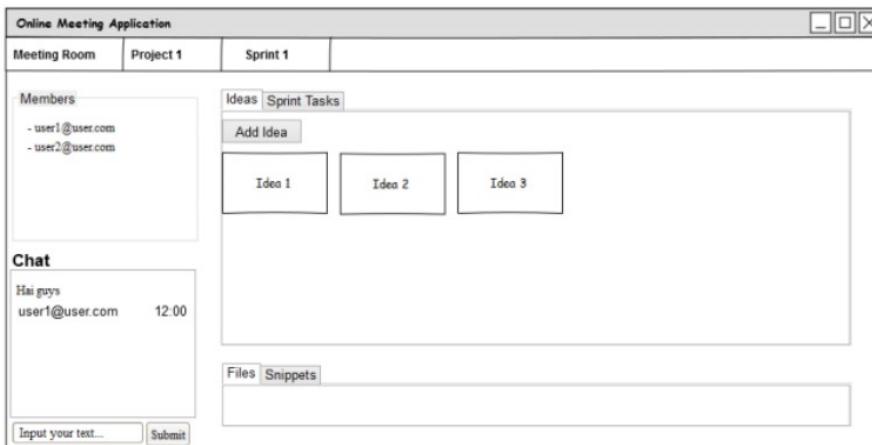


Figure 4 – A bespoke meeting software developed for a software engineering company (Ekodono et al., 2014)

Bespoke software such as the one shown in figure 4 provides all the functionality needed for this company's requirements making it incredibly fit for purpose. However, the software above is not appealing; the UX design for this software is inferior, which may not be a priority when creating the software but does not create an inviting environment to work. A company has to take into consideration that when purchasing bespoke software it tends to cost more to develop and maintain with only one set of developers working on updates as and when the company wants and pays for it. In comparison, a meeting system like Teams is supported by a full Microsoft development team with updates coming as and when needed, which is a lot faster and more comfortable than the bespoke method. However, there is one significant advantage to the bespoke system, which has previously been identified. Bespoke systems allow total customisation and adaptability for the customer; this can be essential for some situations and invaluable for some customers.

2.6. Summary

This chapter performed a critical investigation and discussion into the subject of collaborative meetings, both in-person and remote. This investigation, alongside the evaluation of the digital tools currently available, forms a basis for the rest of this project. As evaluated throughout this chapter, there is no relevant solution for the CMF to support the Tier Process. As a result, a dedicated bespoke tool will need to be designed and developed to improve the current situation. The following chapter

will detail the requirements gathering process, which will provide the foundations for designing and creating this bespoke collaborative meeting tool.

3. Requirements Capture

3.1. Introduction

This chapter explores the creation of requirements and how they influence the design and functionality of the proposed product. Requirements capture and definition are an important activity at the start of any development project; this outlines and highlights what the project is meant to deliver and achieve (Robertson and Robertson, 2014).

3.2. Process

Two of the main problems with any failed project are that the project team fails to deliver what is expected by the client or changes what they want the outcome to be midway through the process. Ambiguous requirements can lead to such situations and leave both the client and developer confused and frustrated because they believed expectations were expressed clearly or that the product met the needs specified. Often, this can be caused by a client modifying or adding further requirements or functionality to the existing scope during the execution of the project; this is known as scope creep (Thakurta, 2013). To prevent this from happening, systems analysts formalise the requirements; usually, in the form of a document that details all the proposed work requirements. This document is called a requirements specification. The stakeholders/client of the project then signs the document to declare their understanding of what is going to be created by the development team, thus ensuring everyone involved in the project has an identical understanding of what is expected (Robertson and Robertson, 2014).

To accompany the requirements specification, the prioritisation of the set requirements provides the ability to explicitly define which requirements are the most essential and those which can be discarded if there is a shortage of time or resource before the project deadline (Moisiadis, 2002). *"Requirement's prioritisation is the setting of ranks or ratings of importance to a set of requirements based on certain criteria like goals, risks, quality, use, and according to the viewpoints of various stakeholders"* (Moisiadis, 2002).

This requirements capture will focus on one main form of requirements gathering, which will be interviews. Interviews are one of the most popular user-based requirements gathering techniques, whereby a guided conversation takes place in which one person seeks information from another using questions (Courage and Baxter, 2005). These questions allow the interview to shape the conversation structure; this means if the interviewee is not giving as much information as required, the interviewer can push for more interaction. Likewise, if the interviews were done in a group setting, some group members would not have as much input as others, with one to one interviews giving every participant equal opportunities to interact.

3.3. Interviews

3.3.1. Introduction

This following section details the outcome of interviews with five different participants from the CMF. These interviews will help detail the requirements prioritisation and influence the creation of the requirements specification (Appendix 11). The questions asked to each participant in the requirements capture process is detailed in Appendix 2. A list of participants and their position is listed below:

Participant	Role
1	IT Business Analyst Intern
2	Automation Engineer
3	IT Infrastructure Lead
4	Automation Department Lead
5	IT Department Lead

Figure 5 – A table of participants and the role's they hold.

3.3.2. Participant 1

The first participant in this study is one of the current IT interns at the CMF, holding that position for the past seven months and attending the Automation Tier 1 at that time. One of the intern's jobs is to help support new IT systems and support existing systems with any operational issues.

When this participant was first introduced to the Tier Process, they described their initial interaction and impression of the tier process as "*a bit all over the place*" and that it "*hasn't got much structure*". This demonstrates that new team members find the Tier Process difficult to understand when first introduced to the process. When speaking to this participant, they clarified that the current Tier Process is good at drawing out the key information needed allowing information such as safety, operational and system issues to be identified efficiently. However, the participant also states that the visibility across the different teams is limited.

The participant noted that when using a meeting function such as Microsoft Teams to speak to the team members, it is harder to get the user's point across due to lack of social cues and physical interactions that can be demonstrated. However, the online solution does give the meeting participants more flexibility when it comes to meeting attendance. Participant 1 states that due to the nature of their team's responsibilities, it means that they can be at any area of the manufacturing facility at any given time, making it impossible for participants to report in-person at every meeting. Therefore, a remote solution provides the opportunity to allow every team member to report in no matter where they are or what they are doing.

When asked about what the participant would change to the current process and how it could be improved, they stated that there needs to be a better layout of information and track that information. Examples of this are identifying who is

assigned what action and when it should be completed by. This is highlighted by the participants answer to the questions about existing and new features for a bespoke application. This participant stated that a key existing feature is the 'Never Miss A Due Date' board (also known as the Action Tracking Board and shown in Figure 2). Participant 1 went on to explain that this is critical for the team to track actions, but this could be more visual and have extra metrics to ensure compliance and track the progress of the team.

3.3.3. Participant 2

Participant 2 is a current Automation Engineer who started this role in October 2020; before this, they held two previous roles in the Global Infrastructure Operations department within the Cramlington IT team since 2019. Due to this, participant 2 has experienced Tier 1 meetings in two separate departments within IT. This participant's current role means that they have to implement new solutions across the site and maintain current automation hardware across the site, including Human Machine Interfaces, Programmable Logic Computers, and other Industrial PC's.

When participant 2 was introduced to the Tier Process, they felt that it did not have a logical flow. However, this changed once they gained experience with it. They also stated that this was mainly due to the guidance received from the team's more experienced members. This participant explained that once an understanding is formed of how the Tier Process works, it is "*good at getting the information out*" about specific issues that have been identified. However, they stated "*there is a lack of visibility of what happens to any escalated actions up the Tier system*", making it difficult to react to any outcomes that may come out of the escalation due to not being involved.

When asked to compare the in-person process to the Teams and OneNote solution, participant 2 stated that whilst in-person allows for easier communication and creates an easier flow to the meeting, the Teams and OneNote solution's data storage is a critical feature that greatly enhances the process. This is due to the ability to reference previous meetings later, indicating past solutions to problems or highlighting previous mistakes. Comparing this to the in-person process, actions/problems would only be visible for a short amount of time before getting rubbed off the board or fading, becoming illegible.

This participant was clear that if a bespoke system were to be created, it would need to mirror the current system. This comes mainly from a compliance point of view, with safety, actions, and operational issues critical talking points within the Tier Process. This would subsequently allow this tier to be more transferable to other departments as these are all existing items in every department's Tier Process within the CMF. Furthermore, this participant states that better visuals to increase engagement and the ability to monitor compliance using statistics within the system would be beneficial to the IT team and the wider site. This would help refine processes and increase productivity within teams which, as stated by Larson and

Callahan (1990), is due to the effect on work behaviour, influencing the perceived importance of the task that is being monitored.

3.3.4. Participant 3

Participant 3 is the IT Infrastructure Lead for the CMF in the Global Infrastructure Operations department, holding the role for more than two years. As the IT Infrastructure Lead, participant 3 attends the IT Tier 1 and 2 and occasionally covers for the IT Department Lead at the Facility's Tier 3. Participant 3's role involves looking after all of the networks and computers across the Facility, reporting, and fixing any issues that may arise.

Participant 3's first impression of the Tier Process was that it was "*very unorganised*" with the meetings happening ad-hoc rather than at arranged times. This led to the team not "*thrashing out the real problems*" that would arise. Since then, the Tier Process has evolved into a structured format where the problems are found and reported immediately. The framework is more robust and creates a platform to engage with issues.

Participant 3 notes that when the meetings were held in-person, there is a much smoother flow. Social cues and physical interactions with the tier board allow for much greater participant engagement. Alongside this, it allows participants to see everything that is going on at once rather than section by section. However, the Teams and OneNote solution is not constrained by physical space, unlike the wall where the in-person process. Likewise, the accessibility of the Teams and OneNote solution is much greater due to the capabilities of remote access.

For a bespoke tool, participant 3 said that notifications and emails notifying people of their outstanding and upcoming actions is a critical feature that must be incorporated. This should be similar to how Microsoft Planner is used to assigning actions and notify users. Finally, participant 3 would like a bespoke tool to be adaptable between in-person and remote working. As restrictions are lifted, and more people are granted access to begin working at the facility again, there will be a split of people working from home and at the site. Holding tier meetings where the medium for communication can be used for both is essential. Both the current Teams and OneNote solution and the in-person process do not provide this capability. Therefore careful UX design considerations should be used to inform the development.

3.3.5. Participant 4

Participant 4, the current Automation department lead within IT, has spent 12 years working in the pharmaceutical industry across different companies, including the CMF, where they have spent the last three years. Having held the role of Automation team lead for the past year and a half, the participant previously held a senior business analyst role within the same department for approximately two years. The

participant's role means that they attend several tier meetings, including the Automation Tier 1, IT Tier 2, and on occasion, the site Tier 3.

For participant 4, the Tier Process was nothing new when they joined the CMF, having previously been a part of a team implementing a similar process within another pharmaceutical company's IT department. Based on the idea of Safety, Quality, Delivery and Cost, these principles of the Tier Process, as described by participant 4, "*look to address issues at that level and only escalate and take things to a further level where appropriate*". This means that the people at those tier meetings are getting the information and making the decisions at the appropriate level, reducing the amount of duplicated information, nor is there issues or decisions taken to a level where it is redundant or not required. When participant 4 was first introduced to the Tier Process at the CMF, they noted that the process was similar and the framework put in place had the potential to be effective. However, the content was satisfactory. Since then, the Tier Process has undergone development to include relevant content that provides a focused discussion in a short amount of time; however, when the whole team is not engaged, it is difficult to retrieve relevant information. Thus, there needs to be a more consistent approach with a standard agenda that everyone should follow as some teams are also more effective at getting the relevant information.

Comparing the two different solutions currently available, engagement with meeting participants can be more challenging with an online tool such as the Teams and OneNote solution. This is due to the ability, when in-person, to read people's expressions and body language; whereas online, it is a one-to-one conversation rather than a discussion amongst the group. In-person is also more engaging due to being more physical rather than just watching a screen, e.g. moving boxes on the board. In contrast, the online Teams and OneNote solution provides more opportunities to expand on the process, creating more interactivity, flexibility, and clarity. As well as greater integration capabilities with other online systems, it is also more accessible to team members, which encourages real-time updates on items rather than waiting for the next Tier meeting to come around.

When speaking about a new bespoke system and what would be required, participant 4 focused on the need for the critical sections of the Safety, Quality, Delivery and Cost principles. The ability to translate a full wall of actions into one screen is a critical feature that will be needed to be a successful product and provide more information than what was previously capable of the physical Tier board. The need for more statistics and performance monitoring is something that, if included, would help the department leads get a better idea of what was going on within the department. Coupling that with the ability to follow up on actions, giving reminders to the people with actions due creates a better method of staying in compliance with upcoming due actions.

3.3.6. Participant 5

The final participant in this study, participant 5, is the current IT Department Lead, holding the position for the past year and a half. Having spent the last fifteen years at the company, starting as an IT intern, participant 5 has experienced all of the different Tier meetings and was around for the first adoption of the Tier Process at the CMF.

Participant 5, as mentioned, was at the CMF when the Tier Process was first implemented, where it was not initially all that relevant to the IT team and thus had to be adapted to be useful within the department. Since then, it has developed into an effective method of drawing out information from the different areas of the facility. The framework that has been refined and adapted has allowed the Tier Process to become effective. However, it still lacks engagement as the activities can sometimes be considered “*tick-box*”, which varies across the site.

Participant 5 sees the in-person as the more effective method due to the refinement over the years; the Teams and OneNote solution has just been put in place to adapt quickly to remote working. As seen by participant 5, the benefits of the in-person process is that it allows a much greater level of engagement through the personal communication that comes with it. The visuals of both setups are not stimulating enough to enhance the engagement, and as a result, this is something that participant 5 believes needs a strong look at. The Teams and OneNote solution still has several benefits. One of those is that it provides a way of back-end automation so that everything does not have to be manually completed by a team member.

Tracking actions, automated reminders, and the general framework and flow of the current Tier Process are all critical features that participant 5 believes must be incorporated into a bespoke tool. These features are the essentials that will grant further iterative development to the process, enhancing the productivity and usefulness of the tool. Beyond this, participant 5 believes that greater visuals alongside more statistical data will create a tool that is not just engaging but provides feedback on the department. This data will allow the evaluation of workloads within the department as well as the performance of each team.

3.3.7. Summary of Findings

From the interviews with all of the participants, it was apparent that all had a good base knowledge of the Tier Process. Even participants 1 and 2, who were relatively new to the process, had a good grasp of how it works. However, they were not all aware of some of the principles behind it. Despite the range of meetings attended by all the participants, it was evident that they all had a similar first experience with the process at the CMF. All felt that the process was initially difficult to follow and did not get to the real problems that needed to be discussed. Likewise, all the participants explained that with time the process became clearer.

All of the participants found one key issue with the Tier Process: the lack of engagement from the meeting attendees. Participant 5, in particular, highlighted that this could be due to the lack of visual stimulus, especially on the Teams and OneNote solution. The majority of what is presented is just plain text. All participants inferred that if the tool were more engaging for the attendees, then the online solution would be better due to the enhanced capabilities and opportunities presented, without the constraint of physical space. Participant 2 noted that data storage is a critical feature of an online system. This was particularly interesting as no other participant mentioned this specifically but rather assumed by indicating that monitoring statistics over some time should be incorporated into the tool.

The principles of Safety, Quality, Delivery and Cost, although mentioned explicitly by participant 4, were highlighted by all that this was an essential framework that will need to be replicated in an online bespoke tool to ensure compliance with company and external policies and regulations. In terms of improvements on the current process and features added to a new bespoke tool, this differed slightly from participant to participant. Most participants said that greater visuals with performance monitoring and action tracking would be a great addition to the process. Participant 3, however, noted that there is potential shortly for many staff, but not all, to return to the facility. This will mean there is a mix of remote working and on-site working, and the tool should be equally effective for both groups of people. Along with the need for greater visual stimulation for the meeting attendees, the design and layout of the proposed application are critical if the tool is to be a success.

Overall, the interviews conducted provided a great insight into how the participants felt about the current process and the areas that need improvement. Feedback from these interviews has allowed creating a detailed requirements specification, approved by a member of the CMF as detailed in Appendix 11. The following section looks at taking the feedback from the interviewed participants and turning these into prioritised requirements to be fulfilled by the project.

3.4. Requirement Specification

Based on the outcome of the requirements capture interviews, an idea could be formed about what functionality the Tier Process application would have. The recordings from the interviews detailed what each participant required from the system, allowing every participant's ideas to be collated and assessed. Using a Requirement Specification template created by the CMF, the basis of the functional requirements was developed. These functional requirements are outlined in the figure below:

Requirement Number	Critical? Y/N	Requirement Description
FU-001	Y	The tool will provide an interactive and engaging design that allows the use of the tool remotely or in-person.
FU-002	Y	The tool will allow the safe and accessible storage of previous Tier meeting's data.
FU-003	Y	The application framework will follow the Safety, Quality, Delivery and Cost principles and follow the current framework set by the CMF.
FU-004	Y	The application will allow users to edit information that is displayed in the Tier Board to reflect the current situation, easily and effectively.
FU-005	Y	The application will provide and display a set agenda that will be followed by all IT representatives.
FU-006	Y	The application will allow department leads to look at an overview of ongoing actions as well as evaluation and monitoring statistics about how the department is functioning.
FU-007	Y	The application will provide the users who have actions assigned to them notifications to remind them of deadlines.
FU-008	Y	The application should display all necessary information in a readable and concise method.
FU-009	N	The application should allow users to log in and view a personalised list of actions that are assigned to them and when they are due.
FU-010	N	The application could provide an interface that allows the monitoring of system downtime and statistics highlighting to the user the most impacted systems.
FU-011	Y	Actions displayed in the application should be able to be searched and filtered by due date.
FU-012	Y	Action items must be comprised of the following elements: Username of assigned team member, title of action, description of action, due date, what type of action it is, the department they are in and what the completion status is.
FU-013	Y	Users should be able to register an account to allow new users to be added to the Tier application.
FU-014	Y	The application should provide functionality to escalate items to the next Tier.
FU-015	Y	Delivery items should be assigned a priority of completion to enable fast response on those items with business-critical impact.

Figure 6 – The functional requirements of the project as detailed in the Requirements Specification.

Once the functional requirements had been identified, requirements surrounding the system's user experience, performance, and security were generated. These ensured that the system would fit in with the CMF's policies and regulations whilst ensuring that the application was designed around the user. Once the requirements

specification was generated, this was then taken back to the client, who signed off the requirements to say that they were happy with the proposed system and what it was going to do.

3.5. Outline and Prioritisation of Requirements

This project's creation will be based on several requirements set out and prioritised as below. The MoSCoW requirements prioritisation technique will be used to order the requirements. These requirements have been defined based on the client interviews above and the requirements specification signed off by the client in Appendix 11. The success of this project is directly proportional to how well the created solution meets these requirements.

The solution **MUST**

- Provide an interactive and engaging design that allows the use of the tool remotely or in-person.
- The safe and accessible storage of previous Tier meeting's data.
- Follow the Safety, People, Quality, Delivery and Cost principles and follow the current framework set by the CMF.
- Allow users to edit information that is displayed in the Tier Board to reflect the current situation.
- Provide a set agenda that will be followed by all IT representatives.

The solution **SHOULD**

- Provide an analysis of ongoing actions as well as evaluation and monitoring statistics about how the department is functioning.
- Provide the users who have actions assigned to them notifications to remind them of deadlines.
- Display all necessary information in a readable and concise method.

The solution **COULD**

- Allow users to log in and view a personalised list of actions that are assigned to them and when they are due.
- Provide an interface that allows the monitoring of quality statistics highlighting to the user the most impacted departments and users.

The solution **WON'T**

- Provide an interface for users to talk and interact, an additional service such as Microsoft Teams meetings or face-to-face meetings will be needed to supplement the content provided by this solution.

3.6. Summary

This chapter took a critical view at an approach to gathering requirements, analysing the best methods to do so, executing a successful gathering exercise. This chapter used interviews as the requirements gathering technique of choice due to this technique's ability to gain detailed and definitive feedback. These requirements gained from the client were then formalised and signed by the client, confirming their agreement, preventing the changing of scope further in the project. The next chapter will look at the tools and techniques that will be used to develop and execute the requirements formed in this chapter.

4. Tools and Techniques

4.1. Introduction

For this project, a web application will be created which follows the layered architecture model. Architecture is defined as "*the fundamental organization of a software system embodied in its components, their relationships to each other and the environment, and the principles guiding its design and evolution*" (ISO/IEC/IEEE 42010: Defining "architecture", 2021). In web development, layered architecture or n-tier architecture is the separation of the presentation layer, business layer and data access layer within the system (Marston, 2021). Figure 7 demonstrates what this system architecture looks like.

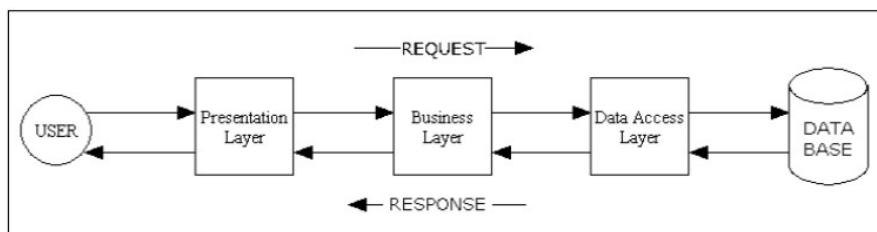


Figure 7 – A demonstration of the layered architecture and the requests and responses from each layer. (Marston, 2021)

Each different layer requires a different component to be created which is detailed by Marston (2021) in the bullet points below.

- The Presentation layer requires skills such as HTML, CSS and JavaScript, plus user interface design.
- The Business layer requires skills in a programming language so that business rules can be processed by a computer.
- The Data Access layer requires SQL skills plus database design.

The following sections look at the different layers and which tools and techniques will be utilised to create each separate component of the layered architecture for this system.

4.2. Presentation Layer

4.2.1. Introduction

This layer is focused on creating a front-end display for the user to interact with. This is a vital section of this project as one of the biggest challenges with this project is creating a product that the user feels comfortable interacting with. A carefully crafted user interface with UX principles such as Nielsen's 10 Heuristics (2020) is essential for the success of this product. This section will look at three different front end development languages, Blazor, React.js and Angular.js.

4.2.2. Blazor

Blazor is a web development language created by Microsoft and released in 2020, used for both front and back end development of a web system. *"Blazor is a framework that allows you to build single-page applications (SPAs) using C# and allows you to run any standard .NET library in the browser. Before Blazor, options for building a SPA were JavaScript or one of the other higher-level languages"* (Himschoot, 2019). Blazor apps are composed of reusable web user interface components implemented using C#, HTML, and CSS. Blazor uses current and open web standards without the need for plug-ins or code transpilation, which is converting code from one programming language to another, which is frequently done in JavaScript to allow languages to run in the browser (Microsoft, 2021).

The main advantage of Blazor is that it is an exciting and emerging technology that will receive plenty of support over the coming years. *"Blazor offers the promise of being able to write true client-side applications using C# and ASP.NET Core, without the need for a JavaScript framework"* (Joshi, 2020), which is a massive advantage against its competitors.

However, Blazor is a relatively new technology, meaning it is only supported by the latest browser versions. If a website needs to support legacy browsers—or even older versions of modern browsers this framework will not be sufficient, at least for the moment. Joshi (2020) also states that *"To run a Blazor WebAssembly application, the browser must download the .NET Core runtime, the .NET assemblies the application requires, and the application code. At the time of writing, this means that browsers must download about 5MB of data before an application can start"*. This is many data for the browser to download, making it unsuitable for many situations. Although this will most likely change, Blazor is not suitable for this project in its current iteration.

Being a relatively new framework means that it is not anywhere near as popular as traditional frameworks such as JavaScript. Furthermore, this means that few websites will have implemented this framework in their design. This is an emerging technology, but time will tell if it replaces the tried and tested JavaScript frameworks mentioned further in this report.

4.2.3. React.js

React.js is a JavaScript framework that is used to develop reusable user interface components. React.js enables the development of large web-based applications which can change their data without the need for page refreshes (Aggarwal, 2018). Facebook developed React.js to facilitate interactive and stateful components; furthermore, it is currently used at Facebook in their production environment. React.js is most effective for rendering complex user interfaces with high performance (Kumar and Singh, 2016).

React.js uses a virtual DOM rather than a regular DOM, unlike other JavaScript frameworks such as Angular.js (Kumar and Singh, 2016). “*The Document Object Model (DOM) is a programming interface for HTML and XML documents. It represents the page so that programs can change the document structure, style, and content. The DOM represents the document as nodes and objects. That way, programming languages can connect to the page*”(Developer.mozilla.org, 2021). The virtual DOM used by React.js is a fast, in-memory representation of the real DOM. The virtual DOM is an abstraction that allows the user to consider JavaScript and DOM as if they were reactive rather than static (Fedosejev, 2015).

Fedosejev (2015) explains how this works in the steps below:

1. Whenever the state of a data model changes, the virtual DOM and React will render a UI to a virtual DOM representation.
2. React then calculates the difference between the two virtual DOM representations: the previous virtual DOM representation computed before the data was changed and the current virtual DOM representation that was computed after the data was changed. This difference between the two virtual DOM representations needs to be changed in the real DOM.
3. React updates only what needs to be updated in the real DOM.

A major positive of React.js is that its learning curve for new users; as Aggarwal (2018) states, “*The easy and non-complex nature of ReactJS enables one to get comfortable with the framework quickly. The learning curve is extremely easy and gets one along without any complications*”. This is a major advantage to any new user of React.js and makes the development process much easier. Alongside this, React.js is designed to make its components reusable, making systems easier to develop and maintain. Another massive advantage of React.js is that it provides incredibly high performance due to the aforementioned virtual DOM. This is a major reason why the React.js framework stands out against the other JavaScript frameworks (Aggarwal, 2018).

One negative compared to other JavaScript frameworks such as Angular.js is that React is only used for the View Layer in the Model, View and Controller design pattern. This limits what it can achieve by itself and will need other tools to complete the full system (Kumar and Singh, 2016). For this project, this is acceptable as only the presentation layer will be written using this JavaScript framework.

4.2.4. Angular.js

Angular.js is also a JavaScript framework, similar to React.js, created by Google and originally released in 2010 (Patel, 2019). Angular.js addresses the challenges of a single-page application and follows the Model, View and Controller design pattern, which results in developing extendable, maintainable, and standardised web applications (Soni, 2017). Soni (2017) discusses how Angular.js works, stating that when a HTML document is loaded and evaluated in the browser, the following steps occur:

1. The Angular.js loads in the browser, and the Angular global object is created. The JavaScript file that registers the controller functions is executed.
2. Angular.js reviews the HTML document to look for Angular.js apps and views and finds a controller function that corresponds to the view.
3. Angular.js executes the controller functions and updates the views with data from the controller.
4. Angular.js listens for browser events, such as buttons clicking, any mouse movements, and altered input fields. If any of these events happen, then Angular.js will update the view accordingly.

Angular.js has several advantages compared to other JavaScript frameworks. It follows the Model, View and Controller design pattern, which, as previously mentioned, is advantageous as it allows the system to be created without using any other tools. The view is written in HTML, the controller written in JavaScript, and the model is written in Angular.js (Yao, 2015). Another advantage, like React.js, Angular.js allows the reuse of components making the development process much simpler (Yao, 2015).

One of Angular.js' disadvantages, documented by Kumar and Singh (2016), is that the learning curve is relatively harsh compared to React.js, making it difficult for beginners to the framework.

4.2.5. Justification of Choice

Both React.js and Angular.js allow complex and reactive front end application development. Summarising the differences between the two, Kumar and Singh (2016) provide the table in figure 8, which depicts the similarities and differences between the two JavaScript frameworks.

Attribute	AngularJS	ReactJS
DOM	Regular	Virtual
Learning Curve	High	Low
MVC	Yes	View Layer Only
Components?	No	Yes

Figure 8 – A comparison between React.js and Angular.js JavaScript frameworks.

To summarise, React.js gives the developer freedom and simplicity but lacks the declarative power of Angular.js. As a result, the developer has to write less code to do more in React.js, also React.js has better performance than Angular due to React.js' implementation of a virtual DOM (Kumar and Singh, 2016). For this reason, React.js will be the front-end development tool that will be used in this project.

4.3. Business Layer

4.3.1. Introduction

The business layer focuses on the business logic behind the application, interacting with both the presentation and data access layer. A RESTful API will be created to

manage this communication whilst creating a comprehensive back-end for the application. A web API is an Application Programming Interface, a programming construct that allows developers to create complex functionality easily. They abstract more complex code, providing simpler syntax in its place (Developer.mozilla.org, 2021). A RESTful API is an API that conforms to a set of architectural constraints known as “REST” (RedHat, 2021). REST stands for Representational State Transfer which means that when an API is called, a server will transfer a representation of the state of a resource. RedHat (2021) explains this, stating, *“When a client request is made via a RESTful API, it transfers a representation of the state of the resource to the requester or endpoint. This information, or representation, is delivered in one of several formats via HTTP: JSON (JavaScript Object Notation), HTML, XML, Python, PHP, or plain text”*. This section will look at different tools that will allow the creation of a RESTful for this project.

4.3.2. PHP

PHP is a popular, general-purpose scripting language tailor-made for server-side web development (Php.net, 2021). PHP is a recursive acronym that stands for PHP: Hypertext Preprocessor (Php.net, 2021). With PHP being a server-side language, the code is executed on the server, which generates HTML and can then be sent to the client-side. The client receives the results of that PHP script but has no knowledge of the code on the server-side (Php.net, 2021).

Prettyman (2016) states the following that summarises PHP effectively *“Today, PHP is one of the most popular languages used for web application development. The language has evolved to allow the programmer to quickly develop well-formed error-free programs using procedural and object-oriented programming techniques. It provides the ability to use any pre-existing libraries of code that either come with the basic installation or can be installed within the PHP environment”*. This statement indicates that PHP is advanced in its life cycle, that it has changed and evolved throughout time to keep up with new and emerging technologies. However, PHP is still one of the most popular choices for web developers.

As mentioned in the statement above of PHP’s major strengths, it allows the developer to use object-orientated and procedural programming techniques. This gives the developer the flexibility and freedom to program in a way that suits their project. Another major advantage of PHP is that it is open source. Prettyman (2016) defines open source as *“An open-source programming language is developed by a community of interested parties. The community accepts input from fellow programmers for suggested upgrades and corrections. Several members of the community work together to present proposals and to make changes to the language”*. This has huge advantages compared to other languages due to its ability to adapt and evolve due to input from the community, who are the ones using the language for real projects and situations. This has allowed PHP to have the longevity that it has. Finally, with PHP, it is easy for a beginner to pick it up as it has an easy

learning curve; however, this does not mean that it does not have features for the more advanced developers who will also find value in using it (Php.net, 2021).

4.3.3. Python

Python is another programming language that could be used to program the RESTful API. Mueller (2018) describes Python as a programming language that makes programmers efficient and productive. A major advantage of using Python is that it is easy to learn, with Harrison (2017) stating that beginners will find it easy to adapt to and is a great steppingstone for other languages. Harrison (2017) also states that Python is scalable, so simple programs and complex enterprise-level systems wrote using Python.

Mueller (2018) further confirms this with the following statements whilst also highlighting other major positives of using Python as a programming language:

- Less application development time: Python code is usually 2–10 times shorter than comparable code written in languages like C/C++ and Java.
- Ease of reading: Python code tends to be easier to read than the code written in other languages.
- Reduced learning time: The creators of Python wanted to make a programming language with fewer odd rules that make the language hard to learn.

However, along with the positives of Python, there are some negatives.

GeeksforGeeks (2021) discusses this, stating that two of the main problems with the language are that Python is slower than other languages such as C, C++, and Java and can be insecure, especially when accessing databases. These negatives could be troublesome when applying this as the language for this project.

4.3.4. Node.js

Node.js is a JavaScript framework for developing web applications, application servers and general-purpose programming. Designed for extreme scalability, Node.js is a server-side JavaScript framework that was not previously seen (Herron, 2016).

Node.js has some massively advantageous features; being a relatively new technology, it has great support and therefore is at the forefront of new concepts. The following is a list of some of the great features of node.js that have been highlighted by Doglio (2018).

- Asynchronous Programming.
- Integration with JSON based services.
- The Node Package Manager.

The first concept, Asynchronous Programming, as described by Doglio (2018), “means that for every asynchronous function that you execute, you cannot expect it to return the results before moving forward with the program’s flow”. This is the

concept that a function does not have to wait for a different, unrelated function to finish executing before itself can execute. This has significant advantages as it allows threads to run parallel, creating a faster, more reliable program. However, this does have its disadvantages. If the code does not work, it can be incredibly difficult to identify the fault and fix Doglio (2018).

The second advantage of Node.js is the integration with JSON based services. This makes it incredibly useful and simple to produce the API itself. Finally, the Node Package Manager (NPM) is a tool that allows the user to integrate other packages and code into their projects. This allows collaboration from the Node.js community and means the programmer does not have to recreate something already in use elsewhere Doglio (2018). There are disadvantages to this also as there can be many instances of a package available, all stating they do the same thing, but only one of them may be suitable for that users' needs Doglio (2018).

4.3.5. Justification of Choice

Overall, each language presented in this section is suitable to create a RESTful API for this project and often, what language is chosen is down to personal preference. In this instance, this is also the case. For this reason, PHP will be chosen for this project. Along with personal experience with the language, it provides the developer with the flexibility and freedom to program in a way that suits their project.

4.4. Database

4.4.1. Introduction

Any system that will manipulate or store data must use a database to be able to do so. Oracle (2021) define a database as an organised set of structured data stored electronically. A database management system or DBMS controls a database. The data inside a database is usually modelled in rows and columns to form tables. The table structure allows the data to be easily accessed, managed, modified, updated, controlled and organised (Oracle, 2021). To write and query data using a database, Structured Query Language or SQL is the most common method. SQL became the standard for database query languages of the International Organization for Standardization (ISO) in 1987 (W3schools.com, 2021), however, there are some exceptions to this which use NoSQL, which will be detailed further in this section.

4.4.2. Firebase

Firebase is a cloud-hosted NoSQL-based database. Firebase is a mobile and web application development platform backed by Google. It is a one-stop solution for all developers to develop high-quality mobile and web applications (Singh and Tanna, 2018). Firebase stores data as JSON and provides syncing across all the connected devices to that database and is available when there is no online connectivity through a local cache (Moroney, 2017). Firebase is an event-driven database that is very different from typical SQL databases; all of the coding is done in the client

rather than the server (Moroney, 2017). Whenever changes are made in the database, events get triggered in the client code, updating the user interface (Moroney, 2017).

The major positives of Firebase are that it allows the user to build a system that is exceptionally scalable even in a short development time. Alongside this, it has in-built crash reporting and integration with other applications such as social media platforms (S, 2018). Furthermore, as previously touched on, the real-time updating of data is something no other current SQL database can provide.

Firebase is a new and emerging technology and therefore receives many support and upgrades to ensure that it stays cutting edge. Firebase is a BaaS (Back-end as a Service) owned by Google, meaning you have to be tied into Google's infrastructure, with developers relying on this service. Along with that, it means that there also may be less support for integration with devices such as IOS (S, 2018).

4.4.3. MySql

MySQL is a SQL client-server relational database management system that includes an SQL server, client programs to access the server, admin tools and a programming interface to write to/query the database (DuBois, 2008). MySQL is open-source, allowing users to develop and extend the code to meet their needs; this allows great flexibility and has allowed the DBMS to enhance over the years. MySQL is effective because it provides a stable DBMS at a low cost, meaning it is great for smaller organisations as the overhead is affordable (Suehring, 2002).

MySQL has some big advantages over its competitors that, according to MySQL.com (2021), "*The world's most popular open-source database*". One of these advantages is that it is incredibly flexible, with all major operating systems being supported and an array of programming languages providing APIs for MySQL, including PHP, C, C++, Java and Perl (Kromann, 2018). In the early days of MySQL, it was known for its power and speed. However, this came with a trade-off, which lacked some features that its competitors used. Now MySQL has these features it lacked previously and more, with a key advantage being that it has enterprise-level SQL features (Kromann, 2018). Finally, another great advantage of MySQL is that it supports a vast array of security and configuration, providing reassurance to the user that their data is secure.

