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1 EXECUTIVE SUMMARY

Amazon has 4 Single-Medium lines (single item per shipment) which were designed to process 5,765 units per hour on 3 purpose-built lines with a tote delivery system directly to each station. The 4th line does not have automatic tote delivery. The average for Single-Medium packs was 7,946 per hour during Peak 2020. During the peak period, this capacity was bridged using contingency packing lines that were manually fed via 4 Indirect Associates (people who are not directly processing orders) per shift. Each day, eight indirect heads during peak (4-day shift, 4-night shift) costed £1,327.41

This project investigated 3 different solutions to automate delivery to the 4th line in order to make this process more efficient, saving time, money and resources and not being so labour intensive. The first solution was only intrusive to one area of the Amazon warehouse and involved just adding an alternative transport destination in PLC01 and building an extra conveyor. Solution two was similar to the first one except that the handshaking between the existing PLC01 and the new tote PLC would be done via a Profinet-Profibus PLC coupler. This was slightly more expensive and would be intrusive to two areas of the warehouse. Solution 3 involved adding an extra divert on the main tote sorter and adding an extra vertical tote lift which was the most expensive and intrusive option. All solutions were then scored against set criteria taking into account technical, economical, practical and cost/benefit implications and key risks were identified. Consequently, solution 1 was selected as the better concept due to it being the least intrusive to existing operations, more cost efficient, less risk and was the most achievable in the time-scales given for project completion.

too much detail for a summary

Legal, safety, environmental and ethical implications were considered. It was identified that the project needed to comply with all relevant legislation such as the Health and Safety at Work Act 1974, Provision and Use of Work Equipment Regulations 1998 and The Supply of Machinery (Safety) Regulations 2008. To support sustainability, it was identified that the belt conveyor could be re-used.

the FDS should have been drawn up before the solutions were considered

In agreement with the customer, a full functional design specification was drawn up and testing plan devised. Various project management techniques such as devising a work breakdown structure and Gantt chart were used to keep the project on track for delivery date and within budget.

2 INTRODUCTION

The customer is one of the world's largest online retail platforms, shipping millions of shipments to customers over the world each year, with 55,000 employees across over 21 locations within the United Kingdom alone. The UK forms part of the Amazon EU operations network comprising more than 40 fulfilment centres (warehouses) across the EU. (Amazon, 2021) *don't reveal your company name in a report*

The company has some robotic lines to process orders, however, most of the orders are packed by hand. This project will deliver a live industrial system based within Amazon's Swansea warehouse to automate deliveries to line 8 as well as modifying the existing system to work with the new line. This will result in savings of £285,897.50 per annum in terms of efficiency, time resources and labour costs. *the company's*

Local engineering and operations and Amazon Fulfilment Technologies (AWCS) will be involved in the project. It has a budget £150,000, must be completed by April 2022 and provide a return of investment within 2 years.

3 PROJECT BACKGROUND AND PROBLEM DEFINITION AND CONSTRAINTS

The project is based in a company which is a major deliverer of online goods and services. It has a large warehouse in Swansea where orders fall into two main categories; Single-Medium or Multi-Medium. A 'Single-Medium' describes a package with only one item (unit) in the box that goes to the customer (shipment) and multi-medium describes a shipment having multiple items.

There are four dedicated Single-Medium packing lines. Three out of the four lines have totes (which are plastic boxes containing items) delivered automatically. During the peak period of 2020, the Single-Medium pack volume exceeded the warehouse's capacity, leading to the use of contingency lines to bridge the gap. Single-Medium packs accounted for 46.9% of the total output volume, amounting to 11,975k units during weeks 40-53. The warehouse's capacity for Single-Medium packs is currently 5,765 units per hour on 3 purpose-built lines with a tote delivery system directly to each station. The average for Single-Medium packs was 7,946 per hour. During the peak period, this capacity was bridged using contingency packing lines manually fed via 4 Indirect Associates (people who are not directly processing orders) per shift. Each day, eight indirect heads (4-day shift, 4-night shift) costs £1,327.41. The use of contingency lines has shown a direct productivity impact, with an average Single-Medium rate of approximately 115 units-per-hour (UPH) ahead of a potential 124 UPH using the conveyance fed lines.

Figure 3-1 shows a layout of the current lines. Totes are diverted from the main infeed loop, down a tote lift across a sorting transfer table then onto the accumulation lines. Totes containing items to be packed will be delivered via the black lines, packed manually and then placed on one of the blue lines which is work out (items to be shipped).

