PROJECT BLUE OCEAN

REPORT

PROJECT NAME	PROJECT BLUE OCEAN
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ABSTRACT

A project was undertaken for Synlait Milk Limited in partial fulfilment of the Master in Engineering Management degree at the University of Canterbury. Project Blue Ocean aimed to discover opportunities for new technology adoption to improve the business operation. The project was initiated to drive the Manufacturing Excellence framework which contains three strong pillars: Safety, Reliability and People.

The project began with the discovery of the current issues, mainly focused on manual handling (critical risk activities), repetitive and low-value tasks. The technology solutions were generated respectively to each issue and a high level concept study was developed for each of the top three technology solutions. Design Thinking methodology was applied throughout the project to understand the problems, define the underlying issues, generate unconstrained technology ideas, and prototype the most feasible solution. Justification methods such as the NTCP Diamond Model, the Total Application Model and the Technology Category Model were combined to create an evaluation matrix to find out the top three technology solutions: Vacuum System at Fluid Bed, Collaborative Robots and Fob Key Integration. Preliminary economic evaluation and recommendation plans were made, based on a high level concept study of each solution.

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Lastly, I would like to acknowledge the work and support of Beverley Hall during the Master of Engineering Management course. I would also like to thank all the MEM colleagues who have been helping and supporting me throughout the project period.

EXECUTIVE SUMMARY

The purpose of Project Blue Ocean was to evaluate the opportunities provided by the adoption of new technologies to improve the business operation and increase value-added tasks. A high level concept study was developed for each of the top three technology solutions.

The project aimed to drive the Manufacturing Excellence framework that empower employees, increase the reliability of the plants, and improve the health and safety level of the working activities. The project started off by looking at current issues in the manufacturing team, mainly on:

- manual labour (high critical risk) activities
- repetitive tasks
- low-value tasks

Design Thinking methodology was used as a framework throughout the project period. This was because this project leveraged the Empathise and Define phases to develop user empathy and understand their feelings and thoughts which cannot be quantified. The Ideate phase was ideal to generate unconstrained new technology solutions. These phases proved to suit the nature of this project better.

EMPHATHISE & DEFINE

The issues were gathered by interviews with key personnel from different teams, an online survey for operators, physically working alongside with the operators and talking to them to better identify fatigue points. The issues were compiled and defined as shown in the table below in the order of priority:

DEFINE ISSUES	DETAILS
COMMUNICATION	Organising and relaying information often induced errors. Therefore poor communication might lead to: • Unplanned downtime • Lost productivity • Decreased employee morale • Other wasted business costs
TRACEABILITY & VISIBILITY	Low traceability and visibility of inventory and information would cause: • Long lead time of internal consumable units • Time wasted to make well-informed decisions • Time wasted to track the past and current information
GOOD INFORMATION	• The current system collects raw data in the plant but it does not translate the data into useful information. • The decision to create an action has to be studied and made by the operators based on their past experiences.
MANUAL HANDLING	Many tasks involved manual handling in the manufacturing process. The same repetitive manual handling tasks would: • Decrease employee morale • Cause workplace injuries • Increase the human error factor

IDEATE

An ideation workshop was organised to generate unconstrained technology ideas because the Commercial Managers were gathered to contribute the ideas together to speed up the process. These ideas were narrowed down to the Top 30 opportunities. They were split into three categories sorted with the rankings.

CATEGORY	DETAILS	TECHNOLOGY SOLUTIONS
LOW-HANGING FRUIT	• Easy to implement • Often off-the-shelves products and solutions • No new or high technology knowledge is required • Relatively low cost	1. Vacuum system in fluid bed 2. Confined Space Inspection Camera 3. Inwards Truck Scheduling System 4. Touch Screen Device 5. QR Codes/RFID tech 6. Infrared and Networked Pest Control 7. TV Live Screen – Communication 8. Digital Radio System 9. 3D Printer & Scanner 10. Live Energy Consumption Monitor
NEW TECHNOLOGY	• Some new technology knowledge is used • Require integration with the current existing system • Might change the original procedure of work • Relatively new to Synlait or the dairy industry	11. Collaborative Robots 12. Augmented Reality Smart Glasses 13. Virtual Reality 14. Drone – Warehouse & Inspection 15. Digital Twin 16. Big Data/IOT Tool 17. Autonomous Guided Vehicle – material transfer
MAJOR CAPEX PROJECT	• No new or little technology knowledge is used • Require significant resources and coordination with several external stakeholders: customers and MPI[1]. • Most likely includes civil and other construction components • Might replace the existing system	18. Fob Key Integration 19. Inline Testing 20. Autonomous Forklift 21. Pallet Shuttle 22. Centralised Communication Centre 23. Laser Cutting of Powder bags 24. Online Login at Permit Station 25. Renewable Energy On Site 26. Automated Laboratory 27. Sterilisation Chamber at Inwards Goods Airlock 28. UV Tunnels – material transfer 29. Antimicrobial Coating 30. Ozone Treatment CIP

[1] Ministry for Primary Industries

PROTOTYPE & TEST

The Diamond NTCP Model, the Total Application Model, and the Technology Category Model were used to compile an evaluation matrix that includes other intangible criteria. A further investigation was implemented to justify and narrow down the list to the top three technology solutions. These solutions were proposed based on the capability of the company at the current state.

The three technology solutions were studied and a high level business case was built respectively. The figures were estimated with an accuracy up to ±30%.

TECHNOLOGY SOLUTION	DESCRIPTION	COST	BENEFITS
Vacuum System at the Dryer Fluid Bed	• Reduce the need of operators to climb into the fluid bed (confined space) for regular cleaning and blockage clearing.	CAPEX of $24,000 per unit	**5 year ROI 63%** **Payback 3 years**
Collaborative Robots	• Assist in lab testing procedure. • Offer a safe and effective alternative to dangerous (or hazardous) tasks that put employee's health and wellbeing at risk.	CAPEX of $60,000 per unit	**5 year ROI 166%** **Payback 1.4 years**
Key Fob Integration	• Require everyone to sign in and out daily for health and safety and evacuation management. • Improve site security, better control who is on site. • Eliminate manual time sheeting.	CAPEX of $70,000 across the site	**5 year ROI 48%** **Payback 2.8 years**

FUTURE WORK

The project presented the opportunities for adopting new technologies to improve Synlait Milk Limited's operations and drive the Manufacturing Excellence framework. The recommendation of technology solutions were only provided a high level preliminary economic evaluation and comparison of alternatives. In order to implement these technology solutions, a further feasibility study should be carried out to develop a User Specification Requirement (URS) because these technology solutions have to be designed and customised to fit the company's purpose. A detailed business case for each solution must be done in order to determine the control budget of the project. This would form the basis for board approval and funding. This document would be a beneficial reference to study the current issues identified in the manufacturing plants and possible technology ideas for future projects.

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1. INTRODUCTION

1.1 BACKGROUND

Synlait Milk Limited ("Synlait") is an innovative dairy company that strives to improve its business operations and create value-adding tasks for the workforce. The company has achieved success in the industry due to its state-of-art equipment and world class management. As the company is growing rapidly, Synlait is seeking for new technology opportunities across the business to drive its Manufacturing Excellence framework.

Figure 1: Manufacturing Excellence Driving Forces

Manufacturing Excellence was originated from the Baldridge Excellence Framework. The framework can be used in different sectors, range from manufacturing, service, non-profit, government, education to health care (Hobcraft, 2017). It is an integrated approach to organisational performance management that results in (Scott, 2017)

- Delivery of increasing value to customers and stakeholders
- Improvement of overall organisational effectiveness and capabilities
- Organisational and personal learning

Manufacturing Excellence is defined as the vision of "perfection" that guides an organisation's leadership in a relentless drive to improve the core value-creation process flow, from raw materials to finished product (The Path to Manufacturing Excellence, 1999). Figure 1 shows the driving forces of Synlait's Manufacturing Excellence framework: Safety, Reliability and People. These three strong pillars are developed in 2017 to improve the operational efficiency and deliver the agreed product cost-effectively while attaining total people involvement (Moess, 2017).

- **Safety**: We want every employee home safe.
- **Reliability**: We want our plants to be maintained and always operate at the optimum working condition.
- **People**: We want to improve manufacturing staff engagement, and provide them valuable training opportunities. The optimum level of Safety and Reliability can only be achieved if we have highly engaged people.

1.2 PROBLEM STATEMENT

Currently, some of the manufacturing processes require staff to undertake a wide variety of tasks that involve **manual handling, repetitive movement** and action, and **low-value work.**

1.2.1 MANUAL HANDLING

Manual handling is ranked among the Top 5 critical risks. In 2017, 82% of the recordable injuries were caused by manual handling activities in the manufacturing plants at Synlait. The most common injuries were sprains and strains incurred at lower back, lower limbs, and upper limbs (Synlait Incidents Record, 2017). The Total Recordable Injuries Frequency Rate (TRIFR) in 2017 was 11.3 assuming Synlait had 550 employees and the average working hour per week was 45 hours per employee.

- It meant that for every 100 employees, 11.3 employees have been involved in a recordable injury.

1.2.2 REPETITIVE ACTIVITIES

Repetitive activities were found commonly in the manufacturing plants, for example, quality testing, lifting and tipping powder bags, and material transfer. The monotonous and mundane activities would drive down the employee engagement and even induce repetitive stress injuries at the workplace (Friedman, 2018).

1.2.3 LOW-VALUE ACTIVITIES

A low-value task is any small task that keeps you busy and stops you from more important tasks that actually benefit the organisation (Oppong, 2017). For example, moving paper from one person to the next, finding someone to retrieve the file, writing down time sheets every day, and regularly checking for notification or email. These activities had limited the employees' productivity and prevented them from focusing on high-value activities.

1.3 PROJECT PURPOSE

Synlait currently utilises typical dairy industry best practice in the process automation such as automatic palletising robot and HMI plant monitoring system. The company aims to improve their operation by adopting new technology to assist operators wherever practical to minimise the manual labour intervention. This can greatly reduce the health and safety risk of the daily activities and improve the operational performance.

The purpose of Project Blue Ocean is to discover new technology opportunities in Synlait's business operations and develop business cases for the future implementation of such opportunities.

The scope of the project is as follows:

- Identifying current issues across the manufacturing process

- Facilitating technology ideation[2] workshop to gather key representatives in the plants
- Compiling and collating data
- Prioritising the Top three technology opportunities
- Developing business cases to support opportunities
- Facilitating a mini exhibition on site to showcase new technology applications

The project presents the following opportunities:

- Health and safety and efficiency issues could be reduced by the adoption of new technology.
- The existing workforce could be trained to become highly skilled staff focused on adding value to the business.
- Increase the awareness of new technology across the company.

[2] Ideation is a process to generate unconstrained ideas (Dam & Siang, What is Ideation – and How to Prepare for Ideation Sessions, 2017).

2. DEVELOPMENT OF A COURSE OF ACTIONS

2.1 DESIGN THINKING METHODOLOGY

During the initial stage of the project, Design Thinking methodology was introduced to tackle and solve the current issues at Synlait. It is a systematic approach that provides a solution-based approach to solving problems by understanding the human needs involved and generating new opportunities (Dam & Siang, What is Design Thinking and Why Is It So Popular?, 2017).

While there are many problem solving or improvement tools, Design Thinking is compared to Lean Six Sigma. The differences between the two approaches (Beckman, 2009) (Hare, 2017) shows that Design Thinking is more appropriate in this project. Design Thinking focuses on understanding the users, watching how they behave and interact, and developing a sense of empathy (Birckhead, 2014). It is a more suitable approach because it helps to understand the working value which cannot be quantified and generate unconstrained new technology opportunities to challenge the traditional dairy industry thinking.

Table 1: Differences between Design Thinking and Lean Six Sigma

ASPECTS	DESIGN THINKING	LEAN SIX SIGMA
CONCEPT	Coming up with potentially radical new and innovative ideas	Continuous, incremental improvement cycle
APPROACH	Explore new markets or opportunities	Improve existing products or process
PROCESS	Iterative (but allows linear progression)	Linear (but allows iteration)
MOTIVATION	Driven by creativity and unconstrained ideas while developing user empathy	Driven by scientific qualitative research and emphasize data measurement

There are five stages in Design Thinking. In practice, Design Thinking is a non-linear process. The five stages are not always sequential – they do not have to follow any specific order and they can often occur in parallel and be repeated iteratively as shown in Figure 2.

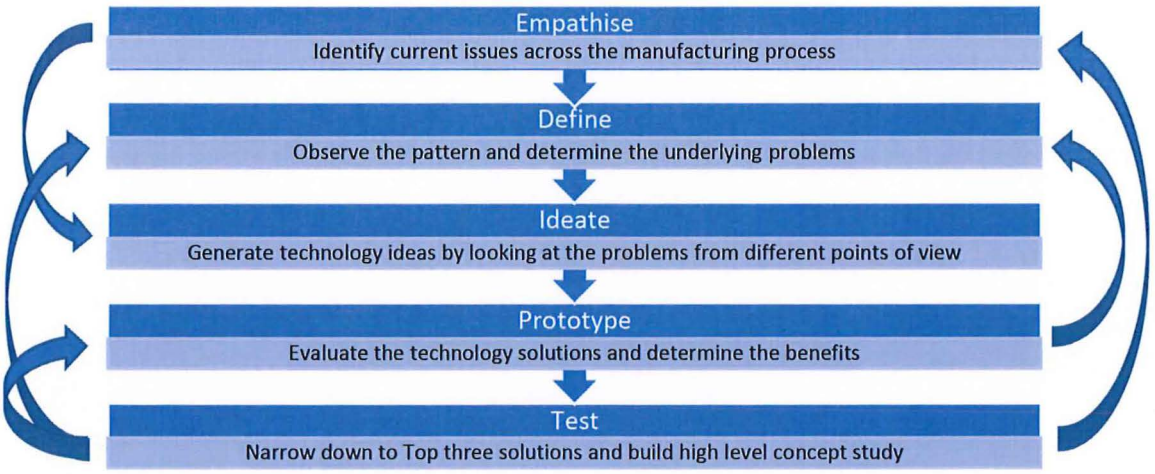

Figure 2: Design Thinking: A non-linear process

2.2 DATA COLLECTION

The data collection was carried out in the first phase of the project - Empathise. The aim of this process was to understand the current issues across the business, mainly looking at the low-value tasks, repetitive activities, critical risks activities, and other operations that require improvements.

2.2.1 DIRECT INTERVIEW - EMPATHISE

The Commercial Managers and key representatives from different teams in the manufacturing process were interviewed to collect the different issues facing their respective teams. The interview structure and complete answers can be found in Appendix A.

Table 2: Examples of key issues from face-to-face interviews

TEAMS	KEY ISSUES
DRYER 1	• Communication issues over bulky radio device • Losing track of consumable units at the satellite storage facility • Repetitive manual material transfer between different hygiene zones • Repetitive quality testing procedure • Cleaning process requiring operators to work in dangerous confined space
DRYER 2	• Taking manual powder moisture readings every hour • Clean In Place (CIP) process schedule clashing • Manual writing and entering data into the ERP system
BLENDING & CANNING	• Manual debagging • Manual weighing macro ingredients • Repetitive manual data input in log sheets • Unplanned downtime due to machine failures
WET MIX	• Manual debagging • Manual weighing of macro ingredients • High energy consumption to dissolve macro ingredients for production
LABORATORY	• Manual time sheeting • Manual handling of highly toxic and hazardous chemical • Double handling tasks such as sticking labels on specimen bags and repacking the powder into specimen bags • Body strains and injury from manual handling tasks
MAINTENANCE	• Site energy consumption is high • Miscommunication leads to time and resource wasting
WAREHOUSE & LOGISTICS	• Inwards goods trucks coming in anytime of the day without a planned schedule • Manual scanning of pallets using handheld bar code scanners • Repetitive material movement for example from the palletiser to the allocated warehouse rows

These issues were compiled from the Commercial Managers' point of view. They offered a higher level/management view on the issues found in their teams. Issues are often reported formally to the Commercial Managers and carry direct monetary impact on the respective teams' operations.

2.2.2 ONLINE SURVEY - EMPATHISE

After collating key issues from Commercial Managers from each team, an online survey was created for shift workers who work in the plant every day. Their opinions and perspectives were considered as they may be different to the opinions expressed in the interviews with Commercial Managers. At the Empathise stage of the Design Thinking, it is important to set aside any assumptions about the issues in order to gain insight into the end users and their needs.

The response rate of the survey was 50% (45 respondents out of 90 surveys sent out). Figure 3 showed the responses sorted by the teams.

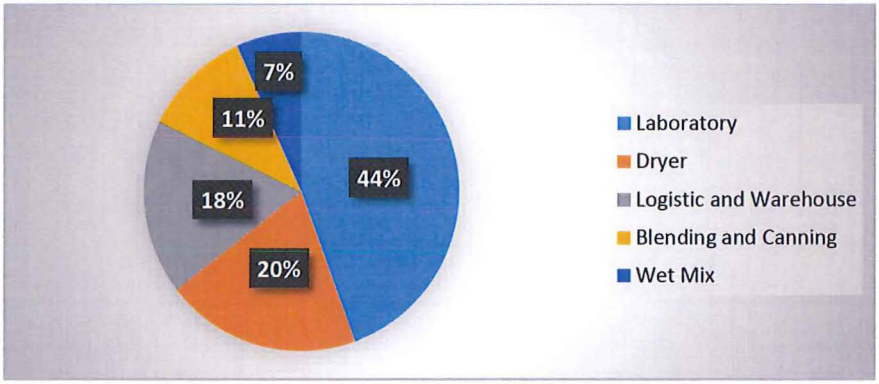

Figure 3: Online Survey Responses

The online survey also acted as a platform for shift workers to voice their opinions anonymously. As the end-users of the processing chain, they have thought about ways to improve the operations. The survey responses showed strong evidence that there were many low-value tasks in the daily activities:

- **60%** of the respondents were able to identify tasks that are not value adding.
- **84%** of the respondents were able to focus on higher priority tasks if all the non-value adding tasks were eliminated.
- **87%** of the respondents had to do repetitive activities mainly on hourly and daily basis.
- **60%** of the respondents could identify alternative ways to do repetitive tasks.
- **44%** of the respondents had to cross the redline[3] at least six times in a day.

