PROJECT BUSINESS CASE

PROJECT NAME	Yeti Crab – Optimal Warehouse Layout
PROJECT OWNER	Aaron Shaw
AUTHOR	Gareth Owens
DATE	20/02/17

ABSTRACT

The purpose of Project Yeti Crab was to develop and provide recommendations as to how Synlait Milk Limited can improve the performance of warehouse operations by optimising its layout. This business case presents the recommended approach for Synlait to optimise its warehouse layout in the near future, and the associated costs and benefits of doing so. Details as to the basis of these recommendations, as well as the process by which they were developed are included in the supporting documents.

DOCUMENT CONTROL

DOCUMENT OWNERSHIP	
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- Matthew Foster for authorising and sponsoring the project at Synlait Milk Limited
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- Beverly Hall for her general support

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Project Overview

Currently, the warehouse is not being utilised as effectively as possible. By optimising its layout, operational performance will be increased by reducing double-handling during picking and increasing the ease with which product can be located by operators. These prospective benefits align with Synlait's major strategic goals for FY17.

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 approximately $125,000 per annum.

- Increased operational performance in the warehouse (picking and staging)
- Improved utilisation of forklifts
- Reduced LPG consumption
- A safer working environment
- More productive use of admin time
- Increased employee satisfaction

Aspects of this project that could be perceived as drawbacks include:

- The need for more pro-active management of storage allocation
- No increase to the maximum warehouse capacity
- The lack of flexibility associated with installing racking in the warehouse

Scope

The key deliverables included in this project are:

- The continued enhancement of recommended solutions
- Piloting of solutions
- Implementation of recommendations
- Evaluation of project outcomes

The major constraint associated with this project is the proposed implementation time, with the least disruptive time to implement a new warehouse layout coinciding with stock take in late July.

Cost and ROI

The implementation of this project has been estimated to require a likely CAPEX of approximately $115,000, with no associated OPEX. The required CAPEX could rise to nearly $250,000 if the purchase of new racking is required.

Based on these costs and the aforementioned benefits, this project has been estimated to have a likely payback period of 0.92 years, with a 3-year ROI of 228%.

Major Risks

The biggest risk associated with this project lies in the accuracy of the data used to measure the performance of picking operations given its relatively small sample size. The continued collection of data in this area will increase the accuracy of the estimated picking rates and subsequently the prospective benefits calculated from these. Essentially, by increasing the sample size the risk of statistical error will be reduced.

Other major risks of the project include the inaccurate inventory forecasts, failure to design an operational layout, and an inability to implement the project within the proposed time period. Strategies have been established to mitigate against both the likelihood and effects of these risks being realised.

Business Impact

The changes associated with this project will have a major impact on the warehouse team. Smaller impacts to the sales, supply chain, manufacturing, information services, and procurement teams are also likely. Whilst the effect on these teams will be largely positive, the development and implementation of a comprehensive communications plan will be key to effectively executing the proposed changes.

Recommendation

It is recommended that the full "do something" solution is pursued and implemented at Synlait Milk Limited in order to optimise the warehouse layout. The expected benefits of achieving an optimal warehouse layout are estimated to far outweigh the costs of implementation. Meanwhile, strategies have been developed to mitigate against both the likelihood and effects of the identified risks associated with the proposed course of action.

1. PROJECT OVERVIEW

KEY PLAYERS

BUSINESS OWNER	Aaron Shaw
PROJECT SPONSOR (GM)	Matthew Foster
PROJECT MANAGER	Gareth Owens
BUSINESS ANALYST	N/A
CHANGE ANALYST	Callum Jones

INTRODUCTION

Project Yeti Crab was initiated in September 2016, with the purpose of providing recommendations towards how Synlait Milk Limited (Synlait) can achieve an optimal warehouse layout. This business case summarises the findings of Project Yeti Crab, with particular focus on the benefits to Synlait of operating with an optimal warehouse layout, and recommendations as to how this could be achieved.

It was initially deemed that the success of recommendations for the warehouse layout would hinge on increasing the effectiveness of operations in the warehouse, as well as increasing its maximum possible capacity. However, it was soon determined that there are no feasible, cost effective options available to Synlait which could further increase the warehouse capacity from its current theoretical maximum. Consequently, the potential benefits of achieving an optimal warehouse layout expressed in this business case are centred primarily on improving operational effectiveness.

PURPOSE OF BUSINESS CASE

The purpose of this document is to present the benefits of optimising the warehouse layout at Synlait Milk Limited, as well as to provide recommendations towards the best way of achieving this, and at what cost. In addition to this, this business case also outlines:

- The perceived drawbacks of implementing the recommendations,
- What is/is not considered within the scope of the project,
- A proposed high-level timeline for executing these recommendations,
- The major risks associated with the recommended course of action and how these should be best managed,
- The impact undertaking this project would have on the business,

This document does **not** provide a ***final*** solution for optimising Synlait's warehouse layout, but focuses on recommendations as to the costs, benefits, and method of achieving this.

REASONS FOR THE PROJECT

Currently, there are very few formal measures, controls, or standards in place for the placement of stock across Synlait's warehouses. Consequently, stock can often end up being placed ineffectively, later resulting in unwarranted, excess operational costs, with the double handling of pallets proving to be particularly common and costly. This has also had a negative impact on Synlait's warehouse operators, who have grown frustrated with the amount of their time at work spent both locating and accessing stock which they have been instructed to retrieve.

A re-design of the warehouse is required to optimise the layout and placement of stock within the available space and to ensure it is being used in the most effective manner possible at any given time. This should reduce/eliminate double-handling during picking, and increase the ease in which product is located by operators.

The drivers of this project align with two of Synlait's major strategic goals for FY17[1]:

1. "Operating with the best systems and processes"
2. "Becoming the best place to work"

In pursuing these goals, Synlait continue to operate in the most effective manner possible, thereby "making the most from milk".

2. BUSINESS OPTIONS

OPTION	COSTS	BENEFITS
DO NOTHING[2]		
No change to current warehouse systems or layout	• Continued ineffective warehouse operations impacting financial & logistical performance • Employee dissatisfaction	• Non-disruptive • No additional resource required
DO THE MINIMUM		
Improve management of current layout	• Ongoing, proactive management of storage allocation • Possible retraining of warehouse operators	• Partially increased picking productivity • Partially reduced forklift and LPG usage • No chance of capacity losses
DO SOMETHING		
Re-design Drystore 3 layout: • Match rows to lot sizes • Specific pallets picked at forklift operators discretion • Product specific zones	• Labour required to re-arrange all pallets in the warehouse • Updating warehouse storage parameters in M3 • Validation of warehouse layout plan • Relocating aisle barcode scanners	• Optimized picking rates • Reduced admin time • Reduced forklift & LPG usage • Reduced lead times • Increased employee satisfaction
Install partial racking in Drystore 2 to store low volume SKUs	• Best case: Re-install of old racking with frame guards • Worst case: Purchase and installation of new racking	• Improved utilisation of space in DS2 • Increased staging productivity (not enough data to quantify potential benefit)

[1] Synlait Milk Limited FY17 Game Plan

[2] This is the baseline against which project costs and benefits are measured against, the "Do Nothing" option is considered to have no associated financial costs or benefits. Rather, the costs and benefits associated with doing nothing are essentially the inverse of the recommended solutions.

3. EXPECTED BENEFITS[3]

MEASURABLE BENEFITS

BENEFIT	DETAILS	CATEGORY	MEASURE
Increased rate of picking	By reducing the time spent at the actual pick point and eliminating the double handling of pallets, picking productivity is increased. This would reduce the amount of labour required to pick orders. In addition to labour savings, faster picking operations would also increase Synlait's shipping capabilities, allowing the company to get more product out of the door on a daily basis.	Financial Logistic	Hours/pallet picked[4]
Extended forklift life	Decreasing the hours of forklift usage whilst picking extends the forklifts usable life, delaying the purchase of replacement forklifts.	Financial	Picking hours/day
Reduced LPG consumption	Decreasing the hours of forklift usage whilst picking reduces the rate of LPG consumption to fuel forklifts and the subsequent cost associated with this.	Financial Environmental	LPG bottles/day
Fewer pallet movements	Allowing pallets to be picked from the end of the row eliminates excess pallet movements and the placement of hastily assembled, unstable pallet stacks in roadways which can also block sightlines. This will reduce the rate of both stack collapses and collisions within the warehouse. From a logistical point of view, reducing pallet movements will reduce the number of scanning errors by warehouse operators, improving the traceability of stock.	Health and Safety Logistic	TRIFR[5]
More productive use of admin time	Utilising product specific areas, and matching row sizes to product lot sizes will decrease the time spent allocating storage space, and generating pick lists by management.	Financial Logistic	Hours/day

UNMEASUREABLE BENEFITS

BENEFIT	DETAILS	CATEGORY	POTENTIAL MEASURE
Increased staging effectiveness	The application of selective racking will increase the ability to locate and access pallets of raw materials and packaging. This will increase the rate at which staging is completed. This reduces the amount of labour required to stage pallets for production, and could also allow staging to operate in a more responsive manner to manufacturing requirements. Unfortunately, this benefit is currently unmeasurable due to a lack of available data to quantify the performance of staging operations. If this data became more readily available it could be utilised in the same manner as picking data to quantify potential benefits and financial savings.	Financial Logistic	Hours/pallet staged

[3] In this business case the benefits outlined are those associated with taking the "do something" approach to optimising the warehouse layout.
[4] Hours/pallet picked was used as the measure in order to easily calculate potential time savings, pallets picked/hour may be a better KPI to use for reporting
[5] TRIFR: Total Recordable Injury Frequency Rate

INTANGIBLE BENEFITS

BENEFIT	DETAILS
Reduced lead times	Being able to pick orders faster could also reduce the lead times on Synlait's customer's orders. If achieved this would increase customer satisfaction and supplement Synlait's vision of becoming "the world's most [innovative and] trusted dairy company"[6].
Employee satisfaction	As outlined previously, there is currently a sense of dissatisfaction amongst warehouse staff associated with the difficulty and variability of picking pallets for orders. Eliminating the tedious and time consuming aspects of picking (e.g. double handling), should result in increased job satisfaction by allowing warehouse staff to achieve more during their time at work.

FINANCIAL BENEFITS

The estimated financial benefits associated with the project are displayed in Table 1. These were determined from the stated measurable benefits, using mainly operational performance data[7].

Table 1: Financial Benefits of Optimising the Warehouse Layout

BENEFIT	ANNUAL SAVINGS			COMMENTS
	WORST CASE	LIKELY CASE	BEST CASE	
TIME SAVINGS				
Reduced picking time	$ 22,675	$ 75,485	$ 128,295	Reduced cost of labour to complete picking tasks
Reduced staging time	N/A	N/A	N/A	Unable to quantify with current lack of data
Reduced admin time	$ -	$ 10,400	$ 20,800	Reduced time spent allocating storage space and picks
Total Time Savings	$ 22,675	$ 85,885	$ 149,095	
AVOIDED COST				
Replacing forklifts	$ 4,371	$ 23,902	$ 43,433	Reduced forklift usage extending usable life
Total Avoided Cost	$ 4,371	$ 23,902	$ 43,433	
OPERATIONAL SAVINGS				
Reduced LPG usage	$ 2,635	$ 14,412	$ 26,189	Reduced forklift usage = reduced fuel consumption
Total Operational Savings	$ 2,635	$ 14,412	$ 26,189	
TOTAL BENEFITS	$ 29,681	$ 124,199	$ 218,717	

[6] Synlait Milk Limited FY17 Game Plan
[7] A breakdown of these estimations is presented in Appendix C: Development of Recommendations

4. PERCEIVED DRAWBACKS

DRAWBACK	DETAILS
Need for proactive management	The successful implementation of the recommended changes to the warehouse layout will rely on managing the warehouse in a much more pro-active manner than is presently the case. Currently, the allocation of new product to storage in specific rows is managed in a mostly reactive manner (especially when the warehouse is near capacity). The overall amount of admin time (resource) spent managing warehouse operations should be reduced as a result of the recommended changes. However, the need to plan storage allocation further ahead of time (to maintain specific storage areas, etc.), could prove challenging and rigid compared to the current, more dynamic, method of working it out as it happens.
No increase to maximum warehouse capacity	The recommendations for this project fail to achieve any increase to the maximum warehouse capacity. As a result, the existing requirements for offsite storage will remain until Synlait's warehouse is expanded.
Lack of flexibility associated with racking	If installed, it would not be the first time racking has been utilised in the warehouse. Prior to the addition of canning and blending to the plant, racking was installed across Drystore 2 for storage purposes, but was subsequently removed. A lack of flexibility and poor space utilisation was cited as the reasoning behind this decision. The situation and use of Drystore 2 has changed considerably since this time, now mainly containing raw materials and packaging (following the construction of Drystore 3), with canning and blending significantly increasing the number of these SKUs stored in the warehouse. Whilst these changes have presented renewed benefits to utilising a small amount of racking in Drystore 2, the lack of flexibility racking can cause, remains a drawback to its utilisation.

5. SCOPE OF THE PROJECT

IN SCOPE DELIVERABLES

DELIVERABLE	DETAILS
Continued enhancement	Validation of recommended "do something" option along with further development/improvement of layout plans to ensure a working solution upon implementation
Piloting	Pilot testing of new storage allocation system for the "do the minimum" option to determine whether it would be worth implementing prior to "do something" solution
Implementation	Installation of new system for optimising warehouse layout, including: • Re-arrangement of pallets by operators • Movement of barcode scanners for each row • Re-installation of selective racking • Adjustment of M3 to new warehouse parameters
Evaluation	Continued measurement of warehouse operational performance to evaluate success of change, and how it could be continuously improved going forward

OUT OF SCOPE DELIVERABLES

DELIVERABLE	DETAILS
Warehouse management system	Identified as a complimentary system to assist in the management and maintenance of an optimal warehouse layout. Considered out of scope due to lack of resource (time) and the fact it does not solve the problem itself, but merely helps manage its solution.
Warehouse expansion	Layout plans will not account for the possibility of any future warehouse expansion. This is considered out of scope as parameters associated with any possible expansion are unknown at this point.
Automate guided vehicles	Identified as a complimentary technology to assist in improving the effectiveness of warehouse operations. This is considered out of scope as it would have little influence on optimising the warehouse layout, and would not solve the main problems being experienced at the pick point itself.
Re-training	There is a possibility that warehouse staff may require re-training as a result of the new layout, storage allocation, and picking systems. This is considered out of scope as it is not clear at this point of the project whether this will be required or not.

ASSUMPTIONS

The major assumptions[8] made in developing the recommended actions of this project are:

ASSUMPTION	VERIFICATION
The primary cause of poor operational performance in the warehouse is time lost at the pick point during picking, as a result of having to locate and retrieve pallets from within storage rows (double handling, etc.)	Verified by discussions with operators & SMEs, visual observation of operations, and data measuring warehouse operational performance
All parameters specified and utilised in Aaron Kenny's warehouse inventory model are suitable for application in this project	All assumptions made in the model (stack heights, pallet spaces, pallet weights, etc.) have been verified by Aaron Kenny and the warehouse team prior to work beginning on this project

CONSTRAINTS

The project constraints which may have an impact on its execution include:

CONSTRAINT	DETAILS
Implementation period	The main constraint associated with the project is the period of time in which the project can be effectively implemented. The ideal time to re-arrange the warehouse layout would be whilst it is in a "static" state (no inputs or outputs). This only occurs during stocktake in late July, meaning the period of time in which the project could be most effectively executed is both fixed and very finite, with stocktake only lasting two weeks.
Prioritisation	It is possible that the ability to execute this project may be hindered if other projects are prioritised ahead of it, thereby reducing the amount of available resource.