4.4.4. SQLite

SQLite is an open-source, serverless, relational database management system designed to provide applications with an easy way to manage data without the overhead that comes with other DBMS' (Allen et al., 2010). SQLite is a lightweight solution with a reputation for being portable, easy to use, efficient and reliable (Allen et al., 2010). Kreibich (2010) defines the features of SQLite, which also comprise of the many benefits of the DBMS, as the following:

- Serverless - SQLite does not require a separate server process or system to operate.
- Zero Configuration - No server means no setup.
- Cross-Platform - The entire database instance resides in a single cross-platform file.
- Self-Contained - A single library contains the entire database system, which integrates directly into a host application.
- Small Runtime Footprint - The default build is less than a megabyte of code.
- Transactional - SQLite transactions are fully ACID-compliant, allowing safe access from multiple processes or threads.
- Full-Featured - SQLite supports most of the query language features found in the SQL92 (SQL2) standard.
- Highly Reliable - The SQLite development team takes code testing and verification very seriously.

All of these features make it a great choice when developing a relatively small application; however using SQLite for enterprise-level applications could potentially cause issues with performance and scalability.

4.4.5. Justification of Choice

For this project, SQLite will be used. This is down to the zero configuration and serverless setup required to run this database. Although there can be issues in terms of scalability, this is a proof of concept where the focus is more on the front and back end development. If this application were to be scaled to an enterprise-level within the CMF, a more comprehensive deep dive into an appropriate level of DBMS would be required. The low cost, reliable option of SQLite will provide a good grounding and is appropriate for this project.

4.5. Techniques

This project will be using a plan-driven approach as the system development life cycle methodology. This is the same approach used by the CMF during the validation of new IT systems that need to be integrated into the site. Agile methodologies such as XP and Scrum are considered the most useful development methodology for highly customisable product development. This is due to the adaptive nature and flexible life cycle, making agile a quick and effective software development methodology (Srivastava et al., 2017). In comparison, a plan-driven approach, such as the one used by the CMF, is outdated; the comparisons of each development method can be summarised using the figure below by Ceschi (2005), who conducted a study comparing the two approaches.

Summary of results		
Survey questions	Agile companies	Plan-based companies
Why have you modified your development process?	Changes in the customers' requirements, 50% Changes in the technology, 70% Other reasons, 40%	Changes in the customers' requirements, 50% Changes in the technology, 70% Other reasons, 40%
Which is your most difficult software development problem?	Delivering the software with all the features on time, 70% Customer relationship, 10%	Delivering the software with all the features on time, 80% Customer relationship, 50%
Which software development problems have you solved by adopting agile methods?	Delivering the software with all the features on time, 40% Customer relationship, 60%	---
How do you plan and organize the software process?	Incremental code development, 70% Precise subdivision of tasks, 30% Precise subdivision of phases, 20% Use of prototypes, 20% Planning only essential functions, 50%	Incremental code development, 70% Precise subdivision of tasks, 40% Precise subdivision of phases, 50% Use of prototypes, 40% Planning only essential functions, 20%
How do you consider your relationship with your customer?	Not very satisfied, 10% Satisfied, 60% Very satisfied, 30%	Not very satisfied, 30% Satisfied, 50% Very satisfied, 20%
What are the most important problems that you usually face with customers?	Variable requirements, 50% Requests to deliver the product too quickly, 40%	Variable requirements, 70% Requests to deliver the product too quickly, 60%
What is a developer's most important quality?	Ability to work in a group, 50% High individual ability, 20% Motivation, 30%	Ability to work in a group, 50% High individual ability, 20% Motivation, 30%

Figure 9 – Comparison between agile and plan-driven approaches (Ceschi, 2005).

The decision, opting for the plan-driven approach instead of an agile methodology, is due to the many restrictions and regulations imposed upon the CMF. These restrictions mean that when a system change is proposed, the system must undergo several assessments and investigations as to whether the system can meet the regulations of the governing bodies such as the US Federal Drug Agency (FDA) or the UK Medicines and Healthcare Regulatory Agency (MHRA). These assessments can take weeks to complete. In an agile methodology approach, where the requirements often change, this would be completely impractical as the assessments would have to be completed every time there is a change. Therefore a flexible project methodology such as agile is not useful within the pharmaceutical manufacturing environment.

To accompany the methodology, a series of system development life cycle documents will be generated. These documents support each phase of the life cycle methodology and detail several key stages of the project. They assist the client to understand the product and ensure that the correct process has been followed to validate the product's use at the site. The documents that will be generated for this project process are detailed in the figure below:

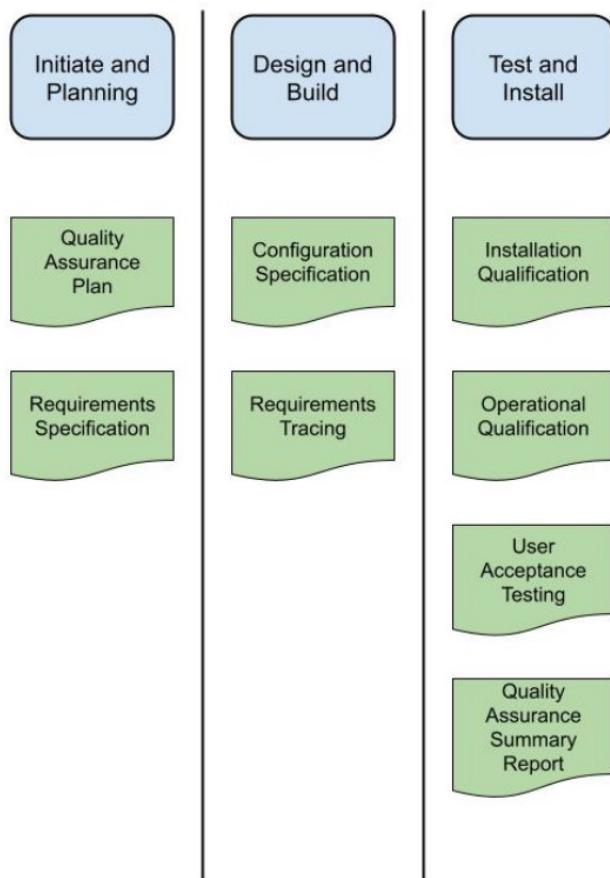


Figure 10 – The documents that will be generated as a part of the project process.

4.6. Summary

This chapter took an in-depth view, describing what tools and techniques could be used to complete this project. Assessing the viability of all appropriate and accessible methods, this chapter has evaluated what solution is the best for this individual project and use case. The following chapters will now look at designing, implementing, and testing this proposed tool using the tools and techniques detailed in this chapter.

Synthesis Chapters

5. Design

5.1. Introduction

The following chapter will provide an overview of the design stages of creating a digital collaborative meeting tool. This will aid the development, implementation, and testing of the final product, allowing the client to provide initial feedback before the development stages, influencing the proposed application's design and structure. This section will discuss the design processes used and reference detailed design documentation created, which carefully describe aspects of the online meeting tool.

5.2. Design Process

The design process is a critical section of any successful project; without it, any product will lack structure, look dull, and be prone to errors. Shakuro.com (2021) states that "*A good design can make people trust you more, alter customer perception, make you memorable, get your message across, make your product work to the fullest, and shine*". This is a critical concept that enhances any product if a design process is followed. This project will follow a design process from the CMF, the steps for which are outlined below:

5.2.1. Requirements Gathering

This step is completed in the initiate and planning phase of a project as it derives the deliverables; however, it is still a critical step in the design process. The requirements form the basis of the product, influencing what the product needs to have within it, hence for a web-based tool such as this project, the requirements define what features the website needs to include. As well as the functional requirements, requirements gathering can also capture UI, data handling, architecture, interfacing requirements, and many others. These requirements define how the users will interact with the product, giving the designers a clearer picture of the design process's following stages.

5.2.2. User Scenarios

User scenarios are stories created by designers to show how users might interact with a system to achieve a goal to understand deeper what motivates a user, any limitations of a potential system, and shows how it would be used in context (The Interaction Design Foundation, 2021). These user scenarios help centre the design process around the user, as ultimately, the user determines whether or not a product meets the requirements and, as a result, is successful or not.

5.2.3. Use Case Diagram and Descriptions

Use case diagrams and descriptions are a type of Unified Modelling Language (UML) diagram that expresses a user's expected behaviour interacting with a system (Fakhroutdinov, 2021). Use cases aim to express what the system can achieve and defines how the system will interact with its environment, such as external factors that may influence the system. Use cases provide a high-level view of the system illustrating how users interact with the system and how the system responds to this interaction without worrying about how the functionality is implemented.

5.2.4. Sequence Diagrams

Like both use case diagrams and descriptions, sequence diagrams are also a form of UML diagrams that focus on the interaction between the user and the subsequent data flow. The CMF uses sequence diagrams to show how the system interacts with its different components without specifying the classes and methods. This is unlike traditional sequence diagrams, focusing on how the system's classes and methods interact, therefore giving a clear design structure of the program. However, within the CMF, not all analysts are programmers. This makes the document difficult to interpret, even more so for an auditor.

5.2.5. Prototyping

A prototype is a simplified representation of what a system will look like once development has been completed. Prototypes can be low or high fidelity, with low fidelity usually focusing on the structural elements. In contrast, high fidelity prototypes can contain content and images (Joyce, 2019). High fidelity prototypes usually look close to what the final product looks like. Prototypes serve multiple purposes, including visualising the user interface design, assessing the technical feasibility, or testing the design's effectiveness (Joyce, 2019). The latter of these purposes is an element of designing a crucial system. Getting feedback on a design from stakeholders before the development process allows the client to have input on the design, preventing them from being in the dark when the product is finished and unveiled.

5.3. Implementing the Design Process

5.3.1. Requirements Gathering

The requirements gathering process for this project was completed and detailed in chapter 3 of this report. Interviews with the client, the IT team at the CMF took place, detailing what their current system looked like and the strengths of that process and detailing where this new tool should improve upon the old system. The reason interviews were chosen as the method of requirements gathering from the client is to have open-ended questions. Each individual being questioned can answer in their way. This ensures that the participant can get their thoughts across without

the pressure of anyone else. Each participant would respond differently if other people were present.

5.3.2. User Scenarios

Two different user scenarios were created for this design phase of the project; the first focused on a user who wanted to update information outside of the allotted time for the Tier Process. This was chosen as this was a key point made by participant 4 in the requirements gathering. Participant 4 noted that the Tier Board should be updated contemporaneously rather than during a meeting. This is to ensure that the meeting not only runs smoothly, but anyone can look at the Tier Board at any time, and they will have the most up to date information.

The second user scenario that was chosen was the process of holding a Tier Meeting. This meeting is the key fundamental aspect of the entire Tier Process, the reason for creating this product. The user story looks at, in particular, how easy it is to navigate between the different sections and how a visual aspect allows the group to easily see the key performance indicators coming out of the department. All five of the participants highlighted that this was an area of improvement that they would like to see and how it would be a key requirement when creating a new tool. Both of these user scenarios can be found within Appendix 4.

5.3.3. Use Case Diagram and Descriptions

There will be five main sections within the application, consistent with the current Tier Process. These sections will be Safety, People, Never Miss A Due Date, Delivery and Downtime. On top of these sections, there will be a Dashboard (homepage) that summarises information. A 'My Account' section for users to log in and register will also be available. For the use case diagram, the five main areas of the application and the 'My Account' section were considered, as this is where a user will directly view and manipulate data within the system.

Firstly the Safety page is split into two different areas, Safety Actions and Site Attendance. Both of these sections were identified as key components within the requirements gathering. Secondly, the People page is also split into two areas of interest, the Department Status and the department's success. Furthermore, the Never Miss A Due Date, Delivery and Downtime pages focus solely on one thing described in the title of the page. These use cases are expanded upon from the current Tier Process and is loosely based on the concept of Safety, Quality, Delivery and Cost as described by participant 4 within the requirements gathering.

Based on the several components mapped out above, the use case diagram was then created, as seen in Appendix 5. The use case descriptions were then created for the system, with fourteen different descriptions created in total. Each of which detailed the trigger, primary scenario, an alternate scenario and then an exceptional scenario if there was one. These descriptions can be found in Appendix 6.

5.3.4. Sequence Diagrams

Following the use case diagram and descriptions, sequence diagrams that show the data flow within the system were created. These sequences looked at the initial input from an actor, such as the user, which impacted the three areas of the system architecture (as described in chapter 4, Tools and Techniques), the presentation layer (React App), the Business Layer (API) and the Database. In total, eight different sequence diagrams were created, each looking at initially returning data from the database when the page loads. Alternatively, a user may want to add a new item or edit an existing item. The sequence diagram shows the flow between the different actors and what is returned to the user.

5.3.5. Prototyping

Finally, high-fidelity prototypes were developed based on all of the above sections. Requirements gathering from the client enabled the creation of the design documents and an indication of the UX requirements. Design documents such as the use case diagram helped detail what pages are needed within the application and the layout and structure. Initially, six different prototypes were developed, and they were: Dashboard, Safety, People, Never Miss A Due Date, Delivery and Downtime. These pages were chosen as they are the fundamental six pages of the application and where most of the interactions will occur. These six prototypes can be found in Appendix 8.

Once the initial six prototypes were developed, they were taken to the client for review. Participants 1,2, and 4 from the requirements gathering process gave feedback on the proposed designs, with all three participants happy with the structure of the proposed application. Participant 2 noted much white space in the initial design making the tool look a bit bland. Participant 1 suggested that the navigation bar could be a solid banner across the top to help break the page. Participant 4 agreed with these details and suggested that the title and logo need to be more prominent on the page.

Taking on this feedback, a second iteration of the design was then created, as found in Appendix 9. This prototype looks at the Dashboard page specifically. Returning to the client, all of the participants agreed that this design was much cleaner and more appealing. Therefore this was the final iteration of the UX design aspect for this project.

5.4. Summary

This chapter looked at the design process approach taken by the project, looking specifically at the five key areas in the CMF's in-house design process. Presenting the design to the client before the implementation allowed a clear input on the overall design. The CMF's constructive feedback came in the UX design of the tool; this was due to the initial requirements gathering method, which highlighted what features needed to be included. This meant that when presenting the designs, they were

more than happy with the structure. Overall the design process was very successful and established a good foundation to progress onto the implementation.

6. Implementation

6.1. Introduction

This chapter will take an in-depth look at how the key features of the collaborative meeting tool were implemented and how it reflects what was detailed in the design chapter. This chapter will be broken down into the two major components of the tool, the API and the React App. Each component will then be broken down and the most important and interesting aspects of the product, each with accompanying sample code. This chapter will justify why certain methods/frameworks were chosen and highlight any unforeseen problems and the changes made to the tool as a result of this.

As mentioned in the design phase, there are seven main pages: The React app, the Dashboard, Safety, People, Never Miss a Due Date (NMADD), Delivery, Downtime, and My Account. Once a user is logged in to the app, they can view and edit items on each page. Figures 11 – 17 show the final product produced for the client, displaying each main page.

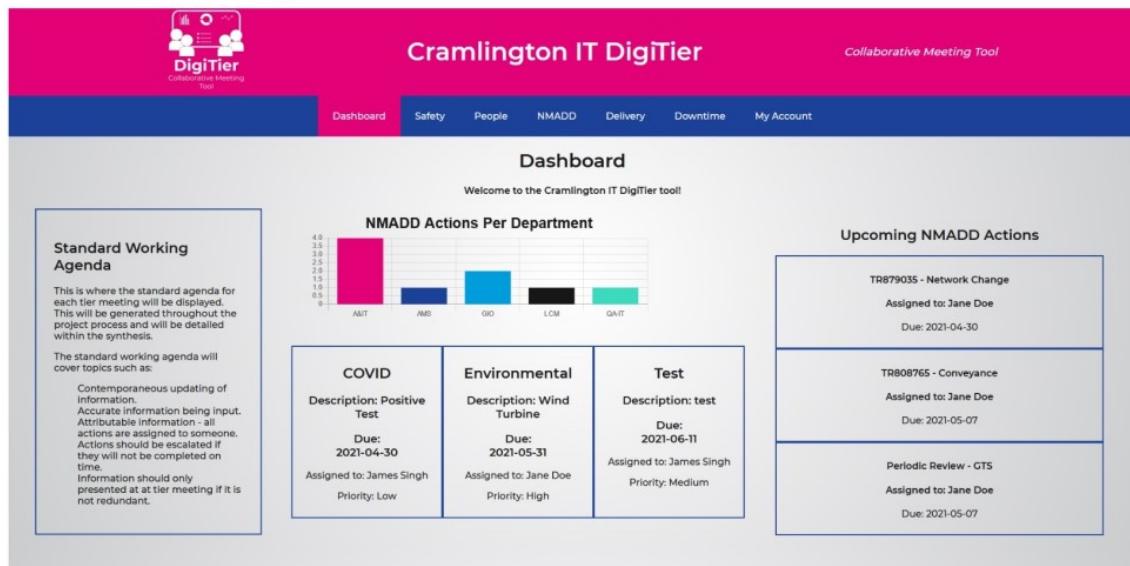


Figure 11 – The main dashboard page of the React App.

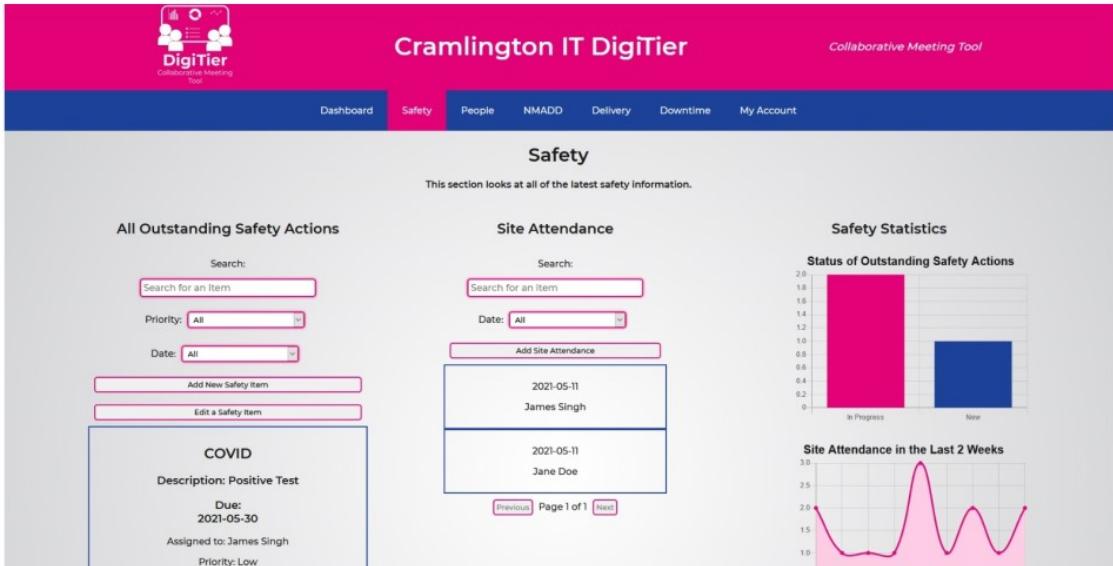


Figure 12 – The safety page of the React App.

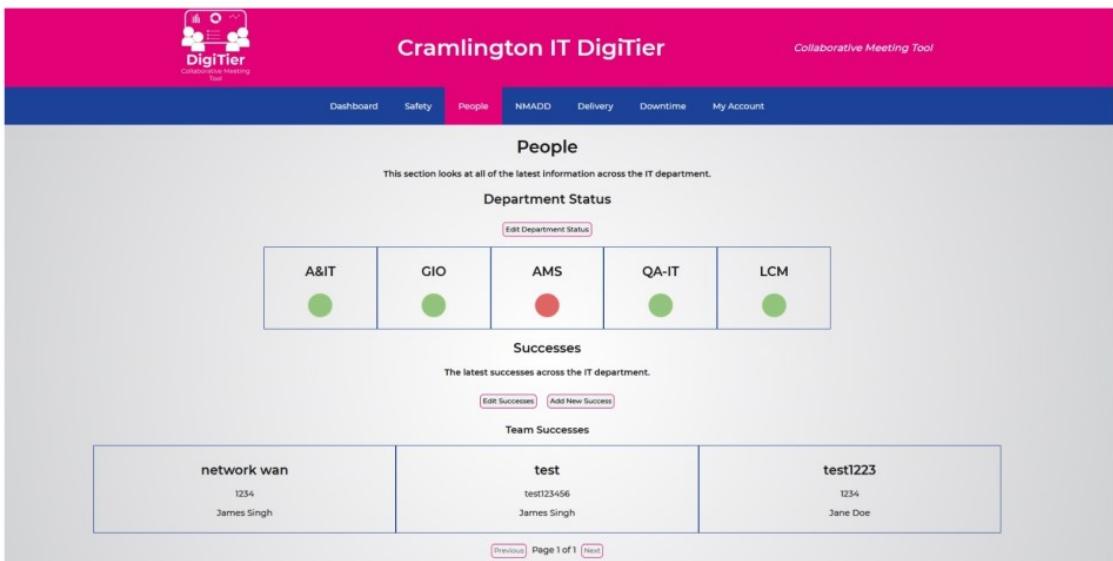


Figure 13 – The People page of the React App.

Figure 14 – The NMADD page of the React App.

Figure 15 – The Delivery page of the React App.

Figure 16 – The Downtime page of the React App.

Figure 17 – The Login/Register page of the React App.

6.2. API

6.2.1. Database

As described in chapter 4 (Tools and Techniques), the database engine chosen for this project is an SQLite database. The major reasons for choosing this database engine are the zero-configuration and serverless setup required to run this database. It was straightforward to set up the file and start creating the tables using DB

Browser for SQLite. DB Browser for SQLite is an open-source visual tool to help create, design and edit SQLite databases (Sqlitebrowser.org, 2021). In total, fourteen different tables have been created, and an entity-relationship diagram (Appendix 3) has been created to show how they relate to one another.

When connecting the API to the database, a singleton database connection approach has been used to ensure that there is only one instance of the connection. This is done to ensure that performance is kept as optimal as possible; the more connections made to a database will slow that performance. To create this approach, the constructor for the class is made private; another method checks if there is an existing connection to the database, and if not, it creates one. This is shown in the PDOdb class below:

```
class PDOdb {
    private static $dbConnection = null;

    /**
     * Make this private to prevent normal class instantiation
     * @access private
     */
    private function __construct() {
    }

    /**
     * Return DB connection or create initial connection
     * @return object (PDO)
     * @access public
     */
    public static function getConnection($dbname) {
        if ( !self::$dbConnection ) {
            try {
                self::$dbConnection = new PDO("sqlite:".$dbname);
                self::$dbConnection->setAttribute(PDO::ATTR_ERRMODE,
                                                PDO::ERRMODE_EXCEPTION);
            }
            catch( PDOException $e ) {
                exceptionHandler($e);
            }
        }
        return self::$dbConnection;
    }
}
?>
```

Figure 18 – PDOdb class, used for making a singleton connection to the SQLite Database.

When looking at the architecture, it is advised that within a layered application, as described in chapter 4 (Tools and Techniques), it is important to have a data access layer. A PDOdb class such as above does this part; however, another important approach taken in this project is a Recordset approach. A Recordset approach is an abstract class that connects to the database and handles the results in a helpful way

for the business layer of the application, which should not make that connection to the database itself. It can then perform either a prepared or regular SQL query and returns the results.

```
abstract class RecordSet {
    protected $conn;
    protected $stmt;

    function __construct($dbname) {
        $this->conn = PDOdb::getConnection($dbname);
    }

    /**
     * This function will execute the query as a prepared
     * statement if there is a params array. If not,
     * it executes as a regular statement.
     *
     * @param string $query The sql for the recordset
     * @param array $params An optional associative array
     * if you want a prepared statement
     * @return PDO_STATEMENT
     */
    function getRecordSet($query, $params = null) {
        if (is_array($params)) {
            $this->stmt = $this->conn->prepare($query);
            $this->stmt->execute($params);
        } else {
            $this->stmt = $this->conn->query($query);
        }
        return $this->stmt;
    }
}
```

Figure 19 – Recordset class, used to execute SQL queries without the business layer making connections to the database.

As the above Recordset class is abstract, the following JSONRecordset class extends Recordset and is used to return the database results in JSON format which can then be used for the API endpoints.

```

Class JSONRecordSet extends RecordSet {
    /**
     * function to return a record set as an associative array
     * @param $query string with sql to execute to retrieve the
     * record set
     * @param $params associative array of params for prepared
     * statement
     * @return string a json document
     */
    function getJSONRecordSet($query, $params = null) {
        $stmt = $this->getRecordSet($query, $params);
        $recordSet = $stmt->fetchAll(PDO::FETCH_ASSOC);
        $nRecords = count($recordSet);
        $status = "200";
        $statusMessage = "ok!";
        return json_encode(array("count"=>$nRecords,
        "status"=>$status,
        "statusMessage"=>$statusMessage,
        "data"=>$recordSet));
    }
}

```

Figure 20 – JSONRecordset class, used return the database results and format them in JSON.

6.2.2. Endpoints

When a client requests a server, an API acts as an access point to this web resource. The API for this project is an information source and therefore returns structured data; in this case, data is formatted in JSON. An endpoint is a URL to which this data request can be sent to. These endpoints can have parameters used to filter the data returned only to include items that include the parameter passed into the request, e.g. a search parameter.

In this project, several endpoints are used to retrieve data that the React App can then use in the presentation layer. The first endpoint that will be analysed is the endpoint for a user to log in to the system. This endpoint uses JSON Web Tokens and the Firebase JSON Web Token PHP class for encoding and decoding the web tokens. Both JSON Web Tokens and the Firebase PHP class were chosen due to being an industry-standard method for tokens and ease of implementation within a solution (Jwt.io, 2021). Below is the code used for the login endpoint in this API:

```

private function json_login() {
    $msg = "Invalid request. Username and password required";
    $status = 400;
    $token = null;
    $input = json_decode(file_get_contents("php://input"));
    $jwtkey = JWTKEY;

    if ($input) {
        if (isset($input->email) && isset($input->password)) {
            $query = "SELECT username, password FROM users
                      WHERE email LIKE :email";
            $params = ["email" => $input->email];
            $res = json_decode($this->recordset->
                getJSONRecordSet($query, $params), true);
            $password = ($res['count']) ?
                $res['data'][0]['password'] : null;

            if (password_verify($input->password, $password)) {
                $msg = "User authorised. Welcome ";
                $res['data'][0]['username'];
                $status = 200;
                $token = array();
                $token['email'] = $input->email;
                $token['username'] = $res['data'][0]['username'];
                $token['iat'] = time();
                $token['exp'] = time()+(60*60);
                $token = \Firebase\JWT\JWT::encode($token, $jwtkey);
            } else {
                $msg = "username or password are invalid";
                $status = 401;
            }
        }
    }
    return json_encode(array("status" => $status, "message" =>
        $msg, "token" => $token));
}

```

Figure 21 – Login endpoint using JSON Web Tokens and Firebase PHP class for authentication.

The second endpoint that is of interest is registering a new user to the system. This endpoint uses an insert SQL query to input the new user's information into the database. Alongside this, the register endpoint uses the PHP function `password_hash()` with the `PASSWORD_DEFAULT` parameter using a bcrypt hashing algorithm to store the user's password securely.

```

/**
 * Register a new user in the database
 */
* @return status message
*/
private function json_register() {
    $input = json_decode(file_get_contents("php://input"));

    if (!$input) {
        return json_encode(array("status" => 400,
                                "message" => "Invalid
request"));
    }

    if (!isset($input->username) || !isset($input->email) ||
        !isset($input->password)) {
        return json_encode(array("status" => 400,
                                "message" => "Invalid
request"));
    }
    else {
        $query = "INSERT INTO users (username, email,
                                password, firstname, surname)
                  VALUES (:username, :email, :password,
                          :firstname, :surname);";
        $params = ["username" => $input->username,
                   "email" => $input->email,
                   "password" =>
                           password_hash($input->password,
PASSWORD_DEFAULT),
                   "firstname" => $input->firstname,
                   "surname" => $input->surname];
        $res = $this->recordset->getJSONArrayRecordSet($query, $params);
        return json_encode(array("status" => 200, "message" =>
"ok"));
    }
}

```

Figure 22 – Register endpoint using the PHP function `password_hash()`.

The final endpoint of note for the API is updated. In the example below, the NMADD update endpoint is shown and like before, the endpoint checks to make sure all values are passed in from the React App and then uses those values with an update SQL query. This performs the update on the database and returns a status message to the React app for use with the update callback method within the UpdateNMADD function. Figure 23 displays the code for this endpoint below:

```

/**
 * Update method to update a NMADD item
 */
* @return status message
*/
private function json_updateNMADD() {
    $input = json_decode(file_get_contents("php://input"));

    if (!$input) {
        return json_encode(array("status" => 400,
                                "message" => "Invalid
request"));
    }

    else if (!isset($input->title) || !isset($input->username) ||
            !isset($input->desc) || !isset($input->due_date) ||
            !isset($input->dept_name) || !isset($input-
>action_type) ||
            !isset($input->completion_status) ||
            !isset($input->action_id)) {
        return json_encode(array("status" => 400,
                                "message" => "Invalid
request"));
    }
    else {
        $query = "UPDATE action_item SET title = :title,
                                         username = :username, desc = :desc,
                                         due_date = :due_date, dept_name = :dept_name,
                                         action_type = :action_type,
                                         completion_status = :completion_status
                                         WHERE action_id = :action_id";
        $params = ["title" => $input->title,
                  "username" => $input->username,
                  "desc" => $input->desc, "due_date" => $input-
>due_date,
                  "dept_name" => $input->dept_name,
                  "action_type" => $input->action_type,
                  "completion_status" => $input->completion_status,
                  "action_id" => $input->action_id];
        $res = $this->recordset->getJSONArrayRecordSet($query, $params);
        return json_encode(array("status" => 200, "message" =>
"ok"));
    }
}

```

Figure 23 – updateNMADD endpoint.

6.2.3. Errors

Errors within any programming application are frustrating both for a developer and the end-user of the system. Providing a helpful message to the user can help detail and understand why the issue is happening. The exceptionHandler() method, as shown in the code below, uses a HTTP response status code to detail to the user what has happened, along with a clear message.

```
Function exceptionHandler($e) {
    $msg = array("status" => "500", "message" => $e->getMessage(),
                "file" => $e->getFile(), "line" => $e-
>getLine());
    $usr_msg = array("status" => "500", "message" =>
                    "Sorry, Internal Server Error");
    header("Access-Control-Allow-Origin: *");
    header("Content-Type: application/json; charset=UTF-8");
    header("Access-Control-Allow-Methods: GET, POST");
    echo json_encode($usr_msg);
    errorLog($msg, "Exception");
}
set_exception_handler('exceptionHandler');
```

Figure 24 – exceptionHandler() method that details a helpful message to the user with a HTTP response status code.

A helpful message to the user is not what the developer wants to see; they need to see the error details. The key details illustrate what the error is, what file the error is in, and where it occurs. This can be shown in the example code for exceptionHandler() above. However, this message cannot be displayed on the webpage for the user to see as well. Therefore a specific error logging method must be used to display the errors to the developer. For this error logging method, the error is written to a .txt file. The error logging method for this API is shown below:

```
function errorLog($msg, $errortype) {
    if ($errortype == "Exception") {
        error_log("Status: " . $msg['status'] .
                  " Message: " . $msg['message'] .
                  " File: " . $msg['file'] . " Line: " .
                  $msg['line'] . "\n\n", 3, ERROR);
    }
    else if($errortype == "Error") {
        error_log($msg, 3, ERROR);
    }
}
```

Figure 25 – errorLog() method that logs the an error message to a .txt file.

6.3. React App

6.3.1. Login and Register

A key part of any application that has users is the user account system and the ability to log in to a user account and register new users. The previous section looked at the API endpoints for the system, and the login and register endpoints are a part of those discussed. For these endpoints to work, the user must enter information in the front end of the application to then be passed as parameters to the API endpoints.

The login section input boxes must be created to allow the user to input their email and password to the system. These values must then be passed to the Admin component, which will then handle the inputs and pass those values to the API. To trigger this, a button must be clicked, which in this case is the login button, as shown below:

```
render() {
  return (
    <div>
      <div className="login">
        <input
          className="inputBox"
          type='text'
          placeholder='Email'
          value={this.props.email}
          onChange={this.props.handleEmail}
        />
      </div>
      <div className="login">
        <input
          className="inputBox"
          type='password'
          placeholder='Password'
          value={this.props.password}
          onChange={this.props.handlePassword}
        />
      </div>
      <button className="buttons"
        onClick={this.props.handleLoginClick}>Log
      in</button>
    </div>
  );
}
```

Figure 26 – Input boxes for the user to input their details.

From the Login component shown above, the onClick is handleLoginClick. This is within the Admin component and passes the email and password from the Login component to the Admin component. The handleLoginClick stores the JSON data in a variable as well as the URL of the login endpoint. This is shown in the code below:

```

/*
Defines the URL and JSON data to be posted to the API for logging
in.
*/
handleLoginClick = () => {
  const url = "http://localhost/API/api/login"
  let myJSON = {"email": this.state.email,
                "password": this.state.password}
  this.postData(url, myJSON, this.loginCallback)
}

```

Figure 27 – handleLoginClick method.

Once the JSON data has been stored in the myJSON variable, another method called postData is called, which uses the URL to post the myJSON in the request's body. The response from this request is then returned, and a callback is performed, setting the user as authenticated and storing a token in the local storage. This is shown in figures 28 and 29.

```

/*
This posts the JSON data to the api, then performs a callback.
*/
postData = (url, myJSON, callback) => {
  fetch(url, {
    method: 'POST',
    headers: new Headers(),
    body: JSON.stringify(myJSON)
  })
    .then((response) => response.json())
    .then((data) => {
      callback(data)
    })
    .catch((err) => {
      console.log("something went wrong ", err)
    })
}

```

Figure 28 – postData method which makes a POST request to the API.

```

/*
Once login is successful it returns the HTTP status code,
sets the user to authenticated and stores the token in
local storage.
*/
loginCallback = (data) => {
  console.log(data)
  if (data.status === 200) {
    this.setState({"authenticated":true, "token":data.token})
    localStorage.setItem('myToken', data.token);
  }
}

```

Figure 29 – loginCallback method.

This format is likewise used to register new users into the system using the registering endpoint, as shown in figure 22. The register component uses input boxes just like the login component, this time with more details to capture all of the information about the user. This is shown by the code below:

```

render() {
    return (
        <div>
            <h2>Register a New User</h2>
            <div className="register">
                <input
                    className="inputBox"
                    type='text'
                    placeholder='Username'
                    value={this.props.username}
                    onChange={this.props.handleUsername}
                />
            </div>
            <div className="register">
                <input
                    className="inputBox"
                    type='text'
                    placeholder='Email'
                    value={this.props.regEmail}
                    onChange={this.props.handleRegEmail}
                />
            </div>
            <div className="register">
                <input
                    className="inputBox"
                    type='password'
                    placeholder='Password'
                    value={this.props.password}
                    onChange={this.props.handlePassword}
                />
            </div>
            <div className="register">
                <input
                    className="inputBox"
                    type='text'
                    placeholder='Firstname'
                    value={this.props.firstname}
                    onChange={this.props.handleFirstname}
                />
            </div>
            <div className="register">
                <input
                    className="inputBox"
                    type='text'
                    placeholder='Surname'
                    value={this.props.surname}
                    onChange={this.props.handleSurname}
                />
            </div>
            <button className="buttons"
                onClick={this.props.handleRegClick}>Register</button>
        </div>
    );
}

```

Figure 30 – Registration input boxes for the user to input their details to register as a user.

Likewise, with the Login component, a handleLoginClick method was used; the register component also needs a handleRegisterClick. The handleRegisterClick method is very similar to the handleLoginClick code, as shown in figure 26 and can be seen below. This handleRegisterClick also uses the postData method shown in figure 27 to make a POST request to the register endpoint.

```
/*
Defines the URL and JSON data to be posted to the API for
registering a new user.
*/
handleRegClick = () => {
    const url = "http://localhost/API/api/register"
    let myJSON = {"username": this.state.username, "email":
this.state.regEmail,
        "password": this.state.password, "firstname":
this.state.firstname,
        "surname": this.state.surname}
    this.postData(url, myJSON, this.registerCallback)
}
```

Figure 31 – handleRegisterClick method.