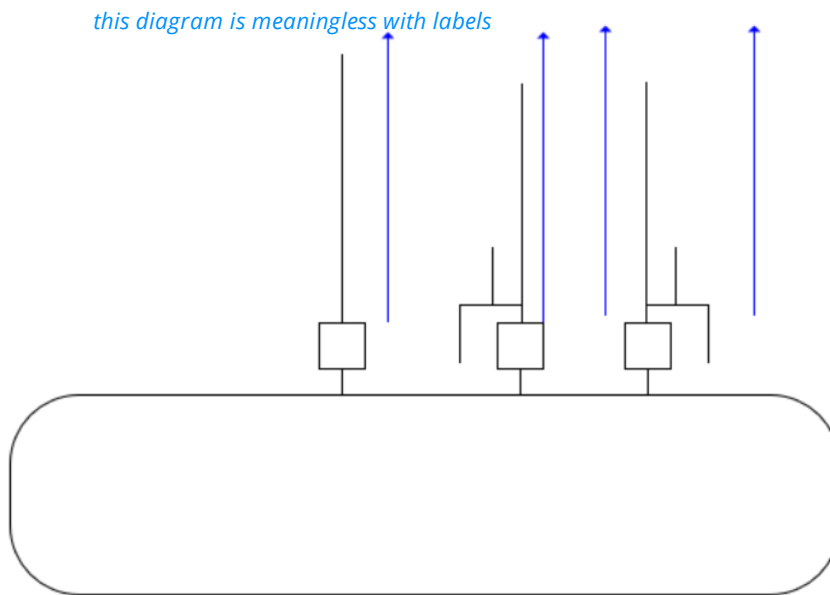


Figure 3-1 Current Layout

the diagram only shows 3, where is the fourth?

As shown, the fourth line has no work delivered to it automatically by conveyance, so it would be taken over manually. This project will investigate ways to automatically deliver work to the pack-stations on line 8 (see Appendix 1 for project proposal).

3.1 PROFESSIONAL CONDUCT AND CODES OF PRACTICE

The Engineering Council regulates the engineering profession in the UK. It sets standards of competence, commitment, required learning, guidance and continuous professional development that engineers and technicians must achieve in order to become professionally registered. These are set out in the UK Standard for Professional Engineering Competence and Commitment and the Information and Communications Technology Technician Standard. It also sets and maintains standards which are accepted internationally and are industry relevant. This provides employers and their customers “with the confidence that professionally registered engineers have met the standards set by the profession and will act in society’s best interests” in an ethical, responsible and sustainable manner (Engineering Council, 2021). Furthermore, The Institution of Engineering and Technology (2022) plays a large part in maintaining professional qualification standards whilst offering support and producing engineering advice and guidance at all levels.

how does this relate to your project?

what will they do? what specific legislation are you referring to?

It will be ensured that everyone involved with this project, operate within frameworks designed to ensure compliance with relevant legislation and safety requirements, the Engineering Council's guidance on sustainability, risk, security and ethical principles and uphold professional standards and codes of practice.

This is vital to maintaining a high level of professional conduct. *which standards and which codes of practice*

This does not need to be said as you are required to demonstrate this from the outset. Don't instruct your reader.

3.2 CONSTRAINTS, LIMITATIONS AND LEGAL REQUIREMENTS GOVERNING ENGINEERING ACTIVITIES

3.2.1 Safety Requirements

The proposed solution must conform to the current relevant UK regulations and standards. As this solution will be implemented in 2022, the UKCA mark will need displaying rather than CE mark. (Department for Business, Energy & Industrial Strategy, 2021). This shows that the machine conforms to the requirements of all relevant regulations.

Prior to Brexit, all work must have conformed to the Machinery Directive 2006/42/EG. Since leaving the European Union (EU) it has been replaced with The Supply of Machinery (Safety) Regulations 2008. These regulations define the necessary tasks for new machines to meet H&S requirements. (Kidman, 2020)

At the end of the project, a declaration of conformity will be signed by the machine manufacturer. This will now refer to the UK legislation (rather than EU directives) and the UK designated standards that will be used to presume compliance with the regulations. The UK designated standards are identical to the EU harmonized standards.

The Supply of Machinery (Safety) Regulations 2008 require that:

- Machines are designed safely *this is better and more specific*
- Operating instructions are produced in English.
- Technical documentation is produced
- A declaration of conformity is issued
- The machine is labelled UKCA compliant displaying the UKCA mark.

The Provision and Use of Work Equipment Regulations 1998 (PUWER 98) must also be adhered to by machine users. As the company will be making significant changes to the equipment already installed, both regulations will need to be followed. *but now you are being general in your explanations again*

All work will be undertaken whilst following the Health and Safety at Work etc Act 1974 (HASAWA). Regulation 6 requires manufacturers to ensure their equipment is safe, Regulation 2 requires employers to ensure the health and safety of their employees and Regulation 3 places the responsibility of both parties to conduct risk assessments. Figure 3-2 shows how they overlap and fall under HASAW.

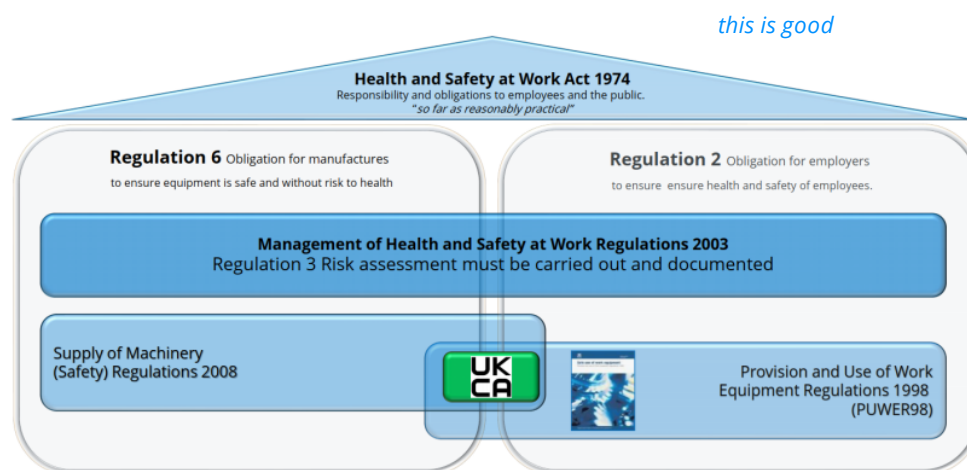


Figure 3-2 HASWA Regulations 2, 3 and 6 and umbrella regulations

HASAWA will also be followed during the build commissioning and end use of the final solution.