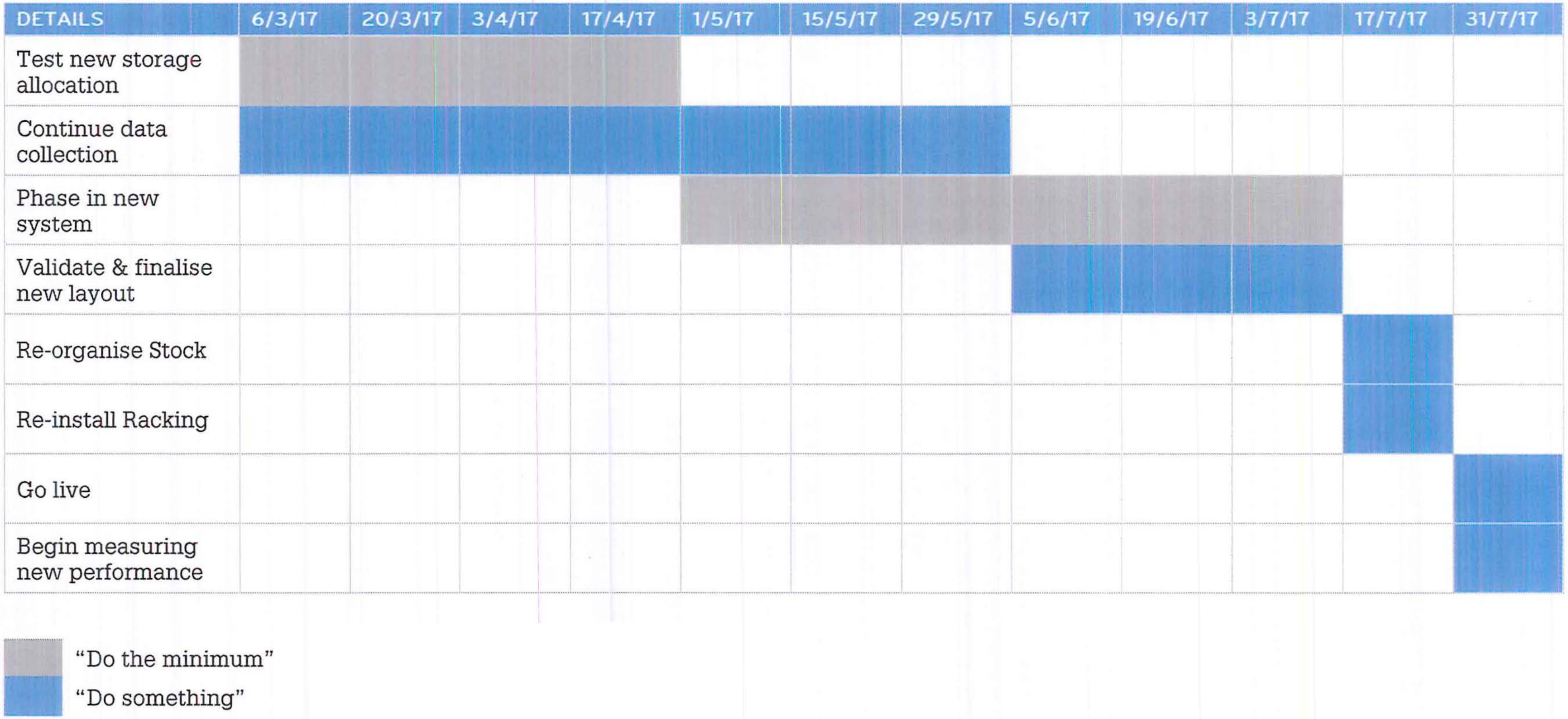
RELATED/ DEPENDENT PROJECTS

PROJECT	DETAILS
Operation Honey Badger	A business case for the project "Operation Honey Badger" was developed a year ago, outlining plans for an improved system for pallet localisation. Were this to be implemented, it would be likely to compliment the outcomes of this project, particularly around the allocation of pallets to storage and picking.

[8] Further minor assumptions made in determining specific aspects of the project have been specified in the relevant areas of the Appendix

6. TIMELINE

The Gantt Chart below outlines the suggested schedule of events for the project, including both the "do the minimum" and "do something" options outlined in the business options section of the business case. This suggested course of events hinges on completing the re-organisation of the warehouse in late July in conjunction with the annual stocktake.



7. COST

Table 2 outlines the estimated costs associated with implementing the "do something" solution outlined in the business options. Note that CAPEX refers to the upfront, one-off cost of implementation, whilst OPEX refers to the annual ongoing costs associated with maintaining the specific recommendations for this project.

Table 2: Estimated Costs of Optimising the Warehouse Layout

CATEGORY	LIKELY COST		HIGH COST		COMMENTS & EXPLANATION
	CAPEX	OPEX	CAPEX	OPEX	
LABOUR					
Layout development	$ 8,000	$ -	$ 12,000	$ -	Likely: 100 hrs @ $80/hr High: 150 hrs @ $80/hr
Re-arrangement of warehouse	$ 43,134	$ -	$ 58,696	$ -	Likely: Cost of labour to move all pallets at standard picking rate High: Cost of ***overtime*** labour to move all pallets at bad picking rate
EQUIPMENT					
Installing Racking	$ 20,225	$ -	$ 131,255	$ -	Likely: 2 workers for 1 week re-install old racking plus frame guards, High: Cost of new racking quoted by Rack n Stack
New barcode labels	$ 42,000	$ -	$ 42,000	$ -	700 rows at $60 per storage row[9]
SOFTWARE					
Updating M3 parameters	$ 400	$ -	$ 640	$ -	Likely: 5 hrs @ $80/hr High: 8 hrs @ $80/hr
SERVICES					
Increased offsite storage	$ -	$ -	$ -	$ 17,286	Likely: No change to warehouse capacity High: 200 pallet spaces @ $6.70/month
TOTAL COST	$ 113,759	$ -	$ 244,592	$ 17,286	

see handout Dave Gardiner
⇒ use the upper limit

[9] Verified by Brent Rodgers – Logistics Analyst

8. INVESTMENT ANALYSIS

As shown in Table 3 below, the project has been estimated to have a likely payback period of just under 1 year, with a 228% return on investment after 3 years[10]. The differences between the likely, best, and worst case estimations was primarily caused by the large variance in potential labour savings associated with improved picking efficiency. This variance was caused by the small data sample available to determine average picking rates, and will be reduced significantly by continued data collection, leading to more precise estimations of financial benefit.

Table 3: Financial Implications of Optimising the Warehouse Layout

MEASURE	LIKELY CASE	BEST CASE	WORST CASE
Initial Investment	$ 113,759	$ 113,759	$ 244,592
Net Annual Returns	$ 124,199	$ 218,717	$ 29,681
Payback Period	0.92	0.52	19.7
3 year ROI	228%	477%	-85%

It should also be noted that the estimated worst case scenario is somewhat misleading. This calculation accounts for the high cost of purchasing new selective racking in Drystore 2. However, due to the lack of available data, the primary financial benefit of improved staging efficiency associated with this investment is currently unmeasurable. Upon the collection and processing of more data to quantify this benefit, a more accurate representation of the benefits of the project will be possible.

Figure 1 shows the estimated net return of the project for the 5 years following its implementation.

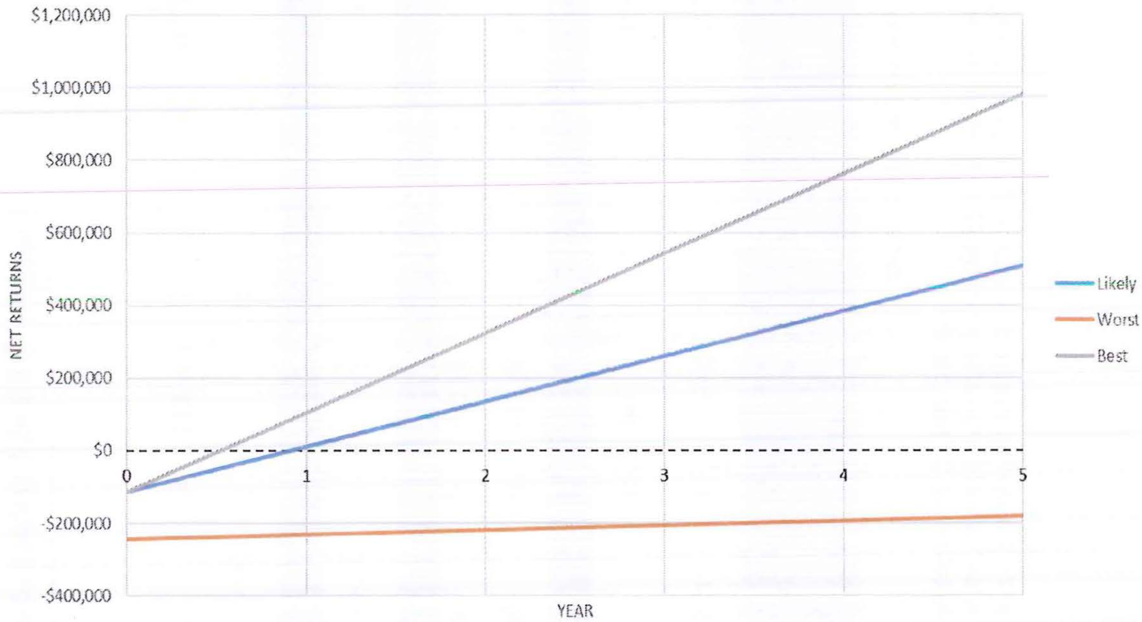


Figure 1: Estimated Net Returns of Optimising the Warehouse Layout

[10] A breakdown of these financial estimations is included in Appendix C

9. MAJOR RISKS

DO THE MINIMUM

RISK	MANAGEMENT STRATEGY
Too difficult to manage	Pilot test in small area of warehouse. If new system is impractical, scrap "do the minimum" plan and wait to implement full "do something" solution at later date.
Warehouse currently too full to effectively implement	As opposed to trying to re-arrange all stock, phase in new method of storage allocation as space becomes available with careful, and pro-active planning.

DO SOMETHING

RISK	MANAGEMENT STRATEGY
Inaccurate inventory forecasts	Variations in forecasted inventory levels accounted for in analysis, with additional space allocated than forecasted requirements as contingency. Additionally, the differences between previously forecasted and actual inventory levels could be analysed to further validate forthcoming storage requirements.
Failure to design an operational/functional layout	Base the majority of design constraints (aisle width, etc.) on those that are already in place and proven to work, with further validation of plans to be carried out by management.
Poor choice of what should be racked	Select stock to be racked base on Pareto analysis of Drystore 2 inventory (rack the remaining SKUs which make up 20% of inventory), and SKUs which fit racking dimensions. Verify choices with supply chain officers and warehouse management.
Inaccurate pricing estimates	Estimated cost of equipment has been based on quotes from industry experts and suppliers[11]. In the scenario that old racking cannot be re-installed, continue to build up a list of quotations from suppliers to validate previous estimates.
Accuracy of data samples on warehouse operations	The measurement of warehouse operational performance should be continued to further substantiate benefits that have been quantified to this point. Particularly emphasis should be placed on: • Picking rates (biggest contributor to lost time) • Staging rates (not enough data to quantify potential savings to this point)
Investment in racking unwarranted	Racking could be sold on. It is also possible that it could be shifted to the canning and blending staging area, where it has been under consideration as a means of improving both workflow and the safety of operators.
Warehouse downtime during implementation	By planning to perform this re-arrangement in conjunction with stocktake (late July), disruptions to warehouse operations should be minimised, if not eliminated entirely, as the warehouse is shutdown (no input or output) for the entirety of the stocktake.
Warehouse too full to effectively re-arrange	Warehouse should be roughly 50% full to effectively re-arrange[12]. Recommended time period for implementation (late July) coincides with warehouse being close to lowest annual capacity level[13].
Warehouse becomes over ideal capacity (~85%)	If it becomes impractical to allocate storage effectively to due lack of space in the warehouse, the levels of offsite storage should be raised. It is likely that the benefit of operating with an efficient warehouse will outweigh the cost of increasing third party storage levels (this could be quantified accurately as warehouse performance is evaluated following changes).

[11] Shown in Appendix B: Primary Sources
[12] Aaron Kenny, Finance Business Partner – Supply Chain
[13] Shown in Appendix A: Analysis of Inventory Levels

GENERAL PROJECT RISKS

RISK	MANAGEMENT STRATEGY
Lack of internal resource	Clear and early communication of the benefits of implementing the project should ensure resource is approved and made available in a timely manner. The support of senior management will be key to achieving this.
Project budget blow out	The development of a realistic budget, which accounts for all internal and external requirements, as well as the effects of any variables on these. Such a budget should also be updated regularly with any major changes reported to senior management.
Project not implemented in time	The early communication of planned changes will be crucial to avoiding any delays in gaining project approval. Additionally, a realistic project plan should be developed in order to ensure everything is in place to complete the warehouse re-arrangement during stock take in late July.

10. IMPACT ON THE BUSINESS

TEAMS IMPACTED BY PROJECT

AREA/TEAM AFFECTED	NATURE OF IMPACT	STRATEGY	IMPACT LEVEL
Warehouse	• Complete overhaul to working environment • Changes to warehouse workflow • More time available for other tasks • Reduced overtime requirements	Manage closely	High
Sales	• Potential for reduced lead times on order shipments • Changes to lead times must be communicated to customers	Keep informed	Low
Supply Chain	• Potential for reduced lead times on order shipments • Could affect shipping schedules/requirements	Manage closely	Med
Manufacturing	• Improvements to staging efficiency • Could affect workflow and staffing requirements in staging	Keep informed	Med
Information Services	• Time taken to update M3 parameters • Time taken to update BI reports	Keep informed	Low
Procurement	• Any potential purchase of new racking would have to be processed by procurement	Keep informed	Med

COMMUNICATIONS PLAN

The key to effectively executing a change to the business, and successfully managing its impact to both specific teams and the wider business as a whole is a communications plan. This is something which will be developed as work on the project progresses. Aspects of the project which are likely to require communication and subsequently be included in such a plan are:

- Planned changes to the business and the purpose of making these changes,
- Implementation start date,
- Measured outcomes of the project,

11. CONCLUSIONS & RECOMMENDATIONS

There are numerous benefits, both measurable and intangible, which would result from optimising the warehouse layout at Synlait. The greatest difficulty associated with these has been finding an accurate way to quantify them. It is for this reason that the continued measurement of operational performance in the warehouse is key to ensuring the validity of the recommended actions. In particular, the collection of data measuring staging rates and the extent to which these can be improved, will be crucial in ratifying any potential investment in selective racking to store raw materials. Meanwhile, as outlined in the investment analysis, further measurement of picking rates will provide a much more precise and robust measure of the potential return on investment associated with the project, thereby greatly reducing the risk associated with its implementation.

The purpose of providing a "do the minimum" option is to allow for a short term means to partially access the benefits associated with an optimal warehouse layout. Whilst it is currently unclear what share of these benefits can be realised by this recommendation, it should provide a low cost improvement on the current system prior to a complete solution being implemented. It is during this time that the recommendations towards achieving an optimal warehouse layout can be further validated, and subsequently developed into a full solution for implementation.

Whilst considered out of scope at this point of the project, it is recommended that an investigation into warehouse management systems is carried out. If correctly selected, such a system could be utilised to support the implementation and management of a new warehouse layout. A warehouse management system could be of particularly value if it is found that the planning and management of warehouse storage following project implementation proves more difficult than anticipated.

Finally, if the outcomes of the project are proven to be positive, a similar approach should be applied to the design and subsequent operation of any future warehouse expansion. This would certainly amplify the prospective benefits outlined in this business case, with the associated extra costs likely to be much lower if implemented from the outset of its operation.

12. APPROVAL

APPROVED BY	Matthew Foster
DATE	31/01/17

13. NOMENCLATURE & DEFINITIONS

TERM	DEFINITION
AGV	Automated Guided Vehicle
AMF	Anhydrous Milk Fat
AS/RS	Automated Storage & Retrieval System
Bulk Stacking	The principle of freely stacking filled pallets on top of one another
Drystore 2	The area of the warehouse connected to the inward goods area in which the majority of raw materials and packaging is stored
Drystore 3	The area of the warehouse connected to the outward goods area in which the majority of product is stored
IFB	Infant Formula Base Powder
IFC	Infant Formula Canned
M3	Java based software used by Synlait to track data on operations and inventory
MT	Metric Tonnes
Picking	The process of retrieving pallets of product from storage to be shipped for orders
ROI	Return On Investment
SKU	Stock Keeping Unit
SME	Subject Matter Expert
SMP	Skim Milk Powder
Staging	The process of retrieving and organising pallets of raw materials, packaging, and ingredients for input into manufacturing processes
TMP	Stock food (usually resulting from the downgrade of other product types)
WMP	Whole Milk Powder

PROJECT
APPENDIX A – ANALYSIS OF CURRENT SYSTEMS

PROJECT NAME	Yeti Crab – Optimal Warehouse Layout
PROJECT OWNER	Aaron Shaw
AUTHOR	Gareth Owens
DATE	01/02/17

EXECUTIVE SUMMARY

An analysis of the current warehousing systems was carried out in order to determine the main problems currently associated with the warehouse layout at Synlait Milk Limited (Synlait). By subsequently recognising the root causes of these problems, the main aspects of the Synlait warehousing environment to be targeted in the research and development of this project's recommendations were able to be identified.