Please see Appendix A for all survey questions and results. This survey concluded that:

- They have thought about ways to improve the operations and alternatives to replace the current set of repetitive tasks and increase their daily efficiency.
- The productivity has been hindered by low-value tasks such as:
    - Double or triple handling process
    - Waiting for personnel or information
    - Manual time sheeting
    - Crossing the redline

[3] Redline is the area separating different hygiene zones. If the operator wants to enter a higher hygiene zone, he/she has to put on coveralls and go through a cleaning procedure at the redline. Each crossing of the redline takes roughly 2-5 minutes.

2.2.3 GOING TO PLACE OF WORK - EMPATHISE AND DEFINE

To further gain an empathic understanding of the problem, I personally went to different part of the plants to work together with the operators across a few weeks. It allowed me to set aside my own assumptions about the issue and immerse myself in the physical working environment. Having the opportunity to talk and interact with the operators greatly helped me to define their pressure points. I better understood the need for an improvement of their working environment and activities.

2.2.4 IDEATION WORKSHOP - DEFINE AND IDEATE

An ideation workshop was then held as part of the Ideate stage of Design Thinking. The workshop gathered Commercial Managers from different teams mentioned above to run through the issues and generate unconstrained technology ideas or solutions.

The objectives of the workshop were to:

- Understand and share the issues around the key representatives from different teams
- Combine the great minds of everyone for an unconstrained creative thinking session
- Bounce ideas off of other people while building on the ones that work

The current issues were compiled from the interviews and survey to produce a summary of all findings. In order to interpret the findings, the workshop participants started to define the underlying issues. At the Define stage, emerging trends were identified and interpreted. There were patterns and clusters of information that could be grouped together as shown in Table 3.

Table 3: Summary of Define stage

DEFINE ISSUES	DETAILS
COMMUNICATION	Organising and relaying information often induced errors. Therefore poor communication might lead to: • Unplanned downtime • Lost productivity • Decreased employee morale • Other wasted business costs
TRACEABILITY & VISIBILITY	Low traceability and visibility of inventory and information would cause: • Long lead time of internal consumable units • Time wasted to make well-informed decisions • Time wasted to track the past and current information
GOOD INFORMATION	• The current system collects raw data in the plant but it does not translate the data into useful information. • The decision to create an action has to be studied and made by the operators based on their past experiences.
MANUAL HANDLING	Many tasks involved manual handling in the manufacturing process. The same repetitive manual handling tasks would: • Decrease employee morale • Cause workplace injuries • Increase the human error factor

In the ideation process, the workshop participants were able to 'think outside the box' to identify new solutions to the problems and look for alternative ways of viewing the problem. The ideation process generated 200 technology ideas. The outcome from the ideation workshop can be found in Appendix B.

2.3 COMPILATION OF TECHNOLOGY SOLUTIONS

The project outcome and technology recommendation must be achievable and practical to fit the business. Hence, it is very important to justify a good technology idea to ensure that it really addresses the end users' need and paves the way for improvement (Linman, 2011).

In order to filter down into a workable range of solutions, these technology ideas were compiled and arranged according to the respective issues. From there on, a step-by-step process was carried out:

1. The most sensible solution was picked respectively to each issue.
2. Some solutions to different issues could be similar and were grouped together.
3. The solutions could be combined together to lead to synergy and a more effective solution.
4. While some creative technology solutions sound promising, it is still premature and impractical to fully adopt at present. They have been filtered out accordingly.

The technology opportunities were collected and refined from the 200 technology solutions into the Top 30 options which can be found in Table 6.

3. INTERPRETATION AND JUSTIFICATION PROCESS

Project justification is a mechanism used to explain why an organization needs to implement a particular solution to a problem and how this solution can be implemented. Assuring interested stakeholders that the project will be the best solution to the problem and why this project will produce the ideal outcome (Linman, 2011).

This process involves analysing the business environment to propose the solution and validate the project. A business case is often used as the best tool to justify a project. However, building 30 business cases in the short timeframe was not viable. Therefore high level concept studies were developed to determine the preliminary economic evaluation and provide recommendation plan.

This justification process (Figure 4) encompassed three different models that represented perspectives from different parties.

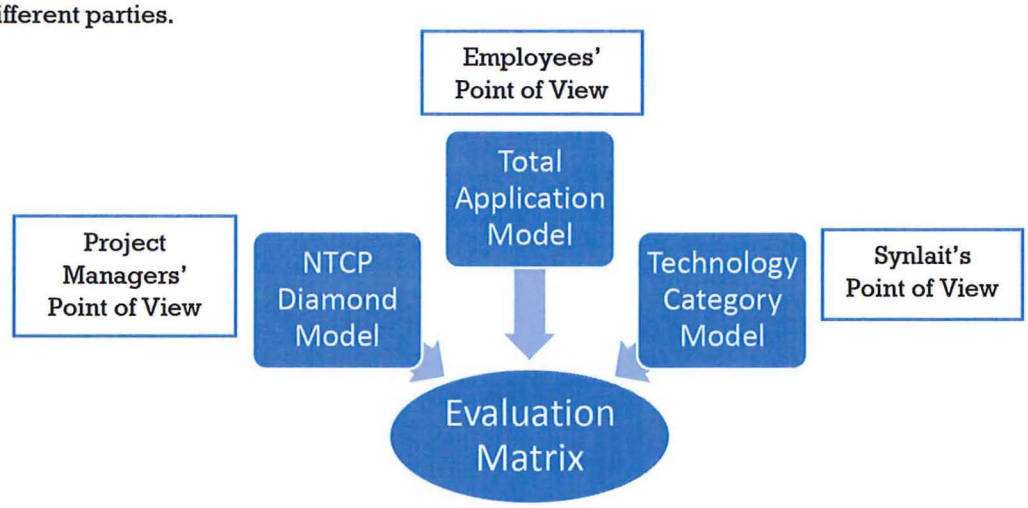

Figure 4: Evaluation Model

3.1 NTCP DIAMOND MODEL

The NTCP Diamond Framework is used to identify and manage risk by understanding the nature of the projects, and diagnosing the gaps between the current capabilities and what is needed to make the project a success (Shenhar & Dvir, Reinventing Project Management, 2007).

A project manager would want to quickly identify the risk of every single technology solution. The higher the risk is, the more resources and planning are required for implementation. While the full result can be seen in Appendix C, the summary of the result is shown in Table 4. The four bases that are used to analyse projects are Novelty, Technology, Complexity and Pace.

Table 4: Summary of the result from the NTCP Diamond Model

RANKS	TECHNOLOGY SOLUTIONS	COMMENTS
TOP 3 LOWEST RISK	• Confined Space Inspection Camera • Vacuum System for Fluid Bed • Digital Radio System	• Off-the-shelves products • Able to implement at the current capability
TOP 3 HIGHEST RISK	• Big Data/ IOT Tool • Digital Twin • Augmented Reality Smart Glasses	• Advanced technology • Require outsourcing of experts

3.2 TOTAL APPLICATION MODEL

The manufacturing process was sectioned into ten relevant teams: Dryer 1, Dryer 2, Dryer 3, Specialty Products, Blending and Canning, Wet Mix Kitchen, Maintenance, Logistics and Warehouse, Laboratory and Admin. The technology solutions were examined to see whether each of them can be used in different teams. If a technology solution could be used across all ten teams, it would bring the biggest benefit to the whole manufacturing process, thus more employees would share the benefit from the technology solution.

Table 5: Summary of the result from the Total Application Model

RANKS	TECHNOLOGY SOLUTIONS	COMMENTS
TOP 3 HIGHEST	• Fob Key Integration • Centralised Communication Centre • Augmented Reality Smart Glasses	• Benefits all teams • Employees are happy that they are part of the improvement
TOP 3 LOWEST	• Pallet Shuttle • Automated Guided Vehicle • Inwards Truck Scheduling System	• Designed to solve a big specific problem • Small portion of employees in the company are able to enjoy the benefits

In Table 5, using key tag for time sheeting would benefit every team in the production line because the hourly salaried staff are currently doing manual time sheeting. Conversely, a pallet shuttle would only directly benefit the Logistics and Warehouse team. The more teams that the technology solution can be applied to, the higher the score in the Total Application model.

3.3 TECHNOLOGY CATEGORY MODEL

The NTCP Diamond Model and the Total Application Model were not adequate enough to justify the selection of the technology solutions. From Synlait's point of view, the company wanted to determine the relation between the type and the scale of the technology projects to the potential business impact. To further break the options down, they were categorised into Table 6 by assigning a magnitude order in the factors of:

- Cost
- Ease of implementation
- Novelty of the technology solutions

Table 6: Category of Technology Solutions

CATEGORY	DETAILS	TECHNOLOGY SOLUTIONS
LOW-HANGING FRUIT	• Easy to implement • Often off-the-shelves products and solutions • No new or high technology knowledge is required • Relatively low cost	1. Vacuum System at Dryer Fluid Bed 2. Confined Space Inspection Camera 3. Inwards Truck Scheduling System 4. Touch Screen Device 5. Infrared and Networked Pest Control 6. 3D Printer & Scanner 7. Digital Radio System 8. Live Energy Consumption Monitor 9. TV Live Screen – Communication 10. QR Codes/RFID tech
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The three categories of technology solutions were then evaluated separately. As a result of this process, one technology solution was picked from each category to form the business cases.

[4] Ministry for Primary Industries

3.4 EVALUATION MATRIX

The evaluation matrix was used to systematically analyse multiple solutions. The evaluation criteria split into two sections: **Implementation** and **Potential Impact to the Business**. These evaluation factors were mostly theoretical and intangible factors because this would produce quick and logical results. Tangible factors such as ROI of each technology solution could not be accurately quantified in this project's timeframe. Although ROI was included in the evaluation matrix, the weighing score was given based on an order of magnitude.

3.4.1 PRIOTISATION GRAPH

In the evaluation matrix, the technology solutions were arranged in terms of implementation and potential impacts to the business. In Figure 5, while it was clear that technology solutions in Priority 1 were the top picks, Priority 2 and 3 quadrants both represented opposing features. The options then were to focus either on high impact, but also hard-to-do feature, or low impact, but easy-to-do features. There was a proven tendency that organisations will prioritise low impact, but easy-to-do features just because they were able to deliver the projects easier (Vendetti, 2010). However, resources in the business should always be reserved for the projects that bring the highest value to the company. This weighed **Potential Impact** above the **Ease of Implementation** and put the upper left quadrant into the second priority. The value added to the business would be enormous although it is hard to implement. Please see the full results for all three technology categories and a combined prioritisation graph in Appendix C.

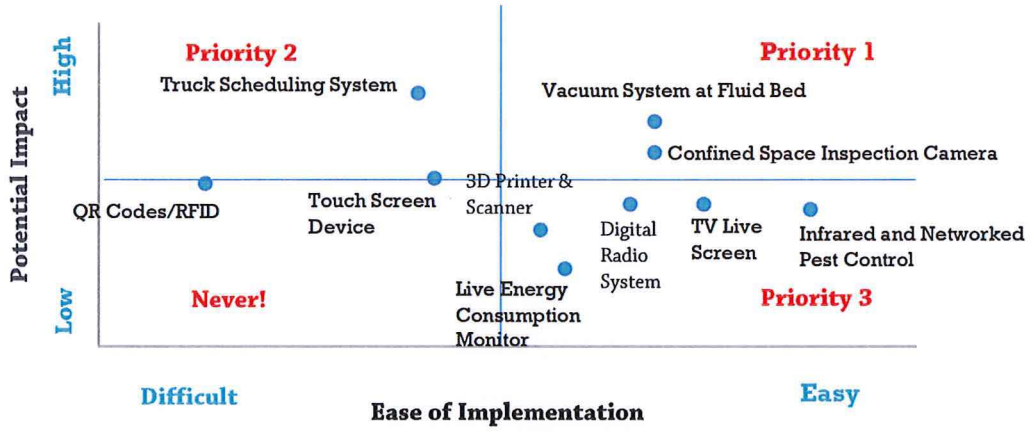


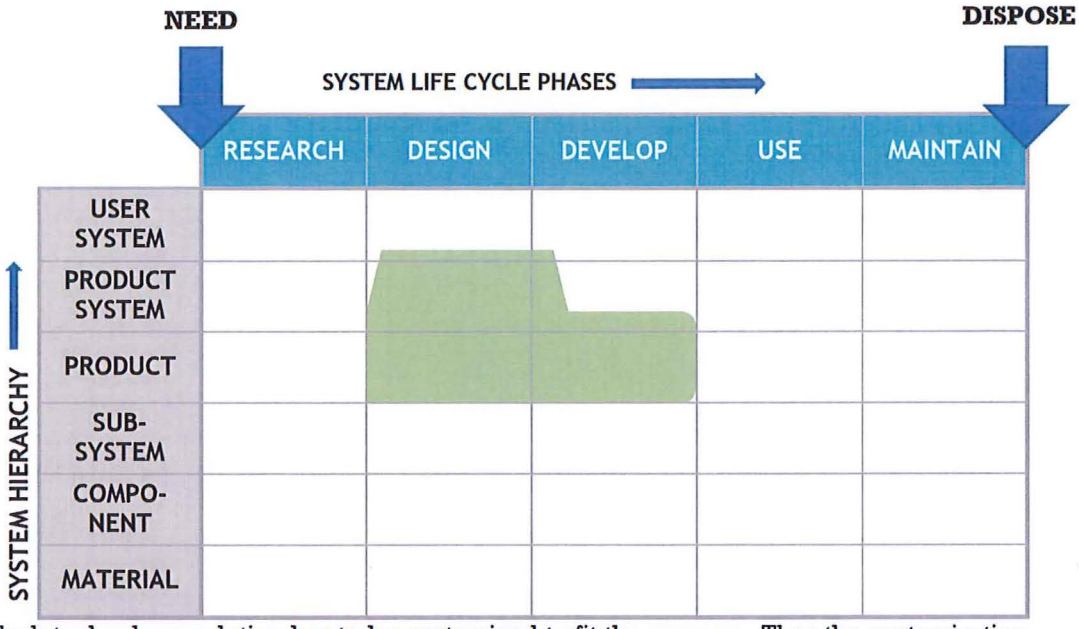
Figure 5: Technology Solution Prioritisation Matrix in Low-Hanging Fruit Category

3.5 OTHER CONSIDERATIONS

The identification process took a longer time than allocated. It might seem simple and straightforward to pick the technology solutions which had the easiest implementation route and highest business value (Figure 6), but the technology solutions had to be further justified by the following:

- **Current Capability**
  - It was recommended that the top three technology solutions should be able to be implemented in the company at its current capability (competency and capacity). The technology adoption space map (Wet & Beukman, 2017) was modified to determine the capability of Synlait as shown in Table 7.

Table 7: Technology Adoption Space Map at Synlait



  - Each technology solution has to be customised to fit the purpose. Thus the customisation goes from material (must be approved for hygiene purpose) to the user system (interaction with employees). The subject matter experts (SMEs) should conduct research on the new technology system and then design and develop with the external technology vendors. The operators should be taught to use and maintain the new technology solutions.

- **Technology Transfer issues**
  - Technology transfer is the process by which technology, in the possession of the 'donor', is transferred to the 'recipient' (Beukman, 2017). Technology transfer is only completed when the recipient can prove compliance with predetermined achievement norms for the operation of the particular technology.
  - There are some key success factors for the technology transfer (Ahmed, 2009):
    - Barriers: political, social, economic, and cultural values of the technology recipient
    - Appropriateness: have a significant impact on its ability to overcome transfer barriers.

- Bonds: intra-firm or inter-firm bonds created through the application appropriate technology or strategy

- **Magnitude of the respective issues**
  - The business impacts of the identified issues were studied. The issues were tracked back historically to check if there was ever any significant business implication, such as serious accident/injury, unplanned plant shut down, injuries, product rework, overproduction, defects and loss of production yield. This information would be helpful to identify the magnitude of the issue. If there was no significant event arising from the identified issue, the technology solution would be side-lined.

- **Recommendation from Commercial Managers**
  - If the technology solution is highly recommended by the Commercial Managers, it means that they see the significant opportunities the technology solution can bring to the business. The recommendation plan would be extremely useful to the Commercial Managers to progress in future.

- **Alignment of Synlait's vision and FY18 strategic goals**
  - It would be beneficial if the technology solution could align with Synlait's vision to be the world's most innovative and trusted dairy company. Synlait also promotes "New Initiatives" to be the leader in product innovation and technology uptake. "Health and Safety" is another strategic goal to be promoted to ensure the safety systems and processes developed are maintained or improved.

- **Mimicking scenario**
  - Mimicking scenario way of justifying the solution would be useful to support the result from the evaluation matrix. Technology solutions that had been implemented by other companies or relevant industries would be more persuasive.

- **Critical risks**
  - The issues that would alleviate critical risks would be placed more importantly than the rest. Synlait has identified four areas as the most significant risks to the business:
    - Confined spaces
    - Carbon dioxide and nitrogen
    - Pallet handling and stack collapses
    - Working at heights

    It was important to minimise the manual labour intervention especially when the employees are carrying out any tasks under these risks.

3.6 RESULT AND DISCUSSION

The top three technology solutions were finalised in Table 8 using all the methods mentioned above. All three solutions were easy to implement and would add high value into the business relative to the other technology solutions in the respective categories.