3.2.2 Ethical, Legal and Risks

Engineers have a responsibility to conduct themselves ethically. According to the Royal Academy of Engineering (2017), four principles should be followed:

- Accuracy and Rigour
- Honest and Integrity
- Respect for Life, Law and the Public Good
- Responsible Leadership: Listening and informing

All involved in this project will be expected to follow these principles. The principles put into practice would be, not knowingly misleading or allowing others to be misled on engineering matters, acting with competence and performing services in areas of current competence.

The 6 principles outlined in the Engineering Council's guidance on risk will also be adhered to by identifying, assessing, managing and communicating the risks via suitable risk assessments and writing job specifications for tasks. This will ensure compliance with all legal requirements and a commitment to *this is good because you are explaining how you implement these safety requirements*

safety, leading by example and communicating the standards by which risks will be managed (Engineering Council, 2021). The main identifiable risks to this project and possible risk mitigation are shown in Appendix 2.

A contract of work will be drawn up between the company, suppliers and any contractors that will be used. This will include schedules of work, project deliverables, timelines and non-disclosures to limit liability and commercial risk. All contracts will be signed by the relevant authorised person on behalf of the company after they have been reviewed by the legal team.

The company's existing PLC code is owned by the vendor that built the warehouse, consequently, they have claim to the intellectual property rights of the original code. The company has a license agreement to be able to use and modify the code. Intellectual property cannot be shared with those not covered under the Original Equipment Manufacturer's (OEM) agreement. Therefore, an interface panel must be built and used to allow the two systems to handshake and communicate with each other as only those named under the contract can view and edit the full PLC code.

3.2.3 Environmental and sustainability limitations and promotion of sustainable development

The Engineering Council states "The goal of sustainable development is to enable all people throughout the world to satisfy their basic needs and enjoy a better quality of life, without compromising quality of life for future generations" (2021). In the 2005 UK strategy 'Securing the Future' the following principles shown in Figure 3-3 have been agreed to achieve sustainable development:

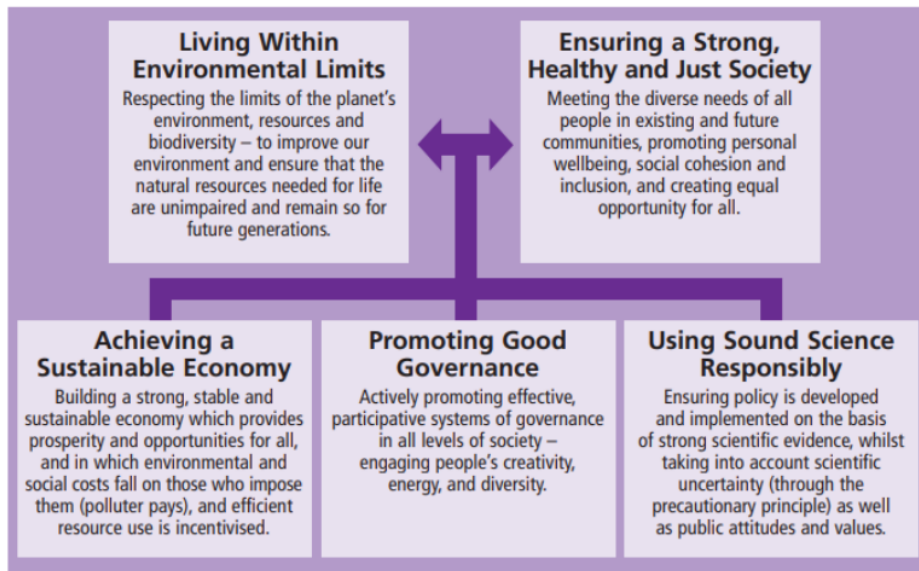


Figure 3-3 The principles of sustainable development in the 2005 UK strategy 'Securing the future'

(HM Government, 2005)

The complexity of economic, social, and environmental challenges due to the adverse effects of resource depletion, environmental pollution, damage to ecosystems, rapid population growth and climate change are forcing companies to manage change, be innovative and adopt new activities (Martens & Carvalho, 2017). With engineering products and processes becoming more complex, engineers have a significant role to play in sustainability. Consequently, when designing this project, the following six principles outlined in the Engineering Council's Guidance on Sustainability (2021) will be adhered to ensuring that all environmental, social and economic impacts are considered;

- (i) Contributing to building a sustainable society, present and future- by considering the full range of implications across the life span of the installation
- (ii) Applying professional and responsible judgement and taking a leadership role
- (iii) Doing more than just comply with legislation and codes
- (iv) Using resources efficiently and effectively
- (v) Seek multiple views to solve sustainability challenges- by sharing good practice and being part of multi-disciplinary teams including non-engineers
- (vi) Manage risk to minimise adverse impact to people or the environment

However, there will always be limitations imposed by the state of technology and the environment's ability to meet present and future needs.

To support sustainability in this project, where possible materials will be reused such as joining an extension to the original pack-conveyor instead of fabricating a new section, waste packaging will be minimised, choosing local installation companies to reduce the project's carbon footprint and waste material will be recycled and disposed of responsibly by choosing suitably licensed waste management companies.