It was found that ineffective picking operations is considered the biggest contributor to poor operational performance in the warehouse, and is mainly caused by the mixture of different product types and batches within storage rows. Consequently, altering the way in which products are allocated to storage was identified as the primary means for increasing the performance of picking operations in the warehouse.

There are a number of root causes to Synlait's warehouse being over-capacity, with many of these outcomes of the company's success, or out of the scope of the project. The poor space utilisation of raw materials and packaging storage in Drystore 2 was identified as a potential area for improvement, with the average the stack of pallets in this area only 2 high compared to almost 5 high in product storage. Based on this discovery, finding a way to increase the utilisation of vertical space in raw materials and packaging storage was the focus of subsequent research and development to increase the maximum capacity of the warehouse.

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1. INTRODUCTION

The first major phase of the project involved a thorough investigation into the warehousing environment, and the systems currently utilised to manage it. The main purpose of this was to:

- Understand the constraints and variables related to the warehouse,
- Identify the problems associated with the current warehouse layout,
- Diagnose the root causes of these problems,

This course of action was based on recognising that an early diagnosis of the root causes of Synlait's warehousing problems would provide clarity as to the best areas upon which to focus both the research and development of potential solutions from the project's outset.

2. GAINING PERSPECTIVE

The first stage of this investigation involved gaining the perspectives of those with the most intimate knowledge of Synlait's warehouse operations. This process consisted of interviews with the following subject matter experts (SMEs) employed by Synlait:

- Gary Hodder, Logistics Manager for Supply Chain (former)
- Aaron Shaw, Warehouse Manager
- Brent Rodgers, Logistics Analyst
- Aaron Kenny, Finance Business Partner, Supply Chain

This investigation focused on what staff considered to be the greatest "pain points" associated with the current warehouse layout and suggestions for potential resolutions to these that should be considered for research. The findings of these discussions are outlined in Table 1:

Table 1: Findings of Discussions with Project SMEs

SME	PAIN POINTS	SUGGESTIONS	OTHER COMMENTS
Gary Hodder	• Lack of controls/standards around the placement of stock around the warehouse. • Excess operational costs associated with the double handling of pallets. • Layout plans limited to a map of the warehouse showing where pallets can be placed.	• Develop KPIs to measure warehouse operational performance. • Ensure stock is stacked as high as possible. • Financial, health and safety, and environmental benefits should all be targeted.	• Approximately 50 staff working in the warehouse at once.
Aaron Shaw	• Stock is simply placed where there is room for it. • Current system (M3) only knows what row a pallet is in but not where it is located within this row. • Lots of time being lost due to ineffective order picking. • There are a few longer rows in the warehouse which are currently very costly to retrieve pallets from.	• Matching row sizes to lot sizes would greatly improve picking rates and reduce the likelihood of double handling. • A forklift "ring road" around the warehouse to improve travel times. • The use of racking to store raw materials which cannot be bulk stacked very high. • Utilisation of automated guided vehicles (AGVs) to assist in warehouse operations.	• There is no data obviously available to measure individual picking times.

Brent Rodgers	• M3 inventory data is limited to knowing what goes into storage and when it leaves, very little is known about what occurs between these two actions. • Ineffective picking operations.	• Warehouse management system (WMS) to compliment M3. • Desired occupancy level of 85% of maximum capacity. • AS/RS to store and retrieve raw materials. • Specific zones in the warehouse for each product type.	• Warehouse operations contribute negligibly to product damages. • Plenty of data available on warehouse occupancy and inventory levels.
Aaron Kenny	• Ineffective picking operations. • Lack of availability of data measuring warehouse performance.	• Specific zones in the warehouse for each product type. • Measurements of the warehouse's overall equipment effectiveness (OEE).	• Finished product should all be stored in Drystore 3, but is currently spilling over into Drystore 2 and offsite storage.

3. ACCESSING RELEVANT DATA

The next step to determining how the current (and any future) warehouse system functions was to quantify the areas of interest identified by SMEs. This required access to data relevant to these areas. This data could then be utilised to gauge the numerous variables which influence the layout of Synlait's warehouse, and its subsequent operational effectiveness.

As acknowledged by the project success factors[1], there are two key aspects of the project which require measurement:

1. Warehouse capacity levels
2. Operational performance

Of these, there was ample data available to quantify and comprehend warehouse capacity at Synlait, with historical and forecasted inventory levels of particular interest.

With regards to assessing warehouse operational performance on the other hand, it was apparent that there were no formal databases, models, KPIs, or measurements available. As reflected by the thoughts of the project SMEs, it has simply been common knowledge that the warehouse has not been operating in an efficient manner for some time. However, with no way to assess or validate any potential solutions born out of the project, the development of measures for evaluating the operational performance in the warehouse became an additional requirement of the project[2].

[1] Described in the Project Brief
[2] This KPI development is detailed later in the Appendix

4. ANALYSIS OF INVENTORY LEVELS

Monthly snapshots of warehouse inventory data for the period January 2015 to September 2016[3] were utilised to analyse historic inventory levels at Synlait.

4.1 FINISHED PRODUCT

Figure 1, on the following page, displays a monthly breakdown of overall product levels over the aforementioned period, with each of the major finished product types within this highlighted. The most prominent feature of this graph was the seasonal nature of overall inventory levels, reaching a trough in July and subsequently peaking around April. This trend reflects the milk supply curve applicable to the dairy industry across the South Island of New Zealand.

With regards to warehouse layout, this trend highlighted how the requirements of a warehouse layout shift considerably through the year. Consequently, storage allocation must be managed in a dynamic manner in order to optimise the warehouse layout. This means that the best layout at one time of year likely to differ considerably to another time of year, particularly with regards to the proportional amount of different product types.

The breakdown of this data into different product types, shown in Table 2, also served to identify the larger contributors to warehouse capacity levels. Additionally, the average residence time within the warehouse for each of the major product types was also examined. This was used to identify the rate at which different products move through the warehouse.

Table 2: Average Inventory Levels & Age of Different Product Types at Synlait

PRODUCT TYPE[4]	AVERAGE FLOORSPACE PALLETS	ERROR (±PALLETS)	AVERAGE AGE OF INVENTORY (DAYS)	ERROR (±DAYS)
WMP	2100	100	120	6
SMP	1060	70	150	11
IFB	1550	90	260	10
IFC	410	40	58	3
AMF	390	30	58	5
TMP	800	100	210	10

It was noticeable that two of the larger contributors to warehouse capacity, IFB, and TMP, have very long residence times in the warehouse. This slow rate of turnover will have been negatively impacting warehouse capacity, with TMP (stock food) of particular concern given its low sale value.

Many of these findings were not relevant to diagnosing the root cause of Synlait's warehousing problems. However, it was thought that this information would be of use in potentially developing recommendations for a new layout later in the project.

[3] This data was drawn from Synlait's M3 computer system and was presented in the form of the number of MT of each SKU present. The application of parameters from Aaron Kenny's warehouse capacity model allowed for the conversion of this data to the number of floor level pallets in the warehouse at a given time. This was deemed the most suitable measure for comparing different SKUs which can be stacked to different heights.

[4] A breakdown of product SKU names can be found in the nomenclature

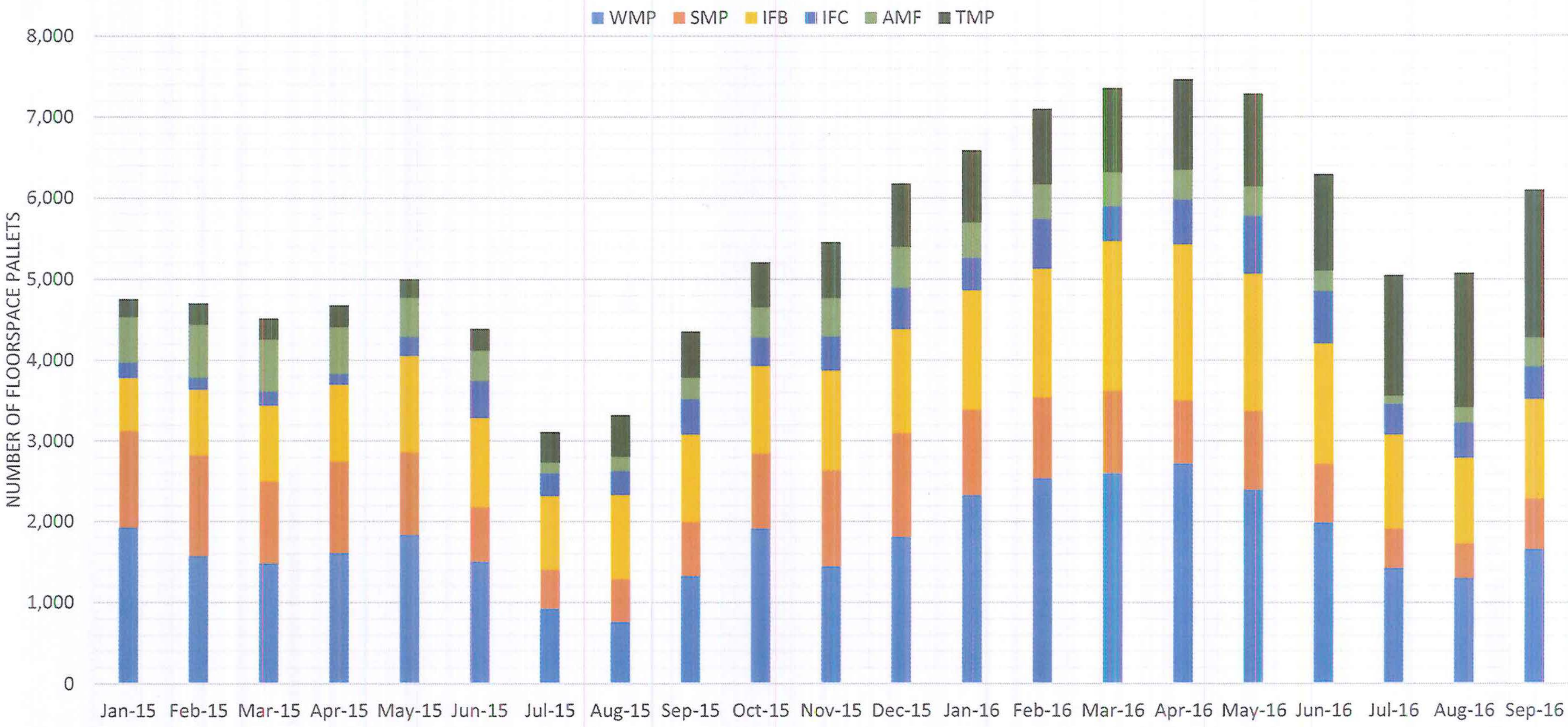


Figure 1: Historic Inventory Levels at Synlait

4.2 RAW MATERIALS & PACKAGING

A similar analysis was attempted on raw material and packaging inventory levels, however it was found that a breakdown of this data was too difficult in the given time frame due to the much larger number of SKUs (90+), and numerous inconsistencies in the M3 data.

This issue notwithstanding, an investigation into Aaron Kenny's warehouse capacity model revealed the average bulk stack height of raw materials and packaging SKUs to be alarmingly low when compared to product stacks, as shown in the graph below. Upon investigation this was found to be caused by the inability to bulk stack many of these SKUs due to being uneven or fragile, as well as the need to be able to quickly access each of the many different SKUs. This was verified by a physical tour of the warehouse, and could subsequently be considered one of the major causes of Synlait's warehouse capacity issues.

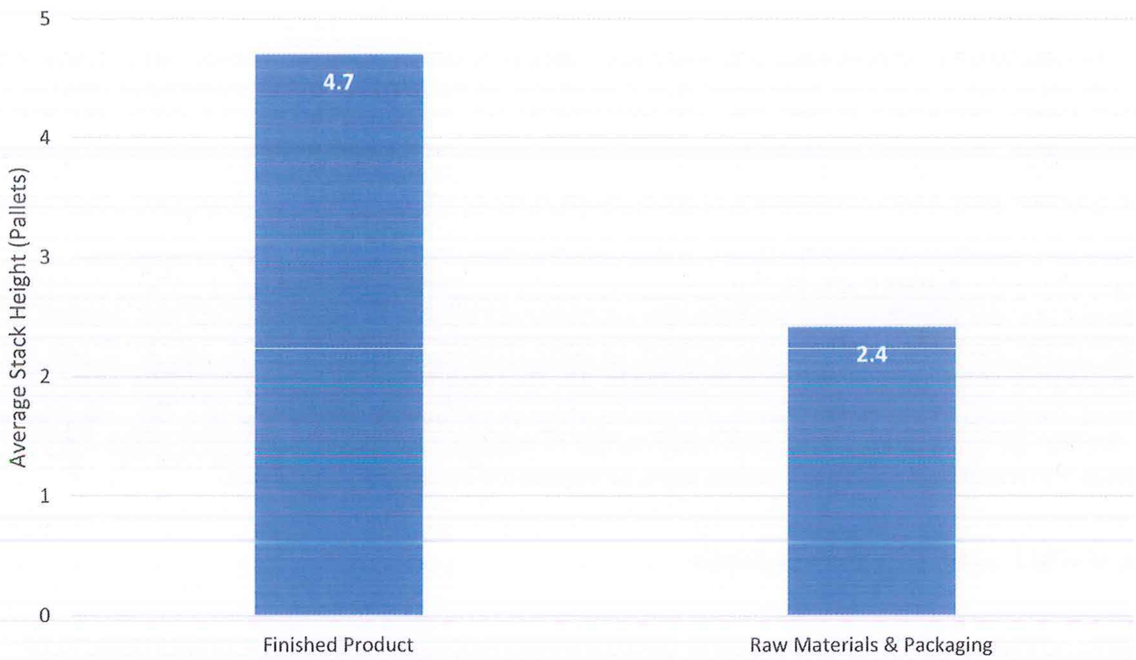


Figure 2: Average Bulk Stack Heights

5. DETERMINATION OF AVERAGE LOT SIZES

In addition to investigating inventory trends, the production schedules[5] for Synlait's milk powder dryers, and canning and blending line were also analysed. The purpose of this was to determine the average lot (or batch) sizes for each product type. This information would be of great use if the suggestion of matching the size of storage rows to different product lot sizes were to be developed further. The findings of this analysis are shown in Table 3:

Table 3: Average Lot Sizes of Different Product Types

PRODUCT TYPE	AVERAGE PALLETS PER LOT	ERROR (±PALLETS)	AVERAGE FLOORSPACE PALLETS PER LOT	ERROR (±PALLETS)
WMP	115	8	24	2
SMP	90	7	19	1
IFB	102	5	27	1
IFC	81	7	15	1
AMF	N/A[6]	-	N/A	-
TMP	N/A[7]	-	N/A	-

Considering the majority of bulk storage rows currently comprise of 12 floor space pallets, it quickly became obvious why Synlait is experiencing problems with having a mixture of lots and product types within rows. As shown by the average lot sizes of each product in Table 2, only WMP has a lot size (24 floor space pallets) which is divisible by 12. This means that all other product types would create incomplete rows when placed into empty areas of storage. In addition to this, the differences in average lot sizes between product types served to validate the idea of developing specific areas within the warehouse for each product type, as suggested by a number of SMEs.

6. ROOT CAUSE ANALYSIS

The overall findings of this investigation allowed for the two major problem areas that Synlait are experiencing to be deconstructed in order to identify the respective root causes. As mentioned previously, it was these root causes which would subsequently be targeted for resolution in the research and development phases of the project. This would allow for recommendations to be produced which will offer the greatest benefit to Synlait.

Figure 3 details the functional decomposition of Synlait's operational effectiveness problem in the warehouse based on the investigation into current systems.