6.3.2. Department Status

One of the key pages within the collaborative meeting tool is the People page. This page looks at what is happening within the larger IT department, indicating successes have happened within the team and how each team is coping with the workload. The latter is used to assess how the department is coping and how they are feeling, too, with the physical Tier Board coloured magnets indicated this. If a department is green, they are properly staffed and can do everything they need. Orange means that one or two people are off or engaged, and therefore it will be a struggle to achieve everything on the workload. Finally, red means that there are several people off or engaged, and the department will not complete their set workload.

Translating this important tactile feature into a virtual environment was a challenging prospect. Participant 4 mentioned during their interview that replicating this tactile feel was something that they thought was important, with participant 3 also stating that transferring the product between in-person and online would be the aim for the future. As a result, this was an area that needed to have effectiveness both in-person and online.

To begin this process, an API endpoint needed to pull the current data from the database. That endpoint shown in figure 32 is quite basic; however, it uses only the relevant information from the one singular table.

```

Case 'status':
    $select = "dept.dept_id, dept.dept_name, dept.status";
    $from = "dept";
    $where = null;
    $order = null;
    $id = "dept.dept_id";
    $search = "dept.dept_name";
    $page = "dept.dept_name";
    $this->page = $this->json_createEndpoint(
        $select, $from, $where, $order, $id, $search, $page);
    break;
}

```

Figure 32 – status endpoint.

For use in the React app, this is then called using a `fetch()` API call in the `componentDidMount()` lifecycle method, which uses the response from this call to store that data in the state of the People component. This is shown in figure 33.

```

componentDidMount() {
    const url = "http://localhost/API/api/status"

    fetch(url)
        .then( (response) => response.json() )
        .then( (data) => {
            console.log(data.data)
            this.setState({data:data.data})
        })
        .catch ((err) => {
            console.log("something went wrong ", err)
        })
}

```

Figure 33 – `componentDidMount()` lifecycle method to retrieve the data from the API endpoint.

The React app then needs to display this content on the page, making sure each piece of data has the correct fields displayed. This is done in two steps. The first of which the data stored in the state of the People component must be mapped to the individual item (figure 34). The individual item is then defined and illustrates what needs to be displayed. This is shown in the `PeopleItem` component, figure 35.

```

    Render() {
      return (
        <div>
          <h1>People</h1>
          <h4>This section looks at all of the latest information
across
            the IT department.</h4>
          <h2>Department Status</h2>
          <button className="buttons"
onClick={this.editPeopleItem}>
            Edit Department Status</button>
          <span className = "peopleTable">
            {
              this.state.data.map( (details, i) =>
                <PeopleItem key={i} details={details} /> )
            }
          </span>
          <Successes />
        </div>
      );
    }
  
```

Figure 34 – Mapping of the data held in the state of the People component to the individual item.

```

  Return (
    <div className = "grid">
      <h2>{this.props.details.dept_name}</h2>
      <img className = "depStat" src={stat}/>
    </div>
  );

```

Figure 35 – The PeopleItem component returning the necessary values.

In figure 34 it also displays an image which is not stored in the database, instead it is stored in the file structure of the React app and is imported into the PeopleItem component.

```

Import React from 'react';
import GreenStat from '../../../../../assets/green.png';
import OrangeStat from '../../../../../assets/orange.png';
import RedStat from '../../../../../assets/red.png';

```

Figure 36 – Imports for PeopleItem component.

Figure 34 also displays an image that is not stored in the database; instead, it is stored in the file structure of the React app and is imported into the PeopleItem component.

```

Let stat = "";

if(this.props.details.status == "Green")
{
    stat = GreenStat;
}
else if(this.props.details.status == "Orange")
{
    stat = OrangeStat;
}
else
{
    stat = RedStat;
}

```

Figure 37 – Status image dependant on the department status.

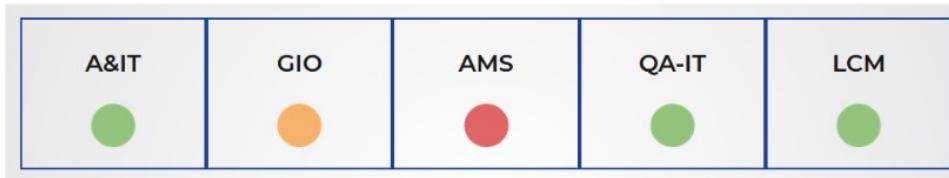


Figure 38– Final result of the department status being displayed.

Following on from displaying the content of department status, a user will also need to update this status within the app. To do this, the user is redirected to a new page when they click on a button; this is done using the withRouter component from the react-router-dom package. This component allows a URL to be pushed and therefore redirect the user. The code below shows this:

```

editPeopleItem() {
    let path = '/editpeopleitem';
    this.props.history.push(path);
}

```

Figure 39 – withRouter component allowing a URL to be pushed.

From here, the new page needs two API endpoints to work with, the first being an endpoint to get the current department status from, figure 32, and then an endpoint to update the data in the database, figure 40.

```

/**
 * Update method to update a dept status
 */
* @return status message
*/
private function json_updateDept() {
    $input = json_decode(file_get_contents("php://input"));

    if (!$input) {
        return json_encode(array("status" => 400, "message" =>
                               "Invalid request"));
    }

    else if (!isset($input->status) || !isset($input->dept_id)) {
        return json_encode(array("status" => 400, "message" =>
                               "Invalid request"));
    }
    else {
        $query = "UPDATE dept SET status = :status
                  WHERE dept_id = :dept_id";
        $params = ["status" => $input->status, "dept_id" =>
                   $input->dept_id];
        $res = $this->recordset->getJSONArrayRecordSet($query, $params);
        return json_encode(array("status" => 200, "message" =>
                               "ok"));
    }
}

```

Figure 40 – updateDept endpoint.

On the front end, the user needs an input method to change the values of the status, with the current value being the one that is displayed before it is changed. Once selected, the state is updated with the new value, then when the update button is clicked, it passes the status value stored in the state to a method in the UpdateDep component, which sends the update POST request to the API endpoint. The EditDep component which displays the selections is shown in full in figure 41.

```

import React from 'react';

/*
This class provides each status to be updated displaying a dropdown box
to allow it to be edited.
@author - James Singh - 17000348
*/
class EditDep extends React.Component {

    state = {
        status: this.props.details.status
    }

    /*
    This sets the new title based on what the user types
    */
    handleStatusChange = (e) => {
        this.setState({status:e.target.value})
    }

    /*
    This passes the new status to the UpdateDep component as well as the ID
    of the item to be updated.
    */
    handleEdit = () => {
        this.props.handleEditClick(this.props.details.dept_id,
                                    this.state.status)
    }

    /*
    This creates the dropdown box to allow the status to be changed as well
    as the update button which calls the handleEdit method.
    */
    render() {
        return (
            <div className = "updates">
                <h2>{this.props.details.dept_name}</h2>
                <p>Status:</p>
                <select className="selection" value={this.state.status}
                       onChange={this.handleStatusChange}>
                    <option value="Green">Green</option>
                    <option value="Orange">Orange</option>
                    <option value="Red">Red</option>
                </select>
                <button className="buttons"
                       onClick={this.handleEdit}>Update</button>
            </div>
        );
    }
}

export default EditDep;

```

Figure 41 – EditDep component.

Once the new status, along with the ID of the department that is to be changed, is passed to the UpdateDep component, the UpdateDep component performs the update. Similarly to the login and register components spoken about previously, the UpdateDep component uses a handleEditClick, postData and updateCallback methods shown in figures 27, 28 and 29, respectively. However, there is one

significant change with the update. The handleEditClick method checks to see if the user is authenticated by checking localStorage to see if there is a token. If they are not authenticated, the update does not happen. If authenticated, the token, the ID of the department and the status are all passed to the endpoint. An update SQL query is then performed. This is shown in the code in figure 42.

```
/*
Defines the URL and JSON data to be posted to the API for updating a
session name, if unsuccessful
sets the authenticated state to false.
*/
handleEditClick = (dept_id, status) => {
    const url = "http://localhost/API/api/updateDept"

    if (localStorage.getItem('myToken')) {
        let myToken = localStorage.getItem('myToken')
        let myJSON = {
            "token":myToken,
            "dept id": dept_id,
            "status":status
        }
        this.postData(url, myJSON, this.updateCallback)
    } else {
        this.setState({ "authenticated":false })
    }
}
```

Figure 42 – handleEditClick method.

6.3.3. Never Miss A Due Date

The Never Miss A Due Date (NMADD) section of the React App is potentially the most critical aspect for the client. All participants in the requirements gathering highlighted that this section is important to the success of a potential web-based tool. Figure 43 shows a visual representation of the current in-person process used for the NMADD board. Each row is a different person with their actions placed in each corresponding bucket. The buckets being: Less than one week left, less than two weeks left, less than four weeks left, less than three months left, and more than three months left.

Figure 43 – Virtual representation of the in-person NMADD board.

Recreating this format would be relatively simple. However, it is just a table; this is not a unique and interesting way of displaying this information and can sometimes lead to empty, unused space. As a result, a different approach was used to create this page. Keeping the similar buckets but condensing them into four accessible buckets compared to the previous five, using less than one week left, less than two weeks left, less than four weeks left, and more than four weeks left. This creates more space on the page, leaving actions to be less cramped. Instead of using a column for names, each bucket has a card for each action, just like the in-person board, whereby the person assigned to the action has their name displayed on the card. Using four different API endpoints, each selecting the actions based on their due dates creating the different buckets, all are pieced together using four different react components and CSS. The less than one-week React component and the CSS to display the different buckets are shown in figure 44 and 45, respectively.

```

render() {
    let noOfPages = Math.ceil(this.state.data.length/
        this.state.pageSize)
    if (noOfPages === 0) {noOfPages=1}
    let disabledPrevious = (this.state.page <= 1)
    let disabledNext = (this.state.page >= noOfPages)

    return (
        <div>
            <span className = "WithinAWeek">
                <h2>Less than 1 Week</h2>
                {
                    this.state.data
                    .slice(((this.state.pageSize*this.state.page)
                        -this.state.pageSize),
                        (this.state.pageSize*this.state.page))
                    .map( (details, i) => (<NMADDCard key={i}
                        details={details} />) )
                }
            <span>
                <button className="buttonsNMADD"
                    onClick={this.handlePreviousClick}
                    disabled={disabledPrevious}>Previous</button>
                Page {this.state.page} of {noOfPages}
                <button className="buttonsNMADD"
                    onClick={this.handleNextClick}
                    disabled={disabledNext}>Next</button>
            </span>
        </span>
    </div>
)
}

```

Figure 44 – Code to display the NMADD items due in less than week.

```
.WithinAWeek {
    background-color: #F15152;
    display: grid;
    grid-template-columns: repeat(1, 1fr);
    margin-top: 10px;
    margin-bottom: 10px;
    margin-left: 150px;
    text-align: center;
    width: 20%;
    height: 100%;
    float: left;
    padding: 10px;
}

.WithinTwoWeeks {
    background-color: #fcba03;
    display: grid;
    grid-template-columns: repeat(1, 1fr);
    margin-top: 10px;
    margin-bottom: 10px;
    text-align: center;
    width: 20%;
    height: 100%;
    float: left;
    padding: 10px;
}

.WithinFourWeeks {
    background-color: #fcdb03;
    display: grid;
    grid-template-columns: repeat(1, 1fr);
    margin-top: 10px;
    margin-bottom: 10px;
    text-align: center;
    width: 20%;
    height: 100%;
    float: left;
    padding: 10px;
}

.MoreFourWeeks {
    background-color: #93c47d;
    display: grid;
    grid-template-columns: repeat(1, 1fr);
    margin-top: 10px;
    margin-bottom: 10px;
    text-align: center;
    width: 20%;
    height: 100%;
    float: left;
    padding: 10px;
}
```

Figure 45 – CSS to style the NMADD buckets.

6.3.4. Chart.js

The final discussion point for the implementation is the use of Chart.js to create visual graphs to visualise the data. In the requirements gathering process, participant 1 stated that a web-based tier process should be more visual, allowing the ability to track the progress of the department. Participant 2 also stated that the added visuals would increase the team's engagement, giving users visual stimulation rather than just text fields. For this reason, a critical requirement of the project became about making the product as visually pleasing as possible; graphs and charts are one such way to do this.

Chart.js is an open-source, responsive, JavaScript chart creation package. This package was used to create several graphs within the React app. The first of which, implemented on the dashboard, summarises the number of actions per department. This gives a good overview of how busy each department is and the team as a whole. To create these charts, there are several steps: to set the labels and data for the chart to an empty array, both of which are stored in the state of the component. This is shown in figure 46 below. When the component is mounted, it takes the data and labels from an API endpoint (shown in figure 47) and then formatted in the render of the component as well as the options that can be set for the Chart.js bar chart (figure 48).

```
Constructor(props) {
  super(props);
  this.state = {

    chartData: {
      labels: [],
      datasets: [
        {
          label: 'Number of Actions',
          data: [],
          backgroundColor: [
            '#E20177',
            '#1B4298',
            '#009DDC',
            '#171717',
            '#3CDCB0'
          ]
        }
      ]
    }
  }
}
```

Figure 46 – Constructor that sets the labels and data to an empty array.

```
componentDidMount() {
  const url =
    "http://unn-
w17000348.newnumyspace.co.uk/part1/api/deptactions";

  let depName = [];

  fetch(url)
    .then(response => response.json())
    .then(data => data.data.map(department_action => {
      depName.push(department_action.dept_name)
      this.state.chartData.datasets.forEach((dataset) => {
        dataset.data.push(department_action.numactions)
      })
    }))
    .then(() => {
      this.setState({chartData: { ...this.state.chartData,
                                labels: depName}})
    })
    .catch(err => {
      console.log(err)
    })
}
}
```

Figure 47 – ComponentDidMount using an API endpoint to set the labels and data for the chart.

```

    Render() {
      return (
        <div className="ActionsPerDept">
          <Bar
            data={this.state.chartData}
            options={{
              showScale: true,
              pointDot: true,
              showLines: false,
              title: {
                display:true,
                text: 'NMADD Actions Per Department',
                fontSize: 25,
                fontColor: '#171717'
              },
              legend:{
                display:false
              },
              tooltips:{
                enabled: true
              },
              scales: {
                yAxes: [{ 
                  ticks: {
                    beginAtZero:true,
                  }
                }]
              }
            }}
            width="600"
            height="200"
          />
        </div>
      );
    }
  
```

Figure 48 – Formatting and options of the department actions chart.

The final outcome of this code is shown below in figure 49.

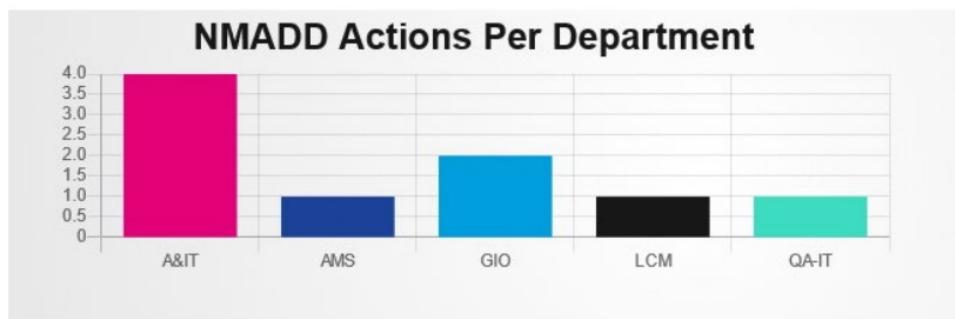


Figure 49 – NMADD Actions per Department Bar Chart.

Several other charts were created, using very similar code, changing only the endpoint from which the data is pulled from and altering whether it was a Bar, Line or Pie chart. A dedicated chart section was created for the NMADD section of the React app as this is an important area where specific metrics and stats are compared across the department. Some of the charts created for this section include the number of actions per username (bar chart), the status of outstanding actions (pie chart), upcoming due dates (line chart) and the number of actions per type (bar chart). The outcome of these charts for the NMADD statistics section is shown in figure 50 below.

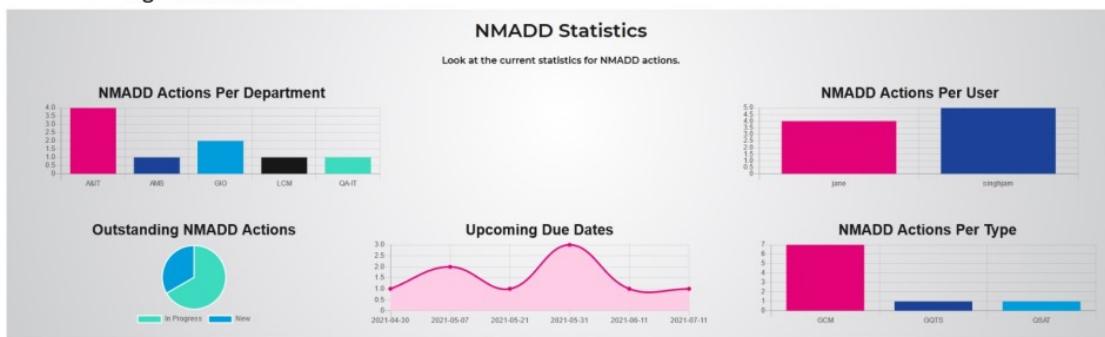


Figure 50 – NMADD Statistics page.

6.4. Summary

This chapter examined the two major components of the product created for this project, the API and the React app. Each section described the critical and unique aspects of the code used to implement the product and detail how this contributed to the overall outcome of the project. Breaking down the code in such a way helped to understand the thought processes behind the decision making. The next chapter will go on to look at how this code was tested to ensure it was fit for purpose, robust and meets the requirements of the CMF.

7. Testing

7.1. Introduction

This chapter will describe methods and findings from completing testing based on the requirements from the requirements gathering exercise and subsequent requirements specification. It will also combine three different forms of testing: installation qualification, operational qualification, and user acceptance testing. Accompanying the testing will be the configuration specification and requirements traceability matrix. The first looks at the software's specific details and how it is set up, and the hardware and network configurations needed. The requirements traceability matrix is a method of ensuring that each requirement is tested against, mapping the requirements specification to the testing document.

The first testing method, installation qualification, ensures that the software can be implemented correctly and in a working fashion with the facility's infrastructure. The second method, operational qualification, ensures that the software meets the functional and business essential requirements and test if the software works as intended. Finally, the user acceptance testing is completed with the client to ensure all user-based requirements are met, e.g. user interface requirements. These requirements are documented in Appendix 11 and traced through a Requirements Traceability Matrix, as shown in Appendix 13. All of these testing methods will be combined into one test protocol stored in Appendix 14.

7.2. Configuration Specification

The main purpose of a configuration specification is to detail how the product is set up to meet the requirements recorded in the requirements specification. There are three main sections within the configuration specification: configuration considerations, system analysis, and functional configuration. The first section, configuration considerations, gives an overview of the system produced, a description of what it is meant to do, the requirements set out for the system and any assumptions about the system. The second section, system analysis, describes the system architecture and external interfaces or connections to other systems. Finally, the functional configuration provides a detailed view of any hardware and software components, what is needed to run those components, any software packages required to run the system, security of the system, performance notes and the availability of the system.

This document intends to give the reader a greater understanding of what is needed to operate the system as intended. The Digital Tier application is a relatively simple system compared to what the CMF is used to. This is because it has no hardware components or external interfaces and only requires a PC with an internet connection to access the externally hosted website. For this reason, this configuration specification is very light touch as there is little configuration needed once the website has been created and deployed to the webserver.

7.3. Requirements Traceability Matrix

A requirements traceability matrix is a method of tracking and monitoring the project's initial requirements, detailed in the requirements specification, ensuring that these requirements are met and tested against. Pinheiro (2004) defines requirements traceability as the ability to follow the life of a requirement.

Requirement's tracing is a critical task when developing or implementing any piece of software. One major reason is to provide verification and accountability as to whether a requirement has been completed or not. Accountability is the clarification of what has been completed and by who. This verifies that requirements have been completed in a compliant manner (Watkins and Neal, 1994).

One other critical reason why requirements tracing is an important activity in any project is that if there are any alterations to the project's requirements, it is tracked. The new requirements will be tested against and not forgotten about, known as change management (Watkins and Neal, 1994).

For this project, a requirements traceability matrix has been created in a spreadsheet, a table providing visibility between the requirements and the test cases. The traceability matrix is stored in Appendix 13, and an example requirement is shown in the figure below.

Requirement Doc. Ref. #	Requirement ID	Requirement Title	Test Doc. Ref. #	Test Section #
<i>Required</i>	<i>Required</i>	<i>Optional</i>	<i>Required</i>	<i>Required</i>
CRAM_Digital_Tier_RS_2021	FU-001	The tool will provide an interactive and engaging design that allows the use of the tool remotely or in-person.	CRAM_Digital_Tier_TP_2021	IQ-001

Figure 51 – An example requirement from the Digital Tier RTM.

7.4. Installation Qualification

The first section of testing performed on the final product was the installation qualification. This testing method confirms that the system is compatible with the site's infrastructure and confirms that no alterations or accommodations need to be made to get it working. Infrastructure enables a facility to improve business processes and gain a competitive advantage over rival companies (Harter and Slaughter, 2003). Without the latest advancements, this could lead to the facility being left behind with vendors and software developers, such as this project, not supporting the company due to their products not being compatible with older technology.

The CMF has a mixture of old and new technology. It is very hit and miss across the site, with some areas using bespoke technology utilising artificial intelligence and machine learning capabilities and others using IBM's OS/2 released in 1987 (Encyclopedia Britannica, 2021). This technology is extremely outdated, and anything other than the highly bespoke software it was designed to run, this OS/2 device would not work. This application is not intended to run on such a device, but

completing this installation testing ensures that the PC it was designed to run on can do so.

As this application is designed to run in a browser, there are not many tests that can be completed to check if it runs. If the page is returned, it was successful; if not, there will be issues either with the hardware or deployment to the webserver. This is a simple yet effective test that ensures that the application can be run, whereby it was successful.

7.5. Operational Qualification

The second section of testing is the operational qualification, which looks at whether the product meets the project's functional and essential business requirements. These requirements were detailed in the requirement specification (Appendix 11). Grisanti and Zachowski (2002) describe operational qualification as "*to demonstrate that the system operates as intended after placement in a user's environment. Testers take a holistic approach whenever possible to ensure proper installation and good system integration*".

This testing section is potentially the most important because test cases are designed to ensure the requirements are met; if they are not met, then this means that the product is not fit for purpose. This test section is also critical for discovering bugs with the product or lack of compliance with any regulations. For this reason, the tester must have a good understanding of the surrounding processes as well as the product produced. Deligiannis et al. (2016) discuss bugs stating that allowing bugs to reach production environments can cost companies much money, but this is not just the case in pharmaceuticals. If the system being tested is part of the supply chain process, this can cause patients to receive incorrect tablets, which can be fatal.

Due to this system not directly impacting the supply chain (as per assessments provided in the Quality Assurance Plan, Appendix 10), testing does not need to be patient-focused but instead ensure the functionality works as expected. For this reason, there is an operational qualification test provided for each page of the system, testing out the expected functionality. An example of this is shown in the figures below.

Objective(s):
• To ensure that the system allows new users to be registered.
Prerequisite:
• IQ-001 and IQ-002 were completed successfully.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Open the React app.	React app opens successfully.	React app opens successfully.	PASS
2	Click on the "My Account" page.	Page opens successfully.	Page opens successfully.	PASS
3	Enter the new user's details.	Details entered correctly: Username: jimmy Email: jimmy@example.com Password: 1234 First name: Jimmy Surname: Smith Role: P1 Department: A&IT	Details entered correctly: Username: jimmy Email: jimmy@example.com Password: 1234 First name: Jimmy Surname: Smith Role: P1 Department: A&IT	PASS
4	Click the "Register" button.	Page refreshes and login field is displayed.	Page refreshes and login field is displayed.	PASS

Figure 52 – Testing the Registration Functionality within the Installation Qualification.

Objective(s):
• To ensure that the system allows users to login.
Prerequisite:
• OQ-001 was completed successfully.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "My Account" page.	Page opens successfully.	Page opens successfully.	PASS
2	Enter the user's email and password as created in OQ-001.	Users email and password entered correctly: Email: jimmy@example.com Password: 1234	Users email and password entered correctly: Email: jimmy@example.com Password: 1234	PASS
3	User clicks "Log in"	User is logged in successfully and navigation bar populates.	User is logged in successfully and navigation bar populates.	PASS

Figure 53 – Testing the Login Functionality within the Operational Qualification.

7.6. User Acceptance Testing

The final piece of testing conducted was the user acceptance testing. The ISTQB Glossary (Glossary.istqb.org, 2021) defines user acceptance testing as "*Formal testing concerning user needs, requirements, and business processes, conducted to determine whether or not a system satisfies the acceptance criteria and to enable the user, customers or other authorized entity to determine whether or not to accept the system*". This is often performed with an end-user of the system to give direct feedback on the system. This testing should be performed within a practical context, meaning that the test cases should reflect how the system would evaluate the overall purpose of the product (Hambling and Goethem, 2013).

The method used to carry out this testing was based on how the CMF approach user acceptance testing. Rather than the users testing all of the functional requirements that can definitively work or not, such as does the page display the information covered in the operational qualification, the users will instead test the non-functional requirements such as the user interface and accessibility. This is because a user has a different viewpoint to the developer, allowing greater insight into how the product meets these qualitative requirements. A tester will be given full access to the software and told to use it to approach any new system. An example of a user acceptance test used within the testing process is shown in the figure below, whereby questions are asked about the system, and the comments are noted.

Objective(s):

- To understand how a user reacts to the way information is displayed.
- Prerequisite:**
- User is logged in.

Question	Comment
Does the application display all necessary information in a readable and concise method?	Yes, the system was very clear at displaying the information.
Does the system have an appropriate design, considering the user's needs?	Yes, the design was very clean and is clear what is happening.
Does the system follow the companies branding guidelines?	The branding matches exactly, even down to the fonts and logo style.
Is whitespace used appropriately within the application design to display information clearly?	Yes, the space doesn't take away from the overall design.
Is the user presented with data irrelevant to their job role?	Yes, allows you to easily filter items also which makes it easy to see what you want.

Figure 54 – Testing the information display method within the User Acceptance Testing.

7.7. Summary

This chapter has examined the testing process used to ensure that the product created is fit for purpose. Basing the testing on the CMF's in house processes has ensured that the system will be easily integrated and validated within the site's ecosystem. A requirements traceability matrix allowed the installation qualification, operational qualification and user acceptance testing to test all functional and non-functional requirements found in the requirements specification, originally derived from the requirements gathering interviews. Consequently, all of the testing performed was successful, showing that the system meets all of the requirements and has been completed to the required standards of the client.

Evaluation Chapters

8. Evaluation of the Product

8.1. Introduction

This chapter will take an in-depth look into the product created throughout this project. A critical discussion will take where the strengths and weaknesses of the product lie, paying particular attention to how the product has met the project's requirements. A further section will detail the approach to gaining feedback from the client and a detailed discussion on what feedback was received, both positive and negative, and a summary of the client's overall opinions. Finally, this chapter will take a brief look at two alternative approaches to completing this project and how the resulting product would have differed.

8.2. Strengths and Weaknesses

8.2.1. Requirements

As detailed throughout this report, the requirements for this project were generated in conjunction with the client, the CMF. As part of the requirements capturing process, interviews were held with several representatives of the client, which aided the creation of a requirements specification (Appendix 11) signed off by a member of the clients' IT team.

The creation of a requirements traceability matrix was used to track and monitor the life cycle of the requirements. This traceability matrix detailed which requirements were met by which tests within the test protocol, ensuring that each test was relevant and covered a piece of functionality necessary to the client. As well as keeping testing on track ensured that there was sufficient functionality within the product; otherwise, tests would have failed. Further development would then be needed to implement the required functionality in order to meet the testing standards.

Due to this, it was evident by a completed requirements traceability matrix and no testing incidents that all requirements were met by the product, thus making it fit for purpose. Due to the formalised requirements specification, the client cannot turn around and say that the system does not do what it is meant to do. However, it is very important that the client is happy with the product as, ultimately, they commissioned the project and are paying for the system. Chapter 8.3 details the feedback from the client and summarises if they were happy with the product or not.

8.2.2. Strengths

One of the system's first and most important strengths is that it closely follows the existing underlying principles, Safety, People, Quality (Never Miss A Due Date), Delivery and Cost (Downtime). These principles have been a foundation of the site's

tier system since its inception. Making this concept into a digital platform was difficult, especially the visual sections such as the department status and the Never Miss A Due Date board. Translating the principles to the digital tool was a critical success and provided a good foundation on which to base all other functionality off.

Secondly, a major benefit of the system is that it provides an interface for remote working whereby anyone can access it from wherever, unlike the in-person process. This allows users to edit information as and when it happens rather than going to a specific space in the facility. With the COVID-19 pandemic, this remote solution is needed due to many workers working from home. The site was previously using Microsoft Teams and OneNote to do this; however, this solution gives the facility a dedicated user interface with custom functionality, rather than making do with text boxes and planner items.

Another considerable strength of the system produced is the user account system. The user account system allows users to register their details in the application and then use that to log in and edit the information within the tier. However, if the user is not logged into the system, they can only view the dashboard, as all other navigation buttons are not displayed. This means that only registered users can edit information as the dashboard is a read-only page. This feature ensures that all edited information is tied to an account, deterring people from entering false information.

As mentioned above, the application has a simple and easy navigation bar. As well as this, the navigation bar is present on every page, standing out due to the contrasting colour. Buttons are also included to navigate to extra pages such as Add a new NMADD item, making it clear that the user will be transitioning to a new area. Removing these pages from the navigation bar removes clutter and is only presented to the user if it is necessary.

A final, significant strength of the product created is the statistics to give a visual representation of the data. This was something that all the interview participants wanted from the product and delivered very successfully. The statistics section, especially within the Never Miss A Due Date provided a much needed statistical overview to give department leads greater detail as to where resource was being used and what times of the month. This is essential when leading a team, as knowing where the team is spending its time allows the manager to plan methods on coping with the workload and evaluating if the team needs more or fewer people to manage that workload. The CMF has never had anything like this previously and will provide a much-needed service for them to use.

8.2.3. Weaknesses

One of the system's weaknesses is that, although interacting with the user interface is easy and self-explanatory, typing on a digital screen can be quite difficult. This is because the application relies on manual input and all actions require notes to be typed out to give detail about what is happening. The digital screen used at the CMF does have an on-screen keyboard to use; although this is clunky and not always the

easiest to type fast, making the process particularly painful. A physical keyboard could also be attached to the screen; however, there is nowhere to rest the keyboard. The user would have to hold it in their hands, making the typing process difficult and painstakingly slow. Updates to the tier board should be done at the time of the event occurring and not during the meeting, so users should log on with their personal PC's and update the tier board this way. However, this does not always mean that the meeting's presenter will not have to update information within the meeting. It will just reduce the number of updates they will need to perform.

Another potential issue with the system that has been created is that, although there is registration functionality to allow users to gain access to the application by inputting their details, there is no functionality to prevent unwanted users from signing up. This could be a potential security vulnerability that should be addressed, as anyone with the URL can create an account and edit the data. Instead, the user should register their details, which then gets sent to an admin, who would be the department lead and their delegate, who then approve that access request. This prevents unwanted users and also adds a further layer of security to the system. As this is not impacting the supply chain, this is not a critical failure of the system but should be implemented to reduce unnecessary problems.

Finally, the last weakness of the system would be that there is no automatic notification system utilised by the product, such as email notifications. This means that users have to manually look at the system to remind them of upcoming due dates and actions. An automated notification system would provide users with a clear message indicating when their action is close to its deadline. This would provide users with reminders to help them but also ensure that actions are more likely to be completed on time, rather than leaving it to the last minute or it being overdue.

8.2.4. Overall

Overall, the product created has many strengths; it is a product that can be used straight away by the client. It met all of the initially formalised requirements and agreed on by the client, and although there are some weaknesses, these are not massive risks but should be ironed out with future development. The product is capable of providing a greater, more comprehensive Tier Process experience than what is currently on offer to them.

8.3. Client Feedback

8.3.1. Positive Feedback

Firstly one significant piece of positive feedback from the client was that the navigation bar and overall design of the application were simple and easy to use whilst appealing to the user. Participant 5 stated that the design was very clean and worked well, with the flow of the application being simple and easy to follow. Participant 1 noted that the navigation bar was clear and concise, giving a clear

indication as to what each page is for. This is very important as this gives a first impression about the application and how easy the application is to use, providing a fundamental feature of any application.

All participants noted that the structure used for the application was very similar to what they were used to. Participant 3 noted that these were the core pillars of what a tier meeting should be. This was a notable positive for them. Although this was a new application with new features and design, the core principles behind the application were the same, providing them comfort. This will help new users to the application to adapt to it as it a process they already know and follow.

The second piece of positive feedback received was that the dashboard was laid out clearly and easy to view what is happening within the IT department. Participant 2 liked the dashboard layout as it clearly shows a breakdown of the entire department with a nice summary for each area without having to deep dive into the application. They also noted that it was easy to have a quick look at items, as it does not feel overcrowded due to the good use of whitespace.

Participant 1 similarly likes how the dashboard introduces the page, giving a welcome message and the standard working agenda. The graphs on the first page also make it visually stimulating. Participant 4 thought that using the application with a digital screen would provide a great overview of what is going on within the department. Participant 5 added that this would be great to have around the workplace to remind people of the key items.

A final area that was noted for positive feedback was the Never Miss A Due Date section. The participants from the interviews stated that the Never Miss A Due Date was a massive improvement on both the current in-person process and the Teams and OneNote solution. Participant 5 noted that the system's visuals would drive a much better process, focusing more on what is coming up, and if actions are of concern, they were easy to flag. Participant 1 mentioned that it was a clear and concise method of displaying and prioritising the tasks. Participant 2 added that it was easy to filter by pages as it makes it a lot clearer to view when there are lots of items.

All participants also noted how the Never Miss A Due Date statistics section was something that they had never seen or utilised before but that it was critical going forward to help monitor the department. Participant 5 said that this was a simple insight into something really important, with participant 1 stating that it would be good to compare the resources between the departments and see where actions are coming from and involved. Participant 2 likewise noted that it was great for management as it allows them to prioritise actions. This shows that the statistics, in particular, were a great feature to add to the existing process.

8.3.2. Improvements

One improvement mentioned by the client was that historical data for the statistics page would come in handy. This was highlighted by participant 4, who stated that it gives a good indication for planning. However, they would like to see historical data as it means that they could review the information and see metrics such as the busiest month or which department had the most to do. This would then lead to discussions around resource and what department needs the most support. This feature would be easy to integrate and something that would not take much time to implement, making it an easy resolution if the client felt that this was a critical feature to have in the application.

A second improvement that the client mentioned was that it would be good to integrate with other IT systems on-site for future versions of the product, reducing the need for manual entry. Participant 5 mentioned that it would be great to get data from the supporting systems as many of the pages shown use a manual process. This can be considered clunky and prone to human error. Removing this would create a more advanced and comprehensive system; however, this is quite advanced and would need specialist connectors to integrate with the CMF's bespoke systems.

A final improvement was that for the Delivery and Downtime sections, actions should be ordered by priority and colour coded to reflect the current situation of those actions. Participant 4 wanted a visual method of representing the priority to highlight the importance. This would be a simple change to make using an image or CSS when the component that displays the cards is mounted on the page.

8.3.3. Overall Opinion

The feedback from the CMF was overwhelmingly positive, with all participants agreeing that the tool created meets all the project requirements. The participants noted that the created tool was much more comprehensive than any tool they have used previously and would be a massive advancement on the current processes they use. All participants acknowledged that there are a couple of improvements to be made to the created tool. However, none of these improvements is essential and can be implemented in future versions of the application. With this, the CMF are more than pleased to integrate and start using this product in the Facility's IT department.

8.4. Alternative Approaches

8.4.1. Desktop Application

An alternative approach to this project would be to create a desktop application rather than a web-based tool. Using a desktop application would provide several advantages over a web-based tool, one of which is that it can be used offline and connected to the internet. This allows the user to have more freedom, as sometimes users may not always have access to a stable internet connection. This also brings

more security to the application as online threats pose a much greater danger to applications, especially when on the internet.