Table 8: Top Three Technology Solutions

CATEGORY	TECHNOLOGY SOLUTION	DETAILS	COST	BENEFITS
LOW-HANGING FRUIT	Vacuum System at the Dryer Fluid Bed	• Eliminate the need of operators to climb into the fluid bed (confined space) for regular cleaning and blockage clearing.	CAPEX of $24,000 per unit	**5 year ROI 63%** **Payback 3 years**
NEW TECHNOLOGY	Collaborative Robots at Laboratory	• Assist the lab testing procedure. • Offer a safe and effective alternative to dangerous (or hazardous) tasks that put employee's health and wellbeing at risk.	CAPEX of $60,000 per unit	**5 year ROI 166%** **Payback 1.4 years**
MAJOR CAPEX PROJECT	Key Fob Integration	• Require everyone to sign in and out daily for health and safety and evacuation management. • Improve site security, better control who is on site. • Eliminate manual time sheeting.	CAPEX of $70,000 across the site	**5 year ROI 48%** **Payback 2.8 years**

The evaluation process was intensely repetitive, going from Empathise to Test across different technology solutions. Having to constantly evaluate potential technological solutions against the weighing criteria and the main objectives of this project helped to better justify the option taking. This project allowed me to demonstrate critical thinking and prevent any form of bias due to personal interest.

4. CONCLUSIONS

There are numerous ways to use technology to improve the working environment and business operations. It ranges from Information Technology, Digital Technology to Operational Technology such as Big Data, Internet of Things, Collaborative Robots, Cloud Computing and Additive Manufacturing. These technologies, combined with the digitalisation of data have become a huge disruption in the manufacturing industry, forming the new industry revolution: Industry 4.0[5].

Industry 4.0 is about connecting the manufacturing techniques to enable systems to share information, analyse it and use it to guide intelligent decisions/actions. With this disruption, comes new opportunities for companies to engage customers, empower employees, optimise operations, and transform products. Businesses must change to survive to capitalise on these strategies.

Being a relatively young and growing company, Synlait is in a good position to adopt Industry 4.0 principles. The management team and employees are open to embracing new ideas and technological opportunities, and this company-wide "Blue-Ocean" mentality is the key for Synlait to remaining globally competitive.

However, the existing infrastructure is the main barrier for the company moving to Industry 4.0. The lack of system integration causes ineffective communication, lack of visibility of work and double handling of information and data. The company is now taking baby steps to address these issues. This kind of transformation is not simply about technology – it requires business leaders to re-envision existing business models and embrace a different way of bringing together people, data, and processes to create value for their customers.

While transforming the company to adopt Industry 4.0 principles is out of scope of this project, Project Blue Ocean has focused on the Manufacturing Excellence framework to bring value to the business by empowering the employees, improve the health and safety level and increase the reliability of the manufacturing process. The vacuum system, collaborative robots and fob key integration are new technologies that provide a better way of doing things. The recommendations from Project Blue Ocean are seen as the early stages of technology advancement at Synlait.

The project is at the concept study phase where it seeks to discover the existing issues related to the working procedure and environment, find the opportunities for new technology adoption, and provide preliminary economic evaluation or comparison alternatives. A further feasibility study has to be carried out in the future for each project to develop a detailed business case and form the basis for board approval and funding. Investigating the Top three technology solutions is highly recommended due to the interpretation and justification of the compiled data. The future investigation should consider the effect on employee morale as a result of adopting new technologies, detailed investigation of work together with

[5] **Industry 4.0** is a name for the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing. **Industry 4.0** creates what has been called a "smart factory".

the technology vendors, and development of the user specification documents to design a technology solution that fits our manufacturing operation.

5. TECHNOLOGY SOLUTIONS

A high level concept study was conducted for each technology suggestion to provide preliminary economic evaluation and comparison between alternatives options. The cost estimation was conducted at a very high level. They have a stated accuracy of ±30%.

5.1 VACUUM SYSTEM AT FLUID BED

5.1.1 PROBLEM STATEMENT

The manual cleaning and blockage clearing activities at the dryer's fluid bed require plant operators to physically climb into the confined space. The operators are exposed to the risk of powder falling from above which could cause engulfment. We need to find alternative ways to get rid of the powder build up in the fluid bed, so that the operators can work in the safe environment. An accident happened last year where the powder fell off from the chamber wall onto an operator who was clearing the powder lumps inside the fluid bed.

5.1.2 APPLICATION

It is recommended that a compressed air pneumatic conveyor, functioning like a vacuum system, to be installed near to the manhole at the fluid bed. It can be designed and custom-made to fit the space available beside the fluid bed. The operators can use the pneumatic conveyor as such like a vacuum system to get rid of the powder. The pneumatic conveyor is designed to conform the requirement of USDA[6], FDA[7] and ATEX[8] certification.

Figure 6: Example usage of pneumatic conveyor (Pneumatic Conveyors)

A high pressure water blaster is also recommended alongside with the pneumatic conveyor. It is to spray the water from the manholes to reach the end of the wall in the fluid bed.

5.1.3 BENEFITS

BENEFITS	EXPLANATION
Reduce the hazard in the operators' job scope	The operators will not need to physically go into the fluid bed for cleaning and blockage clearing.
Improve Health and Safety	The operators will not trip or fall due to the uneven surface inside the fluid bed. They also have to transfer the heavy bag which is full of leftover powder. In the confined space, there is potential that leads to back strain having to carry the powder bag out from the fluid bed to the deck.
Reduce the Lost Time Injuries (LTI)	Lost time injury has a significant cost implication to the company. The victim from the accident last year took an extended break up to three months for recovery.

[6] The U.S. Department of Agriculture

[7] The U.S. Food and Drug Administration

[8] The term 'ATEX' is an acronym, derived from the French title of the 94/9 EC Directive. It is given to the legal requirements for controlling explosive atmospheres and the suitability of equipment and protective systems used in them (ATEX & DSEAR, n.d.).

5.1.4 COSTS

The compressed air pneumatic conveyor from Nilfisk is estimated to cost roughly $20,000. A pneumatic conveyor can be customised by using several design factors: product type, particle size, temperature, moisture, storage, noise level, material, etc. Further discussion with the supplier would be needed to better estimate the cost for this solution. A high pressure water blaster is estimated to cost $4,000. The **payback** period of the both applications is **three** years and the **return of investment (ROI)** in five years is **63%.**

5.1.5 RISKS

RISKS	EXPLANATION	MITIGATION STRATEGY
Intrusive process	The vacuum tube comes in direct contact with the milk powder. If the fluid bed is not cleaned properly, there will be remaining milk powder that potentially comes in contact with the vacuum tube. There would be food quality issue from the intrusive work if the vacuum tube is not clean or sanitised.	It cannot be avoided that the vacuum tube will come in direct contact with milk powder. Regular wash and cleaning of the vacuum tube have to be carried out after every use. High pressure water blaster should be used to clean off every bit of leftover powder.
Takes longer than manual cleaning	The vacuum tube can only be accessed from three manholes, whereas the dryer fluid bed is roughly 10m long. Controlling the vacuum tube from these three manholes might slow down the process and take longer than the manual cleaning, extend the dryer downtime.	Develop a solution that is capable to carry out the activities within 5-10 mins (average time frame needed for operators to get rid of the powder) by adjusting the throughput, airflow and motor size. Use three vacuum tubes at the same time since there are three manholes at the fluid bed. Speed up the work. Could reduce plant downtime.
Microbial contamination	Vacuum are notorious breeding grounds for unwanted microbes. This could put the company at risk because food contamination can cause consumer illness.	Regular wash and cleaning of the vacuum tube have to be carried out after every use. A robust vacuum tube will be designed for easy cleaning and sanitising.
Damage on the surface of fluid bed	The nozzle tip might scratch against the surface and cause damage to the fluid bed. Every scratch in the fluid bed can be a sweet spot for microbes to accumulate and grow. The repair work for a scratch will be time-consuming, reduce plant uptime and this would cause food quality issues.	Custom-made nozzle tip must be made to suit the environment. Always check the condition of the nozzle tip and replace if needed.

5.1.6 CONSTRAINTS

Powder lump is the main contributing issue to the blockage in the fluid bed. The size of the powder lump can vary from a golf ball to a gym ball. The powder form into lumps due to the moisture and the humidity inside the chamber. In the long-term, there will be ways to control the humidity better and reduce the lump formation inside the fluid bed. Thus a compressed air pneumatic conveyor can be put into good use to clear the powder build up inside the fluid bed and prevent the operators from getting into the confined space.

5.2 COLLABORATIVE ROBOTS

5.2.1 PROBLEM STATEMENT

A laboratory is built on site to conduct testing for quality control, quality assurance, research formulation, product shelf life, and product incompatibility. All procedures are fixed and validated by IANZ[9] and customer requirement. The testing procedures require manual handling and highly repetitive movement, which often lead to repetitive strain injury. The activities that are likely to cause repetitive strain injury are slurry preparation and fat shaking test. Manual handling of hazardous chemical, which occurs a lot in the testing procedure, is also seen as the top critical risk activity at Synlait. Such mundane and monotonous activities would eventually lead to loss of employee interest and engagement.

5.2.2 APPLICATION

It is recommended that a collaborative robot (cobot) is the solution to assist the lab technician to do highly repetitive, high volume and low duty work. Cobot is a robot that works in partnership with humans: no more cages, acts as human's assistant, involved in targeted complex, sensitive tasks that can't be automated. They are often in use for lightweight operations because of the limited payload up to 10kg (Henry, 2015). Cobots are tasked with carrying out tough or low-value activities. Human intelligence is refocused on other aspects of the production chain.

5.2.3 BENEFITS

BENEFITS	EXPLANATION
Safer working environment	Cobot is equipped with detection sensors and vision system. It is programmed to immediately stop its work if it detects any danger whatsoever for a person nearby. Cobot can be programmed to handle the hazardous chemical to reduce the risk impact to human.
Cobots are flexible	Cobot can be programmed to do multiple tasks in a day. It does not need to be confined to a single task, they can integrated into numerous projects or activities.
Increased Return On Investment (ROI)	Cobot does not require a protective barrier. It saves costs associated with redundant hardware and room layout. Cobot has very a high repeatability precision movement with the accuracy up to ±0.1mm (Bélanger-Barrette, 2015). It can reduce any human error which could incur cost to the company. Cobot can be conveniently placed anywhere and relocated whenever needed, which essentially leads to eliminating any non-productive or low-value activities during the production hours.

[9] International Accreditation New Zealand

5.2.4 COSTS

The Universal Robot UR5 unit costs $40,000. The program development and installation cost is on average roughly a quarter of the cost of a unit of cobot. The cost is entirely based on the customisation and design work. It is estimated to cost $60,000 for the laboratory solutions to automate the two tasks: slurry preparation and fat shaking test. The **payback** period is **1.4 years** and the **return of investment (ROI)** in five years is **166%.**

5.2.5 RISKS

RISKS	EXPLANATION	MITIGATION STRATEGY
Decrease Employee Morale	People might view cobot as a threat aimed at replacing their jobs. It could cause employees to be more insecure about their jobs and slowly drive down the engagement level at work.	Educate the employee about the technology and how it can help with the mundane highly repetitive tasks in the lab.
Product Contamination	The cobot might carry microbes that would alter the quality testing result. This could result in a false alarm and product recall if the product testing is not approved.	The cobot should be sanitised regularly. The arm can be equipped by custom-made suit which complies the requirement in a high hygiene area.
Accident and Human Injury	The cobot, although is safe, the surrounding environment could cause accident, for example, slippery floor, unsecured mounting, wire trip, etc. This could cause serious injury to the lab technician.	Conduct a detailed risk assessment at the environment. Consult cobot expert to develop a full solution that includes programming, set up, installation and risk assessment.

5.2.6 CONSTRAINTS

The main constraint of the proposed application is the recognition and accreditation from IANZ or other customer requirement. Every single procedure and technique must be audited and accredited by IANZ. This requires a period of time where the cobot can be trialled and tested that it is capable to produce the expected result. However, cobot can be programmed easily and it can mimic the movement of a human arm, so it is expected to pass the accreditation test. There are some examples of lab automation with cobots in New Zealand. Synlait's laboratory team can find some case studies to introduce peer-to-peer learning within the industry. Cobot is a new technology solution in the industry, so adopting it will indicate a breakthrough to the business.

5.3 FOB KEY INTEGRATION

5.3.1 PROBLEM STATEMENT

Currently, contractors, temporary staff and visitors are signing in and out daily using WhosOnLocation[10] system. However, there is no system to monitor the location of Synlait's staff. The current function of a fob is only for door entrance. Employees have to scan their fob before they enter certain buildings but they can exit the building without using the fob because there is no fob scanner on the other side of the entrance. In a case of emergency event that requires site evacuation, no one can generate an updated roll call list.

- Unable to keep track of Synlait's staff

The security guards can only check employees' ID card occasionally prior entering the site due to limited number of security guards with high workload. Hence, there is a potential that an unauthorised person could enter our site and disrupt the plant operation.

- Inadequate security system to check every employee's ID card

Hourly salaried staff have to fill in timesheets daily, while the team leaders spend roughly an hour every week to calculate the working hours manually before submitting a stack of timesheets to the Payroll Team every fortnight. This is a typical example of low-value task that does not add value to business but it is a process required for administrative purpose.

- Manual time sheeting

5.3.2 APPLICATION

It is recommended to install fob out scanner at the entrance of specific locations or plants that employ hourly salaried staff. This would require the staff to scan their fob when they exit. It automatically updates the list of staff working in a specific area. During an evacuation, the health and safety team or the security guards can generate an updated roll call list to tick evacuees off against.

The time sheet can be automated by extracting the information from the fob system, knowing that amount of time at work. It can accurately monitor the Time and Attendance (T&A) of each hourly salaried staff. It eliminates the administrative work and reduce the workload of the team leaders.

5.3.3 RELATED PROJECT

The Projects Team are already working to build a centralised staff car park with a turnstile at two different entrances. All the staff have to sign in and out daily at the turnstile. This system is creating a controlled entry to site in order to know which staff are on-site in real time. This will solve part of the problems, but it does not tell the exact location or building the staff are currently at when they are on-site.

[10] WhosOnLocation is a sign-in system to manage visitors, contractors, staff and evacuation.

5.3.4 BENEFITS

BENEFITS	EXPLANATION
Save cost	This application will reduce the Payroll Team and the team leader's work. The team leaders can then focus on higher priority task that adds value to the business. Companies can save up to 4% of annual payroll expenses with an automated time and attendance system, according to the American Payroll Association (Sutter, 2015) by reducing "buddy punching"[11], salary over-payments, and human error. When the evacuation and roll-call process can be speed up, it means that the plant will resume its operation at the shortest time to minimise the loss from the evacuation.
Improve security level	The security guards now have full information of everyone who comes on site. At the same time, everyone except for employees would have to sign in at the security hut.
Improve Health and Safety	During a site evacuation, the roll-call process at the assembly area can be speed up. The safety warden has an updated list to check who is in the building currently. Safety and evacuation procedure is improved by implementing this application.
Attract more customers	When the overall site security is tightened, the safety of the food will be improved. This application provides traceability to immediately identify any issue and who and when the issue happens. Increased level of food safety will instil a better trust from the customers thus attracts more customers.

5.3.5 COSTS

Installing each fob scanner would cost on average $5,000 depending on the layout of the entrance and the existing wiring work around the area. It was first estimated to install 14 fob exit scanners at several exits. The **payback** period is **2.8 years** and the **return of investment (ROI)** in five years is **48%.**

5.3.6 RISKS

RISKS	EXPLANATION	MITIGATION STRATEGY
Decrease Employee Morale	Employee might feel distrust due to accurately tracking their working hours. Perceived lack of privacy and respect.	Educate them the reason of this system behind which is to reduce low-value task (manual time sheeting). It does not affect the working condition.
Employee Sharing Fobs	If the employee share their fob around, the system will seem redundant because the security cannot track employee accurately.	Tighten the policy of not sharing the fob in the company. Design the fob system as such the staff cannot fob in when they have not fob out. Must be in a sequential pattern (in and out).
Employee cheats on hours	They might purposely stay longer at the workplace to generate longer hours thus higher pay. Long hours at workplace does not translate to productivity.	Educate the staff that this system is set in place to accurately determine the relationship between the amount of time and the amount of work done daily.

[11] An action where more than one employee asking a coworker to clock in or out for him, earning him or her pay for more time than he or she actually worked, and helping avoid penalties for showing up late, leaving home early (What Is Buddy Punching and How Can You Prevent It?, n.d.).

6. IMPLEMENTATION PLAN

6.1 VACUUM SYSTEM AT FLUID BED

An initial contact with Nilfisk (Auckland) has been made. They are at the process to understand the fluid bed situation at Synlait. The information they would like to acquire around the specification of the pneumatic conveyor are description of product to be recovered, machines, collection/storage of the recovered product, piping and electrical system.

It is recommended to set up a conference call for both parties to address the problems and issues. The next step would be inviting a representative from Nilfisk to visit the dryer fluid bed. A professional recommendation would be sought to identify the real opportunity. These information and contact details would be passed to the Health and Safety Team to follow-up in the future.

This pneumatic conveyor is the closest application to the solution developed on paper. However, it might not be the ultimate solution to the manual cleaning process at the dryer fluid bed. It is up to the professional advice from the Nilfisk team to develop a full solution using their products. Another possibility that would eliminate the need of a pneumatic conveyor is that the dryer operating condition will be optimised to an extent where there is no powder block or lump formation inside the fluid bed.