[5] Made available by Samantha Funnel & Michael Hawke, the Master Schedulers of Dryer, and Canning & Blending respectively.
[6] AMF is produced as a by-product of SMP production and therefore has easily measurable lot size
[7] TMP is not produced as a product, instead resulting from the downgrade of other product types

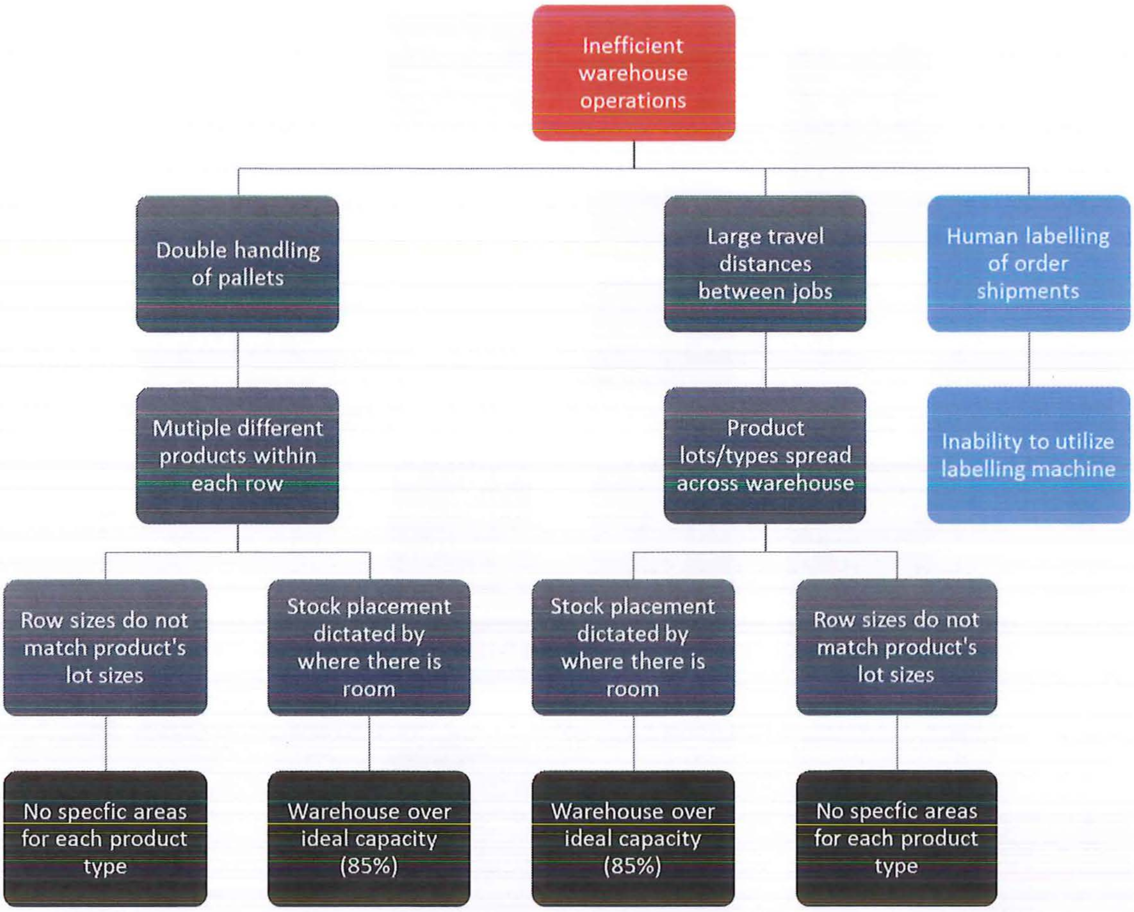


Figure 3: Functional Decomposition of Inefficient Warehouse Operations at Synlait

The identified root causes shown in black were considered within the scope of the project. These served to further validate that the lack of specific areas in the warehouse for each product type was the major root cause of operational ineffectiveness which could be targeted by this project. As a result, resolving this became a major focus of the research and development phases later in the project.

It should be noted that the two major root causes identified essentially trigger one another. Under the current warehouse system, the fact that the warehouse is overcapacity leads to the inability to implement specific product areas due to the need to immediately find space for stock. Likewise, strict adherence to specific product areas could result in wasted space if an effective and accurate way of predicting storage requirements isn't utilised.

Figure 4 (shown on the following page) focused on identifying the root causes of Synlait's overcapacity warehouse and subsequent requirement for offsite storage.

It was immediately obvious that the majority of the root causes identified for the warehouse being overcapacity were either out of the scope of the project or out of the control of the project owner (shown in blue). Subsequently, the one area of the warehouse with the potential to be targeted for improvement was raw materials and packaging storage, specifically finding a way to improve the stackability.

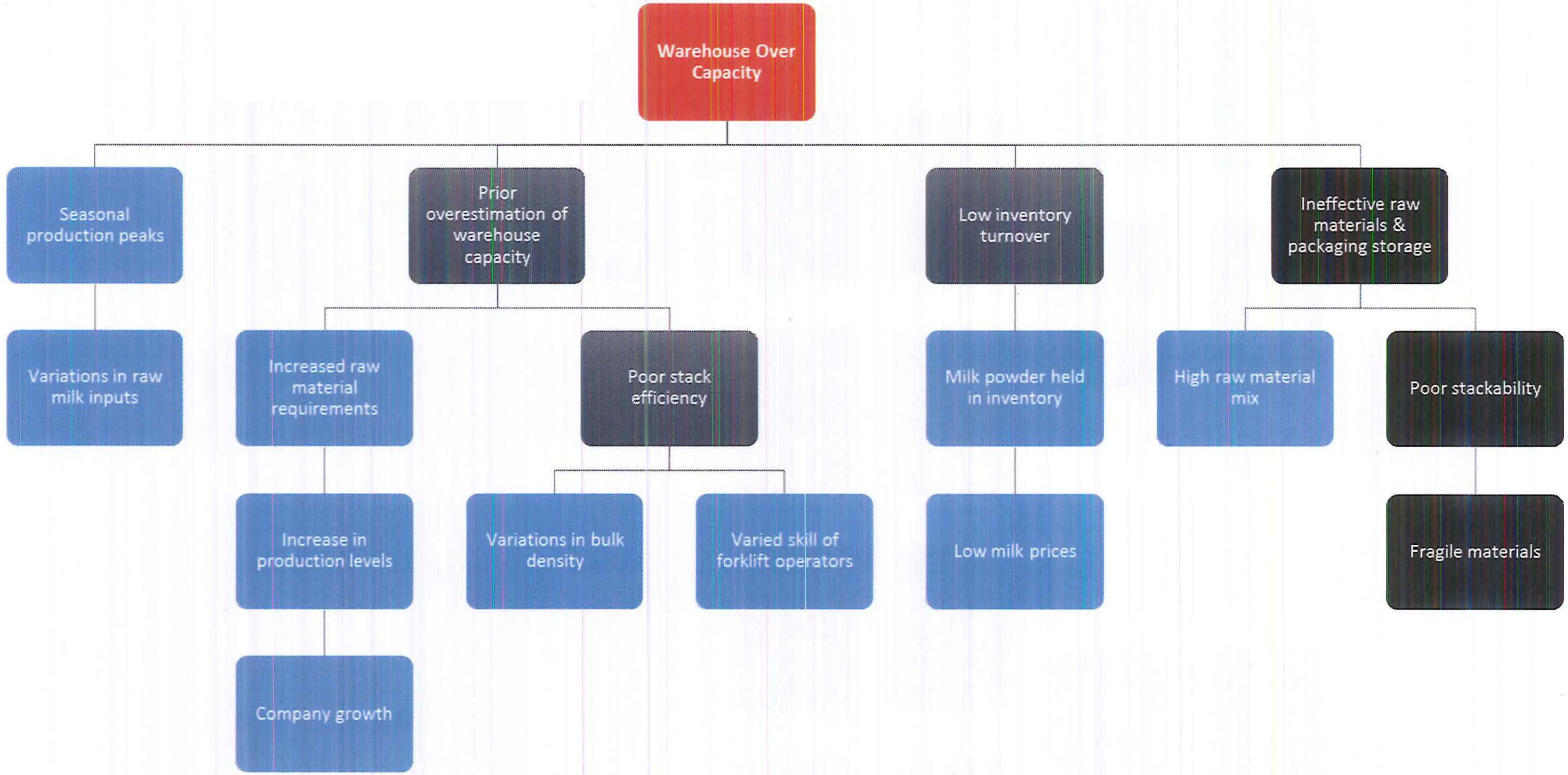


Figure 4: Functional Decomposition of Warehouse Overcapacity at Synlait

7. HEALTH & SAFETY RECORDS

In addition to investigating the causes of Synlait's operational issues in the warehouse, the health and safety records for the warehouse were also examined. These were provided by Craig Caddie, the health and safety manager at Synlait. The purpose of this was to determine whether any past incidents had been contributed to in any way by the current layout of the warehouse. These should subsequently be targeted for improvement within the scope of this project.

Upon inspection however, it was found that the vast majority of incidents were unrelated to the layout. This finding was verified by the warehouse manager, Aaron Shaw. Despite this, it was concluded that any reduction in the frequency and number of pallets being handled by warehouse staff would reduce the likelihood of future incidents occurring.

In particular, it was agreed that finding a way to eliminate the process of removing pallets from rows and hastily assembling stacks in the aisles of the warehouse to reach pallets which required picking would be of great benefit. From a health and safety point of view, this would reduce the likelihood of both stack collapses (fewer uneven standalone stacks), and forklift collisions (improving sightlines through aisles).

8. CONCLUSIONS

The analysis of current systems resulted in two key areas to focus on in the subsequent research and development phases of the project. As outlined in Figure 5, these were raw materials and packaging storage, as well as the way in which finished product is allocated to storage.

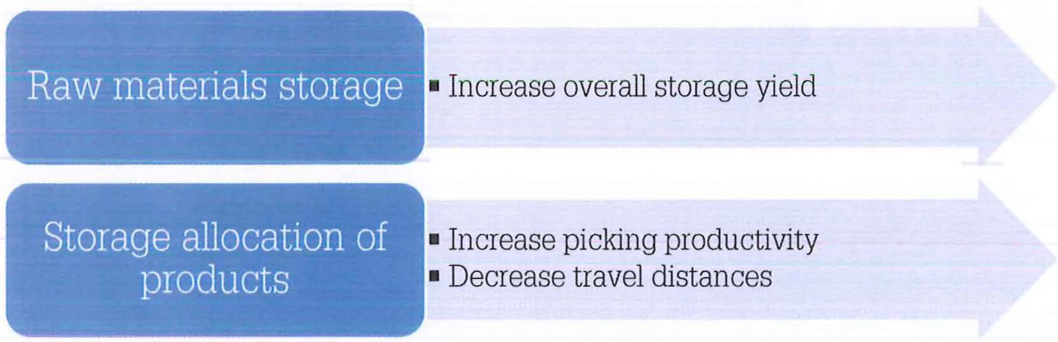


Figure 5: Focus Areas for the Research and Development of Recommendations

Resolving these two issues would not solve all of the problems Synlait have been experiencing with regards to its warehouse. However, it was concluded that concentrating on these two areas was likely to offer the greatest benefit to Synlait from both a logistical and financial perspective.

PROJECT
APPENDIX B – RESEARCH FINDINGS

PROJECT NAME	Yeti Crab – Optimal Warehouse Layout
PROJECT OWNER	Aaron Shaw
AUTHOR	Gareth Owens
DATE	01/02/17

EXECUTIVE SUMMARY

The research phase of the project focused on finding feasible solutions to the root causes of Synlait's warehousing problems, as identified by an analysis of current systems. These potential solutions were subsequently able to be developed into recommendations later in the project. Research was carried out in the form of literature reviews, as well as by personally contacting industry experts. The main areas of research included:

- Warehouse layout & storage allocation
- Pallet racking technology
- Operational effectiveness
- AGV utilisation

With regards to the allocation of products to storage in Drystore 3, two simple layout principles were identified which could be implemented at Synlait and would subsequently improve operational effectiveness. The first of these is bay matching, which refers to the notion of storing stock of the same type as close together as possible. In the context of Synlait, this would involve storing not just product of the same type together but product from the exact same production lot. The second layout principle is adjacency, which essentially means keeping elements of the warehouse which involve a lot of activity between one another close together. If successfully implemented this would reduce travel times throughout warehouse operations.

It was found that there are numerous high tech solutions to the main warehousing problems Synlait is experiencing, particularly with regards to space utilisation in Drystore 2. However, the vast majority of these solutions are unfeasible given the current constraints of the warehouse. Whilst the benefits of technologies such as AS/RS, and AGVs are numerous, these are easily outweighed by the costs associated with implementing these at Synlait. As a result, it was concluded that single selective racking would be the most effective storage solution to apply to raw materials and packaging. However, the prospect of increasing the maximum capacity of the warehouse was now null and void, with the principal benefit of single selective racking being an increase to the effectiveness of staging operations.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The second major phase of the project focused on research into potential solutions to the two key issues identified for improvement following the analysis of current systems at Synlait.

2. AREAS OF CONSIDERATION

Prior to delving into any intensive studies, it was vital to plan ahead and ensure all possible areas of research were considered that could later prove useful during the development of recommended solutions. Based on the suggestions of SMEs, some initial research, and identifications made in the project brief, a number of research areas were identified. These are displayed in Figure 1:

Figure 1: Research Considerations of Project Yeti Crab

Following further discussions with Gary Hodder and Aaron Shaw (the project owners), it was decided that a number of these research areas should be considered out of the scope of this project. This decision was primarily made with time constraints in mind, as well as the fact that many of these factors are not directly related to the layout of the warehouse itself. As a result, the previously identified areas of consideration were condensed into the following major research segments:

- Warehouse layout & storage allocation
- Pallet racking technology
- Operational effectiveness
- AGV utilisation

3. LITERATURE REVIEWS

Literature reviews were carried on each of the four major segments outlined previously. This investigation was centred on desk research and included the study of journal articles, books, videos, online lectures, articles from periodicals, and even blogs. The presented findings of these studies concentrate on the content which was considered the most relevant to this project, and how it could be applied to the warehousing situation at Synlait. Numerous other sources were also examined throughout the course of the research phase, and are acknowledged in the bibliography.

3.1 WAREHOUSE LAYOUT

Table 1: Warehouse Layout Literature Review Findings

SOURCE	KEY FINDINGS	APPLICATION
(Frazelle, Warehouse Processes: Pick Preparation, 2011)	Frazelle claims that fewer than 15% of stock keeping units (SKUs) within a warehouse are assigned to the most efficient location. This results in a 10 to 30% cost increases, primarily due to excess travel times. An ABC analysis of a warehouse is recommended to mitigate against this when laying out a warehouse. This process essentially involves the application of Pareto's Law (the 80/20 rule) to understand warehouse behavior. Examples pertinent to this project include: • 80% of cube usage within the warehouse comes from 20% of products; • 80% of inventory value is in 20% of products; • 80% of problems result from 20% of your inventory; Whilst this 80/20 split is not always the case, it is certainly a robust basis upon which to concentrate solution development.	According to Frazelle's analysis of general warehouse behavior, the Pareto rule should be employed to inform design decisions and subsequent recommendations. Based on this logic, concentrating on 20% of inventory layout issues within the warehouse should yield around 80% of the maximum possible improvement. The major challenge of this approach is correctly identifying this key 20% of layout issues within the current warehousing system. This thinking has been applied by choosing to concentrate on specific product areas and raw materials storage in the development of solution.