On the flip side of this, web-based applications are designed with multiple concurrent users in mind, making this tool much more effective. Multiple users mean that updates can be contemporaneous, providing a necessary format for real-time interactions. Another benefit of a web-based application is that users can access the system from anywhere at any time as long as they have an internet connection, no installations, or pre-requisites to use the application. This is highly beneficial to any end-user, as it means that there is very little pre-work for them to access the application, and they do not have to worry if their hardware is up to scratch. Updates are included in this; when a desktop application has an update, all individual instances of that application have to be updated. If not done by a system centre configuration manager, this has to be done manually, which can be highly frustrating for the user. On the other hand, a web-based application can be instantaneous, meaning downtime is reduced to a minimum, and the user does not feel any effects. For these reasons, a web-based application was chosen and has proven to be an effective method for the Tier Process.

8.4.2. Physical Space

Another alternative approach to this project would be to expand the current physical space. Although this would mean that there is no digital element to the project, further development of the current in-person process would be another improvement method. Refining the process and incorporating a method of statistical analysis would achieve a similar result. However, compared to a digital version, the in-person process would still be archaic and have the same drawbacks as identified earlier in the project. Alongside the COVID-19 pandemic, where workers are forced to work remotely for the foreseeable future, an in-person process would not work. Beyond the effects of COVID-19, in-person meetings might return to as they were before, but this is a big if. If this were to happen, a digital tool is a much more succinct and comprehensive method for displaying and storing meeting data.

8.5. Summary

This chapter acknowledged both the strengths and weaknesses of the product created, both from a personal and client perspective. A critical view of the project has been taken, especially at what could be done for future iterations of the project and the strengths that have made this product, an overall, resounding success. This is shown by the client's profound expression of interest in the product and the future potential it has for the company.

9. Evaluation of the Project Process

9.1. Introduction

This chapter will take a detailed and critical view of the project process as a whole. This will involve making a critical evaluation of the project management tools and methodologies used and scrutinising how this could be performed differently. The chapter will also look at the objectives set out in the Terms of Reference and determine whether or not the project was able to meet them. There were several lessons learnt and skills gained from the project; these would be discussed and any Legal, Social, Ethical and Professional Issues faced during a project. Finally, this chapter will summarise this information and determine if the project was a success or a failure.

9.2. Project Management

9.2.1. Methodology

When critically reviewing the project management of a project, one of the first things is the methodology used. As mentioned in chapter 4, this project used a plan-driven approach, the same approach used by the CMF. A plan-driven approach to system development is outdated compared to that of an agile approach. However, using the plan-driven approach depended on the restrictions and regulations enforced upon the CMF. These restrictions mean that when requirements for the system are formed, the intended system must undergo several assessments and investigations as to whether the system can meet the regulations of the pharmaceutical company's governing bodies. These assessments can take weeks to complete. In an agile methodology approach, where the requirements often change, this would be completely impractical as the assessments would have to be completed every time there is a change.

Although a plan-driven approach is ideal for a project within the pharmaceutical industry, it has many limitations. An agile approach would allow continuous feedback from the client, allowing their recommendations and desires to be implemented before the final feedback. This could have influenced and altered the outcome of the product, making it more aligned to the client's needs. Overall the methodology chosen is not ideal when developing a system; however, due to the nature of the client, it is necessary to use a plan-driven approach to ensure that the project is delivered on time.

9.2.2. System Development Life Cycle Documentation

One of the crucial aspects of the project management process was the system development life cycle documentation produced. This documentation guides the stages of the project methodology, from the initiate and planning phase through to the test and install phase. Each document has a vital role that details the project process itself or the product created. Without these documents, the project would

lack structure as the documents provide stage gates that determine whether that phase is complete; this is especially true when using a plan-driven approach.

The process documentation, such as the Quality Assurance Plan (Appendix 10), details how and why the project will be completed, stating what is going to be delivered at the end. Couple this with the Quality Assurance Summary Report (Appendix 15), which states that it gives the project structure and accountability if the project was completed as stated in the Quality Assurance Plan. Structure and accountability are two crucial components of a project; without them, any project will fall apart, not being completed as intended. Overall, the system development life cycle documentation was a crucial aspect of the project process, ensuring that the project kept on track and delivered what was stated in the original plans. Without it, it would be not easy to achieve the outcome that has been delivered.

9.2.3. Time Management

A project involves completing a series of tasks to complete a specific objective. The project needs to complete the work on time, within budget, and meet the client's requirements (Babu and Suresh, 1996). To achieve this, there needs to be a clear plan of how the project will be completed and when items will be completed. To do this, a detailed project plan was created and included in the terms of reference (Appendix 1). This project plan took an agile approach to the project and ultimately was very different to how the project turned out.

With any project, it is expected to not stick to the plan fully. The project manager has to be aware of this, allowing for contingency and flexibility within the plan. This was evident throughout this project. As shown from the final project plan (Appendix 16), many items ended up with very different timings than the timings estimated at the start of the project and changed the project's proposed methodology approach. Ultimately, the analysis chapters took much longer to complete than anticipated, as such development was pushed back. Similarly, the development of the client-side aspect of the product took slightly longer than expected. However, the server-side development was a lot shorter than an expected, evening out the development process. Without the expectations that this plan would need to change, this could have caused many problems. However, due to the planning and forward-thinking, changes in the plan did not have a negative effect, requiring only some further adaptations to enable the project to be completed on time in a successful manner.

9.3. Objectives

Throughout the terms of reference creation, a number of objectives for the project were identified and can be found below:

1. Perform a requirements capture for a new digital tier system focusing on the IT department and their specific areas of need.
2. Conduct a Literature Review to analyse all relevant documentation.

3. Conduct research into how the current system is used and identify key features and areas for improvement.
4. Investigate and analyse existing collaborative meeting solutions.
5. Research and evaluate the most appropriate tools to develop the client-side and server-side parts of the tool, as well as the database used.
6. Create an entity relationship diagram and data dictionary for the database.
7. Use Human Computer Interaction and User Experience principles to design an appropriate user interface.
8. Develop a collaborative meeting tool that meets the requirements as set out in the requirements specification.
9. Conduct an appropriate level of testing both with and without user interaction to ensure the product is fit for purpose.
10. Develop a set of System Development Life Cycle documents in line with the CMF's policy.
11. Complete an evaluation of the product.
12. Complete an evaluation of the project as a whole, including project management.

Throughout the project process, every objective outlined above has been completed successfully. Without these objectives, the project would lack structure. This provided a clear guide of what needed to be completed to enable this project to be completed successfully. Due to each objective being completed successfully, combined with the client's satisfaction, this project can be considered a resounding success. There are still many lessons to be learnt, as with any project, and these are detailed in the following section.

9.4. Skills Gained and Lessons Learnt

9.4.1. Skills Gained Throughout the Project

One of the crucial skills that have been developed throughout the project was the ability to problem-solve. Many times throughout the development stages, things would not work or did not go as planned. This is expected throughout any software development project. However, the resiliency to stick with the process and assess why something was not working enabled the problem to be solved a lot quicker, rather than just giving up and deciding not to implement that feature. This was particularly prevalent when trying to create the dynamic charts within the chart.js JavaScript framework. This involved several days of problem-solving to try and find a solution which was a very difficult and disheartening process. Once a solution was finally found, it was euphoric. It resulted in the intended features being implemented into the system, creating a much more comprehensive product that met the requirements of the client.

A second skill developed was project management. Prior experience gave a good base knowledge of how to approach such a task. However, with each project, experience is gained, and further insights on how to approach different scenarios are obtained. The structure used to complete the project gave great insight into

managing a complex client project whilst completing all the necessary tasks to complete a software development project.

A final skill gained from the project process is the ability to analyse and critically evaluate similar products and learn from their successes and mistakes. Before this project, analysis and research of such systems and literature were incredibly daunting. Discovering methods to help achieve the goal of performing such a review aided the process heavily. Going forward, if required to undertake such a task, this experience will provide a thorough foundation to begin such work and do so successfully.

9.4.2. Lessons Learnt from the Project

The first lesson learnt from this project is that planning is an essential part of any project; without it, it is more likely to fail. Although the planning throughout this project was well thought out, incorporating contingency and a flexible approach, the changes made to the project could have been catastrophic. Planning allowed the project to run smoothly when things needed to change, whereas if there was no such approach, the project would be delayed and either the deadline would be missed, or the product quality would be sacrificed. For future projects, this has highlighted the need to incorporate such an approach; otherwise, it could lead to unwanted complications.

The second lesson learnt from the project was the need for clear and detailed requirements to be formalised. There were several reasons why this was incredibly important to the project's outcome, the first of which being that it prevented scope creep. A representative from the CMF signed the formalised set of requirements, thus ensuring that this is what they would measure the project against and that they could not change any requirements after it was signed. Secondly, a detailed requirements specification provided a tangible list to design, implement and test against. Providing a detailed framework gave the project direction and created a structure for prioritising and proceeding with the creation of different pieces of functionality. Overall, without the requirements specification, the project would have lacked clarity and would have delivered a product that the client would not want.

9.5. Legal, Social, Ethical and Professional Issues

9.5.1. Legal

As mentioned within the introduction, the client of this project, a human health pharmaceutical manufacturing facility, cannot be referred to by their actual name. This is due to a confidentiality agreement. The CMF is a globally recognised pharmaceutical company, with their medicines being supplied to over one hundred different countries worldwide. For this reason, they have to adhere to many different, strict rules and regulations imposed upon them by many different, national, and international governing bodies such as the US Federal Drug Agency (FDA) or the UK Medicines and Healthcare Regulatory Agency (MHRA). These governing bodies ensure that the medicines manufactured and supplied by pharmaceutical companies meet safety, quality, and efficacy (Gov.UK, 2021). Due to such standards, a series of assessments and investigations have to be performed on the proposed system to mitigate the potential negative impact the system may have on the medicines produced or patient safety. These assessments include a Risk Profile, GxP Regulatory Determination Form, and the Regulatory Risk Assessment. All of these assessments are included in the Quality Assurance Plan, which is stored in Appendix 10.

9.5.2. Social

Throughout this project process, no social issues were discovered or identified. This is due to the project being an individual piece of work requiring no social contact or interaction.

9.5.3. Ethical

One of the main ethical issues with new IT systems is that they can replace human jobs. This project did not encounter this issue, as the system created enhanced people's ability to complete their jobs rather than completing them for them. Providing further analytical tools and methods for completing a task is purely beneficial to the potentially impacted employees.

9.5.4. Professional

There was one major professional issue that was present throughout this project. The project required much interaction with the client, from forging requirements to gaining feedback on the final product. During the COVID-19 pandemic, CMF workers have been forced to work from home, meaning that client meetings were held remotely. As detailed throughout this entire report, remote meetings are far from ideal with the current infrastructure available when comparing the capabilities of an in-person meeting. This made the process much more challenging when working with the client; however, due to a close working relationship with the CMF, the process was made slightly easier. When working life begins to return to normal, this process will be made much easier and potentially yield greater results.

9.6. Summary

This chapter has given a critical evaluation of all aspects relating to the project process. All aspects of the project process have been a resounding success, navigating any issues with sufficient planning and project management. This foundation has provided a platform to create a highly successful product that meets the client's needs, but without the management of the project, it would not have been possible. Overall, the project was a success due to the fundamental aspects of the project process being completed correctly and efficiently.

10. Conclusions and Recommendations

10.1. Introduction

This final chapter will take a brief look at the project as a whole and determine whether it could meet the overall aim. Based on this, a discussion can be made about future work for the project, any changes that would be made and additional work beyond the initial scope. Finally, it will summarise the project as a whole and take a look at what impact this project has had on the CMF.

10.2. Aims

In terms of reference creation, two aims were developed to outline what this project was set out to achieve. These two aims are detailed below:

- To investigate and analyse the importance of how collaborative meetings bring information and issues to the relevant teams within a manufacturing environment.
- To develop a web-based meeting tool with digital data tracking and analytics for a pharmaceutical manufacturing facility.

The first of these two aims were to critically evaluate how collaborative meetings are used in a manufacturing environment; this was achieved in two separate ways. The first was by investigating the CMF's current processes for conducting a collaborative meeting, identifying a problem case, and establishing a structure on which to base the project on. The second way in which the first aim was met was by conducting a thorough literature review on what collaborative meetings are and how they are used within other industries and the manufacturing industry. An analytical overview of what tools are currently available, paying particular interest to their successes and failures, was then conducted to provide a strong platform for working towards the second aim.

The second aim of this project was to develop a collaborative meeting tool for a pharmaceutical manufacturing facility. This was achieved through a well-structured requirements capture exercise, which influenced the design of a potential tool. After further analysis of the tools and techniques available, an implementation method was developed, and the requirements were finally tested. This resulted in a product that met all the requirements, which was evident due to the overwhelmingly positive feedback.

10.3.Further work

As mentioned, both within the strengths and weaknesses of the product and the client feedback, there are several further developments to the product that would be made for future iterations. The first of these being a more robust user account system whereby an admin could approve an access request. This would prevent unwanted users and improves the security of the system. The client also mentioned a couple of cosmetic improvements that would be straightforward to complete whilst also implementing an option to view historical data and present and upcoming statistics. This would be a simple work that would expand the functionality and allow greater in-depth analysis of the metrics by the client. Finally, for future iterations of this project, as mentioned by the client, it would be ideal for implementing integration between the current existing applications at the CMF, reducing the need for manual input.

Beyond the application changes, there would be several other pieces of further work required that fall outside of this project's scope. This project looked at developing a proof of concept application for the CMF's IT department for their Tier 1 and Tier 2 meetings. The next stage would be to start expanding the adoption of this tool to all areas of the facility, such as the bulk manufacturing and packaging departments. Once complete, the next stage would be to modify the system to be used at a Tier 3 level, requiring different sections and pulling data from every department's Tier 1 and Tier 2 meetings. Far in the future, this product would aim to expand to the CMF's sister sites, standardising the process and tool across the company throughout the world.

10.4.Summary

This project, through its entirety, has been a major success, meeting all aims and objectives set and fulfilling all the needs and requirements of the client. This project has shown that, if implemented and utilised correctly, collaborative meetings can be a highly successful tool to help spread information throughout the different areas of an organisation. The outcome of this project has highly impacted the CMF. The system produced has allowed them to move away from the old and outdated processes they were using before completing this process. The CMF can now proceed using a tool that offers them new ways to view and analyse their department whilst keeping the same core principles which made them wary of straying away from their outdated methods.

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Appendix 1 – Terms of Reference

Project Terms of Reference

KV6003: Individual Computing Project

James Singh
17000348
Computer Science

Title:

To develop an online meeting tool for a pharmaceutical manufacturing facility.

Project Tutor:

John Rooksby

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Kay Rogage

General Computing Project

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Project Title

To develop an online meeting tool for a pharmaceutical manufacturing facility.

Background to the Project

This project came about through my placement year where I spent 14 months working for a pharmaceutical manufacturing facility in Cramlington, UK. The CMF is a global pharmaceutical company specialising in areas including research and development, human and animal health manufacturing, vaccines, biosimilars and women's health. The CMF is a site which produces over 5 billion tablets per year with a diverse product portfolio including areas such as diabetes and cardiovascular disease. At the Facility I was a part of the IT team working as a Business Analyst Intern and afterwards, I was offered a permanent role within the department, working part-time till I complete my degree and then transitioning to full time once I graduate. My role as a business analyst consists of a couple of key aspects, but my main focus involves working on projects to enhance the manufacturing facility. Whether this is implementing a brand-new system to measure the hardness of a tablet or introducing new ways of working for people by introducing Microsoft Teams to the site.

Throughout my time at the CMF one main weakness became apparent that the company and the Cramlington site more specifically possess - the site is not digitally up to date. Some of the processes are outdated, with key systems like hardness testing still being paper based before they were upgraded recently. One of these processes which I have become very familiar with is the "Tier Process". There is a need to focus on the "Tier Process" due to a requirement to transition to a digital process as more and more people are working remotely rather than on site. The "Tier Process" is a method of funnelling key information through the site to the right people. Each department within a business unit, each holds a meeting where the members of the meeting go through a series of questions and sections relating to their business function. For example, some of the sections will include health and safety, planned downtime for systems and any ongoing issues. This is called Tier 1. Once the Tier 1 meetings have finished another meeting is scheduled soon after where each of the department leads within that business function get together with the business function lead and go through the same process, discussing the outcomes from the Tier 1 meeting. This is the Tier 2 meeting. For the Tier 3 meeting, each business function lead meets with each other and the plant manager to discuss the outcomes from that business function's Tier 1 & 2 meetings but only if these issues are necessary to be brought to the plant managers attention. Figure 1 shows this process using the IT, Bulk Manufacturing and Packaging departments as an example.

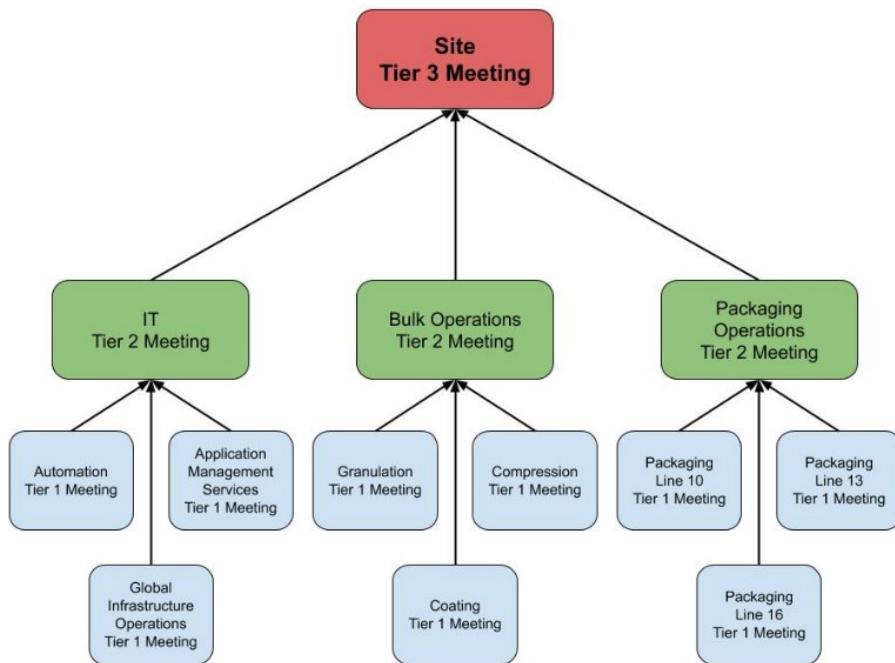


Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples. (Singh, 2020)

Figure 2 – A visual representation of the “Tier Board” used at the CMF as examples. (Singh,

SAFETY		ACTION TRACKING BOARD					DELIVERY OPERATIONS			DELIVERY CHANGES															
Last 3 Days	Next 3 days						Name	<1 Week	<2 Weeks	<4 Weeks	<3 Months	3 Months+	App.	Owner	Status	Comment	Date	Change	Ref	Impact	Area	Status			
[Green circle]	[Green circle]												GTS	AMS	[Green]						[Green]				
Activities for Awareness													SAP	A&IT	[Green]						[Green]				
Safety Action Tracker													MES	A&IT	[Red]						[Green]				
TEAM SUCCESS													IPZI	A&IT	[Green]						[Green]				
Team Successes													WII	GIO	[Green]						[Green]				
Successes for Tier 3													Robo	GIO	[Green]						[Green]				
A&IT GIO AMS QAIT													MMES	AMS	[Green]						[Green]				
[Green]													ZIA	A&IT	[Orange]						[Green]				
[Green]													Z9	A&IT	[Green]						[Green]				
[Green]													Fette	A&IT	[Orange]						[Green]				
2020)																									
DELIVERY DOWNTIME																									
App. Owner Start Finish Status																									
Escalate to Tier 3																									

These meetings took place in person until March 2020, using tools such as large printed out whiteboards that people wrote on – see figure 2. This was a great tool to get people together and discuss issues effectively. Another strength of this method was items could be recorded contemporaneously and was very visible at the Tier 1 and Tier 2 levels. However, this was largely ineffective when presenting at the Tier 3 level as this meeting does not take place in the same location as the Tier 1 and Tier 2 meetings. Therefore, anything needed to be taken to Tier 3 would need to be noted down on the representative that was attending's notebook or laptop. Similarly, if planned downtime was requested for business function A, to work in area B, business function C would not have clear visibility of this request even though they would be able to utilise the downtime in area B. This lack of communication is something that could be problematic in the future if an effective way to communicate these details is not found. Figure 1 shows an annotated display for the IT Tier 1 & 2 meetings, what each section is and what is discussed during these areas.

In late 2019, the World Health Organisation first learned of a new respiratory virus, SARS-CoV-2 (COVID-19), in Wuhan, China, with symptoms of the virus including a fever and a dry cough. In March 2020 COVID-19 was categorised as a global pandemic and had spread to much of the world (World Health Organisation, 2020). On the 23rd of March 2020, the Prime Minister of the UK, Boris Johnson, made a statement to the public, "Without a huge national effort to halt the growth of this virus, there will come a moment when no health service in the world could possibly cope; because there won't be enough ventilators, enough intensive care beds, enough doctors and nurses" (GOV.UK, 2020) thus placing the UK into national lockdown. This meant that there were very limited reasons to permit people from leaving their homes, one of which being travelling to and from work if it cannot be done from home. This greatly affected the CMF as up to 50% of workers had to transition to working from home.

The effects of COVID-19 and working from home resulted in the "Tier Process" needing to transition to an online format, so that every member of staff could continue to be involved in these essential meetings. One problem that was identified was that whatever solution was put in place, it needs to be accessible for each business function as someone in IT may know how to use a tool but someone in packaging may not. As a result, the meetings were transitioned to a much simpler form where they were held in Cisco WebEx meetings using screen sharing to record any information on the Tier Lead's Microsoft OneNote. This was more effective for recording the information, but it meant there was no visibility across the business function or on a larger scale, the entire site. However, it was evident that this online process was more suitable to display the information to the team, with lots of potential for greater interaction.

As previously discussed the solution needs to be accessible which is further highlighted by Nash (2020) who said the following about the world of academia, "*even with the speed at which online academic meetings became the only alternative, is that the platform for these meetings match the intention of the learning experience in promoting digital literacy and it was the role of those initiating these meetings to make reasoned, informed and effective decisions regarding the choice of online platforms*". This confirms the idea that when creating any new tool, especially a digital one, the user's capability needs to be taken into

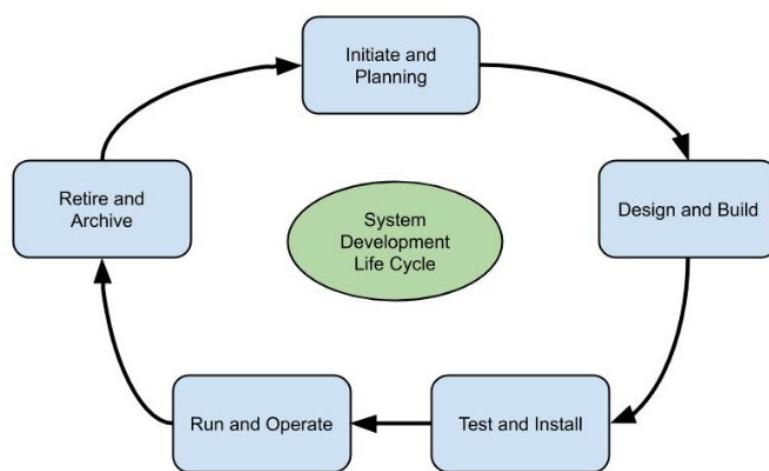
consideration as well as how easy the new process is to learn, often change will be rejected because it strays too far from the original idea and users are reluctant to change.

At the site there is no plan to transition this process to an online version and the plan, once able, is to return to the in-person whiteboard meeting as the current solution using Microsoft OneNote, is not up to standard. This is due to the limitations of OneNote that was previously mentioned, outweighing the positives that solution brings. This means that an online tool would be considered if it had the key aspects of visibility across the site, improved recording of data and then displaying it in an easy and effective way. As discussed by Geyer et al., (2001) "*Meetings are a crucial communication and coordination activity of teams. While computer support for distributed conferences has been investigated, meetings involve much more than the synchronous act of discussion. Meetings relate to all of the various activities of a team, from reporting and scheduling tasks, to raising and debating issues, to reviewing documents*". This supports the idea that both the current in person and remote meetings are not suitable to support the desired outcome. It also highlights that there isn't currently the availability of a tool to solve this issue and therefore it will require the creation of something bespoke just for the CMF and more specifically within the scope of this project, it will be produced for the IT business function.

Proposed Work

The tool proposed will be a web-based client that will be responsible for all of the actions of the in-person meetings (as described in figure 1), whilst also developing new sections and enhancing current methods using data analytics and data tracking to create a broader image of how the IT business function is working. All data used in this system will be stored using a secure database system that will be thoroughly reviewed and evaluated to ensure the correct solution for this product. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. The system will be based on requirements set out by the CMF during a requirements capture and will follow the System Development Life Cycle framework set out by the CMF, see figure 3.

Figure 3 – The System Development Life Cycle used at the CMF. (Singh, 2020)



As shown in figure 3 there will be several stages to the development of the system, each with its own set of documents to complete as per the CMF's policy. Figure 4 shows the documents that will be created for each stage of the System Development Life Cycle. In this project I will be focusing on the first three stages of the System Development Life Cycle – Initiate and Planning, Design and Build and Test and Install.

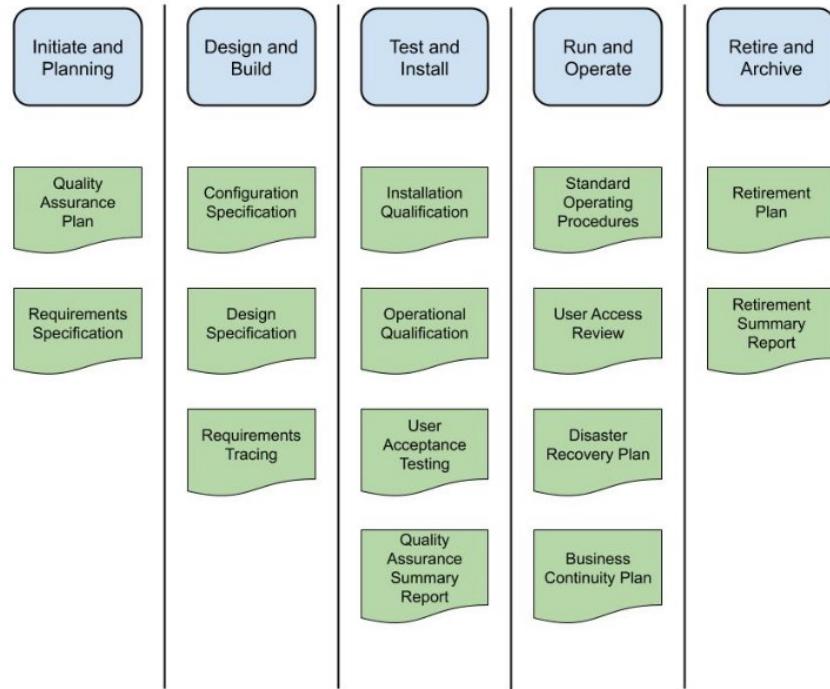


Figure 4 – The documents generated in each phase of the System Development Life Cycle at the CMF. (Singh, 2020)

Alongside the CMF's System Development Life Cycle, creating a user-friendly interface by employing human-computer interaction principles such as Cognitive Walkthroughs and Heuristic Evaluations is a vital step to ensure that everyone's computer literacy is taken into consideration. The literature review for this project will cover several aspects of the development of the system, one of which being an analysis of commercial off-the-shelf digital meeting systems will take place to identify key features that are utilised in this area and how they can be potentially included in the solution. Alternative approaches to digital meetings and the comparison with face-to-face meetings will also be scrutinised and evaluated. Another aspect that will be researched will be the System Development Life Cycle methodology that would be most appropriate for developing a tool for a pharmaceutical manufacturing facility, which has to take into account restrictions imposed by government and health authorities.

Implementing this tool with a client comes with a range of issues but alongside the development process, a range of testing methods will be utilised, including the installation and operational qualification of the software, alongside user acceptance testing to ensure that the product meets the client's needs. Requirements tracing will be pivotal to ensure that the product matches what it was originally set out to achieve.

Aim of the Project

To investigate and analyse the importance of how collaborative meetings bring information and issues to the relevant teams within a manufacturing environment.

To develop a web-based meeting tool with digital data tracking and analytics for a pharmaceutical manufacturing facility.

Objectives

1. Perform a requirements capture for a new digital “Tier” system focusing on the IT department and their specific areas of need.
2. Conduct a Literature Review to analyse all relevant documentation.
3. Conduct research into how the current system is used and identify key features and areas for improvement.
4. Investigate and analyse existing collaborative meeting solutions.
5. Research and evaluate the most appropriate tools to develop the client-side and server-side parts of the tool, as well as the database used.
6. Create an entity relationship diagram and data dictionary for the database.
7. Use Human Computer Interaction and User Experience principles to design an appropriate user interface.
8. Develop a collaborative meeting tool that meets the requirements as set out in the requirements specification.
9. Conduct an appropriate level of testing both with and without user interaction to ensure the product is fit for purpose.
10. Develop a set of System Development Life Cycle documents inline with the CMF’s policy.
11. Complete an evaluation of the product.
12. Complete an evaluation of the project as a whole, including project management.

Skills

Web Development

Throughout university I have undertaken several modules which involve server-side web programming, such as Web Technologies, Web Programming and Web Application Integration. Learning several languages and design principles throughout my time at university and constantly pushing my knowledge through several assignments and pieces of coursework.

Databases

In my first year at university I undertook the module Relational Databases which taught me the basics of databases, such as queries and database design. Second year modules such as Software Engineering and Web Programming expanded on this knowledge, whilst also touching on some database basics throughout my placement year with the CMF.

User Experience and Requirements

In my second and third year at university respectively, I undertook the modules Human Computer Interaction and Smart Technologies and Agile UX Design. Both modules have taught me the basics on how to identify what a user requires from a system. I have then put this into practice in my placement, where I have performed multiple requirements capture exercises and helped shape the development of live systems.

Project Management

My university modules Systems Analysis and Software Engineering required performing project manager duties; whilst my time at the CMF was heavily focused on large scale project management. One instance being that I was responsible for a quarter of a million-pound implementation of a brand-new automation system, which required working effectively with a larger team to ensure we met the time and budget constraints, giving me vital experience.

Academic Report Creation

Throughout my academic career I have written many reports which have all had specific and unique requirements as well as during my time at the CMF, where I have had to produce many reports and pieces of writing. This skill will be further developed with my other modules throughout this year.

System Development Life Cycle

This concept was first introduced to me in the Systems Analysis module in my first year of university. In the Software Engineering module in second year these principles were further utilised. Then during my placement year at the CMF this became a key skill and a part of every project and process I was involved in, therefore gaining key experience with its principles.

Sources of Information/Bibliography

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- Singh, J. (2020). Visual Representation of a Tier Board. [Created 02 Nov 2020].
- Singh, J. (2020). The CMF System Development Life Cycle. [Created 01 Nov 2020].
- Singh, J. (2020). Documents generated in each phase of the System Development Life Cycle. [Created 01 Nov 2020].
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Resources Required

Workstation

A workstation will be required for all stages of the development process and will be the key tool throughout the project. Primarily my personal Windows PC will be used as the workstation for this project.

Web Development Integrated Development Environment

An Integrated Development Environment will be needed to write and compile my code in order to create the product for this project.

Web Server

A web server will be required to host my website, so that is viewable by my client and my supervisor.

Database

A secure database will be needed to store all relevant information recorded and used by my application.

Microsoft Office (Word, Excel and Teams)

Microsoft's Office suite of applications will be required for the report creation, project schedule and communicating with my project supervisor.

Diagram Creation Tool

A diagram creation tool will be needed to enable me to create the relevant diagrams for the project, such as UML diagrams and any wireframes.

Client Workstation/Display

A workstation or display method will be required for user acceptance testing as well as displaying the final product to the client.

Client Dummy Data

Although I cannot use production data from the CMF, I will require some dummy data to populate the database to demonstrate my application. The data will be relevant and detail everything needed without being linked any real data from the CMF.

Structure and Contents of Project Report

Title Page

Authorship Declaration

Acknowledgements

Abstract

An overview of the report and the project, including how the report is structured, the aim of the project and touching upon the conclusions and the overall success of the project.

Contents Page

Introduction

Introduces the purpose and scope of the project, clarifying the aims and objectives, looking at what the project is set out to achieve and how I propose to do this. The introduction will also summarise the background of the project and explore what product will be produced.

Analysis

Literature Review

This chapter will look at relevant literature, evaluating other methods of collaborative meeting spaces, looking specifically at their successes and failures and ultimately how my product can be improvement on previous work.

Requirements Capture

The requirements capture will focus on gathering the specific details of what is needed from the product by the client. This chapter will look at the different human computer interaction methods and CMF polices that I will use to approach this capture. It will then detail the outcome from this process and prioritise the requirements.

Tools and Techniques

In this section I will look at what the most appropriate method for developing my work will be. This will detail different proposed methods and the outcome of what programming languages and database system I will use.

Synthesis

Design

The design of the product will be detailed, based upon findings from the Analysis phase and key design documents such as the entity relationship diagram, data dictionary and class diagram will be generated to show the structure of the product. Final design solutions for the user interface will be identified and justification will be provided as to why those designs were chosen.

Development and Implementation

This section will focus on the development of the software product, detailing methodologies and practices used to help aid this process.

Testing

This section will look at the testing processes used and the outcome of those approaches. Detail as to what mythologies and documents generated will also be identified, followed by a review as to the success of the testing.

Evaluation

A thorough evaluation of both the product and the project process will take place. The product evaluation will focus on the creation of the product and if it meets the initial requirements set out in the Analysis phase. The project process evaluation will assess the project management and if the project met the aims and objectives set in this document.

Conclusions and Recommendations

The conclusion will look at the overall outcomes of the project, the successes and failures and recommendations will be identified to support the rollout of the product to a larger scale and what the next steps would be and any future improvements that should be made.

References

List of Appendices

1. Terms of Reference
2. Requirements Specification
3. Design Documentation – including Entity Relationship Diagram and Data Dictionary
4. Source Code
5. CMF SDLC Documents
 - a. Quality Assurance Plan
 - b. Requirements Specification
 - c. Configuration Specification
 - d. Design Specification
 - e. Requirements Tracing
 - f. Installation Qualification Testing
 - g. Operational Qualification Testing
 - h. User Acceptance Testing
 - i. Quality Assurance Summary Report

Marking Scheme

This project will be a General Computing Project and the marking scheme below outlines what my project will be marked against.