3.3 CONTEXTS IN WHICH ENGINEERING KNOWLEDGE CAN BE APPLIED

The Association for Project Management, defines project management as “the application of processes, methods, skills, knowledge and experience to achieve specific project objectives according to the project acceptance criteria within agreed parameters” (2019). It has final deliverables which are constrained to a timescale and budget. Consequently, engineering knowledge can be applied to all aspects required for managing this project including:

- technical skills to apply knowledge, reasoning, decision-making, operations and determine availability of existing technology to achieve the project objectives
- effective communication to engage stakeholders and lead a team
- business needs
- ability to manage and organise workload and time to deliver the project on schedule, within scope and budget.

Appendix 3 details the context of these stages and how the engineering knowledge has been applied in this project.

4 FUNCTIONAL DESIGN SPECIFICATION AND TEST PLAN

4.1 FUNCTIONAL DESIGN SPECIFICATION (FDS)

The specification has been broken down into specific deliverables, measurable performance parameters and features for inclusion in the final solution. The specification is shown in Table 1 and is broken down into the following categories which is how each point will be referenced. The project must be completed by April 2022. A Functional Design Specification was agreed with the customer.

P- Performance

S - Safety

E - Environmental

A - Aesthetics

F - Finance

T – Technical

Table 1 Functional Design Specification

Reference	Criteria
P1.1	Line must accept minimum of 500 totes per hour
P1.2	Work-out (Pack-line) will run at 80 ft/min with a ramp time of 0.5s
P2	System must highlight faults and be presented to the engineering team via pilot lights and/or the SCADA System.
P3.1	Start-up sequence must be as per other lines, work-out-line (top) to wake on start button or on positive edge of sensor
P3.2	Work-in-line (totes) must start automatically when work is detected
P4	System must be controllable from the current operations interface
P5	System must display faults locally on control panel
P6	Solution must be compatible with the warehouse's OEE system (Metrics dashboard measuring Overall Equipment Effectiveness)
P7	Tote conveyor is an accumulating conveyor, allowing the line to fill with totes and not stop when one tote reaches the end of the line.
E1	Conveyors must have an energy saving mode - after 30 minutes of inactivity, conveyor switches off

S1	Line must conform to SIL 2 reliability rating, stop category 0 (energy disconnect) according to BS EN IEC 62061
A1	Line must keep aesthetics, must match colours of other conveyance. RAL 7016 & 1023
A2	Line must have the same layout as other lines – work-in on the bottom, work-out on top.
A3	Tote-conveyor must be 0.75m high
A4	Pack-conveyor must be 1.42m high
A5	Tote-conveyor must be able to accept totes of the minimum and maximum size and weight as specified in Table 4
A6	Pack-conveyor must be able to fit packages of minimum and maximum size and weights as specified in Table 5
F1	Project must be within budget of £150,000
F2	Project must provide a return of investment within 2 years.
T1	Parts used must be in line with the preferred suppliers list (Appendix 4)
T2	System must display and send healthy signal when system has no faults
T3	BOM, technical and operations manuals are provided

4.2 TESTING PLAN

Based on the FDS above, the following test procedure is planned at the end of the implementation phase to prove the project outcomes and performance criteria have been achieved.

Test Number	FSD Reference	Test Description	Expected outcome
1.	A1	Check colour of frame work	Colours match specification.
2.	A2	Check layout of conveyors is as per FDS	Layout of conveyors is as per FDS
3.	A3	Measure height of tote conveyor	Conveyor is 0.75m high
4.	A4	Measure height pack-conveyor	Conveyor is 1.42m high

5.	A5	Check tote-conveyor can accept totes of the minimum and maximum size and weight as specified in Table 4	Conveyor can accept material within set dimensions and weight (Appendix 5)
6.	A6	Check pack-conveyor can fit packages of the minimum and maximum size and weights as specified in Table 5	Conveyor can accept material within set dimensions and weight
7.	T2	With no faults on the tote line, check PLC01 receives system healthy signal	PLC01 gets healthy signal
8.	P1.1	Load totes onto line for 1 hour, set up photocell on line to trigger a counter	After 1 hour, counter must be greater than 500 to accept line can cope with 500 totes per hour.
9.	P1.2	Measure belt speed using tachometer	Speed is 80 ft/min
10.	P1.2	Check ramp time of VFD controlling motor	Ramp time is 0.5s
11.	P3.1	Press start button for line	Pack-line starts when start button is pressed
12.	P3.2	Flag incoming tote sensor	Tote accumulation line starts
13.	E1	Leave the pack-line for 20 minutes.	When no photocells on the line have been triggered for 20 minutes, the conveyor will turn off.
14.	S1	Activate emergency stop	On activation of E-stop, the line will stop and energy will disconnect.
15.	P2/P5	Place fault on line by blocking sensors,	Fault light displays on panel and sends fault condition signal to PLC01
16.	P4	Route tote to line using operations interface	Tote routes correctly
17.	P6	Modification is able to be added to OEE platform	Modification added to OEE and performance can be measured
18.	P7	Load line with totes	Totes accumulate correctly

19.	T1	Check components used/BOM matches preferred suppliers	Parts used are preferred manufactures
20.	T3	Check documentation list for required documents	All required documentation is present
21.	F1	Project is within budget	Project is within budget
22.	F2	Calculate ROI	Project will have an ROI <2 years

5 LITERATURE REVIEW

Three solutions have been considered to automate tote delivery to line 8. All solutions include the installation of a roller accumulation conveyor and a belt conveyor for processed work. To promote sustainability and cost savings, the conveyor will be reused. For this, an extension bed section will be welded onto the existing bed section.