IMPLEMENTATION PLAN	PARTIES	TIME
Understanding the problems of manual cleaning at the dryer fluid bed	Nilfisk	1 month
Designing the User Requirement Specification (URS)	Nilfisk & Synlait	2 months
Negotiation on solution	Nilfisk & Synlait	1 month
Product development	Nilfisk	3 months

6.2 COLLABORATIVE ROBOT

The collaborative robot – Universal Robot dealer, Design Energy Ltd. has already been in touch with myself, my project owner and the General Manager of Manufacturing. The Managing Director of the Design Energy was invited to visit Synlait's site to observe the process where it requires manual handling and highly repetitive activities, mainly at the laboratory.

The next step would be further investigation on the daily operation starting from the Chemistry team, to In Process Quality Assurance and Subsampling team, and lastly Microbiology team. This investigation would determine the workflow of each testing, looking at the upstream and the downstream work of slurry preparation and fat shaking test. Understanding the technique and the steps required for the test is very important before designing an automation solution.

The following step would be assessing the environment of the workplace. This process might require the existing lab to change the floor plan, making way for the cobot. Customisation of the end-effector is also necessary to suit the existing equipment. The whole process from site visiting to commissioning of the cobot in the lab will take roughly a year at the best case. Blending and Canning and Wet Mix are the next best teams to adopt this technology solution as there are many manual handling activities in the plant.

IMPLEMENTATION PLAN	PARTIES	TIME
Identifying opportunities	Design Energy & Synlait	2 months
Further investigation	Design Energy & Synlait	2 months
Building business case or Cost and Benefit Analysis (CBA)	Synlait	2 months
Product development	Design Energy	5 months
Testing and Commissioning	Design Energy & Synlait	1 month

6.3 FOB KEY INTEGRATION

The centralised staff car park project is already underway and it is estimated to be completed within a year. As this project – installation of fob out scanners at the exit is envisaged as the follow up plan from the centralised staff car park project, it will only be carried out after a year.

The first step would be identify the number of all the hourly salaried staff and the teams they are currently working in. Then understanding the existing payroll system would help to identify the information that can be used by payroll.

A detailed business case should be built to study the Cost and Benefit Analysis (CBA) and the potential business impact to the company. If the project has gained approval from the higher management level, it is expected to take six months to commissioning.

IMPLEMENTATION PLAN	PARTIES	TIME
Identifying opportunities and the current fob system	Synlait	1 months
Building business case	Synlait	2 months
Installation	Vendor	2 months
Testing and Commissioning	Vendor & Synlait	1 month

7. SUMMARY OF PERSONAL DEVELOPMENT

It was a good experience working at Synlait because I got to expose myself to big organisation and to observe how they manage projects. There are some key skills that were applied in the project:

- Negotiation
  - Talked to technology vendors and convinced them to come on site for collaboration work. Was given the chance to represent Synlait to approach several technology vendors myself. Negotiation skill helped me a lot in this process.
- Critical Thinking
  - Very beneficial during the evaluation process that require fair-minded and logical reasoning without any bias. Although new technology solutions are far more interesting, I have to understand what Synlait currently needs the most and the capability of the company at the current state.
- Innovation
  - Understand the technology adoption bell curve and be fully aware of people reaction when new technology is introduced to them. Able to identify early adopters, early majority, late majority and laggards quickly. Use different approach or topic to educate them about new technology.
- Project Management
  - Learnt that the scope of the project has to be well defined early and develop goals which are SMART – Specific, Measurable, Attainable, Realistic and Time-based. Plan every activity to the detail and set deadline for each of them to prevent spinning the wheels.
- Strategic IT
  - Understand the latest IT trends that are used in the industry and introduce the concept to Synlait. I was first introduced to IT trend in the MEM programme and I was surprised how powerful and useful these IT trends are.

The lesson I learnt from working at Synlait is the importance of communication skills. The first phase of the project was collecting issues from interviews and organising ideation workshop. While only having a short time for interviews with the Commercial Managers, I learnt to drive the conversation (preventing both parties from steering away from the main topic) and ask the critical questions that I want. I learnt to draft out the information I needed from the person before heading into an interview to prevent ineffective meeting. I was also taught to over-communicate rather under-communicate to get the information needed.

This project experience gave me an insight into the fast-paced industry. I learnt to do things quick and precise because I have to be self-motivated and independent. This project allowed me to put into practice what I had learned throughout the year, in a real world context. I believe the additional experience in the workforce would mould me into an employee who is able to apply high working professionalism and industry standards in the future career.

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APPENDIX A

DISCOVERY PHASE

PROJECT NAME	PROJECT BLUE OCEAN
PROJECT OWNER	JAYSON SPITTAL
AUTHOR	JASON LAI
DATE	29 JAN 2018

CONTENTS

1. INTRODUCTION

The first phase of Project Blue Ocean involved a thorough investigation into the manufacturing teams, and the issues they were facing in their daily activities. This phase was part of the Design Thinking: Empathise and Define. The purpose of the discovery phase was to:

- Identify the current problems in the manufacturing plants
- Immerse myself in the physical environment to have a deeper personal understanding of the issues involved
- Analyse the observations and synthesise them in order to define the core problems

The **Empathise** and **Define** process were carried out by several methods:

- Interviews with Subject Matter Experts (SMEs) from different teams
- Online Survey for operators
- Working in the plant

2. INTERVIEWS

The first stage of this investigation involved gaining the perspectives of those with the most intimate knowledge of Synlait's manufacturing operations. This investigation focused on collecting the current issues from the key representatives from different teams and their suggestions to improve and solve the issues. This process consisted of interviews with the following SMEs and the findings of the interviews were outlined below:

TEAMS	SME	PAINPOINTS	SUGGESTIONS
Blending and Canning	Asher McMillan *Continuous Improvement Coordinator*	• Staging – scan the powder bags manually and enter data into Excel spreadsheet • Manual bag stripping • Manual weighing of powder at the dispensary stage • Scoop machine has most problems due to different sizes of scoops • Cleaning process once every day - downtime	• MES (Manufacturing Execution System) to automatically generate useful data/graph that helps in decision making • UV tunnel and sterilisation tunnel should be added at the ingredient conveyor • RFID tracking of items • Revalidating the need for cleaning daily
	Reuben Frahm *Commercial Manager*	• Manual labour work at staging • Current HMI is outdated	• Automation system at staging • A new system for real time feedback and prediction of work to reach the target

			• Looking for new HMI system • Digital twin – simulation and virtual and augmented training
Logistics and Warehouse	Sean Murphy *Inwards Goods Manager*	• Many bar code scanning errors • Only one operator for palletiser • Faulty products disrupt the working flow • Packaging teared off during the pallet wrapping	-
	Aaron Shaw *Storage and Distribution Manager*	• Incapability of integration between MEX and M3 • Inwards goods trucks come in any time during the day • Lack of coordination between macro and warehouse for ingredients • Forklift task schedule manually arranged and printed on a paper	• Truck Scheduling System • Better communication plan between macro and warehouse teams • iPad on forklift – easier for task scheduling, eliminate papers
Maintenance	Rex Macpherson *Maintenance Fitter*	• Manual control of valve and flowmeter at baghouse • Lack of clear communication between maintenance team and other manufacturing teams	• Automated control valve and flowmeter according to different product recipes
	Johan Strauss *Commercial Manager*	• Rodents frequently appeared on site • Consume a lot of energy on site • Consume a lot of water for cleaning • Maintenance often require servicing and repairing the parts • Require to go to site or into the plant to observe the issues	• Infrared or ultrasonic pest control to detect the appearance of rodents • Solar panel or other renewable energy sources • Use less water for cleaning, reduce footprint • Use plug-and-fix components, easier to maintain and the solutions are robust • Use Predictive Maintenance by integrating with digital twin

Dryer 1	Rob Capon *Commercial Manager*	• Communication issues between packroom & palletiser, shift leader & dryer operators – bulky radio • Lack of visibility on item tracking at satellite storage • Many daily activities require redline crossing • Material transfer between different hygiene zones, requiring operators to cross redline • Require people to go into confined space for checking and cleaning • Shift leaders and operators have minimal communication to find out what has been done in the previous shift	• Digital radio system, embedded into work uniform, comes with music and radio station • Use electronic device to control the consumable units at satellite storage • Augmented reality – live feed video inside the plant, remote access • UV pneumatic tube to transfer material through different hygiene zones • Automation for the hourly quality testing • ProfilGate – hygiene solution for entrance at warehouse • Automated Guided Vehicle for material transfer • Augmented Reality or robot to carry out tasks in confined space
	Rob Allfrey *Assistant Manager*	• Manual checking of the plant daily • Require upper management to physically enter the plant to understand the plant issue • Require operators to go into confined space for manual inspection and cleaning	• Using Augmented Reality glasses for remote access • Robots to carry out inspection in the confined space
Dryer 2	Andrew O'Connor *Commercial Manager*	• Operators have to enter and write down log sheets manually on papers • Double handling of information as the systems do not integrate with each other	• Analytics tool, Internet of Things • Automated process control for spray dryers, capable to interpret the data itself and help making decision for operators
	Dean Shaw *Assistant Manager*	• Take moisture reading every hour, wasting a lot of time • CIP process clashing with different plants	• Online continuous NIR moisture reading – easy to monitor and better quality control • Digital twin/ Model base predictive control – monitoring and foreseeing the output, forecasting the CIP process and create better schedule for CIP

Laboratory	Priye Murthi *Chemistry Team Leader* Roby George *In Process Quality Assurance (IPQA) & Subsampling Team Leader* Caroline Franks *Microbiology Team Leader*	• Manual timesheet • Uneven load of job • Time wasted from waiting for sample to arrive • Hard to trace back items and samples, often losing samples • Repetitive manual handling task causing back strain and wrist pain	• Barcode on specimen bags, easier to track • Streamline the work schedule • Automated lab process • Automated timesheet • Automated water dispenser
Innovation and Technical Services	Cyril Brajeul *Packaging Technologist*	• Having to print Synlait barcode to every inwards goods pallet • Lack of integration with M3 and other systems	• Buy scanner that can scan every incoming product • Suggest Hornby canning manufacturer to print the OR code onto each product can
Projects	Christi Devathala *Automation Engineer*	• Too much steam produced during the changeover of CIP • Enter the setting manually on each machine on every recipe change • Long down time on B&C seamer size change (4-8 hours)	• Centralised recipe using creating a big matrix • Install a new HMI system to better track the
Wet Mix	Stephen Reid *Commercial Manager*	• Manual handling – bag stripping, weighing macro ingredients • Long down time on plant cleaning (3-4 hours) each day • High energy consumption at the stage of dissolving macro ingredients	• Automated process of bag stripping and ingredients weighing • Evaluating the cleaning process • Better system of energy monitoring
	Jane Cooney *Assistant Manager* Angela Smith *Master Scheduler*	• Having to inform people individually to update everyone by calling • Scheduling using Excel takes time to organise • No detailed target planning for each shift	• Live feed of communication message between Wet Mix and Dryer operators and shift leaders • 3D printing technology to print out the part while waiting for the actual part to arrive

		leader/operators • Waiting for parts to arrive for maintenance • Bringing mobile phones into hygiene zone although it is not allowed, but it is needed for communication	

3. ONLINE SURVEY

The second investigation method was creating an online survey to understand the pain points from the operators who were working inside the plant. Before sending out the survey, research was carried out to develop the questions that met the goal of my survey.

THE GOAL

1. What do I want to know from this survey?
    - I want to know their work in daily operation
    - I want to know the current issues in their daily job
    - I want to know the process or job that needed to be changed

2. Why do I want to know the information?
    - I want to use the data to understand and define their pain points
    - I want to implement solutions to solve the issues using technology
    - I want to add value to their work and eliminate the non-value adding tasks
    - I want to improve their working environment and procedure

THE STRUCTURE

The questions were drafted into three different sections: Value-Oriented, Job-Oriented and Technology-Oriented. These three sections encapsulated the information and the scope I needed from the operators.

VALUE-ORIENTED

These questions were developed to find out the opinion of the operators on their job whether they think it is adding value to the workflow. This would also help the operators to review their daily job to identify the activities that do not add value.

JOB-ORIENTED

These questions were developed to identify their work that involved repetitive actions, manual handling, and other activities that limit their productivity. The operators were also required to list out the activities that involved crossing redline (each time usually takes roughly 3-5 minutes).

TECHNOLOGY-ORIENTED

These questions were developed to see if the operators have thought of any technology solution that can help solving the issues they found. These ideas could come from their past working experience at other workplace or their creative minds. Listening to the employees' recommendation would encourage employee engagement and empower employees in their roles (Morrissey, 2015).

> *"When we thought of penning down the core values of the company rather than asking CEOs, we asked people working in the company about what is it that they enjoy most in the company and the values they relate most to. This was a powerful way to involve the employees, give them a platform to voice their opinion." – Garima Gulati Bhutani* (Bhutani, 2017)

THE QUESTIONS

NO.	QUESTION	TYPE
1	Do all your daily tasks within your job add value in your opinion?	Multiple choice
2	Can you identify tasks that are not value adding?	Multiple choice
3	Please list Top 3 tasks that stop or slow you down and limit your productivity.	Comment box
4	If you can eliminate non-value adding tasks, would you then able to focus on higher priority tasks?	Multiple choice
5	In your daily work, does your role involve repetitive activities? If yes, please list.	Multiple choice and comment box
6	How often do the repetitive activities occur?	Multiple choice
7	Can you identify any alternative ways of doing the repetitive activities? If yes, please list.	Multiple choice and comment box
8	How many times do you go through redline each day on average? What are the activities that require you to cross the redline?	Multiple choice and comment box
9	If there is anything you could change about your job to increase your productivity, what could it be?	Comment box

THE RESULT

The survey was sent out to 90 operators from Dryer 1, Dryer 2, Wet Mix, Warehouse and Logistics, Blending and Canning, and Laboratory. A total of 45 responses were collected.

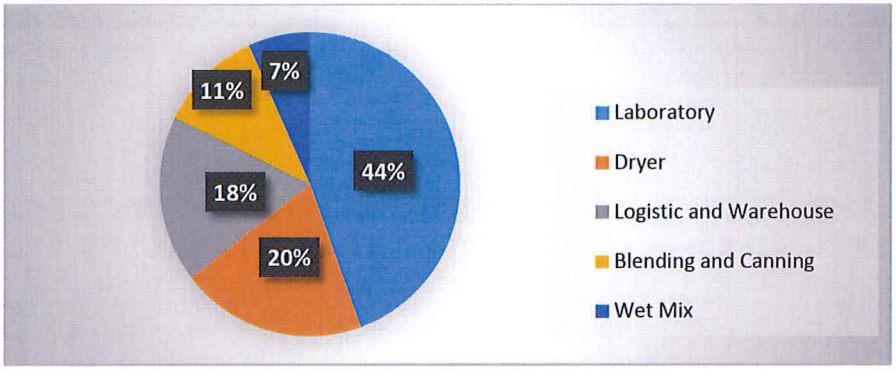
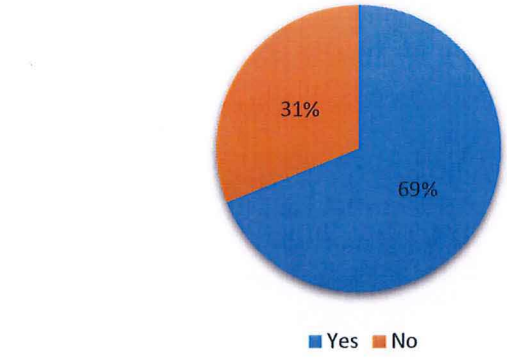


Figure 7: Online Survey Responses

The distribution of the survey response were shown in the Figure 1. The result of the multiple choice questions were compiled together regardless the teams while the answer of the comment-type questions were sorted according to teams because they were different from each other. The respondents remained anonymous to prevent any bias result.

QUESTION	ANSWER
1	

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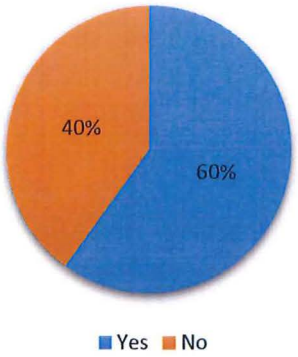

3

Please list Top 3 tasks that stop or slow you down and limit your productivity.

TEAMS	ANSWER
DRYER 1	• Communication with palletiser operator • Plant break downs • Taking samples • Label printing for new run • Handling permits from other plants/teams that are completely out of job scope • Palletiser stop indication
DRYER 2	• Hourly quality testing and check • Cleaning the plants • Collecting and collating data • Inputting data manually • Meetings • Long running CIPs (Clean in Place) • Lack of staff • Admin tasks such as ordering consumables
WET MIX	• Lack of separators • Lactose tipping • Cleaning the other areas that is not part of Wet Mix • Lack of cream space
BLENDING AND CANNING	• Breaks • Daily cleaning • Manual data entry, building worksheets on Excel

		• Foreign Matter shaker test • Doing jobs that are not part of my responsibility • Sending emails, servicing multiple forms of communications • External can cleaner hourly clean • Training new employees • Ineffective meetings leading to poor communication
	WAREHOUSE AND LOGISTICS	• Picking orders at the back of the rows • Lack of staff • Pulling out rows to fix production mistakes • Plan changes at short notice • Checklist every time forklift starts working • Waiting on tasks that are always being released last minute • Scanner issues • Not knowing the inwards goods truck timings
	LABORATORY	• Ineffective meetings • Autoclaving spoons • Ordering consumables • Filling in bag pull forms • Inadequate equipment, equipment being shared amongst other peers • Cleaning dishes • Moving retention boxes between places • Visiting the dryer plant to collect samples every day • Poor communication on task allocation • Losing samples • Unorganised training regime
4		

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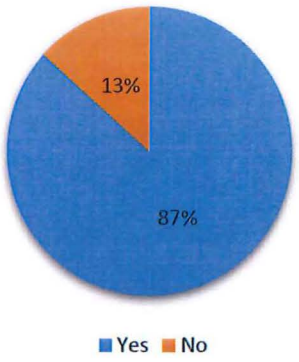

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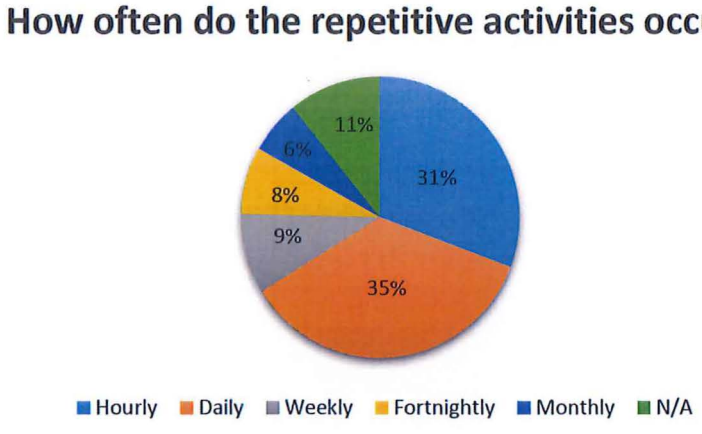
What are the repetitive activities?