Report:

Abstract & Introduction 5%

Analysis 30%

Synthesis 30%

Evaluation & Conclusions 30%

Presentation 5%

Product - 30%

Fitness for Purpose - 50%

- Meeting of requirements – 40%
- Human Computer Interaction – 30%
- Functionality of the tool – 30%

Build Quality - 50%

- Requirements specification & analysis – 30%
- Design documents (ERD, Data Dictionary, UML Diagrams) – 30%
- Code quality – 15%
- Presentation of Code – 5%
- Test plans and results – 20%

Viva - 10%

Project Plan – Schedule of Activities

Key		Assessment																									
Deadline	*	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W1	W2
Not Started																											
In Progress																											
Complete																											
Initiate	The Initiate phase of the project	Time (hrs)												Semester 1												Semester 2	
Arrange weekly meeting Confirmation of Supervisor and Project Idea	Setup time with Supervisor for our Semester.	0.5																									
Project Initiation Document	Send confirmation of Project Supervisor and Project Idea	0.5																									
Review of PID	Summarise chosen idea on a simple Project Initiation Document, state the main aim of the project, the rationale, main challenge, type of product, resources and any external body involved.	2																									
Revise PID	Complete any revisions as suggested in the PID review.	0.5																									
Submit PID	Submission of PID to Blackboard	0.5																									
Planning	The Planning phase of the project	81.5												*													
Terms Of Reference Creation	The TOR is what the project will be measured against and consists of the following sections: Project title, background to project, proposed work, aims of project, objectives, skills, sources of information, resources, structure and contents of project report, marking scheme and project plan.	15																									
Complete Ethics Form	Complete online ethics form to ensure that my project is inline with university standards and then gain ethical approval for my project to go ahead.	3																									
Complete Risk Assessment	This is as required based on my project and ethics outcome.	3																									
Schedule TOR Review	Setup time to review TOR with Supervisor and second marker.	0.5																									
TOR Review	suggest any revisions that need to be made.	1																									
Revise TOR	Complete any revisions as suggested in the TOR Review.	3																									
Upload Revised TOR	Upload the revised TOR document to Client Requirements Capture.	0.5																									
Work on Analysis Chapters	Conduct the client requirements capture, the reader with information they will need to know in order to appreciate and understand the work you have done in the rest of the project.	50																									

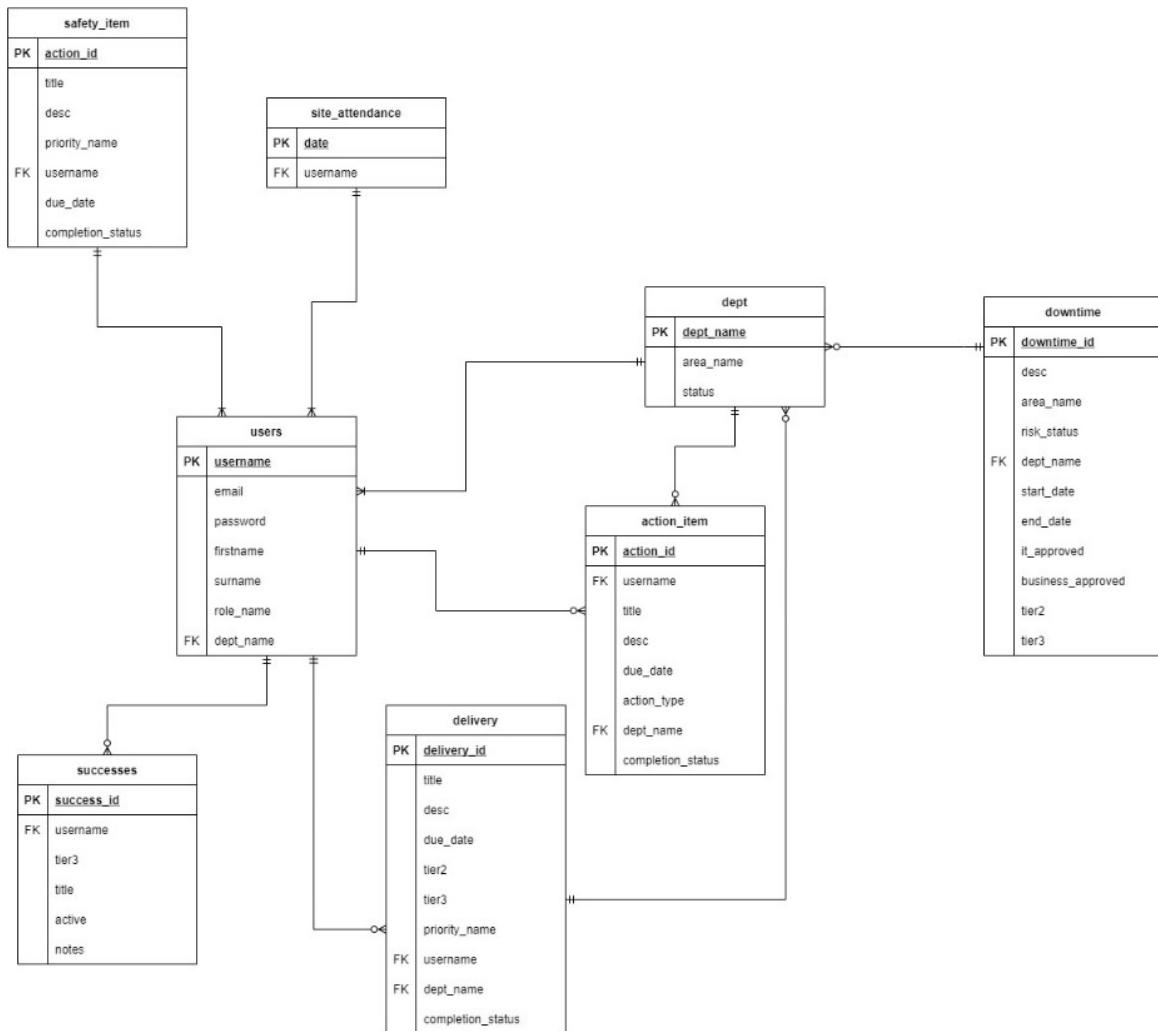
Key	
Deadline	*
Not Started	
In Progress	
Complete	

Item	Detail	Time (Hrs)	Semester 1												Semester 2												Assessment
			W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	
Submit Analysis Chapters to Supervisor	Share the analysis chapters with Supervisor for review and feedback.	0.5																									
Design and Build	The Design and Build phase of the project	164																									
Create UML Diagrams	Creation of UML Diagrams to illustrate the structure of the software.	10																									
Create E/RD and Data Dictionary	Creation of Entity Relationship Diagram and Data Dictionary to illustrate the setup of the Database	10																									
Creation of Database	Creation of Database in accordance to the RRD and Data Dictionary	10																									
Development of Server Side	Development of Server Side functionality of the Website	40																									
Development of Client Side	Development of Client Side functionality of the Website	40																									
Development Meeting	Meeting with Client to discuss progress and future steps	2																									
Make final changes based on Client feedback	Make changes to the product based on feedback from Client	30																									
Final Client Development Meeting	progress and any final changes before testing	2																									
Make final changes	Make final changes to the product based on Feedback from Client	20																									
Test and Install	The Test and Install phase of the project	60																									
Installation Qualification	Qualification on the client's workstation	10																									
Operational Qualification	Qualification on the client's workstation	10																									
User Acceptance Testing	To perform the user acceptance Testing with the client	15																									
Make any changes from Testing	To make any changes needed based on testing outcomes	25																									
Report	The Report phase of the project	88																									
Introduction	Creation of the Introductory Chapters	8																									
Synthesis	Creation of the Synthesis Chapters	40																									
Evaluation	Creation of the Evaluation Chapters	15																									
Conclusions	Creation of the Conclusion Chapters	10																									
Abstract	Creation of the Abstract	3																									
Send report for Feedback	Send report to Supervisor for review	1																									
Make changes based on Feedback	Make changes to the report based on feedback from Supervisor	10																									
Submit Report	Submission of Report to Blackboard	1																									
Viva	The Viva phase of the project	2																									
Organise Viva	Organise a date with Supervisor and second marker to conduct viva	1																									
Viva Presentation	Conduct the viva	1																									
	Total Time	400																									

Appendix 2 – Interview Questions

- 1. Just for some background, can I ask what your role is within the company?**
- 2. And how long have you held that role?**
- 3. Have you had many previous roles within the company?**
- 4. When you were first introduced to the Tier process, did it seem a straightforward process that had a logical flow?**
- 5. Could you briefly explain your understanding of the Tier process?**
- 6. What Tier meetings do you attend?**
- 7. As a whole, do you feel that the Tier process is an effective way of communicating information to the relevant streams of people?**
- 8. Comparing the in-person process to the Teams and OneNote solution, what was more effective by being in person?**
- 9. Likewise comparing the in-person process to the Teams and OneNote solution, what was more effective by performing the meeting via Teams and OneNote?**
- 10. Given the chance, what would you change about the process?**
- 11. If an online web-based tool were to be developed, what features of the current process do you believe are essential to be incorporated?**
- 12. Finally, if an online web-based tool were to be developed, what new features would you like to see be incorporated?**

Appendix 3 – Entity Relationship Diagram



Appendix 4 – User Scenarios

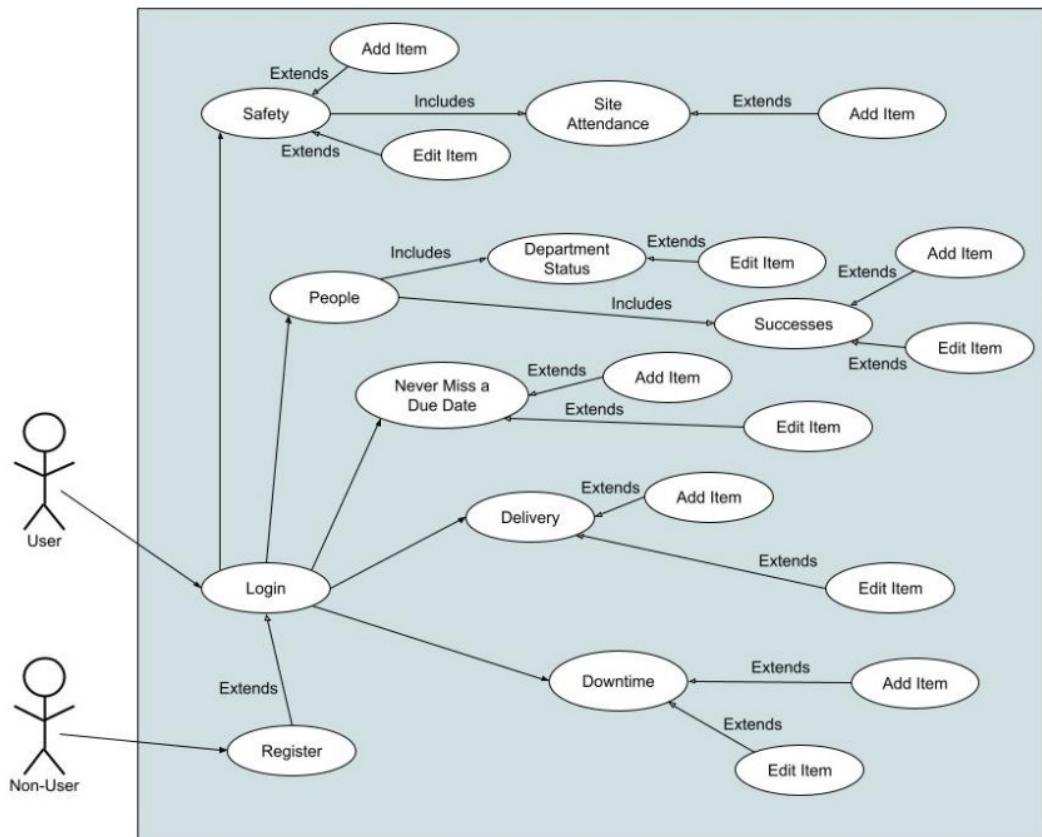
User Scenario 1

Jane is an infrastructure engineer working in the GIO team. She receives a report that the Wide Area Network is being disrupted, causing issues with applications across the facility. She needs a method of making the wider team aware of what is going on, whilst tracking the action herself. She needs to be able to update this remotely as she is currently down in the production facility and will not be able to make it to the department's Tier meeting that morning.

User Scenario 2

Jack is the department lead at a manufacturing facility. He wants to share information about what is happening across the site with the rest of his team. There have been several safety and quality incidents across the past few days and Jack wants a method of sharing all of these quickly and conveniently. He holds a meeting every Monday and Thursday morning with his team but the other team members sound disinterested if he just speaks about the issues. He wants a visual method of displaying all the information to his team as well as method of tracking the actions that are being flagged.

Appendix 5 – Use Case Diagram



Appendix 6 – Use Case Descriptions

Login

Use Case	Login
Summary	This use case looks at the user logging into the system.
Actor(s)	User
Trigger	User wants to look at any of the main content sections.
Primary Scenario	<ol style="list-style-type: none">1. A user goes to the My Account page from the Dashboard.2. User enters email in email input box (Alternative: user enters an incorrect email).3. User enters password in password input box (Alternative: user enters an incorrect password).4. User clicks login and is redirected to the Dashboard.
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user enters incorrect email<ol style="list-style-type: none">a. An error message.b. The user corrects the email or password and logs in.2. Alternative: user enters incorrect password<ol style="list-style-type: none">a. The form shows an error message telling the user that the email or password is incorrect.b. The user corrects the email or password and logs in.
Exceptional Scenario	None
Pre-conditions	The user is not previously logged into their account.
Post-conditions	The user has successfully logged into their account.
Assumptions	The user has an account.

Register User

Use Case	Register User
Summary	This use case looks at creating a new account in the system.
Actor(s)	Non-User
Trigger	User wants to register a new account in the system
Primary Scenario	<ol style="list-style-type: none"> 1. A non-user goes to the My Account page from the Dashboard. 2. Non-user inputs a username (Alternative: non-user enters a username that's already taken). 3. Non-user inputs an email. 4. Non-user inputs a password. 5. Non-user inputs a first name. 6. Non-user inputs a surname. 7. Non-user inputs a role. 8. Non-user inputs a department. 9. Non-user clicks register and is asked to login (Alternative: non-user fails to enter one of the details).
Alternative Scenario	<ol style="list-style-type: none"> 1. Alternative: non-user enters a username that's already taken <ol style="list-style-type: none"> a. An error message. b. The non-user corrects the username and proceeds. 2. Alternative: non-user fails to enter one of the details. <ol style="list-style-type: none"> a. An error message. b. The non-user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	The non-user does not previously have an account.
Post-conditions	The non-user now has an account and is now a user.
Assumptions	The non-user has an email.

Add Safety Item

Use Case	Add Safety Item
Summary	This use case looks at creating a new safety item.
Actor(s)	User
Trigger	User wants to add a new safety item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the Safety page from the Dashboard.2. User clicks on 'Add New Safety Item'.3. User inputs an item title.4. User inputs an item description.5. User inputs an item priority.6. User inputs an item username.7. User inputs an item due date.8. User inputs an item completion status9. User clicks save and is redirected back to the safety page. (Alternative: user fails to enter one of the details).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user fails to enter one of the details.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	None
Post-conditions	The user's safety item is added to the system.
Assumptions	The user is logged in.

Edit Safety Item

Use Case	Edit Safety Item
Summary	This use case looks at editing an existing safety item.
Actor(s)	User
Trigger	User wants to edit a safety item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the Safety page from the Dashboard.2. User clicks on 'Edit Safety Item'.3. User edits one or more of the fields.4. User clicks save and is redirected back to the safety page. (Alternative: user leaves one of the fields blank).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user leaves one of the fields blank.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	There is an existing safety item.
Post-conditions	The user's safety item is changed in the system.
Assumptions	The user is logged in.

Add Site Attendance

Use Case	Add Site Attendance
Summary	This use case looks at adding a new site attendance.
Actor(s)	User
Trigger	User wants to add a new safety item in the system.
Primary Scenario	<ol style="list-style-type: none"> 1. User goes to the Safety page from the Dashboard. 2. User clicks on 'Add New Site Attendance'. 3. User inputs a username. 4. User inputs a date. 5. User clicks save and is redirected back to the safety page. (Alternative: user fails to enter one of the details).
Alternative Scenario	<ol style="list-style-type: none"> 1. Alternative: user fails to enter one of the details. <ol style="list-style-type: none"> a. An error message. b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	None
Post-conditions	The user's site attendance is added to the system.
Assumptions	The user is logged in.

Edit Department Status

Use Case	Edit Department Status
Summary	This use case looks at editing a department's status.
Actor(s)	User
Trigger	User wants to edit a department status in the system.
Primary Scenario	<ol style="list-style-type: none"> 1. User goes to the People page from the Dashboard. 2. User clicks on 'Edit Department Status'. 3. User edits the status field. 4. User clicks save and is redirected back to the safety page.
Alternative Scenario	None
Exceptional Scenario	None
Pre-conditions	There is an existing department.
Post-conditions	The department status is changed in the system.
Assumptions	The user is logged in.

Add Success Item

Use Case	Add Success Item
Summary	This use case looks at creating a new success item.
Actor(s)	User
Trigger	User wants to add a new success item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the People page from the Dashboard.2. User clicks on 'Add New Success'.3. User inputs a title.4. User inputs notes.5. User inputs if the item goes to tier 3.6. User inputs a username.7. User inputs if the item is active.8. User clicks save and is redirected back to the People page. (Alternative: user fails to enter one of the details).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user fails to enter one of the details.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	None
Post-conditions	The user's success item is added to the system.
Assumptions	The user is logged in.

Edit Success Item

Use Case	Edit Success Item
Summary	This use case looks at editing an existing success item.
Actor(s)	User
Trigger	User wants to edit a success item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the People page from the Dashboard.2. User clicks on 'Edit Successes'.3. User edits one or more of the fields.4. User clicks save and is redirected back to the People page. (Alternative: user leaves one of the fields blank).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user leaves one of the fields blank.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	There is an existing success item.
Post-conditions	The user's success item is changed in the system.
Assumptions	The user is logged in.

Add NMADD Item

Use Case	Add NMADD Item
Summary	This use case looks at creating a new Never Miss A Due Date item.
Actor(s)	User
Trigger	User wants to add a new NMADD item in the system.
Primary Scenario	<p>1. User goes to the NMADD page from the Dashboard. 2. User clicks on 'Add New NMADD Item'. 3. User inputs a title. 4. User inputs a description. 5. User inputs the due date. 6. User inputs a username. 7. User inputs the type of action. 8. User inputs the department the action belongs to. 9. User inputs how far completed the action is. 10. User clicks save and is redirected back to the NMADD page. (Alternative: user fails to enter one of the details).</p>
Alternative Scenario	<p>1. Alternative: user fails to enter one of the details.</p> <ul style="list-style-type: none"> a. An error message. b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	None
Post-conditions	The user's NMADD item is added to the system.
Assumptions	The user is logged in.

Edit NMADD Item

Use Case	Edit NMADD Item
Summary	This use case looks at editing an existing Never Miss A Due Date item.
Actor(s)	User
Trigger	User wants to edit a NMADD item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the NMADD page from the Dashboard.2. User clicks on 'Edit NMADD Item'.3. User edits one or more of the fields.4. User clicks save and is redirected back to the NMADD page. (Alternative: user leaves one of the fields blank).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user leaves one of the fields blank.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	There is an existing NMADD item.
Post-conditions	The user's NMADD item is changed in the system.
Assumptions	The user is logged in.

Add Delivery Item

Use Case	Add Delivery Item
Summary	This use case looks at creating a new Delivery item.
Actor(s)	User
Trigger	User wants to add a new Delivery item in the system.
Primary Scenario	<p>1. User goes to the Delivery page from the Dashboard.</p> <p>2. User clicks on 'Add New Delivery Item'.</p> <p>3. User inputs a title.</p> <p>4. User inputs a description.</p> <p>5. User inputs the due date.</p> <p>6. User inputs a username.</p> <p>7. User inputs the priority of the action.</p> <p>8. User inputs the department the action belongs to.</p> <p>9. User inputs if it needs to be reported to Tier 2.</p> <p>10. User inputs if it needs to be reported to Tier 3.</p> <p>11. User inputs how far completed the action is.</p> <p>12. User clicks save and is redirected back to the Delivery page.</p> <p>(Alternative: user fails to enter one of the details).</p>
Alternative Scenario	<p>1. Alternative: user fails to enter one of the details.</p> <p>a. An error message.</p> <p>b. The user fills in all fields and proceeds.</p>
Exceptional Scenario	None
Pre-conditions	None
Post-conditions	The user's Delivery item is added to the system.
Assumptions	The user is logged in.

Edit Delivery Item

Use Case	Edit Delivery Item
Summary	This use case looks at editing an existing Delivery item.
Actor(s)	User
Trigger	User wants to edit a Delivery item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the Delivery page from the Dashboard.2. User clicks on 'Edit Delivery Item'.3. User edits one or more of the fields.4. User clicks save and is redirected back to the Delivery page. (Alternative: user leaves one of the fields blank).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user leaves one of the fields blank.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	There is an existing Delivery item.
Post-conditions	The user's Delivery item is changed in the system.
Assumptions	The user is logged in.

Add Downtime Item

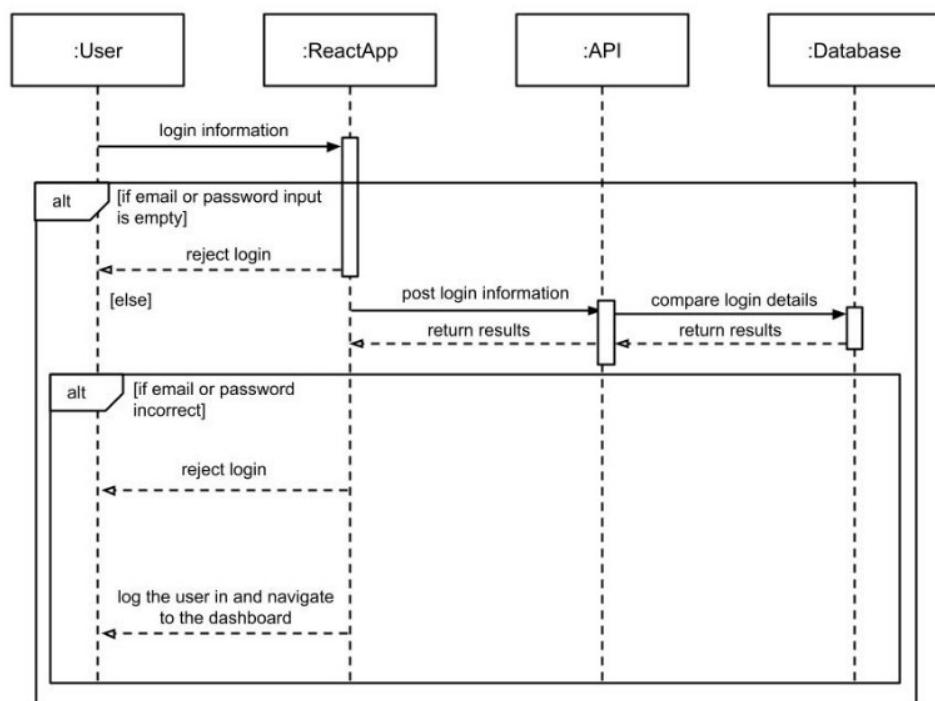
Use Case	Add Downtime Item
Summary	This use case looks at creating a new Downtime item.
Actor(s)	User
Trigger	User wants to add a new Downtime item in the system.
Primary Scenario	<p>1. User goes to the Downtime page from the Dashboard. 2. User clicks on 'Add New Downtime Item'. 3. User inputs a description. 4. User inputs the area of the downtime. 5. User inputs the start date. 6. User inputs the end date. 7. User inputs the department the action belongs to. 8. User inputs the risk level. 9. User inputs if the downtime has been approved by IT. 10. User inputs if the downtime has been approved by the business. 11. User inputs if it needs to be reported to Tier 2. 12. User inputs if it needs to be reported to Tier 3. 13. User clicks save and is redirected back to the Downtime page.</p> <p>(Alternative: user fails to enter one of the details).</p>
Alternative Scenario	<p>1. Alternative: user fails to enter one of the details.</p> <ul style="list-style-type: none"> a. An error message. b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	None
Post-conditions	The user's Downtime item is added to the system.
Assumptions	The user is logged in.

Edit Downtime Item

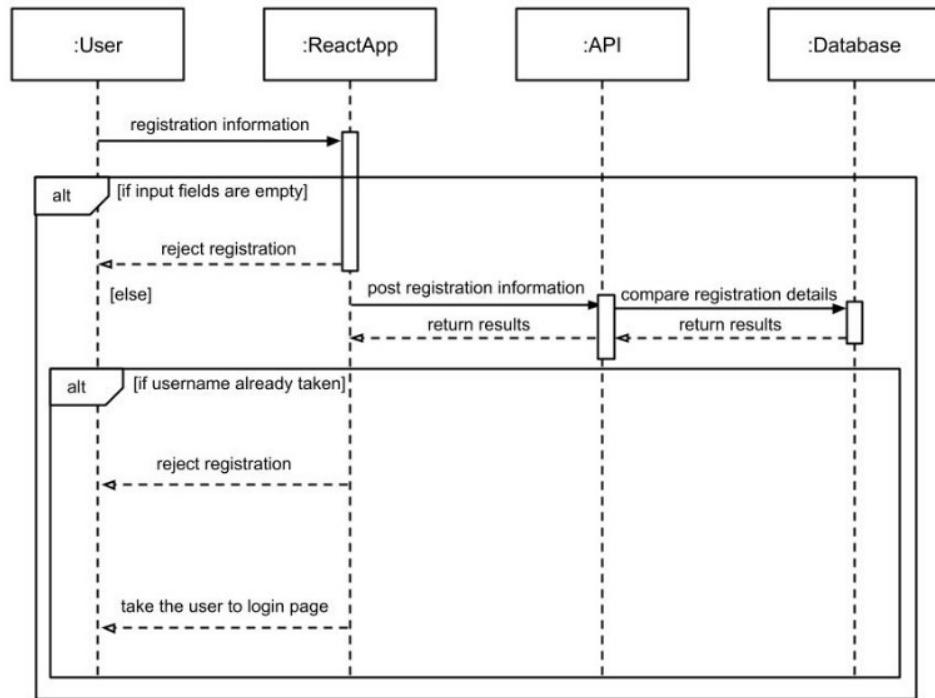
Use Case	Edit Downtime Item
Summary	This use case looks at editing an existing Downtime item.
Actor(s)	User
Trigger	User wants to edit a Downtime item in the system.
Primary Scenario	<ol style="list-style-type: none">1. User goes to the Downtime page from the Dashboard.2. User clicks on 'Edit Downtime Item'.3. User edits one or more of the fields.4. User clicks save and is redirected back to the Downtime page. (Alternative: user leaves one of the fields blank).
Alternative Scenario	<ol style="list-style-type: none">1. Alternative: user leaves one of the fields blank.<ol style="list-style-type: none">a. An error message.b. The user fills in all fields and proceeds.
Exceptional Scenario	None
Pre-conditions	There is an existing Downtime item.
Post-conditions	The user's Downtime item is changed in the system.
Assumptions	The user is logged in.