(Hassan, A Framework for the Design of a Warehouse Layout, 2002)	Hassan's "framework for the design of warehouse layout" outlines a series of steps and rules to follow in order to achieve an effective warehouse layout. In particular, the importance of understanding inventory levels is stressed in order to effectively gauge storage requirements. Additionally, the effective assignment of storage to maximize productivity is also highlighted. The storage of items of the same class and/or demand level together has been identified as of particular benefit.	A number of the ideas and rules outlined within Hassan's framework can be feasibly and effectively applied in this project. The allocation of specific storage areas for each product type within Synlait's warehouse could increase productivity by reducing travel times, and double handling during picking, as well as increase the ease of locating pallets. As stressed by Hassan, forecasts of future inventory levels will be vital to developing an optimal layout for Synlait's warehouse. These will be used as a basis for gauging the storage requirements of different SKUs.
(Frazelle, Warehouse Layout & Material Flow Planning, 2013)	During Frazelle's online lecture on "warehouse layout and material flow planning" there are two key principles to warehouse layouts which are continually referred back to: 1. Adjacency; 2. Bay Matching; Put simply, adjacency refers to locating activities which involve a large amount of movement between one another close together to reduce excess travel. Meanwhile, bay matching is the process of storing identical and/or similar stock together. Frazelle claims that the application of these two simple principles should be the foundation upon which any warehouse layout is designed.	Frazelle's support of bay matching serves to validate the suggestion of implementing product specific zones which was outlined in the analysis of current systems. Adjacency should also be considered in addition to this, and could feasibly be applied to the inventory turnover rates of different product types. Products which spend a shorter period of time in the warehouse should be stored closer to the point of output.
(Roodbergen & Vis, A model for warehouse layout, 2006)	Roodbergen & Vis' model for warehouse layout focuses primarily on the picking of orders within the warehouse. They claim that the picking process is the largest contributor to the operational costs of a warehouse in the vast majority of cases. For this reason, minimizing order retrieval times is key to the successful operation of warehouse. Numerous routing options are trialed within this paper to achieve the optimal picking times. However, no attention is paid to the potential for time to be lost at the pick point itself.	This paper validates the approach of concentrating on order picking in Synlait's warehouse to improve operational effectiveness. Upon reflection, the routing of forklifts during picking is of minimal importance in Synlait's case, with the majority of lost time during picking is at the pick point itself. This paper did highlight that operational performance must be measured to determine what can be saved, as well as validate the approach taken in developed solutions

3.2 PALLET RACKING TECHNOLOGIES

Upon investigation, it was found that there was little independent information of value to be found on racking technology, with the vast majority of online material published by racking suppliers themselves and therefore subject to bias. As a result, suppliers were instead contacted on an individual level in an effort to gain their insights on how racking could be best applied to Synlait's unique situation. The findings of this are detailed in the primary sources section.

Table 2: Pallet Racking Technologies Literature Review Findings

SOURCE	KEY FINDINGS	APPLICATION
(Cernivec, Racking up warehouse efficiency, 2013)	Cernivec's article, "Racking up warehouse efficiency" centres on the use of racking to combat SKU proliferation in the beverage industry. SKU proliferation is essentially a physical manifestation of the Pareto rule, wherein a small number of SKUs make up the majority of stock (80%) whilst a large number of low volume SKUs comprise the remaining minority (20%). In this case, racking is used to utilise overhead space and combat the effects of SKU proliferation on storage density by making all pallets individually accessible. As a result, both storage capacity, and operational effectiveness are increased. AS/RS[1] racking is used to particular effect. These systems do not require aisles for forklift access, and thus achieve the highest density storage whilst ensuring individual access to pallets via the automated retrieval.	With regards to Synlait's requirements, racking should be considered for areas of the warehouse which are achieving poor cube utilization, and suffering from SKU proliferation. This reflects the issues surrounding raw materials & packaging storage, outlined in the analysis of current systems[2]. Racking, therefore, should be strongly considered in developing solutions to these issues. The only concerns around this approach would be the cost of purchasing and installing appropriate racking.

[1] Automated Storage & Retrieval System
[2] Refer to Appendix A

3.3 OPERATIONAL EFFECTIVENESS

Table 3: Operational Effectiveness Literature Review Findings

SOURCE	KEY FINDINGS	APPLICATION
(Won & Olafsson, Joint order batching and order picking in warehouse operations, 2005)	Won and Olafsson's paper in the "Journal of Production Research" discusses the benefits of joint order batching and picking in warehouse operations. This primarily focuses on the optimal path for picking batch of orders from the warehouse in order to eliminate excess travel times. It is proven in this paper that significant performance improvements can be attributed to being able to pick more than one item at once from the warehouse. However, this system relies on the location of items being known with certainty prior to picking.	Very little of the principles put forward in this paper are ***directly*** applicable to this project. However, it does mirror the idea and benefit of specific product zones within the warehouse.
(Cagliano, DeMarco, Rafele, & Volpe, Using system dynamics in warehouse management: A fast fashion case study, 2010)	This investigation into the operational performance of warehouse processes in the fashion industry underlined the importance of understanding system dynamics to successful warehouse management. It is also claimed that warehouse management can lead to competitive advantage in the marketplace, with automated warehousing used in this case to reduce lead times on order shipments to customers. The correct design of a warehouse layout relies on understanding the flow of inventory throughout the warehouse. Additionally, the observation of warehouse operations and issues alone should not be relied upon to inform design decision, but should be validated using historical data.	This paper suggests that improving warehouse operations at Synlait could improve customer relations as well as reducing the cost of operations. This paper also validates the approach of using historical inventory data to understand and diagnose the problems associated with Synlait's warehousing problems. Likewise, remaining mindful of these will be key to producing suitable and effective solutions later in the project.

3.4 AGV UTILISATION

Table 4: AGV Utilisation Literature Review Findings

SOURCE	KEY FINDINGS	APPLICATION
(Digani, Sabattini, Secchi, & Fantuzzi, Ensemble Coordination Approach on Multi-AGV Systems Applied to Industrial Warehouses, 2015)	Digani, Sabattini, Secchi, and Fantuzzi's paper explores the best approach to co-ordinating a multi-AGV system applied to industrial warehouses. Essentially AGVs[3] are utilised to perform picking tasks in the place of human operated forklifts, and are guided via a road map which is manually defined by the user. However, the process of planning the optimal path for AGVs in order to reduce cost can result in high setup times.	The majority of picking tasks in Synlait's warehouse are highly variable. As a result, it would be very difficult to employ AGVs to perform these tasks. Moreover, the programming of a roadmap would be equally difficult to manage given the lack of space currently available in the warehouse, and the expertise required to execute this. Overall, AGVs appear to be best suited to minimising costs associated with travel times in warehouse, and would therefore be of little use in solving the main problem Synlait is experiencing at the pick point itself. Having said that, AGVs could be implemented for simple and repetitive tasks in the future (e.g. shuttling pallets), provided the existing problems are first addressed.

[3] Automated guided vehicles

4. PRIMARY SOURCES

In addition to desk research, a number of industry experts, particularly racking suppliers, were contacted in order to gain their insights on Synlait's specific warehousing situation. By taking into account the constraints and parameters present at Synlait, these professionals were able to provide advice on the feasibility of implementing some of the previously identified options to Synlait. Additionally, more detailed information surrounding the costs of suggested options was provided, this would allow for the development of more informed recommendations later in the project.

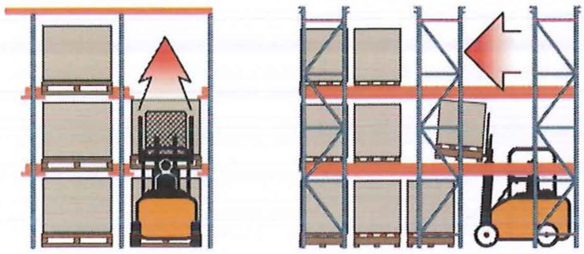
4.1 CARL TINKER – RACK N STACK

The first industry expert contacted during the project was Carl Tinker. Carl is the sales manager at Rack 'n' Stack, a small warehouse racking supplier based out of Hornby in Christchurch. Initial discussions with Carl were made via email, and were followed up by a visit to the Rack 'n' Stack facility on 9th December 2016. The information discussed with Carl was centred around the feasibility of implementing different racking types at Synlait, and the associated cost of doing so.

Table 5: Carl Tinker - Warehouse Layout Recommendations

CONSIDERATIO N	SUGGESTIONS	COST	FEASIBLE
Drive-In Racking	Initially, the prospect of implementing drive-in racking[4] at Synlait was discussed. However, Carl was quick to rule out the application of this system at Synlait given the unique dimensions of the dairy pallets used at Synlait, which are almost twice the width of standard pallets. In addition to this, the means of retrieving pallets from drive-in racking results in stock being rotated on a LIFO (last in first out) manner. This is the precise opposite to the FIFO (first in first out) system Synlait operates on, particularly in its consumption of raw materials.	N/A	No
Single-Selective racking	Due to the pallet dimensions at Synlait, it was recommended that standard single selective racking would be the most appropriate type of racking for application at Synlait. As suggested by the name, single selective racking systems only allow for pallets to be stored 1 deep. The racking can be built as high as there is room within a warehouse. This would allow for raw materials at Synlait to be stored in a manner which utilises vertical space whilst allowing for individual access to all pallets and SKU types. The financial cost of purchasing single selective racking is relatively low at around $150-$200 per pallet space. However, installation would come at the cost of greatly increasing the number and amount of space taken up by aisles in the warehouse in order for forklifts to access the all of the racking spaces.	$150-$200 per pallet space	Yes

[4] Drive-in racking allows for pallets to be stored multiple bays deep, wherein the forklift is able to drive into the racking to retrieve/store pallets at the back of the storage system (shown below).



Frame Guards	Following discussions as to the safety and durability of racking, the application of frame guards to any installed racking was suggested. Frame guards protect the bottom corner of racking frames from impacts with errant forklifts, and have been proven to reduce damage and the probability of collapses.	$75 per frame	Yes

4.2 ANDREW HATTON – DEMATIC

An enquiry was made to Dematic into the cost and feasibility of implementing an AS/RS at Synlait. Andrew Hatton, the manager of design and estimating at Dematic Australia, responded with a number of recommendations as to best practice in dairy warehousing across Australasia.

Table 6: Andrew Hatton - Warehouse Layout Recommendations

CONSIDERATIO N	SUGGESTIONS	COST	FEASIBLE
Bulk Stacking	The first thing stated by Andrew was that bulk stacking is by far the most common practice for storage of dairy products across Australasia, and with good reason. Provided pallets are stable enough to be stacked 4-5 high (as is the case at Synlait), then bulk stacking is perhaps the most efficient use of cubic space in a low ceiling warehouse such as Synlait's. It was recommended that, provided there are very few SKUs to store, bulk stacking is certainly the best option for storage at Synlait.	None	Yes
Single-Selective Racking	In cases where there are multiple SKU types to store, single selective racking is the most commonly implemented storage solution. Whilst floor space is lost due to the increased aisle requirements to access all pallet spaces, all SKUs can be stored 5 pallets high with individual access to all pallets. In normal circumstances, each bay of a single selective racking system would be able to store two pallets. However, given the much larger dairy pallets used at Synlait, it was suggested storage would be limited to one pallet per bay, thereby essentially doubling the cost of implementing the system on a per pallet basis.	≈AU$100 per pallet space	Yes
AS/RS	This was the final storage system discussed, however from the outset, it was advised to not be a particularly viable option given Synlait's circumstances. By utilising a crane system, an AS/RS is able to extend far higher than the majority of other storage systems. As a result, these systems normally come into consideration in warehouses with between 15m and 40m of vertical space (much higher than Synlait's warehouse), and in storing well over 10,000 pallets. Furthermore, given the unique dimensions and heavily stacked pallets in storage at Synlait, an AS/RS could cost upwards of AU$1,500 per pallet space to install. It is for these reasons that the majority of these systems globally are operating in countries where both land and labour are very expensive, utilising specifically designed "high bay" warehouses. It was concluded that a solution of this cost and complexity is not currently warranted at Synlait.	≈AU$1,500 per pallet space	No
AGVs	Andrew suggested automated guided vehicles could be an option if travel paths are simple and repetitive. However, given the relatively small scale of operations at Synlait (on a global scale), and the high cost of purchase, it was concluded that AGV utilisation is highly unlikely to be cost effective at Synlait.	≈$300,000 per unit	Unlikely

5. CONCLUSIONS

Ultimately, the findings of the research phase ended up predominantly validating the majority of the conclusions drawn from the analysis of current systems previously. Furthermore, the recommendations of the consulted industry experts in particularly resulted in a further narrowing down of the feasible options available to improve the warehousing situation at Synlait.

The constraints of the warehouse environment, notably pallet dimensions and overhead space, have essentially resulted in the costs associated with the application of an AS/RS at Synlait far outweighing any potential benefits. Because of this, the possibility of increasing the maximum capacity of the warehouse was now over. The focus from this point of the project was solely on improving operational performance without negatively impacted the maximum capacity. Likewise, the high cost of AGVs in combination with their operational limitations and lack of flexibility when compared to human forklift operators also led to this technology being excluded from further development.

Simply based on what can be feasibly implemented at Synlait, a clear direction upon which to focus the development of recommendations was revealed. The continued bulk stacking of product SKUs in Drystore 3 was identified as the most suitable way forward. The success of this approach hinges on devising a means of keeping the same product types together, thereby embracing Frazelle's principle of bay matching. The use of Synlait's forecasted inventory levels would be key to determining the amount of space which should be allocated to each product type under this principle.

Meanwhile, the development of recommendations towards raw materials and packaging storage was now focused on the application of single selective racking. Throughout the warehousing industry, racking has been proven to successfully combat the effects of SKU proliferation, whilst optimising the use of vertical space, both solutions to problems currently experienced at Synlait. The difficulty in pursuing this approach would lie in successfully balancing the aforementioned benefits of selective racking with the cost of losing floor space to increased aisles requirements.

6. BIBLIOGRAPHY

adaptalift. (2013, July 15). *Logistics & Materials Handling Blog.* Retrieved from adaptalift: http://www.aalhysterforklifts.com.au/index.php/about/blog-post/forklifts_vs._automated_guided_vehicles

Beverage World. (2006, September). *Racking systems: Choosing the right racking system is the first step in warehouse efficiency.* Retrieved from Beverage World: http://web.b.ebscohost.com.ezproxy.canterbury.ac.nz/ehost/pdfviewer/pdfviewer?sid=de4fc9b5-52a6-4459-848b-fd80d778a1dc%40sessionmgr101&vid=1&hid=125

Bragg, S. M. (2010). *Cost Reduction Analysis: Tools and Strategies.* Retrieved from https://books.google.co.nz/books?id=NTqWAAAAQBAJ&dq=analysis+of+gravity+racking&source=gbs_navlinks_s

Cagliano, A. C., DeMarco, A., Rafele, C., & Volpe, S. (2010). Using system dynamics in warehouse management: A fast fashion case study. *Journal of Manufacturing Technology Management.*

Cernivec, S. (2013). Racking up warehouse efficiency. *Beverage Industry.*

Cisco-Eagle. (n.d.). *Fishbone Design Warehouse Aisles.* Retrieved from Cisco-Eagle: http://www.cisco-eagle.com/catalog/c-3050-fishbone-rack-aisle-layout.aspx

Dematic. (n.d.). *Solutions by Supply Chain Function.* Retrieved from Dematic: http://www.dematic.com/en-au/supply-chain-solutions/by-supply-chain-function/pallet-picking/

Digani, V., Sabattini, L., Secchi, C., & Fantuzzi, C. (2015). Ensemble Coordination Approach on Multi-AGV Systems Applied to Industrial Warehouses. *IEEE Transactions on Automation Science and Engineering.*

Engineered Handling. (n.d.). *A Premier Material Handling Systems Integration Provider.* Retrieved from Engineered Handling: http://www.engineeredhandling.com/rack-shelving-types.html

Frazelle, E. H. (2011). Warehouse Processes: Pick Preparation. In G. Richards, *Warehouse Management: A Complete Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse.* Retrieved from https://books.google.co.nz/books?id=oimhAwAAQBAJ&pg=PA79&lpg=PA79&dq=frazelle+warehousing+rules&source=bl&ots=rEb-to87a0&sig=ynSxV982xxCvgEcbSByTMLG-kOY&hl=en&sa=X&ved=0ahUKEwiPnNfYzIPRAhUIWLwKHVXNDFMQ6AEINDAE#v=onepage&q=frazelle%20warehousing%20rules&f=

Frazelle, E. H. (2013). Warehouse Layout & Material Flow Planning. Retrieved from https://www.youtube.com/watch?v=WreqyUV3m6o

Hassan, M. (2002). A Framework for the Design of a Warehouse Layout. *Facilities.*

Hatton, A. (2016, December 6). AS/RS System Pricing. (G. Owens, Interviewer)

Maxthecube. (n.d.). *5 Reasons WHy Clients are Moving from Drive In Racking to Radio Shuttles.* Retrieved from Maxthecube: http://thistlesystems.co.uk/wp-content/uploads/2016/04/5-Reasons-Why-Clients-are-Moving-from-Drive-In-Racking-to-Radio-Shuttles-_3_.pdf

Palletracking. (n.d.). *Satellite Pallet Racking.* Retrieved from Palletracking: The advisory site for pallet racking & warehouse systems: http://www.palletracking.com/satellite-storage-systems/