TEAMS	ANSWER
DRYER 1	• Cleaning • Lifting and loading bags • Contacting palletiser operator if palletiser not working properly • Sampling • Issuing permits • Log sheets
DRYER 2	• Hourly check and cleaning • Changing stock food bags • Testing samples • Dealing with historical issues – maintenance or staffing • Finding correct items at the consumable items satellite storage • Checking downtime and maintenance tasks • Reviewing production results
WET MIX	• Cleaning • Lactose and vitamin tipping • Processing oil inload • Hourly testing
BLENDING AND CANNING	• X-ray retest • Ingredients tipping • Weighing out and scooping powder • Bag stripping • Carrying powder bags to make into ingredient pallets • Sending a hundred emails a day

		• Manual data entry using Excel spreadsheet • Quality testing
	WAREHOUSE AND LOGISTICS	• Loading and unloading pallets • Finding empty rows in the warehouse • Pulling out rows • Moving product pallets from the palletiser • Staging • Fixing staff timesheets
	LABORATORY	• Weighing samples • Daily pipette check • Cleaning and sanitizing benches and equipment • Slurry preparation • Fat shaking test • Checking email notifications on supplier lots • Filling out sampling/printing/scanning forms • Foreign Matter testing • Transfer of broths • Opening and closing containers (screwing the cap) • Manual data entry • Subsampling powders from large sample bags into smaller ones • Disposing leftover powder into large stock food bins
6		

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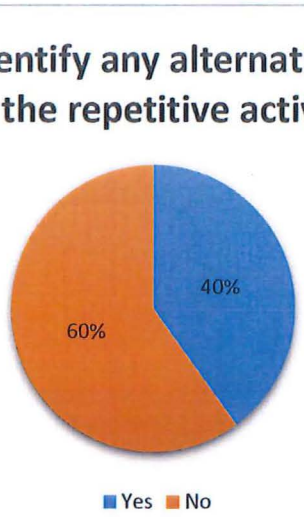

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If yes, what are the alternative ways?

TEAMS	ANSWER
DRYER 1	• Auto bag loader • Bigger sampler capacity • Install indicator lights inside and outside airlock so that if the operator wants to communicate, he can press the switch and light start flashing. • Palletiser needs flashing light so that it can be visible in the warehouse if the palletiser or wrapping station stop working. • Printing label files need to update so that when the operator enter all parameters, it needs to print all labels together, such as composite, RO, special labels and normal labs for run. • In process sampler machine • Create permit station in every control room such as in D2, AMF, Wet Mix • Online log sheets
DRYER 2	• Automate hourly checks • Integrate the systems together • Auto sampler direct off the sifter hopper • Automate time sheets
WET MIX	• Automate bag cutting or robot to cut the bags • Auto sampler to test cream and skim fat coming off the separators
BLENDING AND CANNING	• Install better filler machine that reduce the need of manual top up • MES system • SCADA system
WAREHOUSE AND LOGISTICS	• RFID technology to identify where every individual pallet is located on site

		• Automate time sheets
	LABORATORY	• Use reusable containers for autoclaving spoons so we can do a larger quantities of spoons at a time • Use glass jar for autoclaving spoons • Automate the slurry preparation

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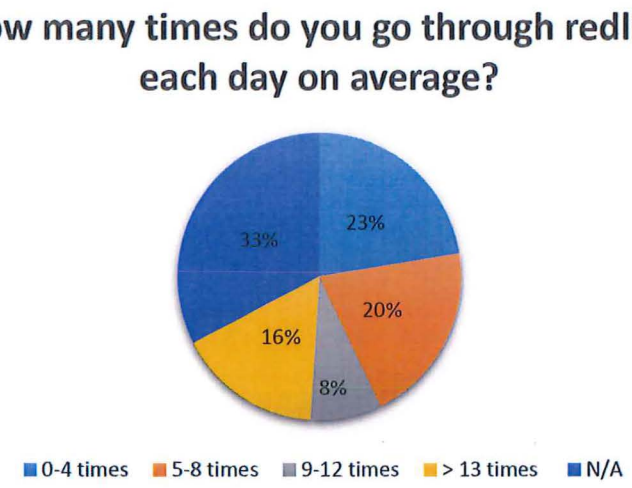

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What are the activities that require you to cross the redline?

TEAMS	ANSWER
DRYER 1	• Magnet test and check • Spec test • Topping up chloroform • Cleaning equipment • Helping palletiser operator • Communicate with supervisor
DRYER 2	• Having to cross dry side and wet side • Meetings • Problem solving and assisting at other parts of the plant • Plant walks
WET MIX	• Checking outside of the plant • Liaising and communicating with team members outside the plant • Processing oil inload • Silo pad management • Filter checks • Application of isolations for work requiring a Work Permit on the silo pad
BLENDING AND CANNING	• Checking the operations in different hygiene zones

		• Having duties at the office • Problem solving • Training other new employees • Paperwork in the office that needs filling out
	WAREHOUSE AND LOGISTICS	• Bag pulls across redline • Recover customer samples
	LABORATORY	• Moving materials in and out of the lab • Equipment maintenance • Training new employees • Collecting materials and samples from warehouse and plant • Foreign matter testing
9	**If there is anything you could change about your job to increase your productivity, what could it be?**	
	TEAMS	ANSWER
	DRYER 1	• Strict on break time • Detailed target planning for every shift • Communication improvements between palletiser and dryer operators • Separate the permit station from Dryer 1 control room • Create permit station at every control room
	DRYER 2	• Hiring a redline cleaner • Reduce the CIP length • Get more staff in the packroom, easier to keep machines going • Easier access to data in different systems such as M3, MasterControl, MEX
	WET MIX	• Install more separators and storage space for skim cream • Install another cream silo • Eliminate the need of crossing redline to do daily task such as processing oil inload • Not cleaning the area under the Wet Mix kitchen • Install lump breaker to break up some of the vitamins before transfer them to the vitamin tanks
	BLENDING AND CANNING	• Update the equipment • Better support from the leads • Business unit intelligence/systems • Some tests need revalidating about their effectiveness in determining whether the product is viable/of quality
	WAREHOUSE AND LOGISTICS	• Production planning to stick to production schedules

		• Tablets on the forklift for the forklift drivers • RFID technology • Have the pallets in rows correctly • Better information regarding the production plans
	LABORATORY	• Better and clearer meeting agendas • Set up a redline airlock out of the retention room to save the technician having to move boxes between and through other rooms • Being able to learn more • Reduce the number of breaks • Better communication from all departments • Increased the batch sizes for sampling • Task delegation with a better organisation

4. WORKING IN THE PLANT

The experience of working physically in the plant alongside with the operators was valuable. It helped to set aside all the assumptions and bias in order to understand the pain points of the operators. Some of the suggestions on improvement were not applicable due to the working environment. There were many constraints around the issues due to the nature of the business and the scale of the improvement work. The improvement work should not interrupt the existing production schedule because Synlait is a manufacturing company where every minute of lost production will cost a significant of money. Any big scale improvement work could only be conducted during the two to three weeks winter shut period.

These are the findings from my work in different teams:

TEAMS	ISSUES FOUND	COMMENTS
BLENDING AND CANNING	• Manual carrying and distributing the powder bags onto each ingredients pallet • Manual loading the powder bags onto the conveyor at staging • Manual bag stripping • Manual hand scan barcode of the ingredients bags • Manual cutting and tipping the ingredients bag into hopper • Manual weighing out the powder at dispensary • Manual topping up the powder into the cans • Manual inspection of incoming cans	• A depalletiser should be customised and installed to fit the staging • Batch weighing can be implemented • Automated system to strip and tip the bags • Many manual and repetitive testing that would cause back strain and wrist sprain
DRYER 1	• Crossing redline every hour to get the samples for lab	• Material transfer takes

	testing • Manual log sheets on a piece of paper • Issuing permit for any contractors working inside D1, D2, AMF and Lactoferrin, and Wet Mix. • Entering confined space such as fluid bed for cleaning and clearing blocks • Having to cross redline just to communicate with packroom operators which are just next door	a long time • Lab testing should be automated • Intercom should be installed for communication between dryer control room and packroom
WET MIX	• Breaking hard lumps by smashing it with hammer/hard objects on the table before tipping • Manual weighing out the powder • Manual cutting and tipping the bag into hopper	• Lump breaker must put in place
LABORATORY	• Manual weighing powder • Manual transfer powder from big packaging to small specimen bags • Manual sanitising the cans and equipment • Manual sticking label onto every specimen bags • No bar code system on the specimen bags • Manual moving retention boxes • Autoclaving spoons • Log sheets into Excel spreadsheet	• All the testing procedure are validated by IANZ and required by customer • Very limited space inside the lab • Many manual and repetitive testing that would cause back strain and wrist sprain

5. DISCUSSION AND CONCLUSIONS

The analysis of the discovery phase resulted in the three key areas to focus on in the subsequent research and development phases of the project. They were manual handling activities, non-value added or low value tasks, and repetitive tasks. Manual handling is listed as Top five critical risks activities identified by the Health and Safety team. The activities that were considered in the critical risks category would be given more attention.

MANUAL HANDLING ACTIVITIES

The most common issue that were discovered from different teams was manual handling. Manual handling activities such as hourly lab testing at dryers, bag stripping and tipping, weighing out powder, manual time sheeting, and manual log sheets are low-value activities. They cannot be eliminated because these activities are the process required to transform the raw materials into finished products. Such necessary yet low-value activities should be automated in order to ensure the employees are working to their strength. These activities do use resources, so the amount of low-value work should be reduce whenever possible. Often, this type of activity fulfils some sort of administrative purpose such as enabling value-added steps, maintaining organisational records, or meeting legal or regulatory requirements (Taylor, Value-Added And Non-Value Added Process Steps, n.d.).

NON-VALUE ADDED OR LOW VALUE TASKS

Poor communication - having to send hundred emails daily or calling each and every individual to update information are the examples of activities that did not add value into the business. The resources are expended, delays occur, and no value is added to the product (Taylor, Value-Added And Non-Value Added Process Steps, n.d.). If these activities could be removed from the process, there would be no effect on the end-product. These are also referred to as waste activities, also including storage, material transfer, and inspection-type of activities (Borysowich, 2007).

REPETITIVE ACTIVITIES

Repetitive activities often lead to repetitive strain injury (RSI), sometimes referred to as repetitive stress injury. It is a gradual build-up of damage to muscles, tendons, and nerves from repetitive motions (Biggers, 2017). Some activities that can increase the risk for RSI are stressing the same muscles through repetition, lifting heavy objects, maintaining the same posture for long periods of time, and being in poor physical condition. The laboratory team reduces the risk for RSI by swapping the jobs between different lab technicians daily. This solution is not suitable for long term because the employee will eventually suffer from RSI if the working procedure is not improved.

APPENDIX B
IDEATION PHASE

PROJECT NAME	PROJECT BLUE OCEAN
PROJECT OWNER	JAYSON SPITTAL
AUTHOR	JASON LAI
DATE	29 JAN 2018

CONTENTS

1. INTRODUCTION

The second phase of Project Blue Ocean involved an ideation process to generate unconstrained creative thinking to find the possible solutions to the issues from the discovery phase. This phase was part of the Design Thinking: **Define and Ideate**. The **Define and Ideate** process were carried out by facilitating an ideation workshop.

2. IDEATION WORKSHOP

An ideation workshop was organised to gather key representatives from different teams to go through the Design Thinking process: Empathise, Define and Ideate. The objectives of the workshop were to:

- Empathise: understand and share the issues from different teams
- Define: determine the underlying big problems and the trend of the issues
- Ideate: generate creative ideas of technology solutions to each issue

EMPATHISE

All the issues were compiled and grouped together if they were similar. The issues were written on the whiteboard so the workshop participants were able to discuss and share their issues with each other. This process allowed the participants to share their experience and knowledge on the issues that they might have come across before. It was a peer-to-peer learning experience.

DEFINE

After all the issues were discussed, the workshop participants managed to analyse the observations and synthesise them in order to define the core problems. In this process, the core problems were defined as problem statements in a human-centred manner (Dam & Siang, Stage 2 in the Design Thinking Process: Define the Problem and Interpret the Results, 2017). The problem statement should be about the people the team is trying to help, rather than focusing on technology or monetary returns. There were patterns and clusters of information that could be grouped together as shown in the table below:

DEFINE ISSUES	DETAILS
COMMUNICATION	Organising and relaying information often induced errors. Therefore poor communication might lead to: • Unplanned downtime • Lost productivity • Decreased employee morale • Other wasted business costs
TRACEABILITY & VISIBILITY	Low traceability and visibility of inventory and information would cause: • Long lead time of internal consumable units • Time wasted to make well-informed decisions

	• Time wasted to track the past and current information
GOOD INFORMATION	• The current system collects raw data in the plant but it does not translate the data into useful information. • The decision to create an action has to be studied and made by the operators based on their past experiences.
MANUAL HANDLING	Many tasks involved manual handling in the manufacturing process. The same repetitive manual handling tasks would: • Decrease employee morale • Cause workplace injuries • Increase the human error factor

IDEATE

The ideation process began with writing down technology ideas on a post-it notes and sticking onto the whiteboard. This allowed the participants to build on the ideas on top of each other while keeping it visible to everyone. The helicopter view framework was introduced to the participants to look at the issues from an aerial view. Stepping outside the problem will make it much clearer than ever before (Muna, 2013).

> *"It all comes down to the ability to go up and down the ladder of abstraction, and being able to see the big picture and the operational implications, which are signs of outstanding leaders and strategists." – Loizos Heracleous*

The helicopter view refers to the ability to rise above the specifics of a particular issue and to see it in its overall context and environment. It is a method of viewing things with a historical perspective that takes into account events in the past, present and potential future (Muna, 2013).

THE OUTCOME

NO.	TECHNOLOGY SOLUTION	DESCRIPTION
1	TV Live Screen for Communication	Require a live stream feed of information to notify people from different teams, ideally to eliminate the need to do phone call, email or text messages for standard daily operation.
2	Touch Screen Device	Touch screen device for maintenance team, satellite storage, forklift driver. • Maintenance: easier to locate issues, items, response to work status, a portable digital device will streamline the workflow. • Satellite storage: keep track of consumable units, ideally comes with a drop down screen with cost centre, item, number, ID • Forklift driver: a touch screen device installed on each forklift, eliminate the task allocation on papers, update their tasks in real time, integrate with planned GPS map, auto cue screen to utilise data from production in real time, reduce communication issue
3	UV Tunnels/Pneumatic tube	Mainly for material transfer which originally requires operators to cross the redline. Can be applied in the lab, dryer control room (auto sampling), etc.