Appendix 7 – Sequence Diagrams

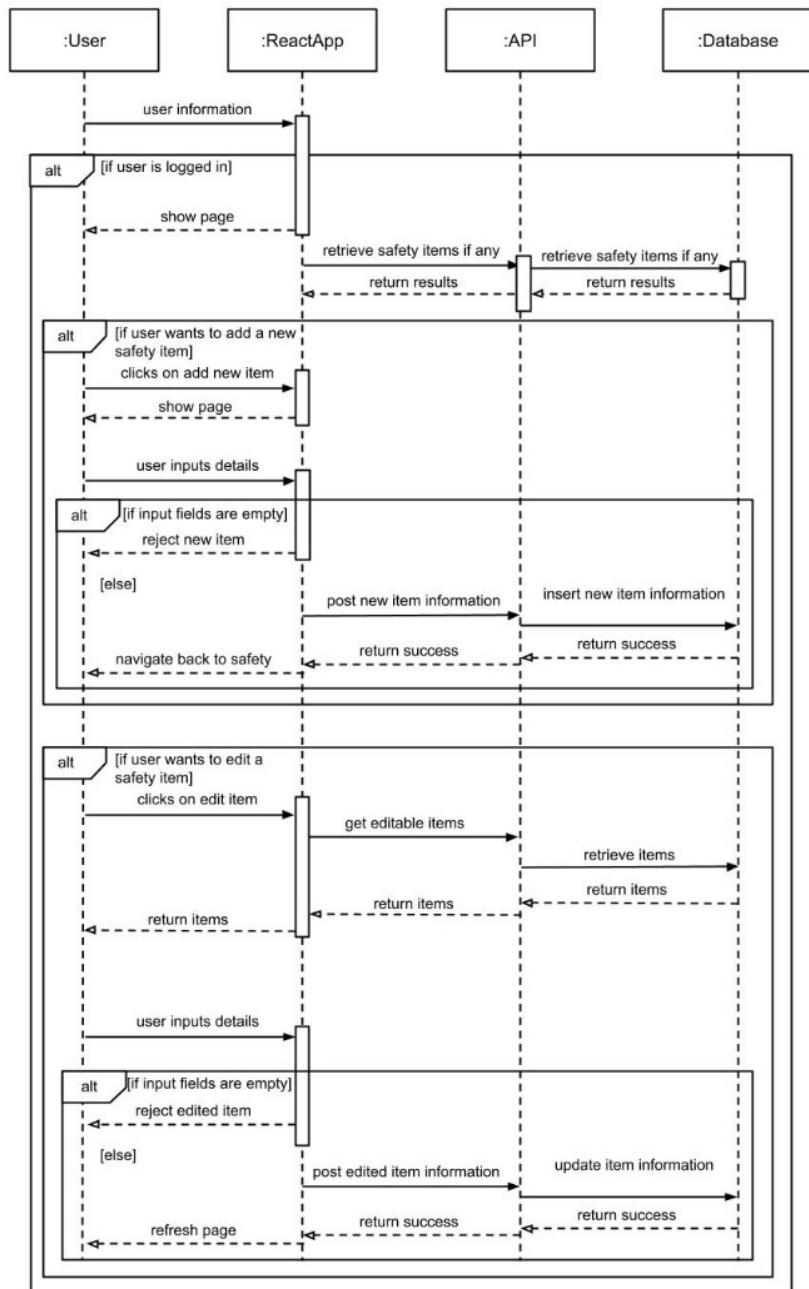
Login



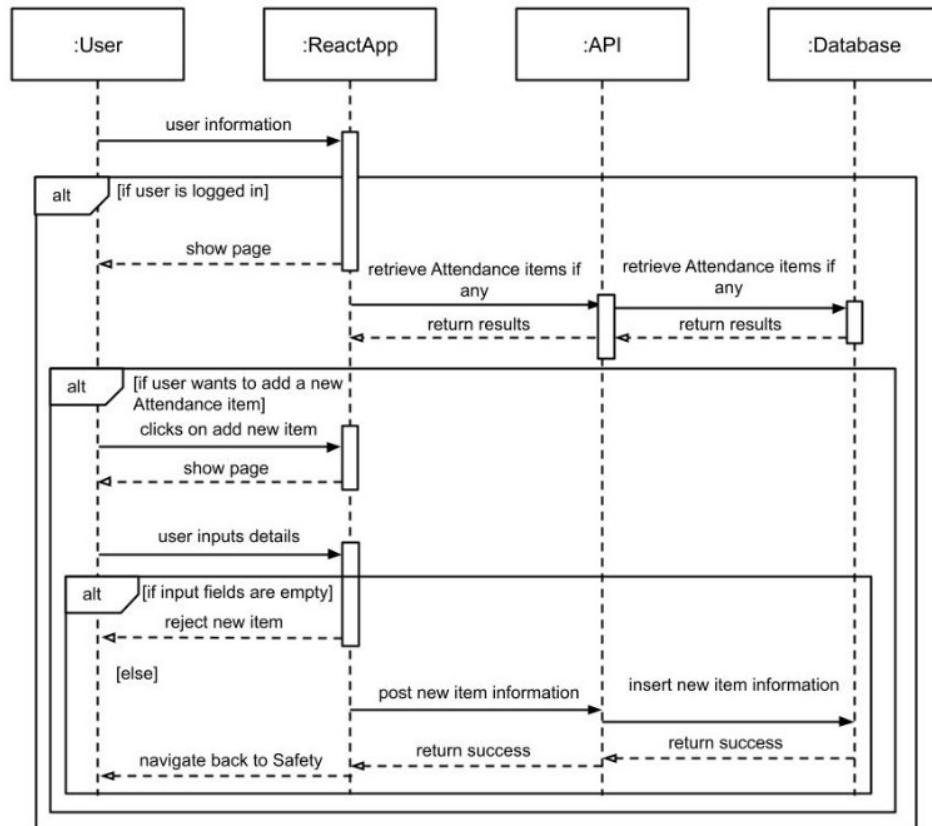
Register User



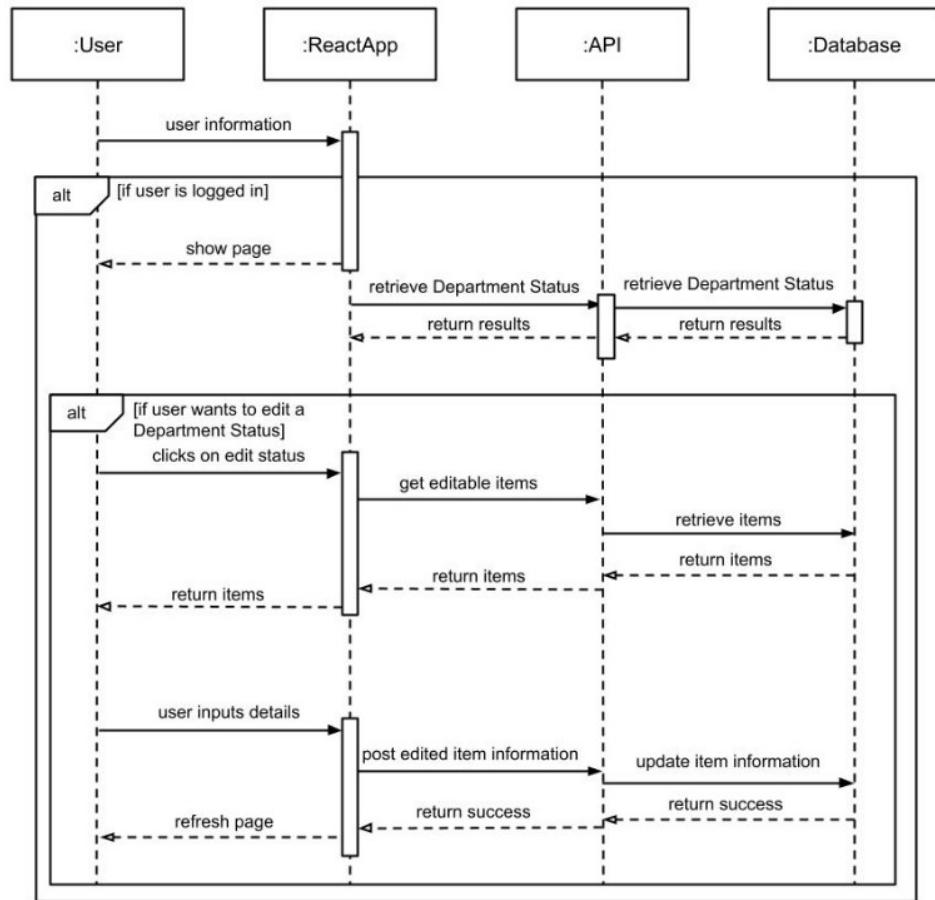
Safety



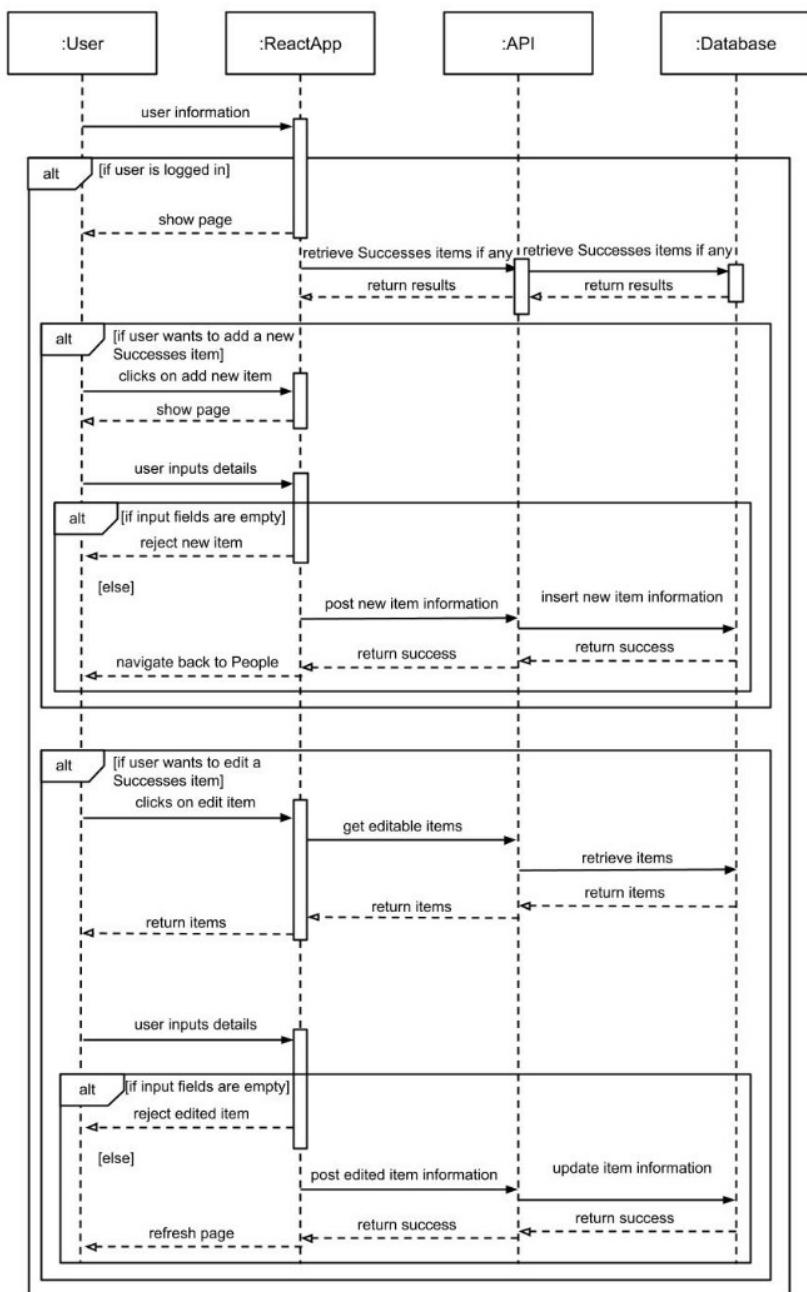
Site Attendance



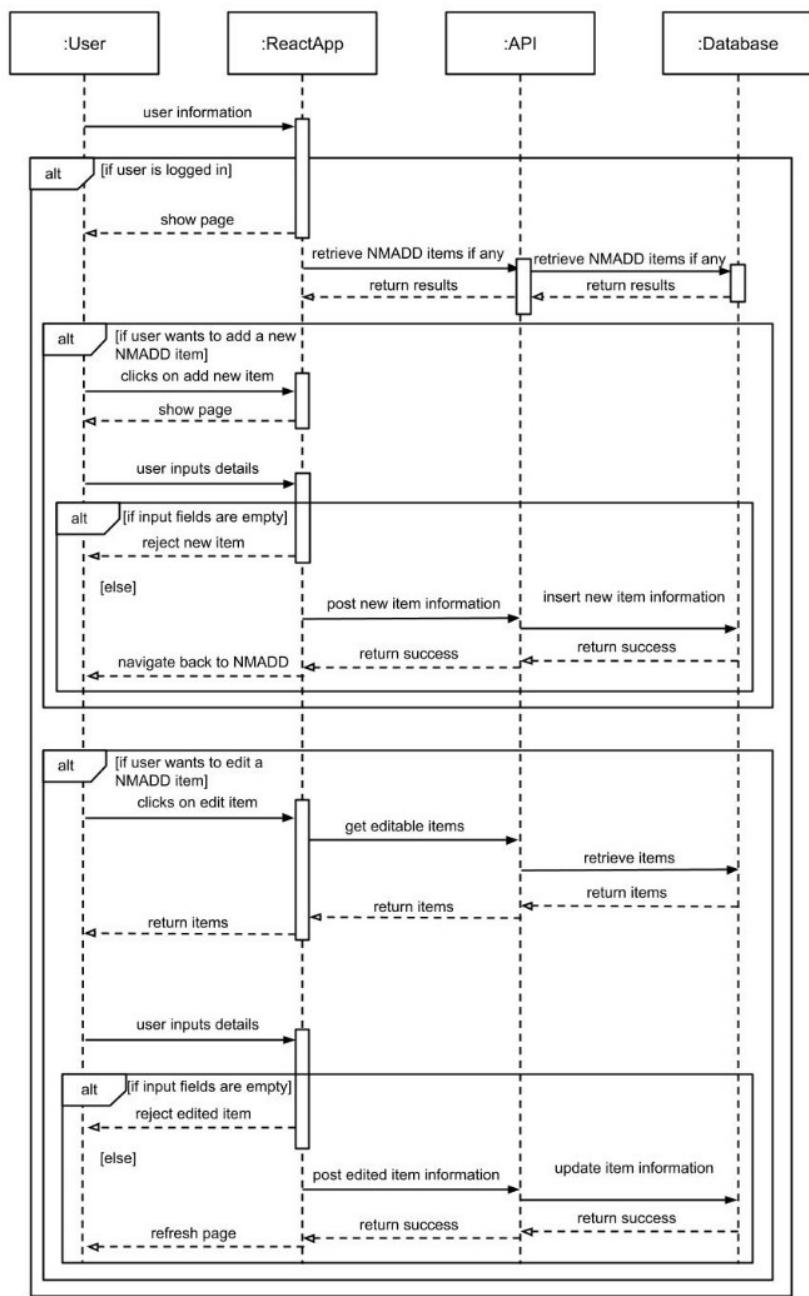
Department Status



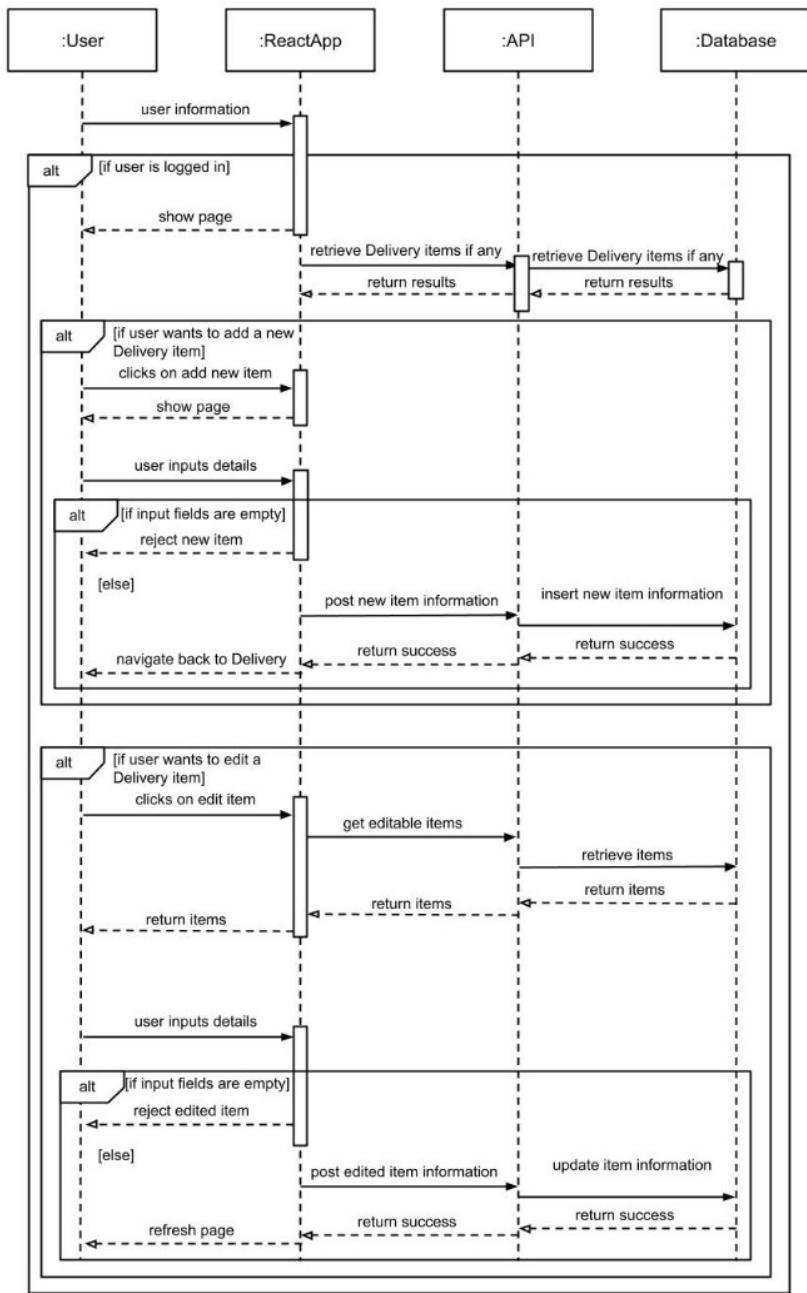
Successes



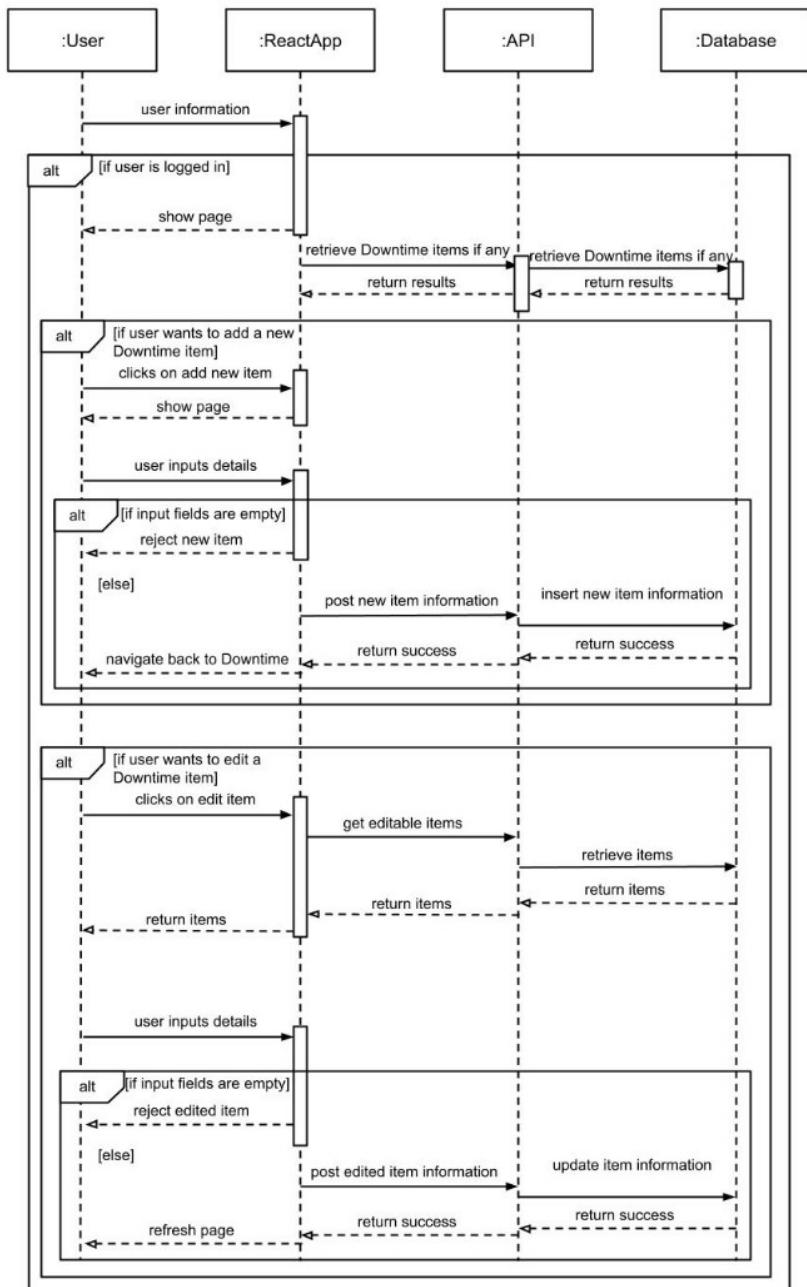
NMADD



Delivery



Downtime



Appendix 8 – Prototypes

Dashboard

The screenshot shows the Digital Tier Dashboard interface. At the top, there is a navigation bar with tabs: Home (selected), Safety, People, NMADD, Delivery, Downtime, and My Account. Below the navigation bar, there is a section titled "Standard Working Agenda" which contains a brief description and a bulleted list of agenda topics. To the right of this is a "NMADD Actions" section featuring a bar chart with four categories: New (pink), Not Started (blue), In Progress (green), and Overdue (red). Below these are two more sections: "Upcoming Actions" and "Latest Safety Events".

Standard Working Agenda

This is where the standard agenda for each tier meeting will be displayed. This will be generated throughout the project process and will be detailed within the synthesis.

The standard working agenda will cover topics such as:

- Contemporaneous updating of information.
- Accurate information being input.
- Available information - all actions are assessed for synthesis.
- Actions should be escalated if they will not be completed on time.
- Information should only presented at tier meeting if it is not redundant.

NMADD Actions

Status	Count
New	1
Not Started	1
In Progress	1
Overdue	1

Upcoming Actions

GCM TR#657142 - Hardness Testers Installation	Due 28 Feb 2021	In Progress
QSAT 152375 - Secure Desktop	Due 03 Mar 2021	Not Started
SOP 14.135 - Administration of Serialisation Systems	Due 14 Mar 2021	New

Latest Safety Events

COVID-19 Incident
Slips, trips and Falls
Environmental Incident

Safety

The screenshot shows the Digital Tier Safety interface. At the top, there is a navigation bar with tabs: Home (selected), Safety (selected), People, NMADD, Delivery, Downtime, and My Account. Below the navigation bar, there are four main sections: "Latest Safety Events", "Site Attendance", "Outstanding Actions", and "Site Attendance Trends".

Latest Safety Events

COVID-19 Incident Due: 17 Apr 2021
Slips, Trips and Falls Due: 27 Apr 2021
Environmental Due: 10 May 2021

Site Attendance

Joe Bloggs Due: 17 Apr 2021
John Smith Due: 27 Apr 2021
Joe Bloggs Due: 10 May 2021

Outstanding Actions

New	1
Not Started	1
In Progress	1
Overdue	1

Site Attendance Trends

People

The screenshot shows the 'People' section of the Digital Tier interface. At the top, there is a navigation bar with tabs: Home, Safety, People (which is selected), NMADD, Delivery, Downtime, and My Account. To the left of the tabs is a logo of a lightbulb with the text 'Digital Tier'. Below the navigation bar, there is a 'Department Status' section showing five circular icons: A&IT (green), GIO (orange), AMS (red), QAIT (green), and LCM (green). The main content area is divided into three sections: 'Successes' (containing Software Fix by Joe Bloggs, Network Upgrade by Jane Doe, and Reduced Downtime by John Smith), 'Successes for Tier 3' (containing Software Fix by Joe Bloggs and Network Upgrade by Jane Doe), and a large empty space.

NMADD

The screenshot shows the 'NMADD' section of the Digital Tier interface. At the top, there is a navigation bar with tabs: Home, Safety, People, NMADD (which is selected), Delivery, Downtime, and My Account. To the left of the tabs is a logo of a lightbulb with the text 'Digital Tier'. Below the navigation bar, there is a grid of four colored boxes representing different timeframes for NMADD reports:

Less than 1 week	Less than 2 weeks	Less than 4 weeks	More than 4 weeks
TR#657453 Joe Bloggs Due: 17 Apr 2021	TR#782345 Jane Doe Due: 27 Apr 2021	TR#808345 John Smith Due: 01 May 2021	TR#690567 Joe Bloggs Due: 17 Jun 2021

Delivery

The screenshot shows the 'Delivery' section of the Digital Tier application. At the top, there is a navigation bar with tabs: Home, Safety, People, NMADD, Delivery (which is highlighted in blue), Downtime, and My Account. Below the navigation bar is a search bar with dropdown menus for Department, User, and Date, and a 'Search' button. The main content area displays four cards representing different delivery tasks:

- Active Directory**
Joe Bloggs
Due: 17 Apr 2021
- WAN Outage**
Jane Doe
Due: 24 Apr 2021
- GTS Reconciliation**
Joe Bloggs
Due: 31 Apr 2021
- KVM Issue**
John Smith
Due: 31 May 2021

Downtime

The screenshot shows the 'Downtime' section of the Digital Tier application. At the top, there is a navigation bar with tabs: Home, Safety, People, NMADD, Delivery, Downtime (which is highlighted in blue), and My Account. Below the navigation bar is a search bar with dropdown menus for Department, Area, and Date, and a 'Search' button. The main content area displays five cards representing different downtime tasks:

- GTS Patching**
Joe Bloggs
Due: 17 Apr 2021
- Ph21 Upgrade**
Jane Doe
Due: 24 Apr 2021
- WAN Reconfiguration**
Joe Bloggs
Due: 31 Apr 2021
- Coater 5 Upgrade**
John Smith
Due: 31 May 2021
- MTS Upgrade**
John Smith
Due: 11 Jun 2021

Appendix 9 – Second Iteration Prototype

Dashboard

The screenshot displays the Cramlington IT DigiTier dashboard interface. At the top, there is a navigation bar with tabs for Home, Safety, People, NMADD, Delivery, Downtime, and My Account. The main content area is divided into several sections:

- Standard Working Agenda:** A section describing the standard agenda for tier meetings, listing topics such as contemporaneous updating of information, accurate information being input, attributable information, and actions assigned to someone.
- NMADD Actions:** A chart showing the status of NMADD actions: New (pink), Not Started (blue), In Progress (green), and Overdue (red). The chart shows approximately 10 New, 15 Not Started, 25 In Progress, and 5 Overdue actions.
- Upcoming Actions:** A list of three upcoming tasks:
 - GCM TR#657142 - Hardness Testers Installation (Due 28 Feb 2021, In Progress)
 - QSAT 152375 - Secure Desktop (Due 03 Mar 2021, Not Started)
 - SOP 14.135 - Administration of Serialisation Systems (Due 14 Mar 2021, New)
- Latest Safety Events:** A section showing three recent safety incidents: COVID-19 Incident, Slips, trips and Falls, and Environmental Incident.

Appendix 10 – Quality Assurance Plan

**CMF Digital Tier
Quality Assurance Plan (QAP)
Automation Validation**

Document ID: CRAM_Digital_Tier_QAP_2021

Document Revision: 1.0

Issue Date: 10-Feb-2021

Document Signatures

AUTHOR	
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By affixing their signature, the individual representing the Vendor acknowledges that they have reviewed and approved the contents of this document and attest that they are accurate.	
BUSINESS UNIT APPROVAL:	
Ryan Pickering Assoc. Spclst, Automation Shopfloor Systems Team	
By affixing their signature, the individual representing the IT Business Unit/Area above acknowledges that they have reviewed and approve the contents of this document and attest that they are accurate. IT Business Unit/Area representative is responsible for ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	

Revision History

Revision	Author Name	Date	Description
1.0	James Singh	10-Feb-2021	Issued for Approval

Introduction

Purpose

The purpose of this Quality Assurance Plan (QAP) is to define the strategy, activities, deliverables and responsibilities to be performed for the development and implementation of the Digital Tier Application at the CMF and to ensure that the effort is consistent with applicable regulatory/other requirements. This document provides the steps required by which System Development Lifecycle (SDLC) activities can be managed and tracked. This plan also ensures all regulatory and compliance requirements are included in the quality assurance approach.

Scope

This document applies specifically to the Digital Tier Application which will be developed and installed for use by IT personnel at the CMF. The the Digital Tier Application will be considered as subject to any exclusion that may be noted in the Limitations, Exclusions, and Assumptions section. This approach and testing strategy provides demonstrated quality assurance and is consistent with the CMF's SDLC.

Assumptions, Limitations and Exclusions

Assumptions, limitations, and exclusions that apply to this QAP for the Digital Tier are as follows:

- All data generated by the the Digital Tier Application will be stored, maintained and managed through a SQLite Database.
- The application will use its own independent login system which is separate to the Cramlington site's active directory for user access.
- User access will be managed by the User Administration SOP; which will be defined in the QASR relating to this project.
- The application database will be backed up by a backup tool provided by the CMF and falls outside of the scope of this project.
- The device in which software related to this system will run on will be a standard ECORE build provided by the IT department.
- The system will be available for use 24/7.

System Overview

The “Tier Process” is a method of funneling key information through the site to the right people. Each department within a business unit, each holds a meeting where the members of the meeting go through a series of questions and sections relating to their business function. For example, some of the sections will include health and safety, planned downtime for systems and any ongoing issues. This is called Tier 1. Once the Tier 1 meetings have finished another meeting is scheduled soon after where each of the department leads within that business function get together with the business function lead and go through the same process, discussing the outcomes from the Tier 1 meeting. This is the Tier 2 meeting. For the Tier 3 meeting, each business function lead meets with each other and the plant manager to discuss the outcomes from that business function’s Tier 1 & 2 meetings but only if these issues are necessary to be brought to the plant managers attention. Figure 1 shows this process using the IT, Bulk Manufacturing and Packaging departments as an example.

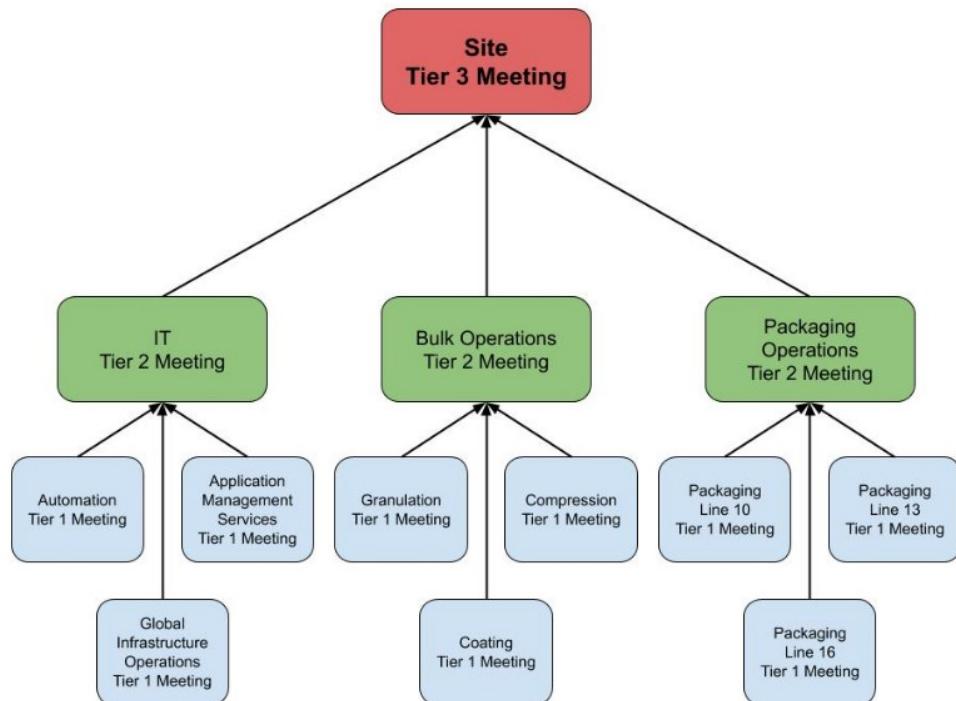


Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples.

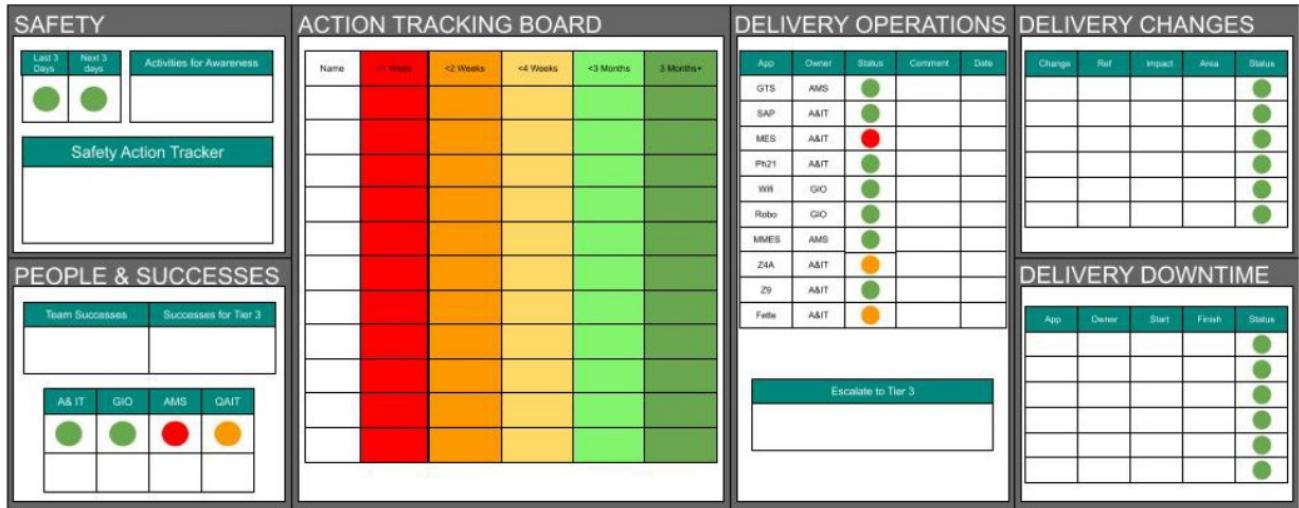


Figure 2 – A visual representation of the “Tier Board” used at the CMF as examples.

These meetings took place in person using tools such as large printed out whiteboards that people wrote on – see figure 2. This was a great tool to get people together and discuss issues effectively. The tool proposed will be a web-based client that will be responsible for all the actions of the in-person meetings (as shown in figure 2), whilst also implementing data analytics and data tracking to create a broader image of how the IT business function is working. All data used in this system will be stored using a secure SQLite database system that will be thoroughly reviewed and evaluated to ensure the correct solution for this product. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. The first initial wireframe of how the homepage of the application will look is detailed below in figure 3.

The wireframe shows a top navigation bar with a 'New Tab' button, a search bar, and various icons. Below the bar is a header with a lightbulb icon and the text 'Digital Tier'. A horizontal menu bar contains 'Home' (highlighted in blue), 'Safety', 'People', 'Quality', 'Delivery', 'Downtime', and 'My Account' (highlighted in pink).

Standard Working Agenda

This is where the standard agenda for each tier meeting will be displayed. This will be generated throughout the project process and will be detailed within the synthesis.

The standard working agenda will cover topics such as:

- Contemporaneous updating of information.
- Accurate information being input.
- Attributable information - all actions are assigned to someone.
- Actions should be escalated if they will not be completed on time.
- Information should only be presented at tier meeting if it is not redundant.

NMADD Actions

A bar chart showing NMADD Actions categorized by status: New (pink), Not Started (blue), In Progress (green), and Overdue (red). The chart shows approximately 10 New, 15 Not Started, 25 In Progress, and 5 Overdue actions.

Status	Count
New	10
Not Started	15
In Progress	25
Overdue	5

Upcoming Actions

Three upcoming action items are listed:

- GCM TR#657142 - Hardness Testers Installation
Due 28 Feb 2021 In Progress
- QSAT 152375 - Secure Desktop
Due 03 Mar 2021 Not Started
- SOP 14.135 - Administration of Serialisation Systems
Due 14 Mar 2021 New

Latest Safety Events

Three latest safety event categories are shown in boxes:

- COVID-19 Incident
- Slips, trips and Falls
- Environmental Incident

Figure 3 – A wireframe of the proposed Tier Application.

Definitions & Acronyms

Abbreviation	Definition
CS	Configuration Specification
DB	Database
DI	Data Integrity
DS	Design Specification
GMP	Good Manufacturing Practice
SDLC	System Development Life Cycle
SOP	Standard Operating Procedure
SQL	Structured Query Language
QA	Quality Assurance
QAP	Quality Assurance Plan
QASR	Quality Assurance Summary Report
RS	Requirement Specification
SDLC	System Development Life Cycle

Strategy for Implementing the System

Deliverables and associated approvals as well as justification for omitting and combining deliverables in support of this Quality Assurance plan will be documented in the table below. The strategy details are elaborated in the subsequent sections.

Table 1 System Development Lifecycle Deliverables

Output/Deliverable	Business Unit	Technical Unit	Quality Unit	Will Complete?	Rationale for Not Completing/Comments
Initiate Phase					
Planning Phase					
Requirements Specification or Requirements/ Configuration Specification	Owner/ Approver	Owner/ Approver	Approver	<input checked="" type="checkbox"/> RS <input type="checkbox"/> RS/CS <input type="checkbox"/> N/A	N/A
Quality Assurance Plan (QAP)	Approver	Owner/ Approver	Approver	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	This document
GLP Regulatory Determination/	Form included with and approved as a part of the QAP		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		N/A
Regulatory Risk Assessment	Form included with and approved as a part of the QAP		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		N/A
Quality Risk Management – Risk Assessment (Functional)	Approver	Owner/ Approver	Approver	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Fulfilled by the Regulatory Risk Assessment
Quality Gates	Quality Assurance Plan is Approved. Requirement Specification is Approved.				
Design & Build Phase					
Design and/or Configuration Specs	N/A	Owner/ Approver	N/A	<input checked="" type="checkbox"/> CS <input type="checkbox"/> RS/CS	N/A
Quality Risk Management – Risk Assessment (Functional) - Review of initial risk assessment during design/development	Approver	Owner/ Approver	Approver	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Fulfilled by the Regulatory Risk Assessment

Output/Deliverable	Business Unit	Technical Unit	Quality Unit	Will Complete?	Rationale for Not Completing/Comments
Design (Qualification) Review Results	Approver	Owner	Approver	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	A Requirements/Configuration specification coupled with an Requirements Traceability Matrix (RTM) will identify the requirements.
System Build and Configuration	N/A	Owner	N/A	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Configuration Specification to be created.
Development Testing	N/A	Owner/ Approver	N/A	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	N/A
Development Summary Report (to include traceability)	N/A	Owner/ Approver	N/A	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	N/A
Quality Gates	Configuration Specification Approved Development Summary Report Approved.				

Test & Install Phase

Acceptance Test Plan	Approver	Owner/ Approver	Approver	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Will be incorporated into the Test Protocol
Completed Traceability Matrix	Approver	Owner/ Approver	Approver	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	N/A
Installation Qualification	Approver (Pre/Post)	Owner/ Approver (Pre/Post)	Approver (Pre/Post)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	N/A
Operational Qualification	Approver (Pre/Post)	Owner/ Approver (Pre/Post)	Approver (Pre/Post)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	N/A
Business Continuity Plan	Owner/ Approver	Approver	Approver	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Will be incorporated into the QASR
Disaster Recovery Plan	Approver	Owner/ Approver	Approver	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Will be incorporated into the QASR

Procedures for Operation and Validation Closeout

Quality Assurance Summary Report (QASR)	Approver	Owner/ Approver	Approver	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	N/A
Quality Gates (Run and Operate Phase Pre-requisites)	Test Protocol and Installation Testing are successfully executed and approved. Requirements Tracing is completed and approved. Quality Assurance Summary Report is approved.				

Planning Phase

Requirements Specification

The Requirements Specification for the Digital Tier Application will be generated by the Project Team and will include the detailed compliance, business, and functional requirements for the application.

GxP Regulatory Determination Assessment Summary

A GxP Regulatory Determination Assessment has been completed for this system and it is attached in Attachment 2. The system was determined to be GMP applicable.

Regulatory Risk Assessment Summary

A Regulatory Risk Assessment was completed. The Digital Tier Application was found to have a Medium risk because Patient Safety and Product Quality Risk was rated no risk, Regulatory Risk was rated low risk, Intended Use and Data Integrity rated medium and Complexity rated high giving an overall System Risk of 6 points. The details as to why this system was awarded this score is detailed in attachment 3 on the completed form.

Design and Build Phase

Tracing Requirements Method

The traceability matrix will be drafted during the Planning Phase. During the Design Phase, the matrix will be updated to map the Requirement and Configuration Specifications.

Test and Install Phase

Testing Approach

The testing of the Digital Tier Application will follow the standard SDLC process and will consist of the following:

- Installation Testing
- Operational Qualification

All testing will be recorded using Test Protocols that will be written by the Project Team and will be pre-approved by the business unit.

The Incident Management procedure will be adhered to when executing all Test Protocols. Events or deviations generated during the testing must be addressed prior to commencement of the next stage of testing.

The completed, executed Test Protocols will be reviewed and post-approved. A summary of the testing will be included in the Quality Assurance Summary Report.

Tracing Requirements Method

The traceability matrix will be started during the Design and Build Phase, where the matrix will map the requirements to the Design and Configuration Specifications. Upon approval of the Installation Testing and Operational Qualification protocols, the traceability matrix will be updated. Approval of the matrix will be prior to execution of the Test Protocol.

Training

On site procedures must be completed before users can be granted access to the application. User training will be documented according to departmental training procedures. Technical personnel involved in the Vibration Analytics System support and maintenance will be trained.

Release Strategy

The QASR approval closes the validation of the system. A summary of activities associated with the project shall be captured under the QASR.

Attachments

Attachment 1 – Risk Profile

Attachment 2 – GxP Regulatory Determination Form

Attachment 3 – Regulatory Risk Assessment Form

Attachment 1 – Risk Profile

Remedy Field	Response Value	Guidance
Application Name Required	Digital Tier	<ul style="list-style-type: none"> No acronyms or abbreviations (exception: Our company's divisions and other generally accepted abbreviations) No vendor or commercial names (unless used out-of-the-box with no additional application development). Name should reflect our company's usage, e.g., Human Resources or Personnel Information System, not PeopleSoft. <p>The vendor name would be reflected in the product name.</p> <ul style="list-style-type: none"> If the name has a hyphen (-), the hyphen should not be surrounded by spaces. Should not be a version of a product – versions are not registered unless two versions of the application exists in parallel with different infrastructure Website address or URLs may not be registered (example: http://www.abc.com).
Description limit to 150 characters Required	The Digital Tier application is an externally hosted web-based meeting application with digital data tracking and analytics.	<ul style="list-style-type: none"> Use the business description provided by (or meaningful to) the end user. • If externally hosted application that will have no infrastructure, start the description with 'Externally hosted application. No infrastructure'. Include the business use of the IS Product What is the application function and how does it provide a service to the business?
Risk Profile		
GxP Indicator: If your system is subject to GxP health authority regulations, please indicate the specific regulations. Please review & complete the SDLC GxP Regulatory Determination Form to determine your GxP status. Required	None	Select 'None' if the application is not subject to regulation. If subject to GxP regulation select GMP, GLP, GCP or Other GxP as appropriate. Use the SDLC GxP Regulatory Determination Form for additional guidance/assistance. Multiple values can be entered by selecting one at a time. Press 'Delete' to clear. You must have clicked on "Enable Content" to enable the multiple value functionality.
Regulated Non-GxP: If your system is subject to non-GxP regulations, please indicate the specific regulations. Required	None	Select 'None' if the application is not subject to regulation. If subject to non-GxP regulation, select the appropriate ones: SOX, Payment Card Industry (PCI) or 'Other non-GxP' if subject to a regulation not specifically noted here. Multiple values can be entered by selecting one at a time. Press 'Delete' to clear. You must have clicked on "Enable Content" to enable the multiple value functionality.
Privacy: Does your system process or store any Personal Information? Required	Low	Please use the following guidance to make your selection: High = Yes, Personal information which equates to what is visible in the GAL. Medium = Yes, Personal information which equates to what is visible in the Global Address List (GAL) Low = No Personal Information
Trade Secret/ Intellectual Property: If your system captures trade secrets or intellectual property, select the highest classification of the data. Required	Proprietary	Please use the Data Classification section of the Guidance Tab to determine if Sensitive, Confidential or Proprietary. Select None if your system does not capture Trade Secret or Intellectual Property data.
Business Impact Analysis (BIA/BG): Identify the system's Business Classification. (Formerly known as recovery class). Guidance: If there was a national disaster and systems need to be recovered based on impact to our business, please select the appropriate classification. Click here for the Business Impact Justification form. Required	Business Supporting	Work with your business stakeholder to determine the business risk/impact in the event of a national disaster and systems need to be recovered. Consider financial, regulatory and reputational impact factors. Please refer to the BIA Determination section of the Guidance Tab for assistance in understanding Business Classification. Note: If your classification is determined to be Mission or Business Critical, please justify the impact in your required BC Plan. Further consultation may be done by the BC Mgmt. team as needed. Additional analysis will be carried out by the DR Engineering Team to determine the feasibility of your technical solution.
System Classification Required	SC5 - Custom System	See the System Classification section of the Guidance Tab for Definitions of Choices
Using Standard Platforms or New/Emerging Technology Required	Data Analytics	Emerging technologies are: Our company's Managed Cloud (AWS), Vendor Cloud, Mobility, Social Media, Data Analytics or Externally Facing Web App. Select None if you are not using any of those technologies. Multiple values can be entered by selecting one at a time. Press 'Delete' to clear. You must have clicked on "Enable Content" to enable the multiple value functionality.