5.1 SOLUTION 1

Solution 1 comprises building a conveyor to accept totes off the end of the transfer conveyor by keeping the transfer belts raised. This would be achieved by utilising an existing transfer function written by OEM SIT. It uses the existing PLC for the totes transfer and requires a new PLC to control the new tote accumulation.

The transfer PLC (PLC01 which is from the Siemens S7-300 series) will need to send telegrams to the Picking Router server (AWCS router). The PLC will need to send two different telegrams; Telegram 99 giving the lane's status to know if it can accept totes, and Telegram 11 which is referred to as a Sort Report. (Amazon Fulfilment Technologies, 2015) . Telegram information is in Appendix 6

As PLC01 is already set up to send these telegrams, a handshake will be required between the new pack-line PLC and the existing PLC01 via hardwired I/O. The company has a standard that where possible, I/O should be remote IO. As PLC01 already utilises an ASI network, two additional ASI slaves would be used for the handshake.

The ASI slave required is the VBA-4E4A-KE-ZE/R, as it can sit in the ASI extended range. Some ASI devices can only sit in the standard address range; 1 to 32. A standard ASI slave would not work due to the number of existing devices on the standard addresses. This model number will accept extended range addresses, 1 to 32A or B, utilising the full range of addresses available, thus maximising PLC resources. (Pepperl & Fuchs, 2008)

The new pack-line PLC would be a Siemens SIMATIC S7-1500 PLC as per the customers company policy. (Amazon Worldwide Design Engineering - Controls Engineering, 2020). According to Siemens, the 1500 series is a flexible system, offering total scalability. It can adapt assemblies and functions perfectly to suit the machine's design due to its modular design. (Siemens, ND)

This solution requires few stakeholders, namely: local engineering team, local operations, finance, legal, Amazon Warehouse Controls Systems (AWCS) team and a conveyor manufacturer. It is the least intrusive to achieve the project outcomes, with line 8 being taken out of use just for the build and commissioning stages. Figure 5-1 shows the solution as a block diagram.

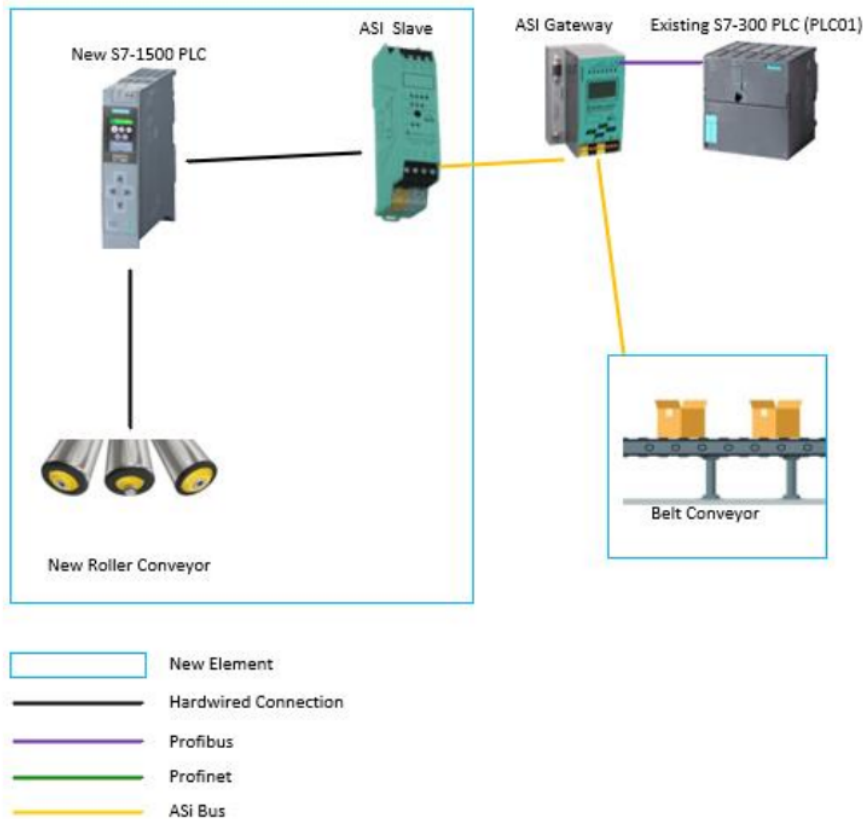


Figure 5-1 Solution 1 Block Diagram

The modified belt conveyor will be controlled via ASi from PLC01. To provide feedback on the status of the accumulation line, the output of the 1500 PLC is connected to an ASI input. PLC01 will use this information to send the correct telegrams to AWCS.