4	Sterilisation Chamber at inwards goods airlock	Reduce the need to manual wipe, clean and sterilise every item that comes into inwards goods airlock.
5	Automated Guided Vehicles (AGV)	Material transfer at open space, it does not require built in track. Can be used to deliver items from consumable storage in the warehouse to the airlock with pick scanner.
6	Automated Laboratory	Develop automated process for each laboratory testing and procedure. Reduce the repetitive manual handling work.
7	Inline Testing	Reduce the hourly testing work at the quality testing in each team. Automate the testing, getting real live data of the quality of the products instead of taking samples from the plant and conducting the same test every hour.
8	Vacuum System for Fluid Bed	Reduce the need of operators to physically climb into the vibrating fluid bed for manual inspection, cleaning and clearing the blocks. Eliminate the critical risk hazard and improve the safety level of the activity.
9	QR Codes	Track the parts that required maintenance. The idea has been introduced by TetraPak. Attach stainless steel tag with printed QR codes and integrate with a mobile/desktop app which includes the map, alarm notification, work instruction and logging maintenance tickets.
10	Confined Space Inspection Camera	Eliminate the need of operators to enter the confined space for inspection. An inspection camera can be used to take images and videos inside the confined space.
11	Drone – Warehouse & Inspection	A warehouse drone can be deployed to track warehouse inventory in order to reduce the errors from misplacing and tracking the pallets. This can reduce the need to pulling out rows of pallets. Inspection of the plant can be carried out by drone because working at height is a critical risk activity. Eliminate the need of building scaffold up for inspection.
12	Antimicrobial Coating	This coating was suggested to be installed on the inner wall of silo for higher hygiene purpose. This coating can be further validated and might reduce the frequency of CIP.
13	Ozone Treatment CIP	High-ozone shock treatment is a process for removing unwanted odour, and killing mold, vermin and microorganisms in commercial and residential buildings. It was suggested that it could replace the current CIP process and might reduce the CIP time.
14	Inwards Truck Scheduling System	It can be used in the warehouse ELA, to schedule the time when the inwards goods trucks arrive, reduce the time for the truck to wait outside the ELA, and better schedule the task for forklift operators.
15	Digital Radio System	High spec digital radio system that allows communication between operators at different rooms under a noisy ambient environment.
16	Renewable Energy On Site	A lot of processes require high energy consumption. This project could be solar panel on warehouse roof, clean up cow water, reuse/recapture energy from exhaust/heat exchange, utilise cow water for non-product contact – heating or cooling, to replace using coal and steam to heat up.
17	Collaborative Robots	It can be used in processes that require repetitive handling task, such as quality testing station in each team, or certain task in the laboratory such as fat shaking and slurry preparation.
18	Virtual Reality	Very useful for training that involve dangerous activities. VR can be used to simulate the real training program and require the new employee to physically

		carry out the training. It can also be used for remote site visit tour using the 3D model of our plant or 360 photos taken in the plant.
19	Big Data/IOT Tool	Need to understand the concept of Big Data and the internal infrastructure rework Synlait has to do before IOT solution can be implemented.
20	Centralised Communication Centre	A concept to bring every plant operators into a control room. This provides peer-to-peer learning experience between the operators.
21	Pallet Shuttle	To reduce the need for the forklift drivers to pull out rows and waste time. It comes with the best FIFO (First In First Out) method to organise the stock. Pallets can be piled up really high with very stable structure.
22	Laser Cutting of Powder Bags	Can be used at the staging at B&C and Wet Mix where the current bag stripping process is carried out manually. A conveyor system, collaborative robots and laser cutting technology will be integrated to eliminate this manual handling tasks.
23	Infrared and Networked Pest Control	Used to replace the current traditional baiting system. Infrared can be used to detect any pest or rodents on site. If each trap is connected to WiFi and integrated with mobile apps, it can eliminate the need for technician to physically walk around the site daily to check for pest.
24	Autonomous Forklift	Can be implemented at the line where repetitive task is carried out such as moving products pallets from palletiser to rows every five minutes and moving samples to air lock.
25	Digital Twin	It represents a 3D virtual model of a process, product or service. This pairing allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations.
26	Live Energy Consumption Monitor	Real time monitoring the energy consumption on site according to different teams. This can ensure everyone is aware of energy usage.
27	Fob Key Integration	Eliminate the manual time sheeting daily. Checking who is on site for health and safety purpose. Tighten the security system.
28	Augmented Reality Smart Glasses	It can be used for remote maintenance, video calls, 3D model representation of the plant, etc.
29	3D Printer and Scanner	Make temporary parts for maintenance while waiting for the actual part to arrive.
30	Online Login at Permit Station	It can be applied to D1 control room. Every contractor and maintenance fitter has to manually log permit at D1 control room to get access to D1, D2, SMD, and Wet Mix. Very disruptive for D1 operators. Getting the contractor to prefill the permit and the respective plant operator will be notified to issue the permit.

APPENDIX C

EVALUATION PHASE

PROJECT NAME	PROJECT BLUE OCEAN
PROJECT OWNER	JAYSON SPITTAL
AUTHOR	JASON LAI
DATE	29 JAN 2018

CONTENTS

1. INTRODUCTION

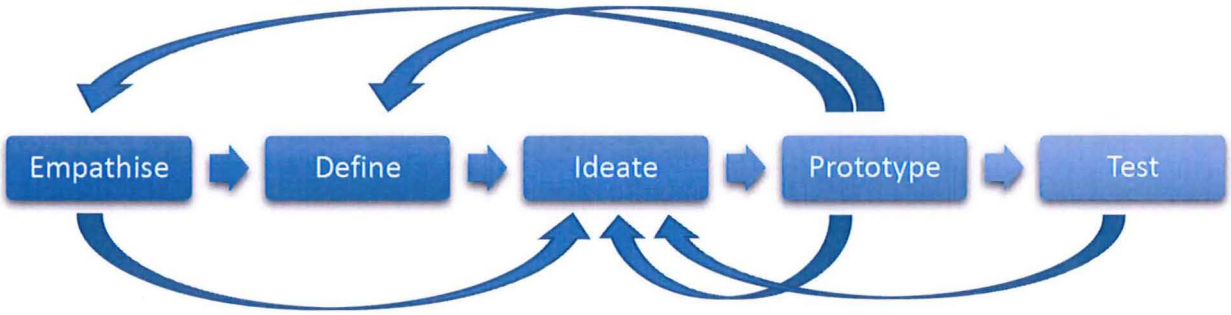
The third phase of the project was to demonstrate critical thinking to evaluate each technology solution. The key objective of this phase was to narrow down the technology suggestions to Top three solutions.

Critical thinking is a self-guided, self-disciplined thinking which attempts to reason at the highest level in a fair and logic way (Elder, 2007). A statement made by Michael Scriven & Richard Paul more comprehensively defines critical thinking as an intellectually disciplined process of actively and skilfully conceptualizing, applying, analysing, synthesising, and evaluation information from any source. It can be seen as having two components:

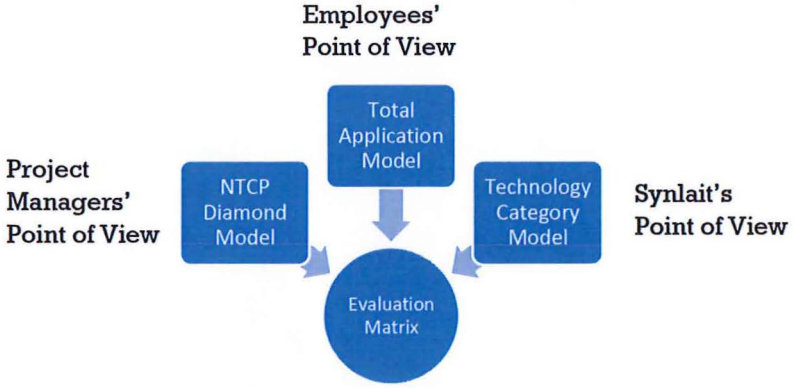
- A set of information and belief generating/processing skills
- The habit, based on intellectual commitment, of using those skills to guide behaviour (Scriven & Paul, 1987)

Despite of the sound technology solutions recommended in the ideation workshop, all sources of information must be questioned and evaluated critically and not take everything that is said as wisdom or truth (Arndt, 2013). The best way to do this is to follow a thinking process to ensure that I am not influenced by the way the information is presented, or my own inherent biases.

The Design Thinking was used throughout the project. The thinking process was repeated iteratively especially in this Evaluation phase. Often the Empathise phase was revised again to understand the fatigue point from the operators' point of view and set aside any assumption made prior. This included interviews and working inside the plant to determine the best solution to fit the purpose.



The Evaluation phase was carried out to get the Top three technology solutions by using several models:



2. NTCP DIAMOND MODEL

The NTCP is an appropriate model to assess containable risks (Shenhar & Dvir, Reinventing Project Management, 2007). The variability in one project to the next introduces uniqueness; this spans four key areas: Novelty, Technology, Complexity and Pace. The relationship each holds to risk can be visually interpreted by Figure 1. The further along each axis results in higher known risks and accordingly requires greater experience and talent to counteract.

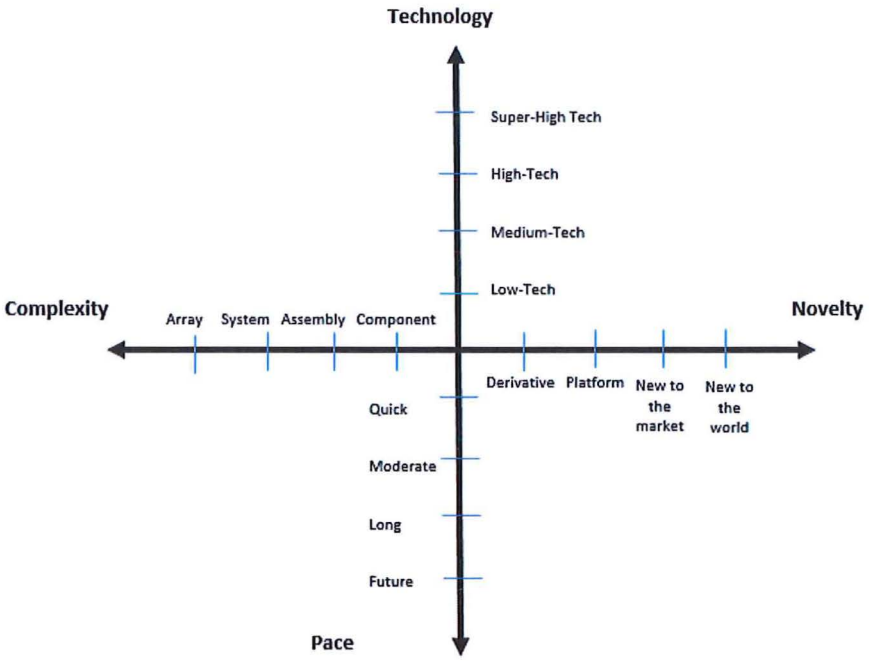


Figure 8: The NTCP Diamond Framework for Project Management

Every technology solution was seen as a single project; every project is unique (Barron & Barron, 2013). Apart from assessing the risk of the project, the NTCP Diamond Model allows project managers to see the gaps between where the project is and where it needs to be. It helps to identify the strength and the capability of the company to carry out the selected projects.

Pace is redefined (Table 1) in this project to better suit for the evaluation purpose because there is no critical time frame for any of these technology solutions.

Table 9: Difference between Original and Updated Definition for Pace element

ORIGINAL DEFINITION	UPDATED DEFINITION
Pace: Urgency of the Innovation – How critical is the time frame of the project. It impacts the time management and autonomy of the project management team.	**Pace:** Time needed of the Innovation—How much time requirement for development and implementation before it can be used. The longer the project implementation period is, the exposure to risk is higher.

Table 10: Diamond of Innovation (Shenhar, Holzmann, Melamed, & Zhao, 2016)

FACTORS	SCALE	DESCRIPTION
Novelty: Market Innovation—how new is the product to the market, users, and customers. Novelty level impacts market-related activities and the time and effort needed to define and freeze requirements (a higher novelty would delay this freeze)	1	*Derivative*: Improvement in an existing product (e.g., a new color option in an MP3 player, the addition of a search feature in a software program)
	2	*Platform: A* new generation on an existing product line (e.g., new automobile model, new commercial airplane)
	3	*New-to-the-market:* Adapting a product from one market to another(e.g., first PC, consumer's microwave oven)
	4	*New-to-the-world:* A product that no one has seen before (e.g., the first Post-it note)
Technology: Technological Innovation—how much new technology is used. It impacts product design, development, testing, and the requisite technical skills (a higher technology level requires additional design cycles and results in a later design freeze)	1	*Low-tech*: No new technology is used (e.g., house, city street)
	2	*Medium-tech:* Some new technology (e.g., automobile, appliances)
	3	*High-tech:* All or mostly new, but existing technologies (e.g., satellite, fighter jet)
	4	*Super high-tech:* Critical technologies do not exist (e.g., Apollo moon landing)
Complexity: Level of System Innovation—represented by the complexity of the product or the organization. Complexity impacts the degree of formality and coordination needed to effectively manage the project	1	*Component/Material:* The product is a discrete component within a larger product, or a material
	2	*Assembly:* Subsystem performing a single function (e.g., CD player, cordless phone)
	3	*System:* Collection of subsystems, multiple functions (e.g., aircraft, car, computer)
	4	*Array:* Widely dispersed collection of systems with a common mission (e.g., city transit system, air traffic control, Internet)
Pace: Time needed of the Innovation—How much time requirement for development and implementation before it can be used.	1	*Quick:* ~ 0 - 6 months, easy and quick to implement
	2	*Moderate:* ~ 6 months - 2 years, moderate time frame, require more than one stakeholder's involvement, eg: TetraPak.
	3	*Long:* 2 – 5 years, require long on-site development and testing before it can be fully implemented, require a few stakeholder companies to approve
	4	*Future:* ~ 5 – 10 years, involve high level of management that require completely new sets of verification from government sector or customer requirement.

Table 2 was used as a reference to assign value to respective the NTCP elements. The total value for each technology solution was added up to produce the graph in Figure 2.

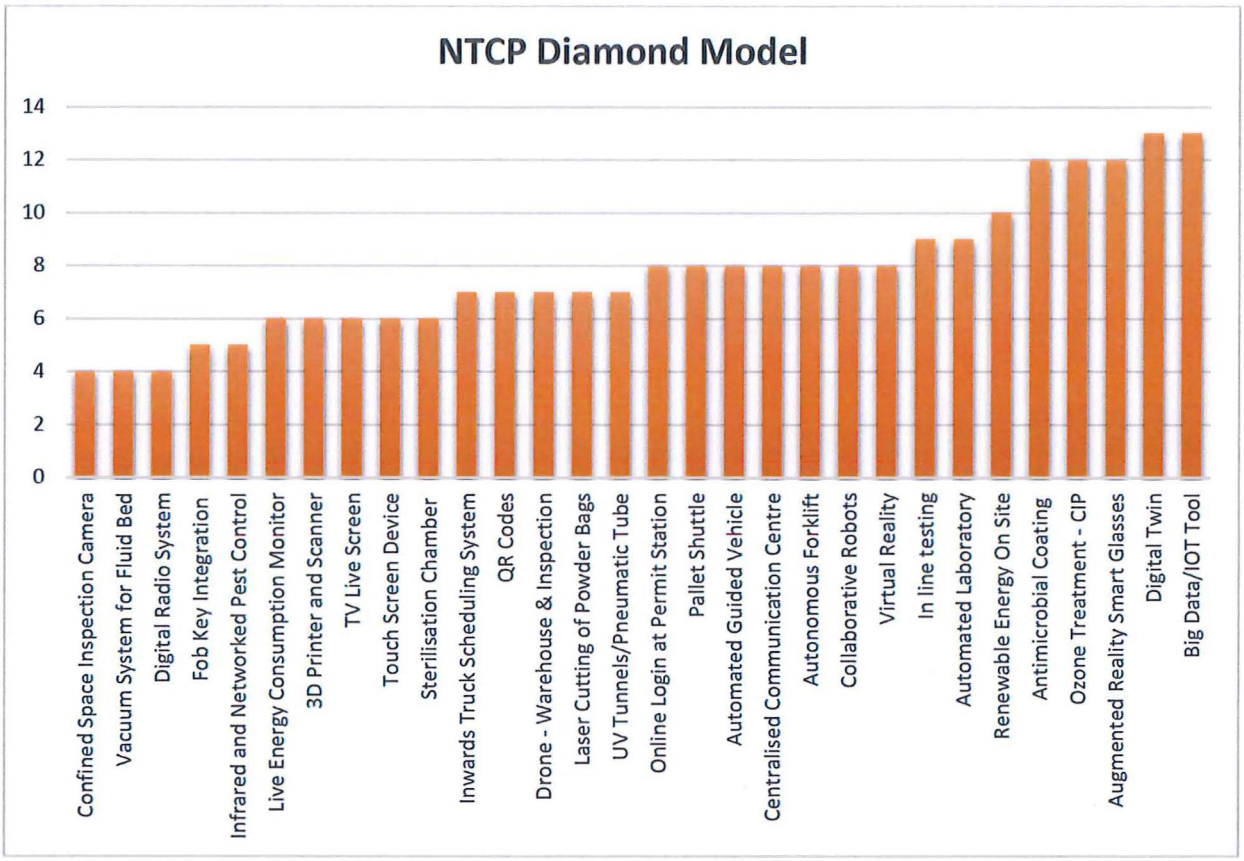


Figure 9: Level of Innovation and Risk

Table 11: Discussion of the NTCP Diamond Model

SCORE	TECHNOLOGY SOLUTIONS	COMMENTS
Top 3 Lowest	• **Confined Space Inspection Camera** • **Vacuum System for Fluid Bed** • **Digital Radio System**	These technology solutions are off-the-shelves products. They can be implemented easily with an immediate improvement of the current system. Scoring low in this model does not necessarily means that these technology solutions are a must-have to the company. Such low-tech projects have almost no technological risk, but they require maximum efficiency to gain returns.
Top 3 Highest	• **Big Data/ IOT Tool** • **Digital Twin** • **Augmented Reality Smart Glasses**	These technology tools contain the highest risk to the company due to the advanced technology and the novelty of the tool in the dairy industry. Synlait should outsource external technology vendors to develop these technology projects because Synlait currently do not have in-house experts to lead and implement them. Increasing technological

		uncertainty requires longer design, build and test periods. Moreover, the internal infrastructure of the business has to be first improved to act as an enabler before implementing any of these technology projects. They are subject to delays, cost overruns and risks of product failure.

This model was made to give an overview of the risk of each technology solution from a Project Manager's point of view. The project manager would assess the risk, understand the capability of the company at current state, and better allocate resources to areas that need more attention or research.

3. TOTAL APPLICATION MODEL

The Total Application Model was implemented to identify the number of teams that can apply and use each of the technology solutions. This model was made to give an overview of the possible application of these technology solutions across ten teams:

- Dryer 1
- Dryer 2
- Dryer 3
- Wet Mix
- Blending and Canning
- Specialty Products
- Laboratory
- Maintenance
- Warehouse and Logistics
- Administration

As the goal of the project is increasing value-adding tasks for our employee, the more employees who can benefit from each technology solution, the higher the score it gets in this model. At this stage, monetary benefit was not considered because it was still at the early stage of evaluation phase.