Attachment 2 – GxP Regulatory Determination Form

Regulatory requirement	System provides functionality for: <i>(Indicate all items that apply)</i>	Regulatory requirement	System provides functionality for: <i>(Indicate all items that apply)</i>
<input type="checkbox"/> GCP	<input type="checkbox"/> Sponsor communications or agreements (e.g. financial agreements, sponsor SOP, qualification and eligibility evidence) <input type="checkbox"/> Managing clinical records – trial monitor qualifications, procedures, communications, visit reports, safety information <input type="checkbox"/> Managing information related to trial administration, protocol violations, and trial conduct <input type="checkbox"/> Managing investigational drug product information (dispensed/returned/destroyed and storage conditions) <input type="checkbox"/> Storing or analysis/monitoring of protocol-specific clinical trials and associated data including CRFs (Case Report Forms) <input type="checkbox"/> Storing decoding procedures for blinded trials, method of randomization <input type="checkbox"/> Managing training records for persons supporting clinical trials <input type="checkbox"/> Tracking and reporting of adverse events and safeguards for patient safety <input type="checkbox"/> IND (Investigational New Drug) submission/registration	<input type="checkbox"/> GLP	<input type="checkbox"/> Planning, performing, monitoring, recording, or reporting of non-clinical laboratory studies used to assess the safety or efficacy of chemicals / pharmaceuticals including: <ul style="list-style-type: none"> - Animal care - Test and control characterization <input type="checkbox"/> Managing GLP records for non-clinical laboratory studies (e.g. approved protocol, study status / final reports, master schedule, inspection records, index of archived records) <input type="checkbox"/> Managing environmental conditions for areas supporting non-clinical laboratory studies <input type="checkbox"/> Equipment maintenance / calibration and tracking (for equipment used for non-clinical laboratory studies) <input type="checkbox"/> CRO / laboratory vendor quality status <input type="checkbox"/> Managing training records for persons supporting non-clinical laboratory studies
<input checked="" type="checkbox"/> GMP	<input type="checkbox"/> Manufacturing of finished pharmaceutical products or primary/secondary packaging <input type="checkbox"/> Shipping genealogy, quarantines and recall management <input type="checkbox"/> Labeling <input type="checkbox"/> Stability, in-process, or product release testing <input type="checkbox"/> Expiry dating <input type="checkbox"/> Release status / release / inventory release / registration status <input type="checkbox"/> Lot identification <input type="checkbox"/> Managing documentation associated with procedures or specifications (SOPs, Batch Sheets, Recipes) <input type="checkbox"/> Managing records for training, change control, deviations, investigations, corrective/preventive actions, or returned drug products or salvage <input type="checkbox"/> Managing environmental conditions for areas supporting production and product release testing <input type="checkbox"/> Equipment maintenance / calibration and tracking (for equipment used for testing and manufacturing of commercial products) <input type="checkbox"/> Manufacturing vendor quality status <input type="checkbox"/> Tracking and reporting of customer complaints	<input type="checkbox"/> Other GxP	<input type="checkbox"/> Regulatory commitments not included above under GCP, GLP, GMP <input type="checkbox"/> GLP, GMP <input type="checkbox"/> Tracking and reporting of adverse events not included above under GCP, GLP, GMP <input type="checkbox"/> Safeguarding prescription drug and sample distribution to ensure safe and effective pharmaceuticals [PDMA regulatory requirement] <input type="checkbox"/> Physically controlling access to a GMP, GCP, or GLP environment
		<input checked="" type="checkbox"/> None	None of the above regulatory requirements apply (GCP, GLP, GMP, Other GxP). The system is therefore categorized as None.

Attachment 3 – Regulatory Risk Assessment Form

System Name	Digital Tier
Select One	
Patient Safety and Product Quality Risk Criteria	
<input type="checkbox"/> High	<ul style="list-style-type: none"> System ensures final product quality prior to product release from the company System determines safety of product and/or control of the manufacturing process This is the only or final system capable of detecting manufacturing or packaging errors in the operation. System generates and/or affixes primary product labels. System plays primary role in making the recall decision and/or the execution of a recall System controls manufacture of a lifesaving product for which CMF is the only manufacturer System provides authentication and provisioning for high risk GxP data System determines patient treatment group System is used as primary means to diagnose patient
<input type="checkbox"/> Medium	<ul style="list-style-type: none"> System that controls/monitors product that has been released System supports safety of product and/or supports the manufacturing process System supports or tracks already detected errors in manufacturing or packaging System supports product labeling System supports adverse event / customer complaint tracking/reporting and the execution of a recall System is the source record for submission data that has impact on product quality (source record is the original record submitted to regulatory body) System non-performance would result in the inability to supply a life saving product for which CMF is the only manufacturer System stores archived GxP data
<input type="checkbox"/> Low	<ul style="list-style-type: none"> Support system used for investigations System provides only supporting checks prior to final system quality check for product release from the company System detects non-regulatory errors System stores backups of GxP data
<input checked="" type="checkbox"/> None	<ul style="list-style-type: none"> System has no impact on patient safety, examples are training systems

Select One	Regulatory Risk Criteria
<input type="checkbox"/> High	<ul style="list-style-type: none"> System performs and/or is used to fulfill one or more regulatory requirements System plays primary role in the execution of a recall System physically used to distribute product System tracks, provides support for and/or stores information that is involved in a submission process Highly likely that this system would be chosen for a regulatory audit System provides authentication and provisioning for regulated systems System archives GxP data
<input type="checkbox"/> Medium	<ul style="list-style-type: none"> System provides evidence that the regulatory requirement is met System used for training records System controls the management of procedures Possibility exists for this system to be audited as a result of another ongoing audit Supports the regulatory requirement(s) and provides the evidence System backups up GxP data
<input checked="" type="checkbox"/> Low	<ul style="list-style-type: none"> Not required to fulfill regulatory requirement but used for audit readiness System is involved with regulatory commitment tracking System used for support and planning of the evidence

Select One	Intended Use and Data Integrity Risk Criteria
<input type="checkbox"/> High	<ul style="list-style-type: none"> System contains the only secured record of the original regulated data System manufactures and/or packages the product Used for Quality or regulatory decisions System contains multiple decision points in workflows Electronic Records and Electronic Signature system System contains meta data not captured anywhere else System utilizes records and/or reports for submission or batch records Compliance risk if down or functionality fails This is the only or final system capable of detecting manufacturing or packaging errors in the operation System output is used for analysis to drive regulatory product decisions System provides the primary source of authentication and provisioning for regulated systems
<input checked="" type="checkbox"/> Medium	<ul style="list-style-type: none"> Stores record but is not the source record System performs support functions Confirmation of information for Quality or regulatory decisions Metrics/trending of Key Performance Indicators Produces either an electronic or paper regulatory record Produces Annual product reviews System that supports or tracks already detected errors in manufacturing or packaging System provides support for security of regulated systems and/or data
<input type="checkbox"/> Low	<ul style="list-style-type: none"> Metrics/trending of supporting factors Single workflow Technical controls for data and security Does not produce a regulatory record No data storage Non-critical business decisions or no decisions at all System monitors security of regulated systems and/or data

Select One	Complexity Risk Criteria
<input checked="" type="checkbox"/> High	<ul style="list-style-type: none"> Custom workflows Technical controls for data and security Custom code Highly configured, adding new logic Technology is new and/or being used beyond its vendor's intended use. Many possible workflows and/or ways to perform operations/functions Interfaces with multiple systems
<input type="checkbox"/> Medium	<ul style="list-style-type: none"> Minor customization/configurations Using vendor selections for configuration Some sequential checks and calculations required, but do not require complicated processes Interfaces with one additional system System provides centralized support for multiple GxP system
<input type="checkbox"/> Low	<ul style="list-style-type: none"> No configurations Single, clear workflows Technology is known and appropriate for functionality Interfaces with no other systems

Risk Criteria	Result	Points	Key
Patient Safety and Product Quality	None	0	High = 3 points
Regulatory	Low	1	Medium = 2 points
Intended Use and Data Integrity	Medium	2	Low = 1 point
Complexity	Low	3	None = 0 points
Total Points		6	
System Risk Level		Key 3 – 5 Points = Low 6 – 9 Points = Medium 10 – 12 Points = High	

Appendix 11 – Requirements Specification

CMF Digital Tier

Requirements Specification

Document ID: CRAM_Digital_Tier_RS_2021

Document Revision: 1.0

Issue Date: 12 FEB 2021

System Version: 1.0

Document Signatures

AUTHOR	
James Singh Assoc. Spclst, Business/Tech. Analysis Shopfloor Systems Team	
By affixing their signature, the individual representing the Vendor acknowledges that they have reviewed and approved the contents of this document and attest that they are accurate.	
BUSINESS UNIT APPROVAL:	
Ryan Pickering Assoc. Spclst, Automation Shopfloor Systems Team	
By affixing their signature, the individual representing the IT Business Unit/Area above acknowledges that they have reviewed and approve the contents of this document and attest that they are accurate. IT Business Unit/Area representative is responsible for ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	

Revision History

Revision	Author Name	Date	Description
1.0	James Singh	12 FEB 2021	Issued for Approval

Introduction

Purpose

The purpose of this document is to detail the Requirements Specification (RS) of the CMF's Digital Tier Application, of which will be implemented in the IT department. The requirements detailed in this RS document provide the specifications for the Digital Tier Application from a business user and a technical/functional perspective. Requirements are defined as being either critical or non-critical to the functionality of the system and will be used to outline the underpinning functionality of the proposed solution.

Scope

This document applies specifically to the Digital Tier for use at the Cramlington site by the IT department. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. This RS will be used to guide the developer's activities and becomes the criteria for evaluation of the system following its successful implementation. The system developer's choice of development tools, application format and system design choices should be informed by the requirements documented in this RS.

Assumptions, Limitations and Exclusions

This document represents required functions for this release of the system as defined by the system users. The following captures the specific limitations, exclusions, and assumptions applicable to the requirements of this system.

- All data generated by the the Digital Tier Application will be stored, maintained and managed through a SQLite Database.
- The application will use its own independent login system which is separate to the Cramlington site's active directory for user access.
- User access will be managed by the User Administration SOP; which will be defined in the QASR relating to this project.
- The application database will be backed up by a backup tool provided by the CMF and falls outside of the scope of this project.
- The device in which software related to this system will run on will be a standard ECORE build provided by the IT department.
- The system will be available for use 24/7.

System Overview

The “Tier Process” is a method of funneling key information through the site to the right people. Each department within a business unit, each holds a meeting where the members of the meeting go through a series of questions and sections relating to their business function. For example, some of the sections will include health and safety, planned downtime for systems and any ongoing issues. This is called Tier 1. Once the Tier 1 meetings have finished another meeting is scheduled soon after where each of the department leads within that business function get together with the business function lead and go through the same process, discussing the outcomes from the Tier 1 meeting. This is the Tier 2 meeting. For the Tier 3 meeting, each business function lead meets with each other and the plant manager to discuss the outcomes from that business function’s Tier 1 & 2 meetings but only if these issues are necessary to be brought to the plant managers attention. Figure 1 shows this process using the IT, Bulk Manufacturing and Packaging departments as an example.

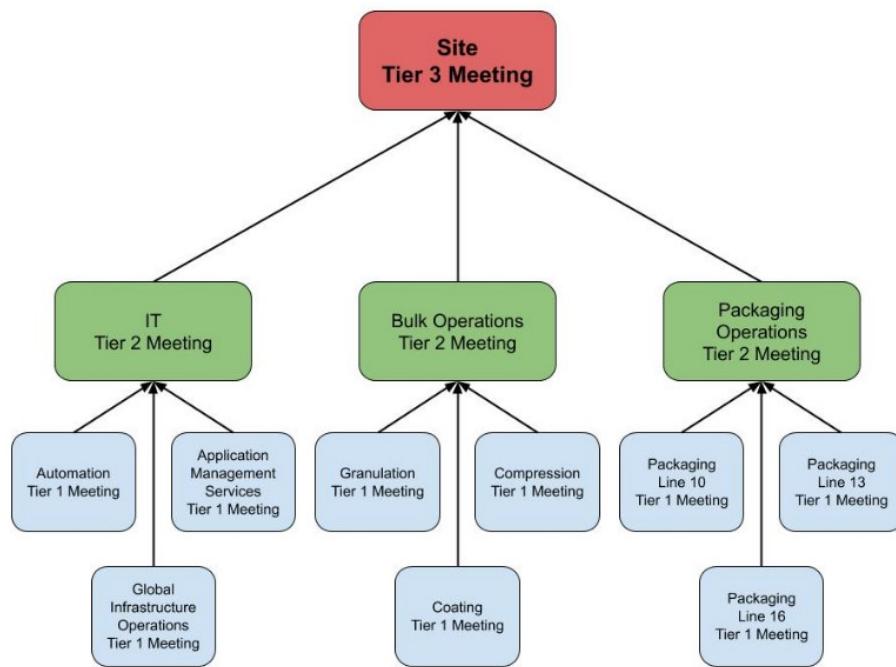


Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples.



Figure 2 – A visual representation of the “Tier Board” used at the CMF as examples.

These meetings took place in person using tools such as large printed out whiteboards that people wrote on – see figure 2. This was a great tool to get people together and discuss issues effectively. The tool proposed will be a web-based client that will be responsible for all the actions of the in-person meetings (as shown in figure 2), whilst also implementing data analytics and data tracking to create a broader image of how the IT business function is working. All data used in this system will be stored using a secure SQLite database system that will be thoroughly reviewed and evaluated to ensure the correct solution for this product. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. The first initial wireframe of how the homepage of the application will look is detailed below in figure 3.

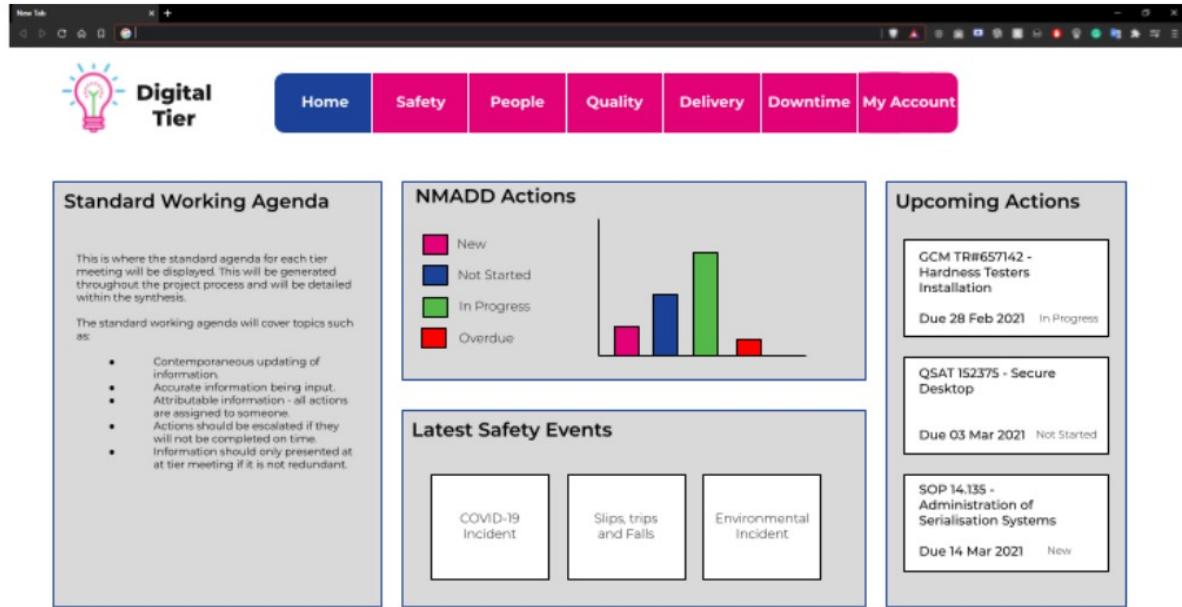


Figure 3 – A wireframe of the proposed Tier Application.

Definitions & Acronyms

Abbreviation	Definition
CS	Configuration Specification
DB	Database
DI	Data Integrity
IT	Information Technology
RS	Requirement Specification
SDLC	System Development Life Cycle
SOP	Standard Operating Procedure
SQL	Structured Query Language
UX	User Experience

Requirements

Functional Requirements

Requirement Number	Critical? Y/N	Requirement Description
FU-001	Y	The tool will provide an interactive and engaging design that allows the use of the tool remotely or in-person.
FU-002	Y	The tool will allow the safe and accessible storage of previous Tier meeting's data.
FU-003	Y	The application framework will follow the Safety, Quality, Delivery and Cost principles and follow the current framework set by the CMF.
FU-004	Y	The application will allow users to edit information that is displayed in the Tier Board to reflect the current situation, easily and effectively.
FU-005	Y	The application will provide and display a set agenda that will be followed by all IT representatives.
FU-006	Y	The application will allow department leads to look at an overview of ongoing actions as well as evaluation and monitoring statistics about how the department is functioning.
FU-007	Y	The application will provide the users who have actions assigned to them notifications to remind them of deadlines.
FU-008	Y	The application should display all necessary information in a readable and concise method.
FU-009	N	The application should allow users to log in and view a personalised list of actions that are assigned to them and when they are due.
FU-010	N	The application could provide an interface that allows the monitoring of system downtime and statistics highlighting to the user the most impacted systems.
FU-011	Y	Actions displayed in the application should be able to be searched and filtered by due date.
FU-012	Y	Action items must be comprised of the following elements: Username of assigned team member, title of action, description of action, due date, what type of action it is, the department they are in and what the completion status is.

Requirement Number	Critical? Y/N	Requirement Description
FU-013	Y	Users should be able to register an account to allow new users to be added to the Tier application.
FU-014	Y	The application should provide functionality to escalate items to the next Tier.
FU-015	Y	Delivery items should be assigned a priority of completion to enable fast response on those items with business-critical impact.

Data Integrity Requirements

Requirement Number	Critical? Y/N	Requirement Description
DI-001	Y	Users cannot delete raw data from the database.
DI-002	Y	An approved process must be available to grant and remove access to/from individuals (users and administrators of the system).
DI-003	Y	The system must prevent the accidental or intentional modification of time settings.
DI-004	Y	All system modifications must be tied to a unique user ID.

Performance Requirements

Requirement Number	Critical? Y/N	Requirement Description
PR-001	Y	The system must support up to 15 concurrent users.
PR-002	Y	The system must be accessible for users with a range of computer literacy skills.
PR-003	N	The system should be responsive. Login for users should take less than 5 seconds from clicking the login button.

Design Requirements

Requirement Number	Critical? Y/N	Requirement Description
DR-001	N	The front facing end-user system must be suitable to be displayed on visual meeting boards.
DR-002	N	The system must be presented in an appropriate design while considering the users needs.
DR-003	Y	Visual graphs must be used where possible to demonstrate data.
DR-004	Y	The systems code must be fully documented and designed using appropriate design principles to ensure easy future maintenance.
DR-005	N	Historic data should be stored but not displayed if irrelevant to the user.
DR-006	N	If a notifications system is in place, users must be able to clear historic notifications.

Requirement Number	Critical? Y/N	Requirement Description
DR-007	Y	A clear and navigable system must be in place to allow end-users to navigate within the application.
DR-008	N	End-user applications must have a clear narrative to demonstrate a general flow of events.

User Experience Requirements

Requirement Number	Critical? Y/N	Requirement Description
UX-001	N	Tooltips must be accessible where possible to provide additional user guidance.
UX-002	N	Users should be presented with different views within the application depending on their user status.
UX-003	N	The system is internal facing and must follow the companies branding guidelines.
UX-004	N	Whitespace must be used appropriately within the application design to display information clearly.
UX-005	Y	Users must not be presented with data irrelevant to their job role.
UX-006	N	User guidance must be provided to ensure the system is accessible for all users.

System (Application/Infrastructure) Environments

Requirement Number	Critical? Y/N	Requirement Description
SE-001	Y	The system is compatible with the Cramlington site's network Infrastructure.
SE-002	Y	The system shall use a standard Windows 10 ECORE PC which meets the minimum requirement specified by the development team.
SE-003	Y	Time must be synchronized with the official Cramlington site's time source to record time and date for data activities. If an application does not use the official Cramlington site's time source, it must be synchronized to a certified time source
SE-004	Y	User access integrated with the Cramlington site's Active Directory where technically possible or provide individual user logins and permission to the application to ensure only authorized users can access the software.
SE-005	N	The database shall use a standard version of SQL which meets the minimum requirement specified by the developer.

Backup/Restore Requirements

Requirement Number	Critical? Y/N	Requirement Description
BR-001	Y	The system must support the backup of source data based on the procedurally defined backup frequency.
BR-003	Y	The system must include automated error handling that verifies the success of the backup.
BR-004	Y	Backups of all relevant raw data and metadata must be stored in a separate and secured location from the raw data (e.g., a separate server).
BR-005	Y	Temporary removable media must not be used to store data, unless required for system operations
BR-006	Y	The system must be able to restore data from a previous version

System Interface Requirements

Requirement Number	Critical? Y/N	Requirement Description
SI-001	Y	The software application must be capable of operating via the Cramlington site network.

System Security Requirements

Requirement Number	Critical? Y/N	Requirement Description
SEC-001	N	Multiple sessions are not permitted - the system restricts the user to a single logon/session.
SEC-002	Y	Assign unique user and administrator identification for each user or administrator of the system.
SEC-003	Y	Access to the software, operation system or application is not based on biometrics, access must be via individual login credentials made up of a combination of a unique user id and a user generated password.
SEC-004	Y	Generic user or administration accounts, such as those shipped with the system, must be turned off, disabled, or have access revoked if they are unnecessary for system operations.
SEC-005	Y	Shared logins or generic user or administrator system accounts must not be enabled with system permissions that can create or modify data.
SEC-006	Y	A non-person service account, used for system interfaces or testing, must have a unique ID and password.
SEC-007	Y	Users must not have access to annotation/editing tools that may be used to obscure or modify the stored or displayed data.
SEC-008	Y	Any regulated data that may be in a temporary storage (e.g. temp files, intermediate file share), such as on a PC or server, must be protected from access, modification, and deletion by any persons.

Requirement Number	Critical? Y/N	Requirement Description
SEC-009	Y	<p>Different access levels are to be assigned to users, non-person accounts and administrators, and ensure that people have access only to functionality that is appropriate for their role.</p> <p>NOTE: The required roles and associated rights are to be based on the system design and are to enforce the principles of segregation of duty and least privilege.</p>

Appendix 12 – Configuration Specification

**CMF
Digital Tier
Configuration Specification**

Document ID: CRAM_Digital_Tier_CS_2021
Issue Date: 20-MAR-2021

Document Signatures

AUTHOR:	
James Singh Assoc. Spclst, Business/Tech. Analysis Shop Floor Systems Team	
By affixing their signature, the individual above acknowledges that they authored the contents of this document and attest that the contents are accurate ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	
BUSINESS UNIT APPROVAL:	
Ryan Pickering Assoc. Spclst, Automation Shop Floor Systems Team	
By affixing their signature, the individual representing the IT Business Unit/Area above acknowledges that they have reviewed and approve the contents of this document and attest that they are accurate. IT Business Unit/Area representative is responsible for ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	

Revision History

Revision	Author Name	Date	Description
1.0	James Singh	20-MAR-2021	Issue for Approval

Introduction

Purpose

The purpose of this Configuration Specification (CS) is to outline and define the specific hardware and software configuration and features required for the successful operation of the CMF's Digital Tier Application. The detailed configuration is relevant for both end-users and IT administrators. Each configuration item must be adhered to to provide a suitable platform for the system and to adhere to the requirements detailed within the requirement specification.

Scope

This document addresses the the CMF's Digital Tier Application, which is an IT software solution. The system is pre-configured to the initial system requirements, which have been supplied by the CMF's IT department. The system runs as a COTS (commercial off-the-shelf) system utilising standard interface and user functionality. Following release of the system, the system will encounter further development to be configured for use within the CMF's wider site network. In this case, this System Configuration Specification defines only those configuration items that are used by the Cramlington Site for the system's initial release for use by the IT department.

Audience

This document is written for all individuals required to support CMF's Digital Tier Application.

Definitions & Acronyms

Abbreviation	Definition
CS	Configuration Specification
DB	Database
DI	Data Integrity
GMP	Good Manufacturing Practice
SQL	Structured Query Language
QA	Quality Assurance
QAP	Quality Assurance Plan
QASR	Quality Assurance Summary Report
RS	Requirement Specification
SDLC	System Development Life Cycle

Configuration Considerations

System Description Overview

The “Tier Process” is a method of funneling key information through the site to the right people. Each department within a business unit, each holds a meeting where the members of the meeting go through a series of questions and sections relating to their business function. For example, some of the sections will include health and safety, planned downtime for systems and any ongoing issues. This is called Tier 1. Once the Tier 1 meetings have finished another meeting is scheduled soon after where each of the department leads within that business function get together with the business function lead and go through the same process, discussing the outcomes from the Tier 1 meeting. This is the Tier 2 meeting. For the Tier 3 meeting, each business function lead meets with each other and the plant manager to discuss the outcomes from that business function’s Tier 1 & 2 meetings but only if these issues are necessary to be brought to the plant managers attention. Figure 1 shows this process using the IT, Bulk Manufacturing and Packaging departments as an example.

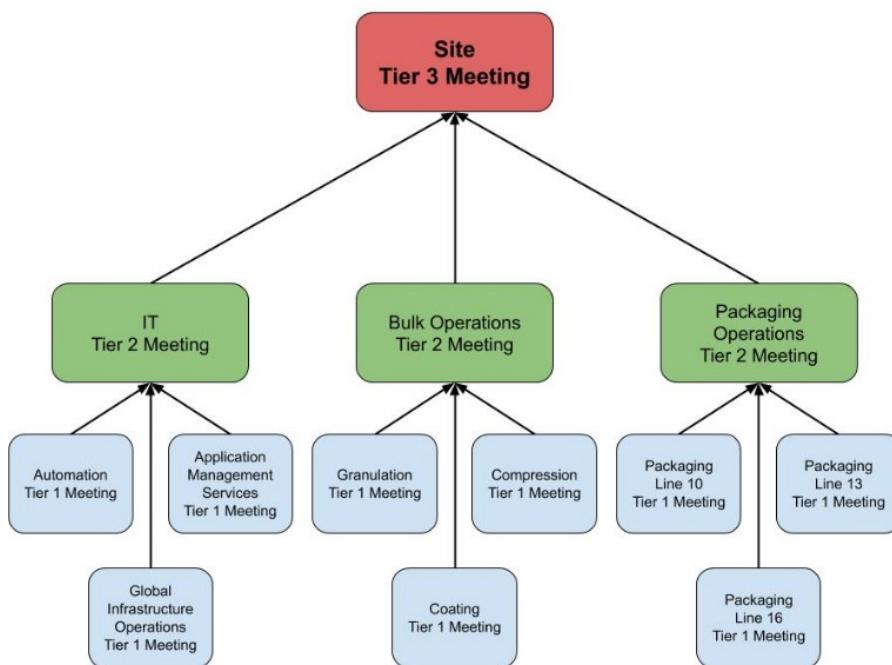


Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples.



Figure 2 – A visual representation of the “Tier Board” used at the CMF as examples.

These meetings took place in person using tools such as large printed out whiteboards that people wrote on – see figure 2. This was a great tool to get people together and discuss issues effectively. The tool proposed will be a web-based client that will be responsible for all the actions of the in-person meetings (as shown in figure 2), whilst also implementing data analytics and data tracking to create a broader image of how the IT business function is working. All data used in this system will be stored using a secure SQLite database system that will be thoroughly reviewed and evaluated to ensure the correct solution for this product. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. The final wireframe of how the homepage of the application will look is detailed below in figure 3.

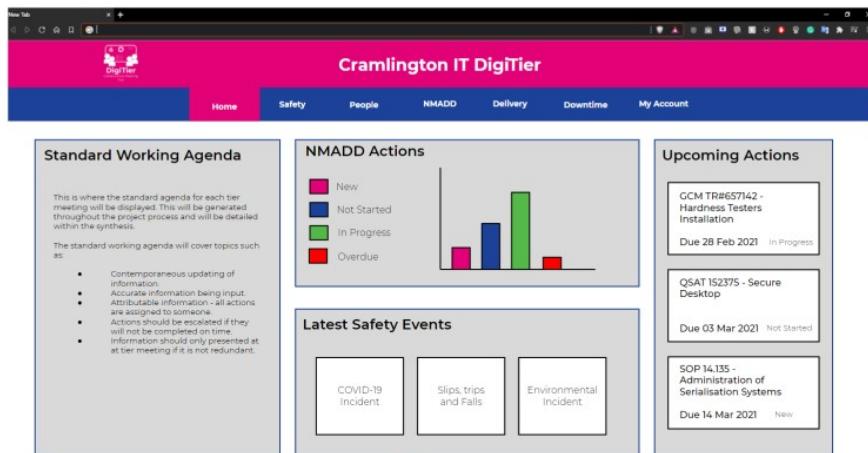


Figure 3 – A wireframe of the proposed Tier Application.

Configuration Decisions

The software is designed and developed to the contents of the CMF's Digital Tier Application Requirements Specification detailed in *CRAM_Digital_Tier_RS_2021*. The following Configuration Specification will detail the configuration and design features to meet the requirements set out in the aforementioned document.

Assumptions

The CMF's Digital Tier Application will be pre-configured to the client's specifications, with user access being controlled within the React Application front end. Application data will not be stored within the application itself and will instead be stored within a centralised SQL database. The fulfilment of system requirements from the system configuration will be tracked using a Requirement Traceability Matrix (RTM), mapping individual requirements to how they will be fulfilled within the design of the system.

The following assumptions for the proposed system can be made:

- All data generated by the the Digital Tier Application will be stored, maintained and managed through a SQLite Database.
- The application will use its own independent login system which is separate to the Cramlington site's active directory for user access.
- User access will be managed by the User Administration SOP; which will be defined in the QASR relating to this project.
- The application database will be backed up by a backup tool provided by the CMF and falls outside of the scope of this project.
- The device in which software related to this system will run on will be a standard ECORE build provided by the IT department.
- The system will be available for use 24/7.

System Analysis

System Architecture

A SQLite Database that:

- Stores all system information.

A server-side web application that:

- Creates JSON endpoints from the database for the front end application.

A client-side web application that:

- Provides a friendly user interface for the data to be displayed.
- Follows the Tier Process in a virtual manner.
- Creates a dashboard of graphs for the user's visualisation.

External Interfaces

The system is a web-based tool and therefore will need a PC with internet capabilities to interact with the system. Authentication within the application will be separate to the Cramlington Site's Active Directory, with users being required to manage a separate password for the system compared to their standard site login.

Requirements Fulfillment

The overall system is to be configured and designed to meet the requirements detailed within the Requirements Specification, *CRAM_Digital_Tier_RS_2021*.

Functional Configuration

Hardware Configuration

Hardware Components

The following list defines the specific hardware components of the system, refer to section 3.1:

- Windows 10 end-user PC

Hardware Interface Configuration

Each PC is required to have a valid internet connection, as standard with all Cramlington devices. This requirement and configuration lies outside of the scope of this document.

Software Configuration

System Software Components / Interfaces

The following table defines the software components associated with the system. All software packages associated with the system, including but not limited to, the operating system, the application, and all associated programs that are required are listed.

Software Name	Software Vendor	Version	Function
Windows 10	Microsoft	Windows 10 Enterprise	Operating System

System Operational Configurations

Security Configuration

Each user will have a unique user ID and password. Account creation and management will be handled from directly within the application.

Performance Configuration

The system will be designed to be able to withstand at least 15 concurrent connections to the system, with login timing being set to no more than 5 seconds from the user placing a login request regardless of the amount of currently signed in users.

System Availability

The system will be available 24 Hours a day 7 days a week providing constant access to the platform.