Reddon, T. (2014, August 4). *AGVs vs Forklifts: Benefits and Drawbacks.* Retrieved from National Forklift Exchange: http://www.nfe-lifts.com/agvs-vs-forklifts-benefits-and-drawbacks/

Roodbergen, K. J. (2011). *An explanation of some rack layout concepts for warehouses.* Retrieved from http://www.roodbergen.com/publications/WarehouseRackLayout.pdf

Roodbergen, K. J., & Vis, I. F. (2006). A model for warehouse layout. *IIE Transactions.*

Russel D. Meller, K. R. (2009). *The Application of New Aisle Designs for Unit-Load Warehouses.* Retrieved from http://www.distributiongroup.com/articles/1211DCWebextraGue.pdf

Schiavo, B. (2008, June). Racking Up The Savings. *Food Logistics.* Retrieved from Food Logistics: http://web.a.ebscohost.com.ezproxy.canterbury.ac.nz/ehost/pdfviewer/pdfviewer?sid=b325ad0c-9d81-484a-91a8-d9d9c3f5bdd2%40sessionmgr4008&vid=2&hid=4109

StorePro. (n.d.). *Shuttle Racking.* Retrieved from StorePro: Storage Solution Professionals: http://www.storepro.co.nz/products/shuttle-racking

Tinker, C. (2016, December 9). Racking Suitability & Pricing. (G. Owens, Interviewer)

TranSystems. (2010). *Rules of Thumb: Warehouse & Distribution Guidelines.* Retrieved from TranSystems: http://www.werc.org/assets/1/Publications/TranSystems%20Rules%20of%20Thumb%202010%20v2.pdf

Witt, C. E. (2005). Maximizing Minimal Warehouse Space. *Material Handling Management.* Retrieved from http://web.b.ebscohost.com.ezproxy.canterbury.ac.nz/ehost/pdfviewer/pdfviewer?sid=e31d0d92-4e53-46fd-8e38-b3ac87867e8f%40sessionmgr104&vid=1&hid=125

Won, J., & Olafsson, S. (2005). Joint order batching and order picking in warehouse operations. *International Journal of Production Research.*

Yildiz, T. (2013, November 19). *What are the advantages and disadvantages of fully automated container terminals?* Retrieved from ResearchGate: https://www.researchgate.net/post/What_are_the_advantages_and_disadvantages_of_fully_automated_container_terminals

Zollinger, H. (2001). *AS/RS APPLICATION, BENEFITS AND JUSTIFICATION IN COMPARISON TO OTHER STORAGE METHODS: A WHITE PAPER.* Retrieved from MHI: http://www.mhi.org/downloads/industrygroups/as-rs/technicalpapers/asrswhitepaper2.pdf

PROJECT
APPENDIX C – DEVELOPMENT OF RECOMMENDATIONS

PROJECT NAME	Yeti Crab – Optimal Warehouse Layout
PROJECT OWNER	Aaron Shaw
AUTHOR	Gareth Owens
DATE	01/02/17

EXECUTIVE SUMMARY

The final phase of Project Yeti Crab was focused on applying the findings of the research phase to Synlait's warehouse in order to form recommendations as to how an optimal layout can be achieved. In addition to this, the costs and benefits associated with these recommendations were identified and quantified (where possible). Finally, based on these findings, the financial consequences of implementing the recommended solutions were able to be estimated.

The application of the feasible solutions to Synlait's major warehousing problems identified in the research phase resulted in two main recommendations:

1. The resizing of bulk storage rows in Drystore 3 to match the average lot sizes of different product types.
2. The application of racking in Drystore 2 to store only the low volume raw materials and packaging SKUs.

The feasibility of implementing these recommendations was validated by producing a proposed warehouse layout based on forecasted inventory levels, as well as through communication with both internal and external experts.

The benefits associated with these recommendations were quantified into likely financial savings of approximately $125,000 per annum Alongside the financial savings there are further non-financial benefits in the areas of health and safety, environmental, and employee satisfaction. The increased collection of operational performance data in the warehouse has been recommended in order to improve the reliability and accuracy of the estimated savings, as well as quantify potential improvements to staging operations which are currently unmeasurable.

The costs associated with implementing the recommendations have been estimated at a likely one-off investment of just over $110,000. The major contributors to this figure are the labour required to re-arrange the warehouse, the cost of new bar code labels used to scan stock in and out of rows by operators, and the re-installation of old single selective racking in Drystore 2. This up-front cost of implementation could rise to nearly $250,000 if the purchase of new racking is required.

Combining these estimated costs and benefits of the recommendations into a financial analysis, resulted in a likely payback period of 0.92 years, with a 3-year ROI of 228%.

It was also recommended that the implementation of a new warehouse layout occur in late July 2017. This coincides with both low levels of inventory and the annual warehouse stock take, meaning the disruption to operations would be minimised as the warehouse is in a static state during this time. The period between now and late July should be used to further validate and enhance the recommendations of this project.

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1. INTRODUCTION

The final phase of the project focused on the development of a recommended course of action to optimise the warehouse layout at Synlait This was based on the potential solutions identified in the research phase. This process comprised of three major steps:

1. The application of researched solutions to optimise Synlait's warehouse layout
2. Quantification of the benefits attributable to optimising the warehouse layout at Synlait
3. Financial analysis of the costs and benefits of implementing the recommendations

The outcomes of this phase of the project formed the basis of the majority of the business case presented to the project sponsor. It should be noted that there is a large amount of overlap between this part of the Appendix and the business case itself, and rather than repeating information, reference will be made to the business case where necessary.

2. APPLICATION OF SUITABLE OPTIONS

Based on the two key focuses for improvement identified in the analysis of current systems (Appendix A) combined with the findings of the research phase (Appendix B), there were two separate and defined areas around which recommendations were developed:

1. The re-arrangement of the layout of Drystore 3 to implement product specific zones
2. The installation of racking in Drystore 2 to store raw materials and packaging

The actual process of applying these concepts to Synlait's warehouse resulted in some compromises, as well as the development of a suggested post-implementation layout.

2.1 DRYSTORE 3 - PRODUCT SPECIFIC ZONES

Applying the principle of bay matching to Drystore 3 resulted in two major recommendations:

1. The re-sizing of bulk storage rows to match the lot sizes of different product types, and as a result;
2. The implementation of product specific zones to maintain uniform row sizes in aisles;

2.1.1 Resizing Storage Rows

Matching the number of available pallet spaces in a storage row with the number of filled pallets produced in a batch of a given product type would result in that row being completely occupied with pallets of exactly the same product and batch.

This methodology eliminates the main problems currently experienced whilst picking. Forklift operators would now be able to simply pick pallets from the front of the row, as all pallets within that row would be essentially identical. Such a system would remove the double handling of pallets to access picks deep within rows, as well as the associated difficulty of locating the required pallet(s) in the row to begin with.

As picking operations are currently allocated on a pallet by pallet basis by admin staff, the success of this system would require a change to pallets being selected at the forklift operator's discretion. This would allow operators to pick the most accessible pallet from a row, only on the basis of correct weight and lot number.

2.1.2 Implementing Product Specific Zones

As identified previously[1], there is some variation between the average lot sizes of different product types. Consequently, the resizing of rows to match lot sizes will result in a range of different length rows throughout the warehouse. To ensure that the aisles of the warehouse remain straight following this change, the implementation of product specific zones will be required. By keeping all product of the same type together, all rows of the same length will also be kept together, resulting in warehouse aisles remaining straight and uniform[2].

2.2 DRYSTORE 2 - RACKING RAW MATERIALS & PACKAGING

The initial concept of this recommendation was to rack all raw materials and packaging stock in Drystore 2 in order to increase both the maximum capacity of the warehouse (by stacking higher), and the efficiency of staging operations (more accessible pallets). However, due to the unfeasibility of racking technologies which could offer both of these benefits[3], the focus was shifted to improving the performance of staging operations.

The additional aisle requirements of implementing single selective racking resulted in the decision to focus the implementation of racking on the storage of low volume SKUs only. Racking these SKUs alone and maintain bulk stacks for high volume SKUs, will allow for much easier access to the vast majority of pallets required by forklift operators for staging. Similar to the picking situation, this solution would reduce the effects of double handling when retrieving pallets from within a row of bulk stacks.

The selection of which SKUs are suitable for racking was determined via a Pareto analysis of average inventory levels in Drystore 2. Based on this approach, the small number of SKUs which cover 80% of capacity will remain in bulk stacks, with the remaining 20% to be racked (unless identified otherwise). The results of this analysis are shown in Table 1:

Table 1: Pareto Analysis Identifying SKUs Suitable for Racking

SKU	AVERAGE PERCENTAGE OF CAPACITY	CUMULATIVE PERCENTAGE OF CAPACITY	TO BE RACKED	COMMENTS
Lactose	24.3%	24.3%	No	
D90	22.5%	46.8%	No	
WPC35	9.6%	56.4%	No	
900g Cans	8.7%	65.1%	No	
GOS	6.7%	71.9%	No	
Bags	6.7%	78.6%	No	
400g Cans	1.1%	79.6%	No	Too tall to be racked
AMF Drums	0.4%	80.1%	No	Already stacks 5 high
730g Cans	0.2%	80.3%	No	Too tall to be racked
A2 Cartons	5.1%	85.4%	Yes	
All Others	14.6%	100%	Yes	

[1] Appendix A: Analysis of Current Systems
[2] This is illustrated in the suggest layout
[3] Detailed in Appendix B: Research Phase

2.3 PROPOSED LAYOUT

In order to verify that these two areas of recommendations could actually be applied to the warehouse at Synlait in practice, a proposed layout was developed. The amount of space allocated to each product type was determined from the analysis of forecasted inventory levels, with the forecasts for the end of July selected as the parameters for this layout. Naturally, inventory levels vary throughout the year; July was chosen as it is likely to be the best time to implement a new layout as capacity levels tend to be near their lowest at this time of the year. This would reduce the volume of stock required to be moved, and cost associated with doing so. Additionally, the annual warehouse stock take is carried out in the final two weeks of July as the financial year draws to a close, during which time the warehouse is in a "static" state, with all ins and outs frozen. This would also increase the ease of implementing change at this time.

A number of existing warehouse constraints were utilised to ensure the proposed layout would be operational were it to be implemented, these included:

- The width of aisles
- Areas where stock cannot be placed (e.g. staging areas for manufacturing)
- Fire exits

Figure 1, displayed on the following page, shows the resulting layout designed on the basis of the aforementioned parameters. Drystore 3 is located to the left and contains all product in storage. Drystore 2 is situated to the right where canning blending begins and the first row of racking is located. It should be noted that each cell in the diagram refers to one floor space pallet, with the entirety of the warehouse sized based on this scale. The key below the diagram details where different product types, raw materials & packaging, and other considerations lie in the layout.

Storage in Drystore 3 has also been allocated on the basis of adjacency. Product types with fast rates of inventory turnover, such as IFC, have been placed near the outward goods points. Meanwhile, IFB has been placed close to canning and blending as it is used as an ingredient in that process, as well as being shipped as a product.

It should also be noted that the net change in maximum capacity between the original layout and this proposed new layout is negligible. Whilst this means no reduction in offsite storage requirements, it at least results in no added cost associated with increasing this requirement.

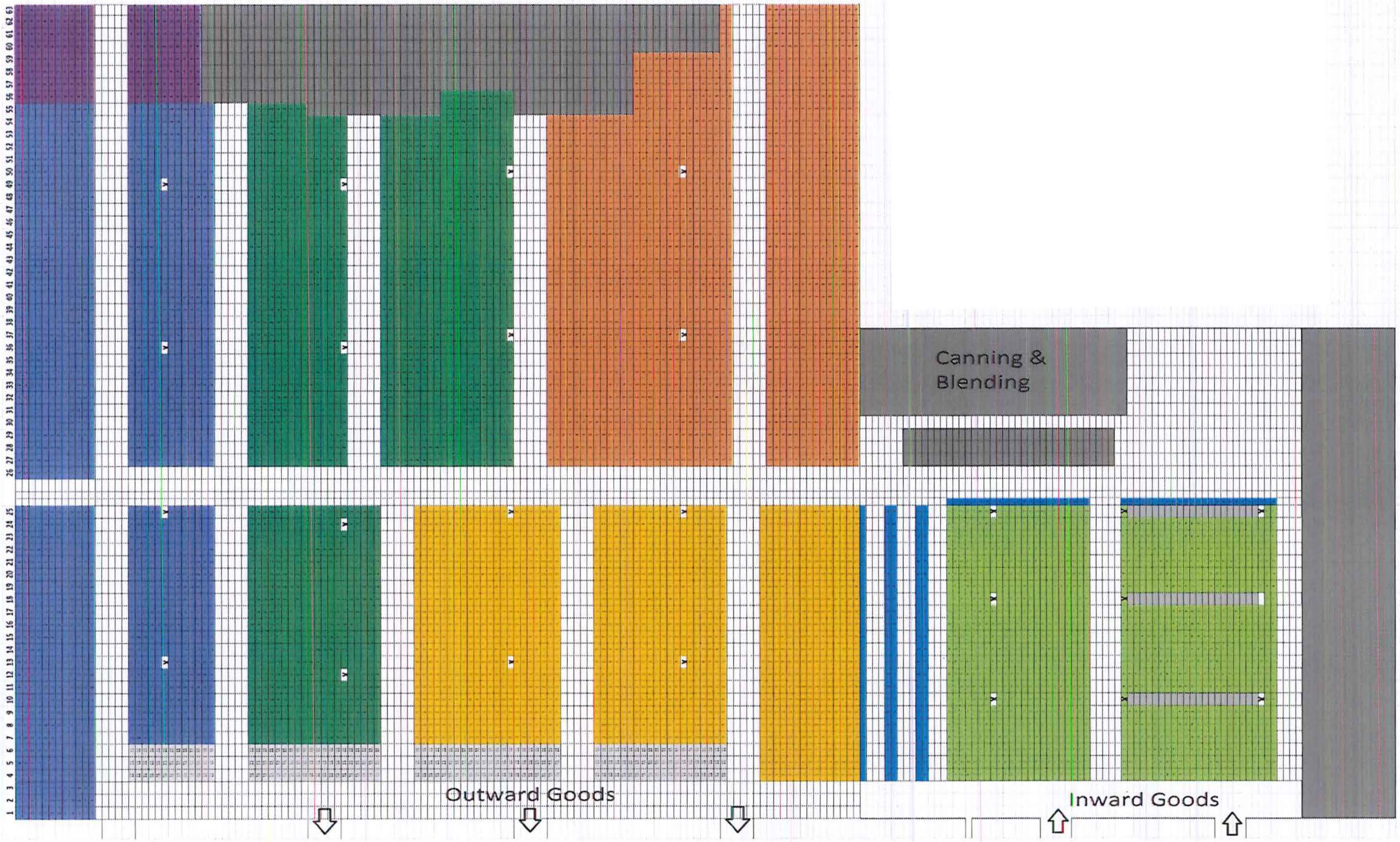


Figure 1: Proposed Warehouse Layout for Implementation in Late July 2017

Key[4]

- WMP
- SMP
- IFC
- IFB
- TMP
- Raw Materials (bulk stacked)
- Raw Materials (racked)
- Unusable space

[4] It was determined that AMF does not require any dedicated storage as it is currently sold so quickly after production

2.4 VALIDATION

As outlined in the V-model below, the verification and validation of project designs and outcomes is key to ensuring their successful long term implementation. This logic was kept in mind throughout this project, and was applied with particular devotion following the conceptual application of developed solutions to the warehouse.

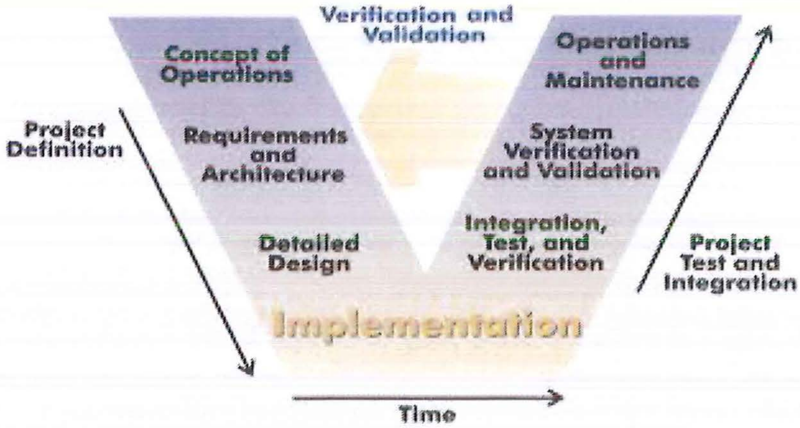


Figure 2: V-Model for Project Verification & Validation

Throughout the process of development, the recommendations which resulted in the presented layout suggestion were discussed with project SMEs. Their concordance and advice assisted in ensuring both the feasibility of potentially implementing these recommendations, as well as their ability to solve the main issues associated with current warehouse operations.