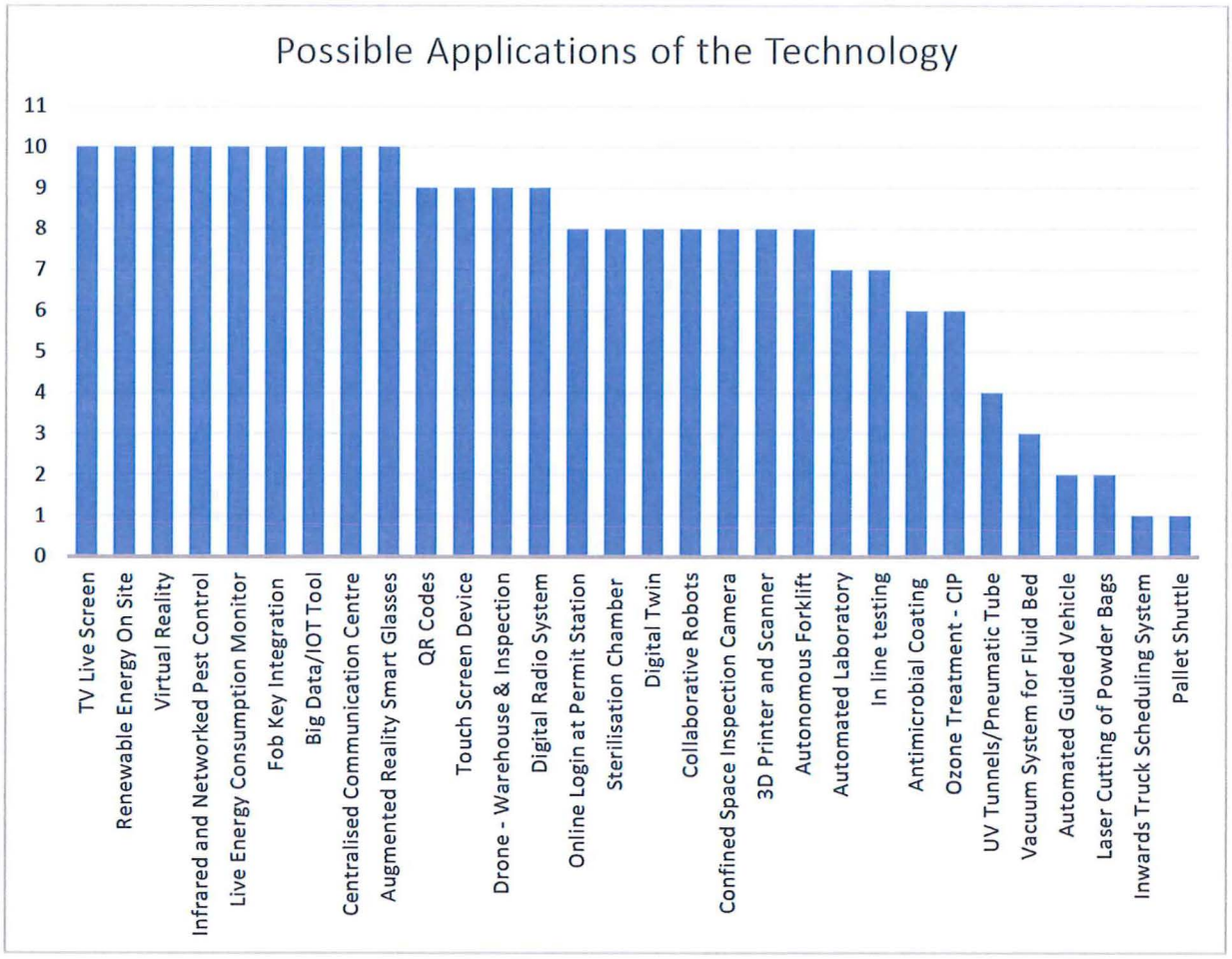


Figure 10: The Total Application Model

Table 12: Discussion of the Total Application Model

SCORE	TECHNOLOGY SOLUTIONS	COMMENTS
Highest	• **TV Live Screen** • **Renewable Energy On Site** • **Virtual Reality** • **Infrared and Networked Pest Control** • **Live Energy Consumption Monitor** • **Fob Key Integration** • **Big Data/IOT Tool** • **Centralised Communication Centre** • **Augmented Reality Smart**	These are the technology solutions where employees across the ten teams identified can enjoy the positive benefits directly. Most of the solutions in the category are using a general approach to solve a problem which occurs across the whole site. For example, the fob key integration project aims to install fob out readers at the exit of specific plant or location that employs hourly salaried staff. This solutions can be directly applied across all ten teams. This does not necessarily mean that these technology solutions which can be used across the whole site would bring the highest monetary

	Glasses	benefit. This model only assessed the number of areas that can apply the technology solutions. The higher the number of areas can benefit from each technology solution, the more employee can share the benefit.
Lowest	• **Pallet Shuttle** • **Inwards Truck Scheduling System** • **Laser Cutting of Powder bags** • **Automated Guided Vehicle**	These technology solutions can only be used in a certain areas of the business. The solutions in this category are usually designed specifically to solve a bigger scale problem. For example, laser cutting of powder bags can be used to strip the powder bags at the staging-tipping process at Blending and Canning and Wet Mix team. Implementing this technology alone will eliminate roughly ten employees who are currently manually stripping off the outer layer of the powder bags. This would have a bigger financial benefit to some of the technology solutions which score higher in this model. Although these technology solutions are only applied in certain areas of the business, they also have minimal business impact to other teams which sit around with the workflow. For example, laser cutting of powder bags might be able to speed up the process, increase the quality of product due to automated high precision laser cutting, and reduce the number of damaged powder bags. This would reduce the waste activities such as rework and double handling process for the staff in the Warehouse and Logistics team.

This model was built to give an overview of possible applications from the employees' point of view. Employees who were involved in this project, including every individual who had filled in the online survey to key people whom I have interviewed earlier, would like to see some improvement done around the problems they identified. If the technology solution can be applied across the whole site, more employees would benefit from it.

4. TECHNOLOGY CATEGORY MODEL

This model assessed the cost and the implementation of each technology solutions. The Top 30 suggestion were arranged into three categories:

- Low-Hanging Fruit
- New Technology
- Major CAPEX project

COST

The cost was generated using Rough Order of Magnitude (ROM) at this stage. It is using a top-level general estimates by looking at what a similar project cost in the past (Jensen, n.d.). At this time, not much is known about the technology project and everything can change as planning progresses. The numbers are calculated for the whole project, not for individual tasks or major deliverables (Billows, 2017).

The range of the order of magnitude were expressed as below:

- <$10,000
- <$50,000
- <$100,000
- <$250,000
- <$1,000,000
- <$10,000,000
- Anything above $10 million

Rough Order of Magnitude (ROM) was used over the estimated cost basis because at this stage, by putting myself as a project manager, I did not know how much work the deliverables will require. An accurate estimation of the cost and duration were not possible within the timeframe. The order of magnitude would reflect the uncertainty of the technology solutions.

IMPLEMENTATION

The technology solutions were assigned an implementation factor, a weighing scale from 1 to 10.

- *1 – Easy to implement*
  The company has the capability and infrastructure ready to implement the technology solution at this moment.

- *10 – Difficult to implement*
  The company does not have any subject matter expert (SME) who can lead and implement the technology solution. This might involve external stakeholders such as civil construction company or approval from Ministry of Primary Industries (MPI).

Cost vs Implementation graph was drawn to split the technology solutions into two categories: Low-Hanging Fruit and Major CAPEX project as shown in Figure 4.

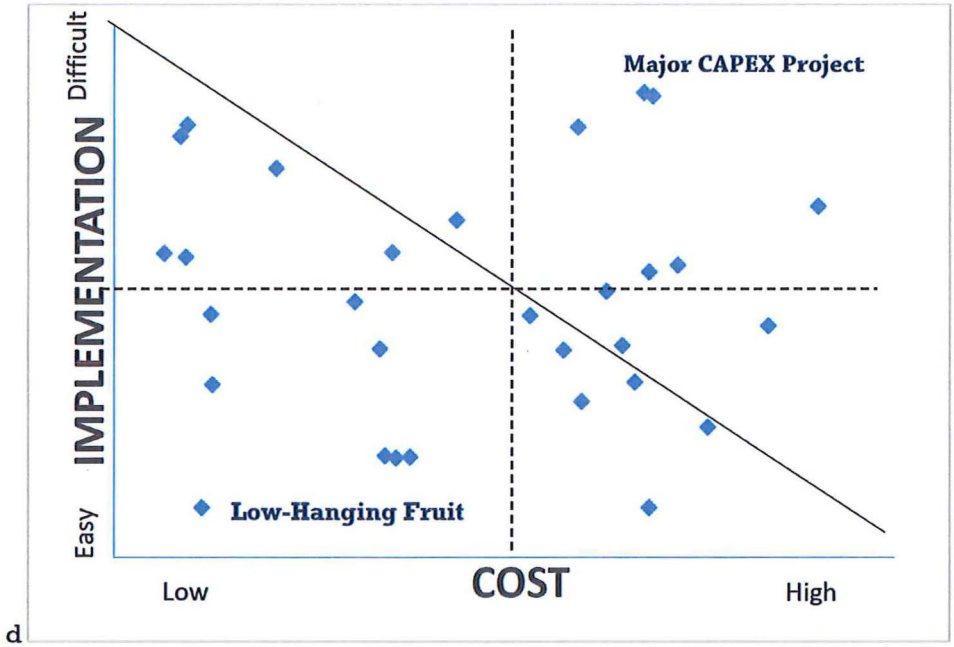


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Figure 11: Cost vs Implementation

NEW TECHNOLOGY

A new category was then added to clearly identify the technology solutions which were relatively new to Synlait or the dairy industry. The addition of a new category would help to assess the current capability of the company in order to adopt new technology applications, while identifying the internal infrastructure work that have to be completed before implementing these applications.

Table 13: Technology Categories

CATEGORY	DETAILS	TECHNOLOGY SOLUTIONS
LOW-HANGING FRUIT	• Easy to implement • Often off-the-shelves products and solutions • No new or high technology knowledge is required • Relatively low cost	• Vacuum system in fluid bed • Confined Space Inspection Camera • Inwards Truck Scheduling System • Touch Screen Device • Infrared and Networked Pest Control • 3D Printer & Scanner • Digital Radio System • Live Energy Consumption Monitor • TV Live Screen – Communication • QR Codes/RFID tech

NEW TECHNOLOGY	• Some new technology knowledge is used • Require integration with the current existing system • Might change the original procedure of work • Relatively new to Synlait or the dairy industry	• Collaborative Robots • Virtual Reality • Augmented Reality Smart Glasses • Drone – Warehouse & Inspection • Big Data/IOT Tool • Digital Twin • Autonomous Guided Vehicle – material transfer
MAJOR CAPEX PROJECT	• No new or little technology knowledge is used • Require significant resources and coordination with several external stakeholders: customers and MPI[12]. • Most likely includes civil and other construction components • Might replace the existing system	• Fob Key Integration • Online Login at Permit Station • Pallet Shuttle • Laser Cutting of Powder bags • Renewable Energy On Site • Inline Testing • Autonomous Forklift • Centralised Communication Centre • Sterilisation Chamber at Inwards Goods Airlock • Automated Lab • UV Tunnels – material transfer • Antimicrobial Coating • Ozone Treatment CIP

After arranging the Top 30 technology solutions into three categories, it was decided to determine the best technology solution from each category for the Top three recommendations. Thus the three recommendation would represent different nature of projects.

- **Low-Hanging Fruit**
  Project that can be commenced immediately at the current state with an immediate benefit to the company

- **New Technology**
  Project that can improve the new technology awareness and uptake, aligning with Synlait's vision to become the most innovative dairy company.

- **Major CAPEX Project**
  Project that require more stakeholders to cooperate together in order to create greater financial benefit.

[12] Ministry for Primary Industries

5. EVALUATION MATRIX

The NTCP Diamond Model, the Total Application Model and the Technology Category Model were then combined to create a big evaluation matrix with more detailed weighing factors. The evaluation criteria split into two sections: **Ease of Implementation** and **Potential Impact to the Business**. The outcome of the evaluation matrix was the top solution from the three categories: Low-Hanging Fruit, New Technology and Major CAPEX Project. Therefore, an evaluation matrix was created for each category.

IMPLEMENTATION FACTORS

In the Implementation section, it was further categorised into positive criteria and negative criteria. The weighing of the criteria was reasonably assigned according to the importance that impacts the end user and the business.

Table 14: Positive Criteria under Implementation Factors

POSITIVE CRITERIA	WEIGHING	DETAILS
EASE OF OPERATION	10	Describes the degree to which the application improve to operational aspects, such as start-up, back-up, and recovery processes.
EASE OF INSTALLATION	10	Describes the degree to which conversion from previous environments influenced the development of the application.
EASE OF MODIFICATION	6	Describes the flexible of the application and the ability to quickly adapt to changes, e.g. product change, change of working environment.

Table 15: Negative Criteria under Implementation Factors

NEGATIVE CRITERIA	WEIGHING	DETAILS
CAPEX & OPEX	8	The capital and operating expenditure of the technology application.
RISKS LEVEL	8	Degree of the harm and hazard that the technology application will cause to the surrounding environment.
NUMBER OF EXTERNAL STAKEHOLDER	6	The number of external stakeholders required to be involved to implement this technology application. Examples of external stakeholders are MPI, FDA[13], IANZ[14], and WorkSafe NZ.
INSTALLATION TIME	6	The time needed to install and commission the technology application.

[13] FDA stands for U. S. Food and Drug Administration.
[14] IANZ stands for International Accreditation New Zealand.

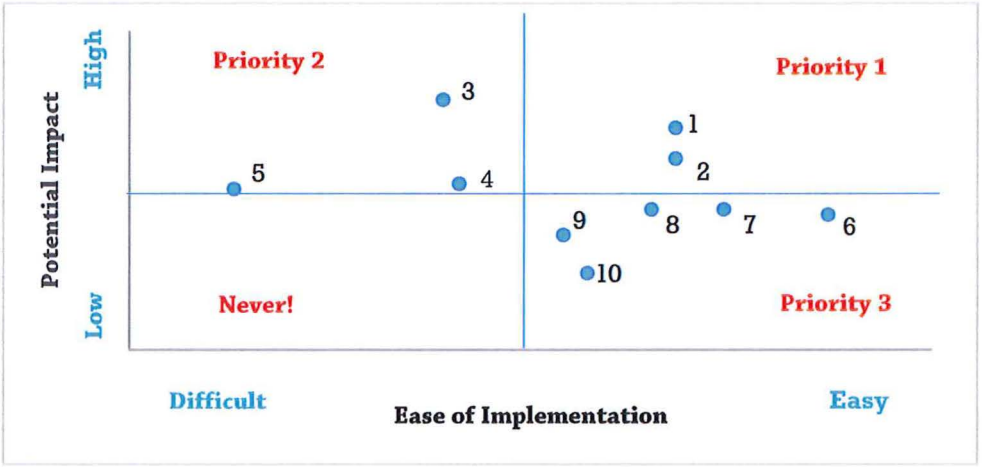
POTENTIAL IMPACT FACTORS

The potential impact directly indicated the business value. The higher the positive impact of the technology solution, the higher value it will add into the business.

Table 16: Criteria under Potential Impact Factors

POTENTIAL IMPACT	WEIGHING	DETAILS
COST SAVINGS	10	How much operating expenditure can be saved after implementing the technology solution?
RETURN ON INVESTMENT	10	How quick is the payback period after the implementation of the technology?
INCREASE HEALTH & SAFETY	10	Does it improve the health and safety of the staff and by how much?
INCREASE EMPLOYEE SATISFACTION	8	Would employees' satisfaction be improved due to the implementation of the technology?
MAXIMISE VALUE TO DAILY TASKS	8	Does it reduce the non-value added tasks so the staff can better focus on higher priority and value tasks?
INTANGIBLE BENEFITS	8	How much benefits can be earned in terms of economic, environmental, social or personal value?
TIME SAVINGS	8	How much time can the technology solution save for the company and simultaneously increase the productivity of work?