Appendix 13 – Requirements Traceability Matrix

Cramlington Manufacturing Facility Digital Tier RTM

Cramlington Manufacturing Facility Digital Tier				
Requirements Traceability Matrix				
Requirement Doc. Ref. #	Requirement ID	Requirement Title	Test Doc. Ref. #	Test Section #
▼	▼	▼	▼	▼
<i>Required</i>	<i>Required</i>	<i>Optional</i>	<i>Required</i>	<i>Required</i>
CRAM_Digital_Tier_RS_2021	FU-001	The tool will provide an interactive and engaging design that allows the use of the tool remotely or in-person.	CRAM_Digital_Tier_TP_2021	IQ-001
CRAM_Digital_Tier_RS_2021	FU-002	The tool will allow the safe and accessible storage of previous Tier meeting's data.	CRAM_Digital_Tier_TP_2021	IQ-002
CRAM_Digital_Tier_RS_2021	FU-003	The application framework will follow the Safety, Quality, Delivery and Cost principles and follow the current framework set by the Cramlington Manufacturing Facility.	CRAM_Digital_Tier_TP_2021	OQ-004
CRAM_Digital_Tier_RS_2021	FU-004	The application will allow users to edit information that is displayed in the Tier Board to reflect the current situation, easily and effectively.	CRAM_Digital_Tier_TP_2021	OQ-007
CRAM_Digital_Tier_RS_2021	FU-005	The application will provide and display a set agenda that will be followed by all IT representatives.	CRAM_Digital_Tier_TP_2021	OQ-003
CRAM_Digital_Tier_RS_2021	FU-006	The application will allow department leads to look at an overview of ongoing actions as well as evaluation and monitoring statistics about how the department is functioning.	CRAM_Digital_Tier_TP_2021	OQ-007

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CRAM_Digital_Tier_RTM_2021

Cramlington Manufacturing Facility Digital Tier RTM

CRAM_Digital_Tier_RS_2021	FU-007	The application will provide the users who have actions assigned to them notifications to remind them of deadlines.	CRAM_Digital_Tier_TP_2021	OQ-003
CRAM_Digital_Tier_RS_2021	FU-008	The application should display all necessary information in a readable and concise method.	CRAM_Digital_Tier_TP_2021	UAT-001
CRAM_Digital_Tier_RS_2021	FU-009	The application should allow users to log in and view a personalised list of actions that are assigned to them and when they are due.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	FU-010	The application could provide an interface that allows the monitoring of system downtime and statistics highlighting to the user the most impacted systems.	CRAM_Digital_Tier_TP_2021	OQ-009
CRAM_Digital_Tier_RS_2021	FU-011	Actions displayed in the application should be able to be searched and filtered by due date.	CRAM_Digital_Tier_TP_2021	OQ-008
CRAM_Digital_Tier_RS_2021	FU-012	Action items must be comprised of the following elements: Username of assigned team member, title of action, description of action, due date, what type of action it is, the department they are in and what the completion status is.	CRAM_Digital_Tier_TP_2021	OQ-007
CRAM_Digital_Tier_RS_2021	FU-013	Users should be able to register an account to allow new users to be added to the Tier application.	CRAM_Digital_Tier_TP_2021	OQ-001
CRAM_Digital_Tier_RS_2021	FU-014	The application should provide functionality to escalate items to the next Tier.	CRAM_Digital_Tier_TP_2021	OQ-008
CRAM_Digital_Tier_RS_2021	FU-015	Delivery items should be assigned a priority of completion to enable fast response on those items with business-critical impact.	CRAM_Digital_Tier_TP_2021	OQ-008
CRAM_Digital_Tier_RS_2021	DI-001	Users cannot delete raw data from the database.	CRAM_Digital_Tier_TP_2021	IQ-002
CRAM_Digital_Tier_RS_2021	DI-002	An approved process must be available to grant and remove access to/from individuals (users and administrators of the system).	CRAM_Digital_Tier_TP_2021	OQ-001
CRAM_Digital_Tier_RS_2021	DI-003	The system must prevent the accidental or intentional modification of time settings.	CRAM_Digital_Tier_TP_2021	IQ-001
CRAM_Digital_Tier_RS_2021	DI-004	All system modifications must be tied to a unique user ID.	CRAM_Digital_Tier_TP_2021	OQ-007
CRAM_Digital_Tier_RS_2021	PR-001	The system must support up to 15 concurrent users.	CRAM_Digital_Tier_TP_2021	OQ-002

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CRAM_Digital_Tier_RTM_2021

Cramlington Manufacturing Facility Digital Tier RTM

CRAM_Digital_Tier_RS_2021	PR-002	The system must be accessible for users with a range of computer literacy skills.	CRAM_Digital_Tier_TP_2021	UAT-002
CRAM_Digital_Tier_RS_2021	PR-003	The system should be responsive. Login for users should take less than 5 seconds from clicking the login button.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	DR-001	The front facing end-user system must be suitable to be displayed on visual meeting boards.	CRAM_Digital_Tier_TP_2021	IQ-001
CRAM_Digital_Tier_RS_2021	DR-002	The system must be presented in an appropriate design while considering the users needs.	CRAM_Digital_Tier_TP_2021	UAT-001
CRAM_Digital_Tier_RS_2021	DR-003	Visual graphs must be used where possible to demonstrate data.	CRAM_Digital_Tier_TP_2021	OQ-003
CRAM_Digital_Tier_RS_2021	DR-004	The systems code must be fully documented and designed using appropriate design principles to ensure easy future maintenance.	-	Cannot be tested
CRAM_Digital_Tier_RS_2021	DR-005	Historic data should be stored but not displayed if irrelevant to the user.	CRAM_Digital_Tier_TP_2021	OQ-007
CRAM_Digital_Tier_RS_2021	DR-006	If a notifications system is in place, users must be able to clear historic notifications.	-	Cannot be tested
CRAM_Digital_Tier_RS_2021	DR-007	A clear and navigable system must be in place to allow end-users to navigate within the application.	CRAM_Digital_Tier_TP_2021	OQ-004
CRAM_Digital_Tier_RS_2021	DR-008	End-user applications must have a clear narrative to demonstrate a general flow of events.	CRAM_Digital_Tier_TP_2021	OQ-004
CRAM_Digital_Tier_RS_2021	UX-001	Tooltips must be accessible where possible to provide additional user guidance.	CRAM_Digital_Tier_TP_2021	UAT-002
CRAM_Digital_Tier_RS_2021	UX-002	Users should be presented with different views within the application depending on their user status.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	UX-003	The system is internal facing and must follow the companies branding guidelines.	CRAM_Digital_Tier_TP_2021	UAT-001
CRAM_Digital_Tier_RS_2021	UX-004	Whitespace must be used appropriately within the application design to display information clearly.	CRAM_Digital_Tier_TP_2021	UAT-001
CRAM_Digital_Tier_RS_2021	UX-005	Users must not be presented with data irrelevant to their job role.	CRAM_Digital_Tier_TP_2021	UAT-001
CRAM_Digital_Tier_RS_2021	UX-006	User guidance must be provided to ensure the system is accessible for all users.	CRAM_Digital_Tier_TP_2021	UAT-002
CRAM_Digital_Tier_RS_2021	SE-001	The system is compatible with the Cramlington site's network Infrastructure.	CRAM_Digital_Tier_TP_2021	IQ-001

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CRAM_Digital_Tier_RTM_2021

Cramlington Manufacturing Facility Digital Tier RTM

CRAM_Digital_Tier_RS_2021	SE-002	The system shall use a standard Windows 10 ECORE PC which meets the minimum requirement specified by the development team.	CRAM_Digital_Tier_TP_2021	IQ-001
CRAM_Digital_Tier_RS_2021	SE-003	Time must be synchronized with the official Cramlington site's time source to record time and date for data activities. If an application does not use the official Cramlington site's time source, it must be synchronized to a certified time source.	CRAM_Digital_Tier_TP_2021	IQ-001
CRAM_Digital_Tier_RS_2021	SE-004	User access integrated with the Cramlington site's Active Directory where technically possible or provide individual user logins and permission to the application to ensure only authorized users can access the software.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SE-005	The database shall use a standard version of SQL which meets the minimum requirement specified by the developer.	CRAM_Digital_Tier_TP_2021	IQ-001
CRAM_Digital_Tier_RS_2021	BR-001	The system must support the backup of source data based on the procedurally defined backup frequency.	-	Covered by web server Newnumyspace
CRAM_Digital_Tier_RS_2021	BR-003	The system must include automated error handling that verifies the success of the backup.	-	Covered by web server Newnumyspace
CRAM_Digital_Tier_RS_2021	BR-004	Backups of all relevant raw data and metadata must be stored in a separate and secured location from the raw data (e.g., a separate server).	-	Covered by web server Newnumyspace
CRAM_Digital_Tier_RS_2021	BR-005	Temporary removable media must not be used to store data, unless required for system operations	-	Covered by web server Newnumyspace
CRAM_Digital_Tier_RS_2021	BR-006	The system must be able to restore data from a previous version	-	Covered by web server Newnumyspace
CRAM_Digital_Tier_RS_2021	SI-001	The software application must be capable of operating via the Cramlington site network.	CRAM_Digital_Tier_TP_2021	IQ-001

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CRAM_Digital_Tier_RTM_2021

Cramlington Manufacturing Facility Digital Tier RTM

CRAM_Digital_Tier_RS_2021	SEC-001	Multiple sessions are not permitted - the system restricts the user to a single logon/session.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SEC-002	Assign unique user and administrator identification for each user or administrator of the system.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SEC-003	Access to the software, operation system or application is not based on biometrics, access must be via individual login credentials made up of a combination of a unique user id and a user generated password.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SEC-004	Generic user or administration accounts, such as those shipped with the system, must be turned off, disabled, or have access revoked if they are unnecessary for system operations.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SEC-005	Shared logins or generic user or administrator system accounts must not be enabled with system permissions that can create or modify data.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SEC-006	A non-person service account, used for system interfaces or testing, must have a unique ID and password.	CRAM_Digital_Tier_TP_2021	OQ-002
CRAM_Digital_Tier_RS_2021	SEC-007	Users must not have access to annotation/editing tools that may be used to obscure or modify the stored or displayed data.	CRAM_Digital_Tier_TP_2021	IQ-002
CRAM_Digital_Tier_RS_2021	SEC-008	Any regulated data that may be in a temporary storage (e.g. temp files, intermediate file share), such as on a PC or server, must be protected from access, modification, and deletion by any persons.	CRAM_Digital_Tier_TP_2021	IQ-002
CRAM_Digital_Tier_RS_2021	SEC-009	Different access levels are to be assigned to users, non-person accounts and administrators, and ensure that people have access only to functionality that is appropriate for their role. NOTE: The required roles and associated rights are to be based on the system design and are to enforce the principles of separation of duty and least privilege.	CRAM_Digital_Tier_TP_2021	OQ-002

Proprietary

CRAM_Digital_Tier_RTM_2021

Appendix 14 – Test Protocol

**CMF
Digital Tier
Test Protocol**

Document ID: CRAM_Digital_Tier_TP_2021
Document Revision: 1.0
Issue Date: 17-APR-2021

Document Signatures

AUTHOR:	
James Singh Assoc. Spclst, Business/Tech. Analysis Shop Floor Systems Team	
By affixing their signature, the individual above acknowledges that they authored the contents of this document and attest that the contents are accurate ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	
BUSINESS UNIT APPROVAL:	
Ryan Pickering Assoc. Spclst, Automation Shop Floor Systems Team	
By affixing their signature, the individual representing the IT Business Unit/Area above acknowledges that they have reviewed and approve the contents of this document and attest that they are accurate. IT Business Unit/Area representative is responsible for ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	

Revision History

Revision	Author Name	Date	Description
1.0	James Singh	17-APR-2021	Issue for Approval

Introduction

Purpose

The purpose of this protocol is to document the Installation Qualification, Operational Qualification and User Acceptance Testing of the CMF's Digital Tier. This will be done by challenging the systems requirements using operational use cases to actively simulate real-life scenarios. This document will identify the test strategy and cases in order to thoroughly test the functionality of the system. Each individual test case is classified as either "Pass" or "Fail", with each test identified as a failure being remediated prior to the system's full release.

Definitions & Acronyms

Abbreviation	Definition
CMF	CMF
OTS	Off the shelf
DB	Database
DI	Data Integrity
GMP	Good Manufacturing Practice
OQ	Operational Qualification
RS	Requirement Specification
SDLC	System Development Life Cycle
SQL	Structured Query Language
TP	Test Protocol

System Overview

The “Tier Process” is a method of funneling key information through the site to the right people. Each department within a business unit, each holds a meeting where the members of the meeting go through a series of questions and sections relating to their business function. For example, some of the sections will include health and safety, planned downtime for systems and any ongoing issues. This is called Tier 1. Once the Tier 1 meetings have finished another meeting is scheduled soon after where each of the department leads within that business function get together with the business function lead and go through the same process, discussing the outcomes from the Tier 1 meeting. This is the Tier 2 meeting. For the Tier 3 meeting, each business function lead meets with each other and the plant manager to discuss the outcomes from that business function’s Tier 1 & 2 meetings but only if these issues are necessary to be brought to the plant managers attention. Figure 1 shows this process using the IT, Bulk Manufacturing and Packaging departments as an example.

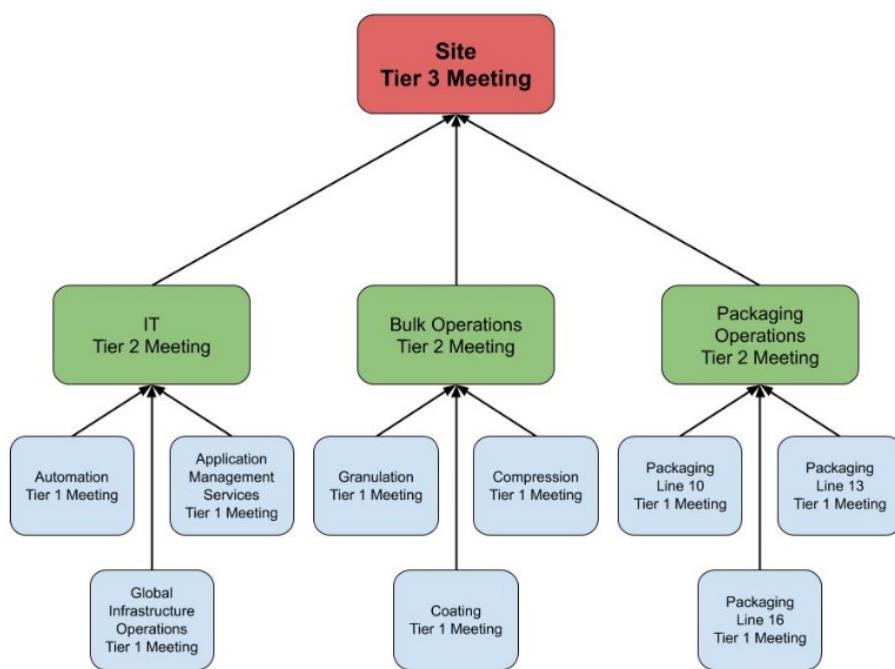


Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples.



Figure 2 – A visual representation of the “Tier Board” used at the CMF as examples.

These meetings took place in person using tools such as large printed out whiteboards that people wrote on – see figure 2. This was a great tool to get people together and discuss issues effectively. The tool proposed will be a web-based client that will be responsible for all the actions of the in-person meetings (as shown in figure 2), whilst also implementing data analytics and data tracking to create a broader image of how the IT business function is working. All data used in this system will be stored using a secure SQLite database system that will be thoroughly reviewed and evaluated to ensure the correct solution for this product. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. The final wireframe of how the homepage of the application will look is detailed below in figure 3.

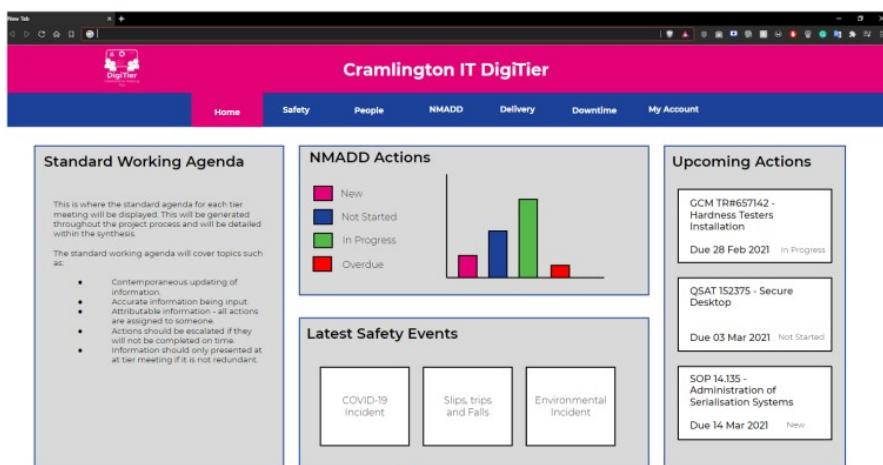


Figure 3 – A wireframe of the proposed Tier Application.

Test Protocol Information

Test Strategy

This system is designed as an OTS system that can be picked up and used by anyone, therefore this testing will not focus on the design of the system. However, the following test strategy will look at challenging the system through various workflows to succinctly draw out any issues within the system.

Test Support

The following devices are required for testing:

- Windows 10 PC with internet access

Acceptance Criteria

All test activities within the test specification have been completed and documented as defined in this document. The following is a list of the completed documentation:

- Signatures and Incident Log are completed if necessary.
- All test scripts have been successfully executed or have been appropriate addressed through the Test Incident process including retesting, if necessary.
- All supporting documentation is available, labeled, annotated and properly cross-referenced.
- All incidents, if applicable, have been closed.
- All test scripts have been signed by the tester.

Protocol Pre-Requisites

Prior to executing any of the tests within this protocol, the prerequisites in the following table must be met.

Pre-Requisites
This protocol has been pre-approved.
The operational environment for the system has been correctly configured.

Installation Qualification Testing

IQ-001 – Set up on Cramlington Site's Infrastructure

Case ID: IQ-001	Case Title: Set up on Cramlington Site's Infrastructure
Objective(s):	
<ul style="list-style-type: none">To ensure that the system is compatible with the CMF's site infrastructure.Prerequisite:<ul style="list-style-type: none">A standard Windows 10 ECORE PC is setup and available with internet access and is connected to the touch screen digital display.	

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Turn on the PC and login.	PC turns on and user can login.	PC turns on and user can login.	PASS
2	Confirm that time on the PC matches that of the CMF's time server.	Time on the PC matches.	Time on the PC matches.	PASS
3	Open up a browser and navigate to: http://unn-w17000348.newnumyospace.co.uk/part1/api/	Browser opens and once navigation complete, API loads correctly.	Browser opens and once navigation complete, API loads correctly.	PASS

4	Navigate to: http://unn-w17000348.newnummyspace.co.uk/part2/	Dashboard is displayed and charts are populated.	Dashboard is displayed and charts are populated.	PASS
5	Display the system on the digital screen.	Both the API and React App can be displayed on the digital screen.	Both the API and React App can be displayed on the digital screen.	PASS

Performed by:	James Singh	Signature:	Review Date:	19 Apr 2021
				

IQ-002 – Database Access

Case ID: IQ-002	Case Title: Database Access
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Objective(s):

- To check if user can access the development database.

Prerequisite:

- User is logged into a Cramlington Site's PC and is able to navigate to the API and React app.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Attempt to gain access and modify data within the SQLite database.	User cannot access the database.	User cannot access the database.	PASS

Performed by:	James Singh	Signature:	Signature	Review Date:	19 Apr 2021
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Operational Qualification Testing

OQ-001 – User Registration

Case ID: OQ-001	Case Title: User Registration
Objective(s):	
<ul style="list-style-type: none">To ensure that the system allows new users to be registered.	

Prerequisite:

- OQ-001 and OQ-002 were completed successfully.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Open the React app.	React app opens successfully.	React app opens successfully.	PASS
2	Click on the "My Account" page.	Page opens successfully.	Page opens successfully.	PASS
3	Enter the new user's details.	Details entered correctly: Username: jimmy Email: jimmy@example.com Password: 1234 First name: Jimmy Surname: Smith Role: P1 Department: A&IT	Details entered correctly: Username: jimmy Email: jimmy@example.com Password: 1234 First name: Jimmy Surname: Smith Role: P1 Department: A&IT	PASS

4	Click the "Register" button.	Page refreshes and login field is displayed.	Page refreshes and login field is displayed.	PASS
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Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-002 – User Login

Case ID: OQ-002	Case Title: User Login
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Objective(s):

- To ensure that the system allows users to login.

Prerequisite:

- OQ-001 was completed successfully.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "My Account" page.	Page opens successfully.	Page opens successfully.	PASS
2	Enter the user's email and password as created in OQ-001.	Users email and password entered correctly: Email: jimmy@example.com Password: 1234	Users email and password entered correctly: Email: jimmy@example.com Password: 1234	PASS
3	User clicks "Log in"	User is logged in successfully and navigation bar populates.	User is logged in successfully and navigation bar populates.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-003 – Dashboard

Case ID: OQ-003	Case Title: Dashboard
Objective(s):	
<ul style="list-style-type: none">To access the dashboard.	
Prerequisite:	
<ul style="list-style-type: none">OQ-001 and IQ-002 were completed successfully.	

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "Dashboard" page.	Page opens successfully.	Page opens successfully.	PASS
2	Dashboard contains all necessary items.	Dashboard contains all items including: <ul style="list-style-type: none">Standard working agendaSafety action overviewUpcoming NMADD actionsChart of outstanding items and what department they are assigned to.	Dashboard contains all items including: <ul style="list-style-type: none">Standard working agendaSafety action overviewUpcoming NMADD actionsChart of outstanding items and what department they are assigned to.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-004 – Navigation

Case ID: OQ-004	Case Title: NMADD
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Objective(s):

- To ensure NMADD page works correctly.

Prerequisite:

- User is logged in.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Navigation is displayed.	Navigation is displayed with the following items: <ul style="list-style-type: none">• Dashboard• Safety• People• NMADD• Delivery• Downtime• My Account	Navigation is displayed with the following items: <ul style="list-style-type: none">• Dashboard• Safety• People• NMADD• Delivery• Downtime• My Account	PASS
2	User clicks on each page.	User is able to click on each page which displays correctly.	User is able to click on each page which displays correctly.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-005 – Safety

Case ID: OQ-005	Case Title: NMADD
Objective(s):	
	<ul style="list-style-type: none">To ensure the Safety section works correctly.
Prerequisite:	
	<ul style="list-style-type: none">User is logged in.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "Safety" page.	Page opens successfully.	Page opens successfully.	PASS
2	Safety items are displayed on the page.	Safety items, site attendance and relevant charts are populated.	Safety items, site attendance and relevant charts are populated.	PASS
3	Click on the "Edit a Safety Item" button.	User is able to update a Safety item.	User is able to update a Safety item.	PASS
4	Click on the "Add New Safety Item" button.	User is able to add a new Safety item.	User is able to add a new Safety item.	PASS
5	Click on the "Add Site Attendance" button.	User is able to add a Site Attendance item.	User is able to add a Site Attendance item.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-006 – People

Case ID: OQ-006	Case Title: People
Objective(s):	
• To ensure the People section works correctly.	
Prerequisite:	
• User is logged in.	

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "People" page.	Page opens successfully.	Page opens successfully.	PASS
2	People items are displayed on the page.	Department's status and successes are displayed.	Department's status and successes are displayed.	PASS
3	Click on the "Edit Department Status" button.	User is able to update a Department Status.	User is able to update a Department Status.	PASS
4	Click on the "Edit Successes" button.	User is able to update a Success story.	User is able to update a Success story.	PASS
5	Click on the "Add New Success" button.	User is able to add a new Success story.	User is able to add a new Success story.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-007 – NMADD

Case ID: OQ-007	Case Title: NMADD
Objective(s):	
<ul style="list-style-type: none">To ensure the NMADD section works correctly.	

Prerequisite:

- User is logged in.

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "NMADD" page.	Page opens successfully.	Page opens successfully.	PASS
2	Action items are displayed on the page.	NMADD items are displayed in correct buckets.	NMADD items are displayed in correct buckets.	PASS
3	Click on the "Edit a NMADD Item" button.	User is able to update a NMADD item.	User is able to update a NMADD item.	PASS
4	Click on the "Add New NMADD Item" button.	User is able to add a new NMADD item.	User is able to add a new NMADD item.	PASS
5	Click on the "NMADD Statistics" button.	Accurate charts are displayed.	Accurate charts are displayed.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-008 – Delivery

Case ID: OQ-008	Case Title: Delivery
Objective(s):	
• To ensure the Delivery section works correctly.	
Prerequisite:	
• User is logged in.	

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "Delivery" page.	Page opens successfully.	Page opens successfully.	PASS
2	Delivery items are displayed on the page.	Delivery items are displayed in correctly.	Delivery items are displayed in correctly.	PASS
3	User filters the delivery items.	User is able to filter the delivery items.	User is able to filter the delivery items.	PASS
4	Click on the "Edit Delivery Item" button.	User is able to update a Delivery item.	User is able to update a Delivery item.	PASS
5	Click on the "Add New Delivery Item" button.	User is able to add a new Delivery item.	User is able to add a new Delivery item.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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OQ-009 – Downtime

Case ID: OQ-009	Case Title: Downtime
Objective(s):	
• To ensure the Downtime section works correctly.	
Prerequisite:	
• User is logged in.	

Step No.	Action(s)/Input(s)	Expected Result(s)	Actual Result(s)	Pass/Fail
1	Click on the "Downtime" page.	Page opens successfully.	Page opens successfully.	PASS
2	Downtime items are displayed on the page.	Downtime items are displayed in correctly.	Downtime items are displayed in correctly.	PASS
3	User filters the Downtime items.	User is able to filter the Downtime items.	User is able to filter the Downtime items.	PASS
4	Click on the "Edit Downtime Item" button.	User is able to update a Downtime item.	User is able to update a Downtime item.	PASS
5	Click on the "Add New Delivery Item" button.	User is able to add a new Downtime item.	User is able to add a new Downtime item.	PASS

Performed by:	James Singh	Signature:		Review Date:	19 Apr 2021
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User Acceptance Testing

UAT-001 – Displaying Information

Case ID: UAT-001	Case Title: Displaying Information
Objective(s):	
• To understand how a user reacts to the way information is displayed.	
Prerequisite:	
• User is logged in.	

Question	Comment
Does the application display all necessary information in a readable and concise method?	Yes, the system was very clear at displaying the information.
Does the system have an appropriate design, considering the user's needs?	Yes, the design was very clean and is clear what is happening.
Does the system follow the companies branding guidelines?	The branding matches exactly, even down to the fonts and logo style.
Is whitespace used appropriately within the application design to display information clearly?	Yes, the space doesn't take away from the overall design.
Is the user presented with data irrelevant to their job role?	Yes, allows you to easily filter items also which makes it easy to see what you want.

User Signature:		Review Date:	19 Apr 2021	Pass/Fail:	PASS
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UAT-002 – Accessibility

Case ID: UAT-002	Case Title: Accessibility
Objective(s):	
	<ul style="list-style-type: none">• To understand how a user feels about the accessibility features of the app.
Prerequisite:	
	<ul style="list-style-type: none">• User is logged in.

Question	Comment
Is the system accessible for users with a range of computer literacy skills?	Yes, it is very straightforward and meets standards for the company sites.
Are tooltips present to provide additional user guidance?	Really handy to have them on the graphs and charts.
Is there sufficient user guidance provided to ensure the system is accessible for all users?	Yes, clearly points you in the right direction and gives the user a structure.

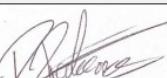
User Signature:		Review Date:	19 Apr 2021	Pass/Fail:	PASS
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Appendix 15 – Quality Assurance Summary Report

**CMF
Digital Tier
Quality Assurance Summary
Report (QASR)**

Document ID: CRAM_Digital_Tier_QASR_2021
Document Version: 1.0
Issue Date: 28-Apr-2021

Document Signatures

AUTHOR:	
James Singh Assoc. Spclst, Business/Tech. Analysis Shop Floor Systems Team	
By affixing their signature, the individual above acknowledges that they authored the contents of this document and attest that the contents are accurate ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	
BUSINESS UNIT APPROVAL:	
Ryan Pickering Assoc. Spclst, Automation Shop Floor Systems Team	
By affixing their signature, the individual representing the IT Business Unit/Area above acknowledges that they have reviewed and approve the contents of this document and attest that they are accurate. IT Business Unit/Area representative is responsible for ensuring alignment with policies, guidelines, and procedures governing System Development Life Cycle Methodologies and current regulations.	

Revision History

Revision	Author Name	Date	Description
1.0	James Singh	16-APR-2021	Issue for Approval

Introduction

Purpose

The purpose of this Quality Assurance Summary Report (QASR) is to provide a summary of the Quality Assurance Plan activities for the Digital Tier application. It summarizes the activities and deliverables which were completed during the Initiate & Planning, Design & Build, and Test & Install as well as in preparation for the Run & Operate SDLC Phase. This report will include any deviations and IT Variances from the Quality Assurance Plan. This report will document the procedures that will govern production use of the system along with any system exceptions and/or limitations.

The Release Authorization Notice (RAN) is included within this document.

Scope

The scope of this summary includes a description of the approach taken to assure the Digital Tier application was developed and implemented according to the CMF's standards and established testing practices. This Quality Assurance Summary Report documents the effort and acceptance criteria and applies specifically to Digital Tier application for use at the CMF.

System Overview

The “Tier Process” is a method of funneling key information through the site to the right people. Each department within a business unit, each holds a meeting where the members of the meeting go through a series of questions and sections relating to their business function. For example, some of the sections will include health and safety, planned downtime for systems and any ongoing issues. This is called Tier 1. Once the Tier 1 meetings have finished another meeting is scheduled soon after where each of the department leads within that business function get together with the business function lead and go through the same process, discussing the outcomes from the Tier 1 meeting. This is the Tier 2 meeting. For the Tier 3 meeting, each business function lead meets with each other and the plant manager to discuss the outcomes from that business function’s Tier 1 & 2 meetings but only if these issues are necessary to be brought to the plant managers attention. Figure 1 shows this process using the IT, Bulk Manufacturing and Packaging departments as an example.

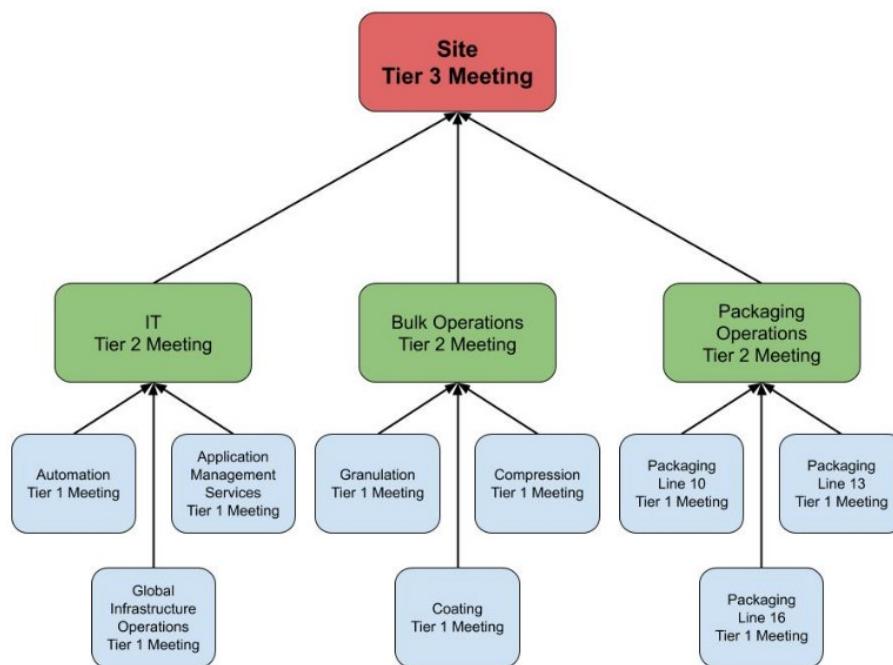


Figure 1 – A demonstration of the Tier 1, Tier 2 and Tier 3 meetings that take place using the IT, Bulk Manufacturing and Packaging departments at the CMF as examples.



Figure 2 – A visual representation of the “Tier Board” used at the CMF as examples.

These meetings took place in person using tools such as large printed out whiteboards that people wrote on – see figure 2. This was a great tool to get people together and discuss issues effectively. The tool proposed will be a web-based client that will be responsible for all the actions of the in-person meetings (as shown in figure 2), whilst also implementing data analytics and data tracking to create a broader image of how the IT business function is working. All data used in this system will be stored using a secure SQLite database system that will be thoroughly reviewed and evaluated to ensure the correct solution for this product. This system will be a proof of concept for the IT department with the idea to expand to the larger site in the future. The first initial wireframe of how the homepage of the application will look is detailed below in figure 3.

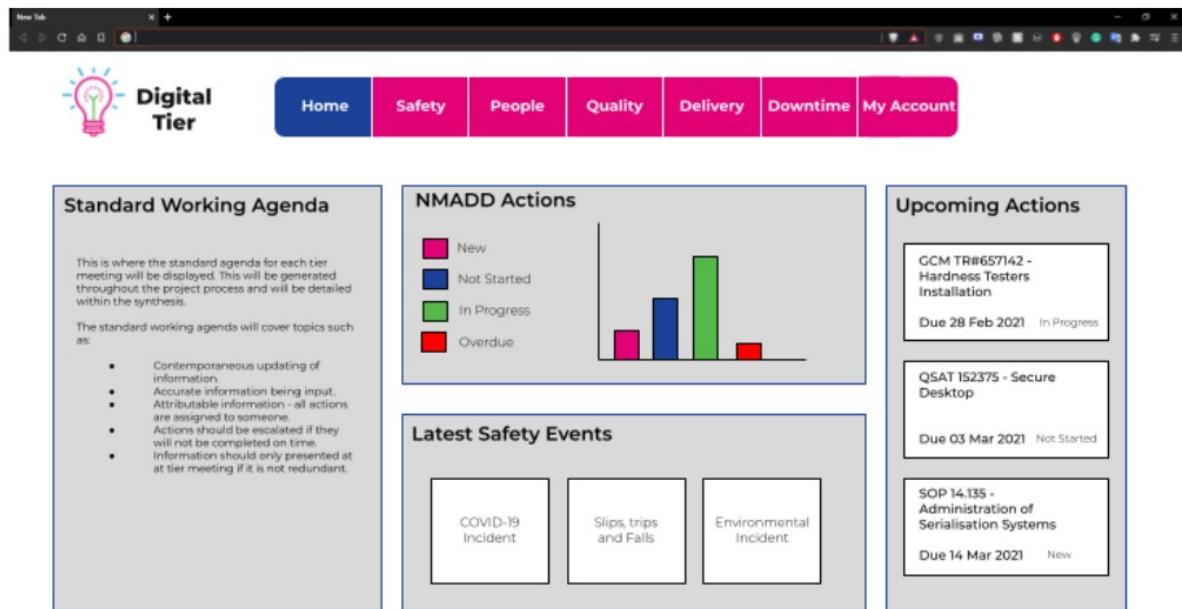


Figure 3 – A wireframe of the proposed Tier Application.

Definitions & Acronyms

Abbreviation	Definition
CS	Configuration Specification
DB	Database
DI	Data Integrity
IPT	Integrated Process Team
IT	Information Technology
RS	Requirement Specification
SDLC	System Development Life Cycle
SOP	Standard Operating Procedure
SQL	Structured Query Langage
UX	User Experience

Training

All users of the new and/or upgraded systems will be appropriately trained in the new procedures, according to the user role required. All users of the system will receive appropriate training prior to go-live.

The training has been identified, controlled, and executed by the Site.

Test Summary

All planned testing including User Acceptance Testing, Installation Testing and Operational Testing of the Digital Tier application were successfully completed. All the defects which were opened during each of the above testing efforts have been closed upon successful retesting as required or have been deferred for future release as documented in Section 4.2 Test Defect/incident Summary.

Overview

Installation and Operational qualification testing has been conducted for the Digital Tier application at the CMF.

Test Incident Summary

Test Protocol Testing:

During Test Protocol testing, a total of 0 incidents were identified.

Listed below are the incidents found during Test Protocol:

Incident ID	Test Protocol Test	Description of Incident	Disposition (open/close)	Justification for open
N/A	N/A	N/A	N/A	N/A

Installation Testing to Production Environment:

There were no incidents identified during IQ execution in Production environment and therefore no incidents were logged.

Deviations from the Quality Assurance Plan

There were no deviations or any IT Variances from the approved Quality Assurance Plan.

Release Activities

The Digital Tier application is accepted for production use because the following conditions were met:

- All documentation defined in the Quality Assurance Plan and other project-specific documents were completed and approved as specified in this Quality Assurance Summary Report (QASR).
- All test activities identified in the Quality Assurance Plan were successfully completed, documented, and approved as specified in this QASR.
- The Business Unit and other designated approval authorities agreed, by signature on the QASR (this document) that the required functionality was met and is appropriate for production use.
- A Release Authorization Notice (RAN) will be approved (with this document) to notify users that the system is available for production use.

Conclusion Statement

All the quality assurance activities as described in the Quality Assurance Plan unless otherwise noted in Section 4 – Variance from the Quality Assurance Plan have been completed. Therefore, the acceptance criteria have been met and the Digital Tier application is hence deemed to be appropriate for production use.

The approval of this QASR, as well as the Release Authorization Notice, signifies the completion of system development, implementation, and quality assurance activities; and approves the system as suitable for use in production.

Release Authorization Notice (RAN)

This QASR authorizes the release of the Digital Tier application for business use. This notice serves as the mechanism for communicating that all support mechanisms are in place and all lifecycle requirements have been satisfied. The scope of intended use is local.

The summary of the activities and deliverables is provided in the Quality Assurance Summary Report (QASR).

Appendix 16 – Final Project Plan

Key		Item	Detail	Time (hrs)	Semester 1						Semester 2						Resources
Deadline	In Progress				W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	
Not Started		The Initiate phase of the project		4.5													
In Progress		Setup time with Supervisor for our weekly project meeting for 1st Semester.		0.5													
Complete		Arrange weekly meeting															
		Confirmation of Supervisor and Project Idea															
		Send confirmation of Project Supervisor and Project Idea		0.5				*									
		Summarise chosen idea on a simple Project Initiation Document, state the main aim of the project, the rationale, main challenge, type of product, resources and any external body involved.															
		Project Initiation Document					2										
		Review of PID in weekly project meeting		0.5													
		Review of PID															
		Revise PID															
		Submit PID															
		The Planning phase of the project		121.5													
		The TOR is what the project will be measured against and consists of the following sections: Project title, background to project, proposed work, aims of project, objectives, skills, sources of information, resources, structure and contents of project report, marking scheme and project plan.											*				
		Terms Of Reference Creation															
		Complete online ethics form to ensure that my project is inline with university standards and then gain ethical approval for my project to go ahead.															
		Complete Ethics Form															
		Complete Risk Assessment															
		Schedule TOR Review															
		Setup time to review TOR with Supervisor and second marker.		0.5													
		Time to go through my TOR and suggest any revisions that need to be made.															
		TOR Review															
		Revise TOR															
		Upload revised TOR document to Blackboard.		0.5													
		Client Requirements Capture		5													

Key		Item	Detail	Time (Hrs)	Semester 1												Semester 2												Assessment
Deadline					W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	
Not Started	*	This part of the report should provide the reader with information they will need to know in order to appreciate and understand the work you have done in the rest of the project.		90																									
In Progress		Work on Analysis Chapters																											
Complete		Submit Analysis Chapters to Supervisor	Share the analysis chapters with Supervisor for review and feedback.	0.5														*											
Design and Build		The Design and Build phase of the project.		135																									
Create UML Diagrams		Creation of UML Diagrams to illustrate the structure of the software.		10																									
Create ERD and Data Dictionary		Creation of the Entity Relationship Diagram and Data Dictionary to illustrate the setup of the Database		10																									
Creation of Database		Creation of Database in accordance to the ERD and Data Dictionary		10																									
Development of Server Side		Development of Server Side		10																									
Development of Client Side		Development of Client Side		90																									
Client Feedback Meeting		Meeting with Client to discuss feedback on the product.		5																									
Test and Install		The Test and Install phase of the project.		40																									
Installation Qualification		To perform the installation qualification on the client's workstation		10																									
Operational Qualification		To perform the operational qualification on the client's workstation		10																									
User Acceptance Testing		To perform the user acceptance testing with the client.		20																									
The Report Phase of the Project		105																											
Introduction		Creation of the Introductory Chapters		5																									
Synthesis		Creation of the Synthesis Chapters		50																									
Evaluation		Creation of the Evaluation Chapters		25																									
Conclusions		Creation of the Conclusion Chapters		10																									
Abstract		Creation of the Abstract		3																									
Send report for Feedback		Send report to Supervisor for review and feedback		1																									

Key		Detail	Time (Hrs)	Semester 1												Semester 2						Assessment						
Deadline	*			W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W1
Not Started		Make changes to the report based on feedback from Supervisor	10																									
In Progress		Submission of Report to Blackboard	1																									*
Complete		The Viva phase of the project	2																									
		Organise a date with Supervisor and Second marker to conduct viva	1																									
		Viva Presentation	1																									*
		Conduct the viva	1																									
		Total Time	408																									