To confirm its robustness, validation of the project's recommendations was also sought externally. Ian Connor, a third party logistics specialist familiar with Synlait's warehouse operations, was consulted on this topic in late December. He agreed in particular with the diagnosis of the root causes of Synlait's warehousing issues, and approved of the recommended actions to alleviate these.

3. QUANTIFYING BENEFITS

There are numerous benefits associated with achieving an optimal warehouse layout in the manner recommended. The table below outlines these benefits as well as identifying whether they can, or cannot currently be measured.

Table 2: Identified Benefits of Operating with an Optimal Warehouse Layout

BENEFIT[5]	MEASURABLE	EXPLANATION
Reduced picking time	Yes	Reduced labour requirements
Reduced admin time	No	Can be estimated
Reduced forklift usage	Yes	Less time spent using forklifts
Reduced LPG consumption	Yes	As above, also an environmental benefit
Reduced staging time	No	See below
Safer working environment	No	Fewer pallet movements

[5] Each benefit is explained fully in the business case itself

Reduced lead times	No	Faster picking
Increased employee satisfaction	No[6]	Warehouse operators able to be more productive

Based what has been identified, quantifying the benefits of optimising the warehouse layouts rely on being able to measure the operational performance of both picking and staging, as well as the extent to which it can be improved.

3.1 MEASURING PERFORMANCE

3.1.1 Picking Operations

In the initial stages of the project, it was unclear whether there was any data available at all to measure the performance of picking operations at Synlait. However, after speaking to Quoyah Barr Glintborg[7] it was revealed that some measurement of picking rates in the warehouse had been underway since the end of June 2016. This system is currently limited to warehouse operators filling out data collection sheets detailing how many pallets they had picked in a given time period and whether they had experienced any difficulties in doing so.

The number of sheets which had been filled out and collated into a database was relatively small, and led to approximately 150 rows of available data at the time of this project's completion. However, enough data has been collated and analysed to determine an average pick rate per pallet at Synlait. In addition to this, the potential savings per pallet picked could also be determined based on picks which had/had not been effected by an issue that would be resolved by optimising the warehouse layout. The findings of this are shown in Table 3[8].

Table 3: Determination of Average Picking Rates

PICK TYPE	NUMBER OF PALLETS	PERCENTAGE OF PICKS	AVERAGE PICKING RATE (HOUR/PALLET)	STANDARD ERROR[9]
Good Picking	1949	39.9%	0.162	18.1%
Bad Picking	2929	60.1%	0.206	10.1%
Total Picks	4878	100%	0.183	9.2%

Based on these findings, there is a **potential saving of approximately 2 min 38 secs per pallet picked** across 60% of picks in Synlait's warehouse associated with optimising the warehouse layout.

In order to convert this to a saving over time, the daily number of pallets picked had to be determined. This was achieved via an analysis of outward goods documentation, wherein the total number of pallets shipped from Synlait's warehouse between 1 July and 30 November 2016 was estimated at 41,807. Working under the assumption that the rate of shipments is fairly constant throughout the year, this reduces to **275 pallets picked per day**.

As a result of these findings, by optimising the warehouse layout, the amount of **picking time saved has been estimated at 7.20 hours per day.** This was subsequently used to quantify operational savings.

[6] Could be measured in a qualitative manner through employee surveying
[7] Supply Chain Officer – Product Allocation
[8] Note that it was assumed that all forklift operators work at exactly the same pace
[9] Based on the standard deviation of the data samples

3.1.2 Staging Operations

Unfortunately, there was not enough data available to quantify the performance of staging operations at Synlait. For this reason, it has been recommended that data collection in this area is continued and increased in order to quantify this benefit in a similar manner to that of picking operations.

3.2 OPERATIONAL SAVINGS

This section details how the financial benefits of optimising the warehouse layout which were presented in the business case were estimated. In most cases, the standard error was calculated from the uncertainty associated with average picking times, and was subsequently applied to determine the best and worst case scenarios presented in the business case. These savings were calculated on the basis of 365 days of operation per year.

3.2.1 Reduced Picking Time

The financial savings associated with the reduction in time spent picking by warehouse operators was calculated on the basis of the aforementioned time saving of 7.20 hours per day, and the cost of warehouse labour. It should be noted that 10% of current picking labour is classed as overtime.

Table 4: Estimated Labour Savings from Optimising the Warehouse Layout

PICK TYPE	LABOUR RATE ($/HR)	OVERTIME RATE ($/HR)	DAILY PICKING TIME (HRS)	DAILY LABOUR COST	ANNUAL LABOUR COST	STANDARD ERROR
Proposed System	$24	$30	26.72	$641	$234,106	$21,613
Current System			33.93	$848	$309,591	$31,197
Saving	-	-	7.20	$207	$75,485	$52,810

3.2.2 Forklift Usage

As was the case with labour savings, the financial benefit of reduced forklift usage was determined based on the reduced time spent picking by forklift operators, and the subsequent extension of a forklifts life cycle.

Table 5: Estimated Forklift Usage Savings from Optimising the Warehouse Layout

FORKLIFT COST	AVERAGE FORKLIFT LIFE (HRS)	FORKLIFT OPERATION COST ($/HR)	DAILY PICKING SAVING (HRS)	DAILY FORKLIFT USAGE SAVING	ANNUAL FORKLIFT USAGE SAVING	STANDARD ERROR
$100,000	11,000	$9.09	7.20	$65.48	$23,902	$19,531

3.2.3 LPG Consumption

LPG consumption was also determined on the basis of reduced time spent picking by forklift operators.

Table 6: Estimated LPG Savings from Optimising the Warehouse Layout

LPG BOTTLE USAGE (/HR)	DAILY PICKING SAVING (HRS)	DAILY LPG BOTTLES SAVED	GAS BOTTLE COST	DAILY LPG SAVING	ANNUAL LPG SAVING	STANDARD ERROR
0.17	7.20	1.2	$32.89[10]	$39.49	$14,412	$11,777

3.2.4 Admin Time

Whilst not directly measurable at this point in time, the amount of admin time that would be saved was estimated to be between 0 and 2 hours per day at an internal labour rate of $40/hour. This would comprise of reduced time spent, selecting specific pallets for picking, which would now be at the forklift drivers discretion, and allocating storage to new product stock.

4. FINANCIAL ANALYSIS

4.1 COST ESTIMATION

Whilst the majority of costs associated with the project recommendations are explained adequately in the business case itself, more detail can be provided on the two more complex cost estimations:

1. Re-arrangement of the warehouse
2. Installation of racking

4.1.1 Re-arrangement of the Warehouse

Estimating the cost of re-arranging the stock within the warehouse to form a new layout based on the recommendations of this project hinged solely on determining labour requirements. The table below outlines how this was determined, with the time taken to move each pallet in this scenario assumed to be equivalent to the picking rates determined previously:

Table 7: Estimated Cost of Re-arranging Warehouse Stock

PARAMETER	LIKELY	HIGH	SOURCE
No. pallets to move	9799	9980	Likely: Forecasted inventory level in late July High: Forecasted inventory level + standard error
Pick rate (pallet/hr)	0.18	0.21	Likely: Good picking rate High: Good picking rate + standard error
Total Hours	1797	1996	Calculated from above parameters
Labour Rate ($/hr)	$24	$30	Likely: Standard pay rate High: Overtime pay rate
Total Labour Cost	$43,134	$58,697	

[10] Cost provided by Aaron Kenny – Finance Business Partner, Supply Chain

4.1.2 Installation of Racking

It was discovered upon enquiring into the prior use of racking in the Synlait warehouse that there is a significant quantity of disassembled single selective racking owned by Synlait which is currently sitting in offsite storage. As a result, it was found that the estimated cost of installing racking in Drystore 2 as recommended could differ significantly depending on whether this could simply be re-installed or not.

In the **likely scenario** of simply re-installing the original racking, costs would be limited to the labour required to perform the re-install, plus the purchase of frame guards to protect the racking from damage from forklift collisions. These costs have been estimated at:

Table 8: Estimated Cost of Re-installing Old Selective Racking

PARAMETER	LIKELY	SOURCE
Labour	$8,000	2 external workers @ $100/hr for 1 week (40 hours)
Frame Guards	$12,225	163 guards @ $75/frame[11]
Total Re-Install Cost	$20,225	

In order to assess the **high cost scenario,** wherein the purchase of brand new racking is required, the pricing system for single selective racking quoted by Carl Tinker was utilised. The required number of beam pairs, frames, and frame guards was based on the suggested optimal warehouse layout. The results of these calculations are shown below:

Table 9: Estimated Cost of Purchasing New Selective Racking

APPARATUS	NUMBER REQUIRED	COST PER UNIT	TOTAL COST
3.4 MT beam pairs	536	$150	$69,680
Frames	141	$350	$49,350
Frame Guards	163[12]	$75	$12,225
		Total Purchase Cost	$131,255

4.2 CASHFLOW ANALYSIS

Combining the total financial cost and benefit estimations (presented in the business case) allowed for an analysis of the potential net financial gain/loss of optimising the warehouse layout. In order to appropriately represent the precision of the financial estimations, the best, likely, and worst case scenarios were all modelled. These were based on the following combinations of cost and benefit estimates:

- Likely Case: Likely Cost + Likely Case Benefit
- Best Case: Likely Cost + Best Case Benefit
- Worst Case: High Cost + Worst Case Benefit

A 3-year period for the return on investment (ROI) was chosen due to the rapid rate of growth and change at Synlait. Looking any further into the future to realise benefits was considered unrealistic. Discussion of the findings of these analyses can be found in the business case. The results for the likely case are shown in Table 10:

[11] Quoted by Carl Tinker, Sales Manager at Rack 'n' Stack

[12] Additional 22 frame guards required to apply to existing row of racking in warehouse

Table 10: Likely Financial Returns of Optimising the Warehouse Layout

YEAR	COST	BENEFIT	NET GAIN/LOSS	CUMULATIVE RETURNS
0	$ 113,759	-	-$ 113,759	-$ 113,759
1	-	$ 124,199	$ 124,199	$ 10,440
2	-	$ 124,199	$ 124,199	$ 134,639
3	-	$ 124,199	$ 124,199	$ 258,838
4	-	$ 124,199	$ 124,199	$ 383,037
5	-	$ 124,199	$ 124,199	$ 507,237
			Payback Period	0.92
			3 year ROI	228%

The results for the best case are shown in Table 11:

Table 11: Best Case Financial Returns of Optimising the Warehouse Layout

YEAR	COST	BENEFIT	NET GAIN/LOSS	CUMULATIVE RETURNS
0	$ 113,759	-	-$ 113,759	-$ 113,759
1	-	$ 218,717	$ 218,717	$ 104,958
2	-	$ 218,717	$ 218,717	$ 323,675
3	-	$ 218,717	$ 218,717	$ 543,392
4	-	$ 218,717	$ 218,717	$ 761,109
5	-	$ 218,717	$ 218,717	$ 979,826
			Payback Period	0.52
			3 year ROI	477%

The results for the worst case are shown in Table 12:

Table 12: Worst Case Financial Returns of Optimising the Warehouse Layout

YEAR	COST	BENEFIT	NET GAIN/LOSS	CUMULATIVE RETURNS
0	$ 244,592	-	-$ 244,592	-$ 244,592
1	$ 17,286	$ 29,681	$ 12,395	-$ 232,196
2	$ 17,286	$ 29,681	$ 12,395	-$ 219,801
3	$ 17,286	$ 29,681	$ 12,395	-$ 207,406
4	$ 17,286	$ 29,681	$ 12,395	-$ 195,011
5	$ 17,286	$ 29,681	$ 12,395	-$ 182,615
			Payback Period	19.73
			3 year ROI	-84.8%

5. CONCLUSIONS & RECOMMENDATIONS

The general trend of the cost benefit analysis shows that the recommended means of optimising the warehouse layout at Synlait resulting from this project would be worth developing into a full solution for implementation. This is further supported by validation from both internal and external parties of both the work throughout the project and its resulting recommendations.

There is an inherent risk associated with the large degree of variance between the best and worst case scenarios presented. However, the continued collection of operational performance data in the warehouse will result in these upper and lower limits being considerably narrowed, and allow the benefits to staging operations to also be quantified. There is a risk of the proposed post-implementation layout being unfeasible or incorrectly designed. This should be alleviated by someone with a greater knowledge of Synlait's warehouse environment further validating and improving upon the recommendations of this.

The successful implementation of the recommended changes to the warehouse layout will rely on managing the warehouse in a much more pro-active manner than is presently the case. Currently, the allocation of new product to storage in specific rows is managed in a mostly reactive manner, particularly when the warehouse is close to full capacity. Stock is mostly placed wherever there is room for it. Whilst the overall amount of admin time spent managing the warehouse is likely to be reduced following the application of the proposed changes, storage allocation itself will require a much greater degree of prior thought. This, as well as the failure to increase maximum capacity and the lack of flexibility associated with installing racking, are likely to be perceived as the biggest drawbacks of the recommended changes to the warehouse layout.

Whilst the recommended implementation period for the proposed changes is not until late July 2017, a short term fix is possible. Altering the way storage is currently allocated could allow for the identified benefits of operating with an optimal warehouse layout to at least be partially realised prior to implementation of a full solution. A concerted effort to keep even the majority of product batches together more often than is currently the case would reduce the likelihood of doubling handling whilst picking. Furthermore, there is no existing barrier to utilising inventory forecasts with more regularity in order to plan warehouse storage allocation out further in advance than is currently the case.

APPENDIX D - MEM LEARNING INSIGHTS

Optimal Warehouse Layout

Gareth Owens – MEM 2016

It is safe to say that there is no way I could have produced the work I have on my project prior to my year studying the MEM. The course has transformed me into a far more responsible and self-motivated professional than I ever was before. Complacency and procrastination that used to affect my work are gone, instead replaced by a drive to both get the job done, and do it right first time. Ultimately, MEM has really motivated me for my career and I can't wait to get out there!

The variety of lectures and workshops included in the MEM provided me with the perfect toolkit to tackle my project, and will continue to serve me well for the rest of my career. Table 1 highlights the key areas of the course I utilised throughout my project, and how they were applied:

Table 1: Application of MEM Teachings to Project

Teaching Area	Application to Project
Systems Engineering	The principles of systems engineering were applied rigorously throughout my project. My knowledge of systems allowed me to define the scope and requirements of my project early on. This provided me with the confidence to focus on the key areas of the problem, without feeling like I had missed any other opportunities for solutions. Following the practices of the V-model, the rigorous validation of my findings, assumptions, and decisions throughout my project allowed me to provide robust recommendations I was more than confident presenting to Synalit.
Strategy	My studies in strategy allowed me to contextualise the problem I was trying to solve in my project, understanding how it fitted into the wider business as a whole. This knowledge was used to inform my decision making throughout my project, focusing on developing solutions which would offer the greatest benefit to the company as a whole. Working under the mantra of "what gets measured gets done" allowed me to really translate the value of the recommendations I was making by quantifying their benefits. This showed to Synlait that what I have proposed in the recommendations resulting from my project are worth pursuing, and could result in its subsequent prioritisation.
Finance	The knowledge and skills I picked up in the finance component of the course allowed me to make feasible estimations of implementations costs and subsequently provide an investment analysis for my recommendations. This included knowing what degree of contingency to include in the projected budget, as well as calculating return on investment and payback periods for the recommended course of action.
Operations	My experiences in the operations module of the MEM gave me a much better understanding of the supply chain environment I was working within during my project. Highlights of this include the understanding that warehousing is a cost adding step to a company, adding no value to the product itself so should be streamlined as much as possible to reduce any added costs. Also the principle of treating the next stage of a business' processes as the customer was extremely helpful in providing quality solutions for the wider business.