5.2 SOLUTION 2

Solution 2 is similar to solution 1. The difference being that the handshaking between PLC01 and the new tote PLC would be done via a PLC coupler. PLC01 uses Profibus to communicate, as a result, a Profinet-

Profibus Coupler would be required. An Anybus X-gateway device would be used for this as it allows for the seamlessly inter-connect PLC control systems and their connected devices between Profibus and Profinet networks. (Anybus, ND)

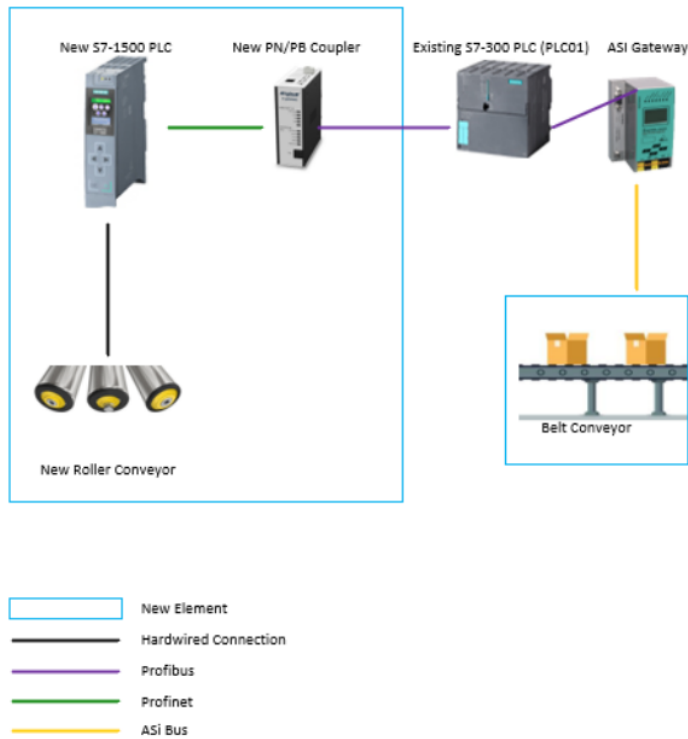


Figure 5-2 Solution 2 Block Diagram

5.3 SOLUTION 3

Solution 3 would mirror an existing tote line. It would involve the installation of a new tote divert exit point from the sorter, and a Nerak lift to bring the totes from high level to ground level. Nerak are “experts in vertical elevation lifts and material handling.” (Nerak, ND).

The lift alone would cost £10,000 plus £15,000 for the software integration. The new tote sorter divert would be £50,000. This solution would be very intrusive to current operations as it would require stopping

the tote sorter for an extended time period to add the diverter. It would also require many stakeholders, namely; local engineering team, local operations, finance, legal, Amazon Warehouse Controls Systems (AWCS) team, AWCS Side Launch team, Conveyance Vendor, Nerak, Nerak Controls Integrator.

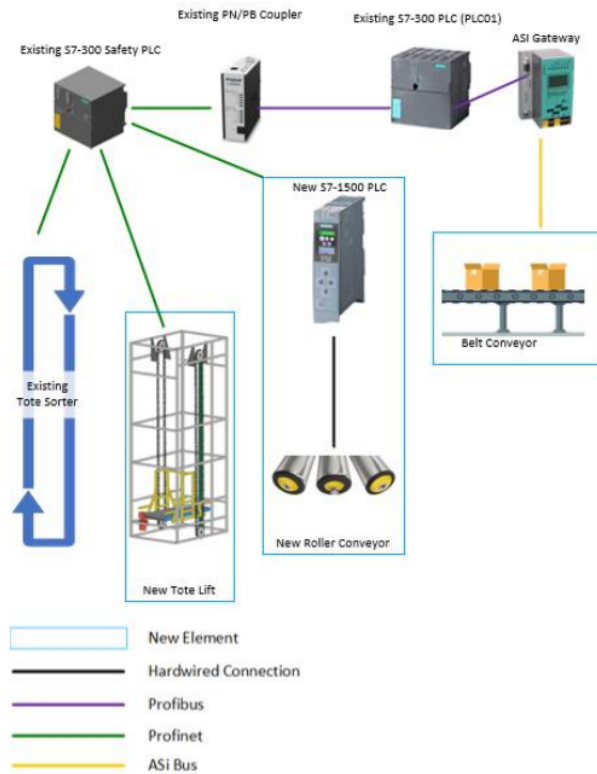


Figure 5-3 Solution 3 Block Diagram

5.4 SOLUTION COMPARISONS

The advantages of using a PN/PB coupler in solution 1 is that you do not need physical cables to be connected between the PLC, saving space in tray work and cabinets, lowering cost on materials and allowing for easy future expansion. Solution 2 would have the same stakeholders as solution 1 however, slightly more intrusive. That is because to use a coupler, you need to run a cable from each PLC to the coupler. Due, to the location of PLC01, to run a Profinet cable to a coupler placed in the PLC01 panel, it would mean isolating line 7 so that the cable could be run safely.

Solution 3 had the advantage of not reducing the throughput of the other lines unlike other solutions, but has higher costs and was more intrusive to the other operations.

The three proposed solutions will be evaluated and scored against the following criteria to determine the most suitable solution:

- Cost
- Deliverability in timeframe
- Complexity
- Intrusiveness to existing operation
- Number of stakeholders involved

You could have added another row to your table for the totals

Scoring was undertaken on a scale of 1 to 5, 5 being the best score. A score of 5 is a low cost, 1 is high. A score of 5 for complexity or intrusiveness means the least complex or intrusive. Solution 1 had the best score. See Appendices 7 & 8 for costings, scoring breakdown and radar graph.