TECHNOLOGY CATEGORY	PRIORISATION GRAPH AND RANKING
LOW-HANGING FRUIT	

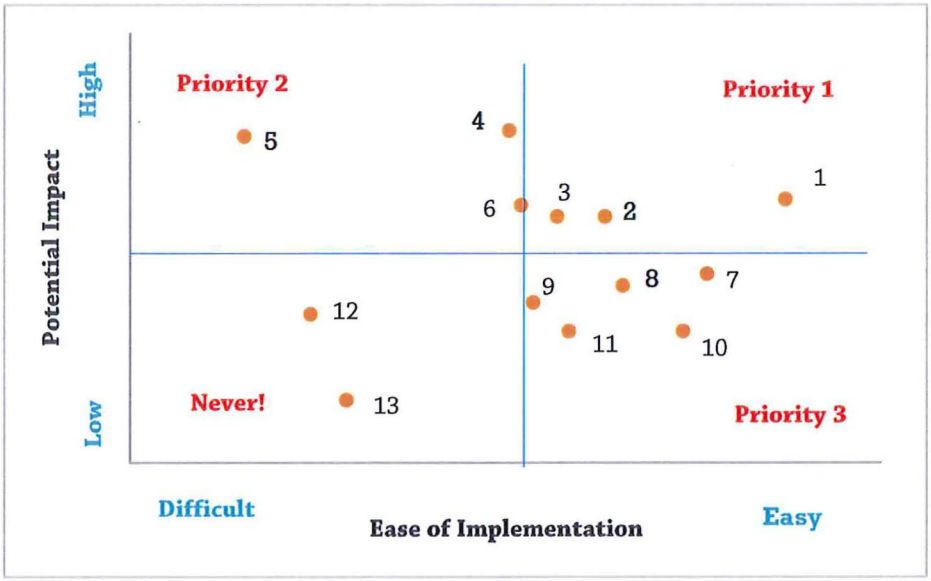


RANKING	PRIORITY	TECHNOLOGY SOLUTION
1	Priority 1	Vacuum System at Fluid Bed
2	Priority 1	Confined Space Inspection Camera
3	Priority 2	Truck Scheduling System
4	Priority 2	Touch Screen Device
5	Priority 2	QR Codes
6	Priority 3	Infrared and Networked Pest Control
7	Priority 3	TV Live Screen
8	Priority 3	Digital Radio System
9	Priority 3	3D Printer & Scanner
10	Priority 3	Live Energy Consumption Monitor

NEW TECHNOLOGY

	RANKING	PRIORITY	TECHNOLOGY SOLUTION
	1	Priority 1	Collaborative Robots
	2	Priority 1	Augmented Reality Smart Glasses
	3	Priority 1	Virtual Reality
	4	Priority 1	Drone – Warehouse & Inspection
	5	Priority 1	Digital Twin
	6	Priority 2	Big Data/IOT
	7	Priority 3	Automated Guided Vehicle

MAJOR CAPEX PROJECT



RANKING	PRIORITY	TECHNOLOGY SOLUTION
1	Priority 1	Fob Key Integration
2	Priority 1	Inline Testing
3	Priority 1	Autonomous Forklift
4	Priority 2	Pallet Shuttle
5	Priority 2	Centralised Communication Centre
6	Priority 2	Laser Cutting of Powder Bags
7	Priority 3	Online Login for Permit Station
8	Priority 3	Renewable Energy Project On Site
9	Priority 3	Automated Laboratory
10	Priority 3	Sterilisation Chamber at Inwards Goods Airlock
11	Priority 3	UV Tunnels – Material Transfer
12	Never!	Antimicrobial Coating
13	Never!	Ozone Treatment - CIP

6. CONCLUSIONS

This evaluation process was repeated iteratively using Design Thinking. It was found that the Top three technology solutions were:

- Low-Hanging Fruit: Vacuum System at Fluid Bed
- New Technology: Collaborative Robots
- Major CAPEX Project: Key Fob Integration

However, the decision to pick the best technology solution from each category was made to compare the amount of benefit from different nature of projects. Low-hanging fruit project does not necessarily apply new technology knowledge but it is an immediate fix to a current problem. New technology project often brings greater benefit compared to the low-hanging fruit project because it involves new technological advancement which is backed up by new breakthroughs in science to allow a better solution. Major CAPEX project involves significant upfront cost but the return will be higher.

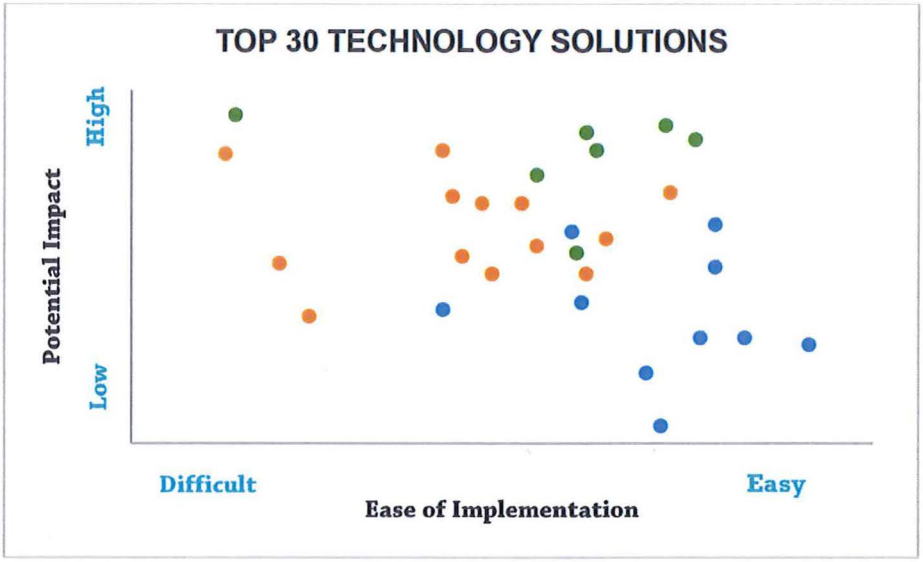


Figure 12: Prioritisation Graph for All 30 Technology Solutions

Figure 5 shows all the 30 technology solutions on the prioritisation graph on the same scale. The distribution of the technology solutions shows a pattern. The solutions in New Technology Category are clustered between the other two categories by weighing the Ease of Implementation factor, but their potential impact to the business are above average compared to the rest. Low-Hanging Fruit projects are easy to implement but the potential impact are low. On the other hand, Major CAPEX projects are more difficult to implement but they have greater impact to the business.

If the Top 30 technology solutions are not split into three categories, the Top three technology solutions would be Collaborative robots, Virtual Reality and Augmented Reality which are all landed in the New Technology Category. Although these three technology solutions are ranked at the top, Synlait currently

does not have the capability to implement Virtual Reality and Augmented Reality at this stage. While the company is organising and building its business infrastructure, Synlait will only be ready to adopt Virtual Reality in roughly two years' time and Augmented Reality in roughly five years' time at the best case scenario. Therefore, the recommendation might not applicable as Synlait hopes to implement the final Top three recommendation at the current stage.

APPENDIX D
RECOMMENDATION DEVELOPMENT PHASE

PROJECT NAME	PROJECT BLUE OCEAN
PROJECT OWNER	JAYSON SPITTAL
AUTHOR	JASON LAI
DATE	29 JAN 2018

CONTENTS

1. VACUUM SYSTEM AT FLUID BED

Description of Issue

This is seen as the **top critical risk** in the confined space activities, as manual cleaning and blockage clearing at the locations below are highly dangerous activities:

- Dryer 1 static fluid bed
- Dryer 1 vibrating fluid bed
- Dryer 2 vibrating fluid bed
- Dryer 3 vibrating fluid bed

An accident happened in September 2017 at the Dryer 3 vibrating fluid bed. While clearing the powder lumps, the powder fell off from the chamber wall onto the dryer operator. The weight of the powder was estimated to be 100kg. The operator ended up taking an extended period of break up to three months for recovery. This resulted in lost-time injury and significant cost and potential legal implications to the company.

The powder built up on the wall mainly because of the moisture inside the chamber. In Dryer 1, a chamber wash happens every 20-30 days. The operators will climb into the confined space and often take out around 50-100kg of powder. This issue was prioritised because of the significant impact from this accident.

Business Options

NO.	OPTIONS	CONS	PROS
	DO NOTHING		
1	Manual cleaning and clearing out blockage	• Prone to human accident	• Non-disruptive • No additional resource required • Ensure it is clean
	DO THE MINIMUM		
2	Vacuum system at the fluid bed	• Might not be able to collect 100% powder out due to the nature of vacuum stick • Possibly take longer time than manual cleaning • Unable to break the powder lumps	• Reduce human intervention in the confined space • Improve the health and safety • Does not interrupt the manufacturing process
	DO SOMETHING		
3	Redesign the fluid bed to have several drain holes	• Potential for more powder to be lost during production	• Improve the health and safety

	or bigger drain holes to clear the powder	• The quality of the powder after construction work will have to be validated	

Expected Benefits

The benefits expected to follow the implementation of this project are listed below. The likely savings associated with these benefits have been estimated at nearly $18,000 per annum.

Cost and ROI

The implementation of this project has been estimated to require CAPEX of approximately $20,000 and OPEX $5,000. The CAPEX will be roughly $24,000 if water blaster is included in the purchase.

Based on these costs and the aforementioned benefits, the project has been estimated to have a **payback period of 3.08 years**, with a **5-year ROI 63%** calculated with 8% discount rate.

	Yr0	Yr1	Yr2	Yr3	Yr4	Yr5
Capital	-$ 24,000					
Costs		-$ 5,000	-$ 5,000	-$ 5,000	-$ 5,000	-$ 5,000
Discounted Costs		-$ 4,630	-$ 4,287	-$ 3,969	-$ 3,675	-$ 3,403
Revenue		$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000
Discounted Revenue		$ 16,667	$ 15,432	$ 14,289	$ 13,231	$ 12,250
Total	-$ 24,000	$ 12,037	$ 11,145	$ 10,320	$ 9,555	$ 8,848

This was calculated using the cost implication Lost Time Injury (LTI). The assumption made was there would be similar injury in the future that would take 3 months off work for recovery.

Recommendation

It is recommended approval be granted to proceed with **Option 2 – Vacuum System at the Fluid Bed** to reduce human labour intervention inside the dryer confined space.

Option 2 is chosen over Option 3 because Option 2 is considered an effective fix. Option 2 does not require any structural changes. It is an off-the-shelve product but custom-made design can be requested to fit the limited space available around fluid bed.

Although the vacuum system is not able to get rid of 100% powder at the fluid bed during the full CIP, high pressure water blaster can be used on top of that to clean leftover powder through the drain holes.

Lead-time from order to install is 7 months. The system will be tested off-site before it is installed and commissioned.

2. COLLABORATIVE ROBOTS

Description of Issue

There are many manual handling processes in the lab. Most of the associated activities are process required, meaning that these steps are necessary to complete the lab testing procedure (Taylor, Value-Added and Non-Value Added Process Steps, n.d.). These activities are validated and verified against the requirement by customers: US (FDA) & China (CFDA), IANZ and our promise to our end customers.

Some examples of **manual handling** and highly repetitive activities in the lab are:

- fat shaking
- slurry preparation
- weighing samples
- washing dishes
- autoclaving spoons
- double handling of material

The lab team leaders tried to by constantly rotate staff to do different tasks every day to prevent any one person doing the same manual task all the time which could result in a repetitive stress injury. This solution is not tenable in the long term. These activities often involve lifting and moving heavy trays of specimens, resulting in back strain and long-term injuries.

Some of the lab activities involve **manual handling of hazardous chemicals** such as retinyl palmitate and retinyl acetate. This is also considered as one of the top critical risks activities at Synlait. Over-exposure of these chemicals could cause birth defects in the worst possible case.

Business Options

NO.	OPTIONS	CONS	PROS
	DO NOTHING		
1	Manual repetitive procedure to handle heavy specimen	• Employee dissatisfaction • Health and safety impact – injuries and strains • Potential legal risks	• Non-disruptive • No additional resource required
2	Manual handling of hazardous chemical	• Prone to human error • High implication of side effects if handled wrongly • Potential legal risks	• More flexible on controlling the process
	DO THE MINIMUM		

3	Custom-made apparatus and machine to carry out testing	• Regular maintenance • Fixed to only do one task • Require validation from IANZ and customers	• Reduce workload • More time to do higher priority tasks
	DO SOMETHING		
4	Use collaborative robots to carry out repetitive and high risk tasks	• Regular maintenance • Retraining lab operators to use collaborative robots	• High accuracy • Highly flexible • Safe to work with lab operators • Improve health and safety

Expected Benefits

The benefits expected to follow the implementation of this project are listed below. The likely savings associated with these benefits have been estimated at nearly $53,350 per annum.

- Improved health and wellbeing of employees
- Ergonomic benefits
- Increased productivity

Cost and ROI

The implementation of this project has been estimated to require CAPEX of approximately $60,000 and OPEX $5,000.

Based on these costs and the aforementioned benefits, the project has been estimated to have a **payback period of 1.37 years**, with a **5-year ROI 166%** calculated with a discount rate of 8%.

	Yr0	Yr1	Yr2	Yr3	Yr4	Yr5
Capital	-$ 60,000					
Costs		-$ 5,000	-$ 5,000	-$ 5,000	-$ 5,000	-$ 5,000
Discounted Costs		-$ 4,630	-$ 4,287	-$ 3,969	-$ 3,675	-$ 3,403
Revenue		$ 53,350	$ 53,350	$ 53,350	$ 53,350	$ 53,350
Discounted Revenue		$ 49,398	$ 45,739	$ 42,351	$ 39,214	$ 36,309
Total	-$ 60,000	$ 44,769	$ 41,452	$ 38,382	$ 35,539	$ 32,906

It was calculated with the number of hours spent doing slurry preparation and fat shaking test. The hourly wage were included in to identify the cost the cobot can save in the long-term.

Business Impact

This project will mostly impact the laboratory team. It changes the workforce allocation and the flow of work. Due to the possible increased productivity, the powder can be sent to the lab for testing in a bigger batch. The Manufacturing Orders (MOs) can be closed earlier and speed up the flow of the

finished goods. Logistics and Warehouse team and Sales team will also have little impact from this project.

Recommendation

It is recommended approval be granted to proceed with **Option 4** to reduce human labour intervention in the laboratory.

Lead-time from order to install is 1 year. The system will be tested off-site before it is installed and commissioned.

The lab is grouped into three teams: Chemistry, Microbiology and IPQA. The collaborative robots will be tested out in the Chemistry team.

3. FOB KEY INTEGRATION

Description of Issue

Hourly salaried staff have to **fill in timesheets** daily. The team leaders or supervisors have to calculate the working hours of the team members manually and submit a stack of timesheets to the Payroll team every fortnight. This manual time sheeting reduces the productivity of the team leaders or supervisors.

Only contractors, temp staff and visitors have to sign in and out daily for security purpose which enables the security to keep track of them easily. There is **no system to check which employee is on site at any particular time.** This could be a major issue in the case of an emergency that requires site evacuation. No one could generate a daily updated roll call list to tick evacuees off against. The shift roster is not fully reliable because the roster might be different due to leave and staff replacement.

Due to the limited number of security guards, they only occasionally check the ID card at the security hut and the gate entrance. It means that there is potential an unauthorised person can access the site without ID card and possibly disrupt Synlait's plant operation.

Business Options

NO.	OPTIONS	CONS	PROS
	DO NOTHING		
1	Manual filling of timesheets and calculation of working hours	• Employee dissatisfaction • Reduce productivity • Prone to human error	• Non-disruptive • No additional resource required
2	No system to track employee on site	• Ineffective process during site evacuation	

3	Fob only for door entry access	• Poor security control	
	DO THE MINIMUM		
4	Create controlled entry points on site	• Building turnstiles at entry points • Rewrite the company security protocol	• Control who is on site • Improve the site security • Reduce the security workload
5	Install fob out reader at the entrance of plant	• Employee distrust • Perceived lack of privacy • Cannot track employee effectively if the fob is shared	• Monitor movement of employee • Automate the timesheet • Automatic update roll call list
	DO SOMETHING		
6	Install iris-recognition system	• Require new registration of each employee • Might take longer response time than fob scanner	• Eliminate the need of fob • No more sharing of fob • Increase site security control • Automatic update roll call list • Automate the timesheet
7	Prepare portable fob reader at assembly area	• Can only be connected via WiFi so connection might be weak at assembly area	• Speed up the roll call process • Reduce the warden's work

Expected Benefits

The benefits expected to follow the implementation of this project are listed below. The likely savings associated with these benefits have been estimated at nearly $33,400 per annum.

- Improved site security
- Speed up the roll call process in case of emergency event
- Automated timesheets and payroll
- Visibility of employee location on site
- Attract more overseas customer

Cost and ROI

The cost for Option 4 was excluded because it has been undertaken by the Projects Team. The implementation of Option 5 and 7 has been estimated to require CAPEX of approximately $70,000 and OPEX $5,000.

Based on these costs and the aforementioned benefits, Option 5 and 7 have been estimated to have a **payback period of 2.79 years**, with a **5-year ROI 48%** calculated with 8% discount rate.

	Yr0	Yr1	Yr2	Yr3	Yr4	Yr5
Capital	-$ 70,000					
Costs		-$ 5,000	-$ 5,000	-$ 5,000	-$ 5,000	-$ 5,000
Discounted Costs		-$ 4,630	-$ 4,287	-$ 3,969	-$ 3,675	-$ 3,403
Revenue		$ 33,400	$ 33,400	$ 33,400	$ 33,400	$ 33,400
Discounted Revenue		$ 30,926	$ 28,635	$ 26,514	$ 24,550	$ 22,731
Total	-$ 70,000	$ 26,296	$ 24,348	$ 22,545	$ 20,875	$ 19,329

The potential revenue was calculated by using the amount of hours every team leader has to spend to manually calculating the time sheet.

Business Impact

The changes associated with this project will have significant impact on payroll and teams that have hourly salaried staff. This will impact everyone on site due to the controlled entry points.

Recommendation

It is recommended approval be granted to proceed with Option 4, 5 and 7 to replace Synlait's current fob sign in system and manual timesheet procedure.

Step 1: Option 4 – Create controlled entry points on site

- Work is already under the progress by the Projects Team
- Build a big centralised car park and require employees to go past the turnstiles at two entrances
- The current car park in front of the reception office will only be available to visitors and contractors who are required to sign in using WhosOnLocation
- More than 1 turnstile should be installed at each entrance to prevent congestion

Step 2: Option 5 – Install fob out readers at the specific entrance of the plant

- Monitor the location of each employee for H&S reason
- The specific locations are critical area such as D1 entrance, Lab entrance, and B&C entrance
- (Possibly) automate the time sheet process
- The fob must be programmed for alternate in and out (the fob cannot be used to sign in twice in a row, to prevent employee sharing their fob)

- The cost of installing fob out reader varies depending on the current infrastructure of the network. The installation will involve civil work, wires connection, and installation of lock and magnetic strips.

Step 3: Option 7 – Prepare portable fob reader at assembly area

- It is used for fob validation at assembly area in a site evacuation event.
- In a case of emergency event, employees who evacuate to the assembly area can scan their fob with the portable fob reader carried by the area wardens to prove that they are safe.
- This process can quickly identify who is unaccounted for and might still be in the evacuated building.

While Option 4 is already a work in progress, it will take one year for construction and commissioning.

After the new car park is installed, this project can proceed to Option 5 to install fob out readers at the specific entrance of the plants. The lead time from order to install is 6 months. The system will be tested out with a control group before it is widely introduced to everyone on site.