PROJECT BRIEF

YETI CRAB

OPTIMAL WAREHOUSE LAYOUT

Document Information

Date:	07/10/16	Release:	Final
Author:	Gareth Owens		
Owner:	Gareth Owens		
Sponsor:	Mathew Foster		
Document Number:	4.0		

Note: This document is only valid on the day it was printed

Revision History

Revision Date	Summary of Changes	Page number (s) of changes
19/09/16	Initial basic information added to document	3, 4
03/10/16	Overview, requirements, costs and schedule developed	3, 4
04/10/16	Risks and considerations added, scope redefined, appendix added	3, 4, 5, 6, 7
05/10/16	Minor adjustments to overview, scope, stakeholders, and risks sections	3, 4, 5
05/10/16	Scope, success factors redefined, appendix 3 added	3, 4, 8
06/10/16	Adjustments to scope, project deliverables section added, appendices modified, additions to considerations	3, 4, 6, 7, 8
07/10/16	Finalisation of deliverable document	3

Document Approvals

This document requires the following approvals. A signed copy should be placed in the project files.

Name	Signature	Title	Date of Issue	Version

Distribution

This document has been distributed to:

Name	Title	Date of Issue	Version
Angela Smith	Peer review	04/10/2016	Draft
Erika Kuhn	Review	04/10/2016	Draft
Gareth Lepper	Review	05/10/2016	Draft 2
Gary Hodder	Review	06/10/2016	Draft 3
Gareth Lepper	Final document	07/10/16	Final

1. OVERVIEW

1.1 BACKGROUND

Currently there are very few formal measures, controls, or standards in place for the placement and stacking of stock across Synlait's warehouses. Consequently, stock can often end up being placed ineffectively, later resulting in unwarranted, excess operational costs, with double handling of stock proving to be particularly common. A re-design of the warehouse is required to optimise the layout and placement of stock within the available space and to ensure it is being used in the most effective manner possible at any given time.

The drivers of this project align with Synlait's strategic goal of achieving operational excellence by developing and implementing the best possible systems and processes available. In pursuing this, Synlait continue to operate in the most effective manner possible, thereby making the most from milk.

1.2 SUMMARY OF PAST ACTIVITY

To this point, there has been no formal past activity on this project. Existing documentation of stock layout is limited to warehouse floorplans which purely illustrate the current theoretical capacity of the warehouse. As alluded to previously, there are also no existing standards in place for the optimal height to which pallets of stock should be stacked. Currently, only an internal standard exists which limits pallets of any type to be stacked to a maximum height of 5 on the basis of health and safety, insurance, and firefighting. Enforcement of this standard is rarely necessitated however, with the stacking of pallets at the discretion of forklift drivers who informally evaluate the suitability of the products and stack to an according height.

2. REQUIREMENTS

2.1 SCOPE

The project is centred on formulating recommendations for whether producing a model for continually optimising both the use of space and placement of stock within the warehouse would be worthwhile, and what we would be required to develop it. This will include further investigation into the current systems (both formal and informal) for stock placement within the warehouse to determine which aspects do and do not currently perform adequately, as well as research into what mechanisms could improve this. Based upon this, it is envisaged that a model could then be developed and implemented to continually determine how warehouse space could be most effectively utilised. Such a model would also have to be robust enough to accommodate for future changes in warehouse parameters.

The early establishment of all the project's requirements will be crucial to its success. This will be accomplished via regular consultation with SMEs as early as possible in the project. Following the establishment of these requirements, the project is expected to progress through 3 further phases (listed below), with a Gantt chart detailing the proposed breakdown and timeframes for each of these phases attached in Appendix 3:

- Research
- Solution Investigation and Development
- Derivation of Recommendations

Key considerations for the development of a solution which have been identified to this point include:

- Warehouse racking systems (e.g. satellite racking)
- Standards for the height of pallet stacking, and distribution of stock across individual pallets
- Forklift routes through the warehouse (e.g. a one-way system)
- The classification of stock within the warehouse (e.g. for shipment, for storage etc.)
- Systems for measuring the overall equipment effectiveness in the warehouse (OEE)
- Matching rows within the warehouse to the size and type of product lots
- Utilisation of automated guided vehicles (AGVs)

2.2 PROJECT SUCCESS FACTORS:

A successful layout model for the warehouse will result in a trade-off between logistics, space, and financial considerations. With this in mind, recommendations for a solution resulting from this project would principally be based upon balancing two key performance indicators:

- The reduction of operational costs associated with the movement of stock throughout the warehouse. A measurement for this will be developed as a part of the project but will most likely be associated with forklift usage times (e.g. hours per forklift).
- An increase in the maximum possible warehouse storage capability (currently at approximately 1.6-1.8 tonnes/m^2).

Recommendations towards what should be considered a successful measurable change for these parameters will be investigated and determined as a part of the project.

2.3 PROJECT DELIVERABLES

Recommendations for a warehouse layout model will be delivered in the form of a business case outlining the costs and benefits of developing and utilizing a solution for the warehouse layout, as well as what a developed solution could/should include. This could be supported by an example static model outlining an optimal warehouse layout for one "what-if" scenario for the warehouse (e.g. average annual warehouse load). This would subsequently be confirmed and approved by SteerCom.

No solution implementation is expected within the scope of this project.

3. PROJECT STAKEHOLDERS

Project Sponsor: Mathew Foster

MEM Sponsor: Piet Beukman

Project Owner: Gary Hodder, Gareth Lepper

Project Supplier: Erika Kuhn

Project Manager: Gareth Owens (MEM intern)

Subject Matter Experts: Aaron Shaw, Brent Rodgers, Aaron Kenny

Project Size Estimate: The project is to be carried out by MEM project intern Gareth Owens, who will contribute 700 hours of work towards its completion.

4. COST AND SCHEDULE

Cost of Business Case: The project is expected to cost a total of $26400. This will consist of:

- $20000 in student scholarship to be paid on the following schedule:
  - 20th September: $4000
  - 20th October: $4000
  - 20th November: $4000
  - 20th December: $4000
  - 20th January: $4000
- $6400 of internal employee time based on 80 internal hours @ $80/hour

Time of Business Case: The final draft business case/proposed solution will be delivered by 20th January 2017, with the final document due on 3rd February 2017. Progress towards this will be monitored via monthly status reports. Key dates around these deliverables, as well as the progression of the project are outlined in Appendix 1 & 2.

Assumptions/Contingency: Assumptions made in formulating this document include:

- The cost of internal employee time is based on the assumption that roughly 80 hours will be spent by other employees (e.g. SMEs, project owners) assisting with the project, with their time valued at approximately $80 per hour.
- The warehouse currently has a capacity of about 1.6-1.8 tonnes/m^2

Expected Benefits: As described in section 2.2, the anticipated benefits of the project to the company are a reduction of operational costs associated with excessive movement of stock throughout the warehouse, as well as an increase in the maximum storage capability of the warehouse. A further indirect benefit also associated with reduced stock movements could be fewer instances of damage to stock.

5. RISKS AND CONSIDERATIONS

5.1 RISKS

The key risk areas for the project have been identified in the table below, this includes the overall level of each risk to the project's success (based on their likelihood and consequence) and any actions which will be taken to mitigate against them.

Risk	Likelihood (1-4)	Consequence (1-4)	Risk Score (1-16)	Mitigating Actions
Scope creep	4	4	16	• Early and thorough establishment of requirements. • Early correspondence with all relevant stakeholders and SMEs • Regular reference back to project brief, scope, and requirements throughout project life
Poor estimations of time taken to complete each proposed phase of the project	4	3	12	• Allow for contingency in all phases of project • Follow a flexible, high-level plan
Lack of commitment to the project	1	4	4	• Maintain continued communication with stakeholders • Conduct regular reviews to ensure project is continuing in the desired direction
Failure to adequately balance logistics, space, and financial considerations	2	4	8	• Ensure consistent communication with stakeholders and SMEs • Regularly refer back to all project requirements following their establishment
Lack of sponsor/supervisor support	1	4	4	• Sustain consistent, clear, and effective communication

Risk Index	Risk Level
1-4	Low
5-8	Moderate
9-12	High
13-16	Critical

5.2 HEALTH AND SAFETY

Outside of taking due care within the warehouse, there are no direct risks to employee health and safety associated with this project. Health and safety will however have a huge baring on the development of the new layout model. Despite the fact forklift speeds are limited to 10km/hr, the warehouse can be a dangerous environment given the mass of stock both idol and being transported, with the risk of stock collapse of the greatest concern. In attempting to increase the storage capability of the warehouse, no changes that could potentially decrease the health and safety of staff will be suggested. Moreover, any feasible steps that are proven to minimise the risks to employee health and safety associated with the aforementioned factors will be included in the recommendations resulting from the project (e.g. adopting one-way forklift routes).

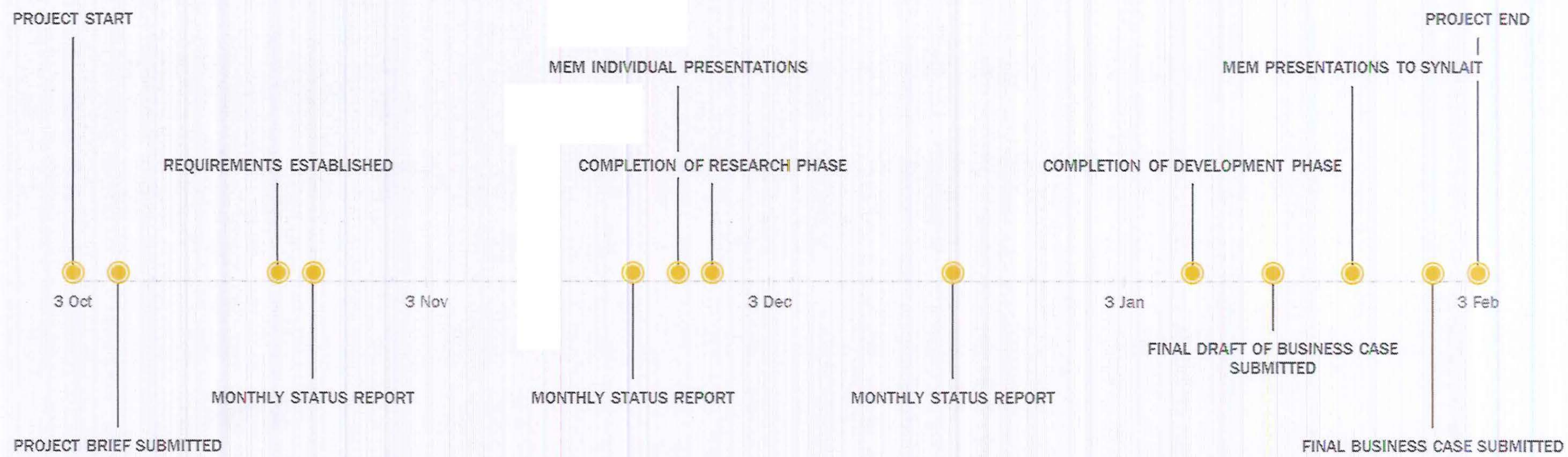
5.3 ENVIRONMENTAL

There are no direct environmental risks associated with this project, with the project only concerned with internal warehouse operations. Reducing stock movements within the warehouse will have the environmental benefit of a reduction in emissions resulting from LPG usage. Also by increasing the storage capabilities of Synlait's onsite warehouse, a further potential environmental benefit of the project would be the reduction in emissions associated with having to transport stock for offsite storage.

5.4 CHANGE IMPACT

Given the extent of its scope, the project itself will have a minimal impact on staff at Synlait. However, were a developed solution to subsequently be implemented, it would have a direct impact on all of the 50 plus staff who work within the warehouse each day, as well as potential indirect impacts on supply chain operations.

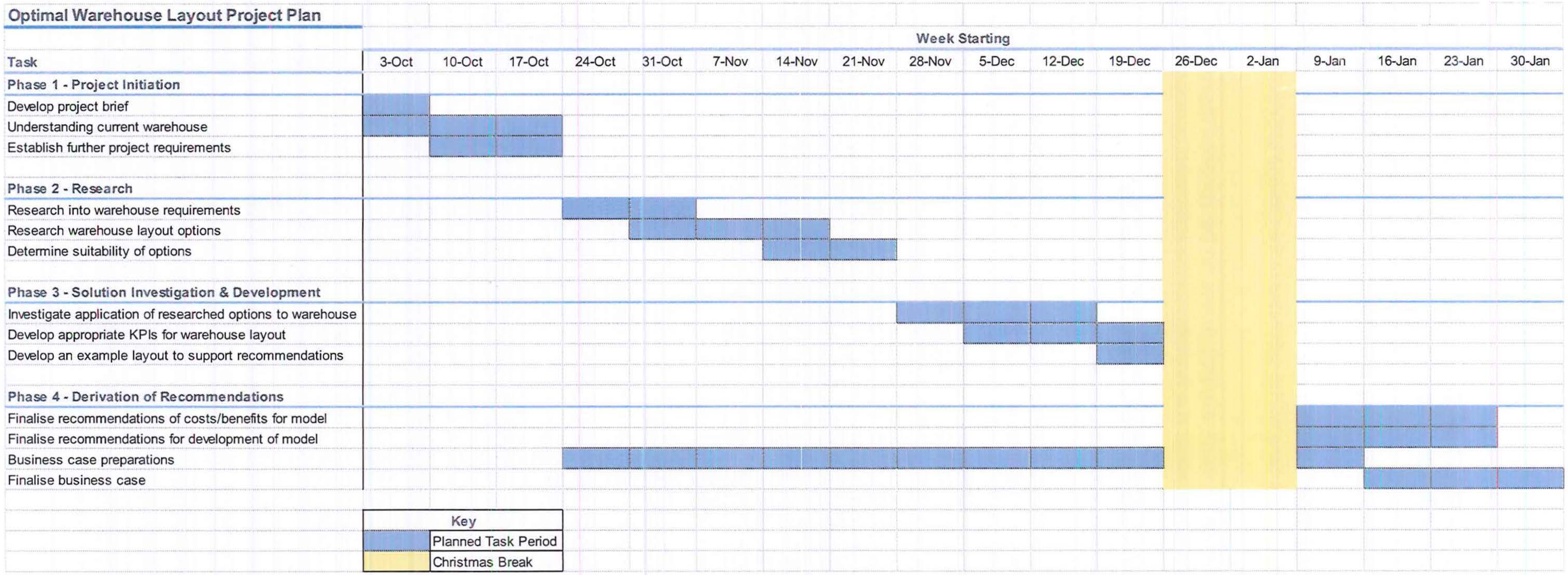
APPENDIX 1: PROJECT TIMELINE



APPENDIX 2: KEY PROJECT DATES

DATE	MILESTONE
3-Oct	Project Start
7-Oct	Project Brief Submitted
21-Oct	Requirements Established
24-Oct	Monthly Status Report
21-Nov	Monthly Status Report
25-Nov	MEM Individual Presentations
28-Nov	Completion of Research Phase
19-Dec	Monthly Status Report
9-Jan	Completion of Development Phase
16-Jan	Final Draft of Business Case Submittec
23-Jan	MEM Presentations to Synlait
30-Jan	Final Business Case Submitted
3-Feb	Project End

APPENDIX 3: PROJECT GANTT CHART



APPENDIX 4: MEM PROJECT WAIVER

As part of the MEM master's degree programme at the University of Canterbury, students are required to undertake a study of a business enterprise, institution or similar and make recommendations for future operation.

This letter serves to introduce Gareth Owens who has prepared the attached project brief for your approval. A copy of the final business case will be submitted to the College of Engineering to partly fulfil the MEM degree requirements.

A copy of the business case will be made available to you on the condition that neither the student, supervisor, nor the University will have legal responsibility for the statements or recommendations made therein. If your company intends to rely on the contents of the report or to implement any of its recommendations it must do so solely in reliance on its own judgement.

Yours faithfully,

.... Date: .... Date:

Student   Supervisor

We, Synlait Milk Ltd, hereby advise that we approve the project brief attached hereto. We acknowledge that neither the student, supervisor nor the University will have any legal responsibility for the statements or recommendations made in the business case and expressly waive all and any legal claims in relation thereto.

.... Date

Mathew Foster (on behalf of Synlait Milk Ltd)

Note: A confidentiality agreement has been signed by the student (Gareth Owens) in accordance with Synlait Milk Ltd Requirements.