6 PROJECT PLANNING, WORK BREAKDOWN AND MANAGEMENT TECHNIQUES

A work breakdown structure (WBS) will initially be used to plan the project, dividing the project into the following tasks; Design, Documentation, Manufacturing, Software Integration and Management to make it more manageable and approachable. This management technique displays the divided tasks in a chart to ensure an easy progression between them so that all the tasks can be visualised to deliver the project. The WBS rule being utilised for this project is the 40-hour rule which is the rule-of-thumb for decomposing tasks. (Project Manager, ND) . Appendix 8 shows the WBS for this project which will define tasks that will be displayed.

A resource plan will then be created to effectively manage and source the required resources to implement the project and a communication plan created to ensure smooth communication procedures between management, the project team and all interested parties. Potential risks will be identified, quantified and risk mitigation strategies planned as shown in Appendix 2.

the Gantt chart should be a plan for implementation not a look back to September
From the WBS, a Gantt chart will then be developed and utilised which is a useful management technique of visually displaying the tasks against time to monitor and review progress (Association for Project Management, 2019). Appendix 10 shows the Gantt chart that will be used to schedule dates against the tasks, together with a costing spreadsheet to keep within budget. Regular project review meetings with stakeholders will be undertaken and the Gantt chart will be updated to monitor the progress of the project against the baseline. A technical logbook will also be kept and used in review meetings.

7 CONCLUSIONS AND RECOMMENDATIONS

A business case was initially made for the need to automate tote delivery to line 8 in order to make efficiency savings and promote a more sustainable and efficient way of working. Technical, economic and practical aspects of the project were assessed, along with the estimated costs/ benefits and key risks were identified. Consequently, a Functional Design Specification was agreed with the company, broken down into specific deliverables, measurable performance parameters and features for inclusion into the final solution. This resulted in three solutions being considered.

Following analysis of all concepts and evaluation against set criteria, it was concluded solution 1 (building a conveyor accepting totes off the end of the transfer by keeping the transfer belts raised) would be the better option. The reasons being, was that it was the least intrusive to existing operations, more cost efficient, less risk and was the most achievable in the time-scales given for project completion. To support sustainability, where possible materials will be re-used.

To advance this project, it is recommended that solution 1 is implemented by utilising the existing PLC for the transfer of totes and a new PLC to control the new tote accumulation. For the two additional ASI slaves required for the I/O handshake, model VBA-4E4A-KE-ZE/R should be used as it sits in the ASI extended range, utilising the full range of available addresses and maximising PLC resources. The new pack-line PLC requires a Siemens SIMATIC S7-1500 PLC as per the customer's company policy due to the flexibility and total scalability it offers.

An evaluation of project management techniques determined that a combination of the WBS structure, together with the Gantt chart and cost spread sheet will be the most effective to ensure the project is delivered on time within budget and within scope. At the end of the implementation phase, testing will be required to prove the outcomes of the project have been achieved together with its performance criteria.

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9 APPENDICES

9.1 APPENDIX 1 – PROPOSAL PROJECT PROPOSAL DOCUMENT

Student Name: Jonathon Williams
Project Title: Automated Tote Delivery
Date: 01/10/21
Budget: £150,000

Description of Project

The project will be based at Amazon's CWL1 Fulfilment Centre in Swansea, looking at their Single Medium packing process. Project stakeholders will be: Outbound Operations, Reliability Maintenance Engineering Team (RME), Automation Engineering (AE), Amazon Fulfilment Technologies (AFT). The project would need to be completed by April 2022.

Current Situation

Amazon Swansea has 4 Singles Medium packing lines. Three out of the four lines have totes (which are plastic boxes with items in them) delivered automatically. During the peak period of 2020, the Single Medium Pack volume (number of boxes containing a single item) exceeded the warehouse's capacity leading to the use of contingency lines to bridge the capacity gap. Single Medium Packs accounted for 46.9% of the total output volume which amounted to 11,975k units during weeks 40-53. The warehouse's capacity for Singles Medium Packs is currently 5,765 units per hour on 3 purpose-built pack lines with a tote delivery system directly to each station. The average for Single Medium Packs was 7,946 per hour. During the peak period, this capacity was bridged using contingency Packing Lines that were manually fed via Indirect Associates (people who are not directly processing orders). During peak times this accounts for 4 Indirect Associates per shift. The use of the contingency lines has shown a direct productivity impact, with a Single Mediums rate of an average of approximately 115 UPH (units per hour) ahead of a potential 124 UPH using the conveyance fed lines

Proposal

Automate tote delivery to Packline 08 so that the need for indirect heads can be removed saving £1,322.41 per day. The automated delivery could be taken from the main delivery infeed, or have the totes re-routed from one of the existing packing lines.

Agreement for project proposal

Student Signature:  Date: 25/10/21

Martin Apsitis | RME AM | CWL1 Swansea

Industrial Supervisor Signature: E: martinap@amazon.com P: +44.7966999472 Date: 25/10/21

Academic Tutor Signature: _____ Date: _____

9.2 APPENDIX 2 - RISK

Risk is an undesirable future event that could affect the project. Risks facing this project have been identified in Table 2 below. Understanding the consequences of the risk is vital to come up with risk mitigation strategies and contingencies to deal with them.

Table 2 Risk Management

Sources of Risk	Risk Handling Actions to Control Risk
External Risks - changes in senior management decisions, customer needs and behaviour e.g. lack of understanding, customer requirement changes, supplier relations, subcontractors labour availability (Covid), material availability, project assumptions	• Link project goals and objectives to stakeholders needs, focusing on customer requirements • Develop team communication and management reporting procedures, job roles, project change procedures, and how project funding and invoicing will be undertaken • Agree functional design specifications (FDS) and test plans • Examination of available technology to achieve project objectives • Develop a list of alternative suppliers/manufacturers for approval in case shortage of labour/materials for preferred ones
Project Management – unrealistic scheduling, creeping scope, insufficient or incorrect collaborative contacts, not closing down project correctly	• Identify key personnel, contractors and stakeholders required to form part of the project team with the required skill set, working across functional boundaries and foster strong relationships between them • Look at available solutions to meet FDS to ensure that the project will be in scope • Set a baseline project plan to provide an estimate of the project's tasks and resource requirements • Develop work breakdown structures (WBS) • Estimate project costs to summarise the planned expenses and create resource plan • Make a Gantt chart to assign time estimates to each activity in the work breakdown structure and create the target start and end dates for the project to keep the project on time, within scope and within budget • Establish a project control and monitoring system to measure progress against the Gantt chart and manage any changes needed to the baseline project plan

	• Implement communication strategy between project team members, management. • Communicate the status of the project plan with the entire project team and communicate any revisions to the plan to all interested parties so that everyone understands how the plan is evolving • Closing down the project-Notify everyone of completion of project, finalise review and testing of all equipment, determine any strengths, weaknesses and faults and ensure that all contractual terms of the project have been met.
Internal Risks- staff needing key skills, personnel shortfall due to sickness, employment retention or having to isolate because of the pandemic; not identifying changes or fulfilling needs	• Identify any training needs for new or existing staff that may need to use the equipment or if contractors need inductions before coming onto site • Identify staff that can cover each other in the event of personnel shortfall and senior managers who may have to sign off on contingency plans • Ensure compliance with any documentation or write instructions if required- BOM, technical and operations manuals will be provided
Technical/ Equipment and Systems- Unavailability or delay or shortfall of equipment and system components especially during the current pandemic; equipment failure; time/cost performance; complexity, company support, upgradability .	• Draw up a list of alternative manufacturers, suppliers and contractors should the ones on the company's preferred list be unable to undertake the work/ supply the equipment on time due to shortage of staff and materials during the current pandemic. • Research if the manufacturers supply instruction manuals are sufficient for end users- BOM, technical and operations manuals are provided by manufacturer and if not, draw up instructions for end users • Consider each component or functional block and how it can fail, determine the effect of the failure and its severity, the likely occurrence and ways of easily detecting any failures to correct any defects • Test equipment prior to commissioning it, ensuring that it doesn't develop the wrong functions • Have some spares and consumables on site in case of equipment failure • Research makes and model of equipment to be installed to ensure that it fulfils customer's needs, (both present and future)- ensure that it

	meets the required budget, the correct user interfaces are used, that it won't need a continuous stream of updates, but at the same time is capable of upgrades if required in the future • Obtain quotes to ensure that equipment is cost effective and will perform the required functions- don't need 'gold plating' but does need to meet growth and future needs
Legal- including health & safety, contracts, intellectual property rights, product safety, liability and commercial risk	• Adhere to all government legislation including Health and Safety At Work etc Act 1974, The Supply of Machinery (Safety) Regulations 2008, Provision and Use of Work Equipment Regulations 1998. • Have regard to safe design assurance techniques- FMECVA, FMEA and FTA which are key techniques in safety assessment • Future proof project by researching if any new legislation is likely to be introduced or updated and complying with codes of practice by the Engineering Council and researching literature on the project deliverables • Ensure that a declaration of conformity will be signed by the machine manufacturer to show it is safe and conforms to all regulations. • Carry out all necessary risk assessments and job specs. • Ensure that all intellectual property rights are known and licence agreements are adhered to. Protect intellectual property rights by drawing up contracts to include work schedules, contractors signing non-disclosures • All contracts to be signed by authorised person on behalf of company and reviewed by legal team • Carry out project in a professional and ethical manner • Work to be undertaken sustainably having regard to resources and compliance with environmental legislation and wider social implications- reuse as much as possible- e.g. belt conveyor, use existing PLC01 and adding two additional ASI slaves for the I/O for the handshake.

9.3 APPENDIX 3 – WIDER ENGINEERING CONTEXT

"has been considered". Don't preach at your reader

The wider engineering context must be considered in any project. Table 3 below details the contexts in which engineering knowledge can be applied for this project:

Table 3 Wider Engineering Context

Contexts in which engineering knowledge can be applied	
Operational and application considerations when deriving possible solutions to automate line 8	Need engineering knowledge to consider: • ease of maintenance/repairs needed to maintain equipment once installed • type of power and control circuitry needed, needs high reliability to reduce breakdowns and faults • environmental factors in which equipment is to be installed • power consumption/efficiency and performance • size and weight to ensure there is enough room to install solution and determine if any further structural support is required for its weight • aesthetics
Business Needs	• knowledge of legislation and codes of practice required to ensure compliance with all relevant standards, looking ahead to any possible changes. As this project is due for completion in April 2022, UK standards and legislation will apply. • project to be undertaken using ethical and sustainable practices • understanding of contracts, intellectual property rights and product safety to prevent liability and limit commercial risk to the company • understanding of the company's organisation structure and ways of working to develop the functional design specification (FDS) and forge good communication strategies and work collaboratively to enable the project to run as smoothly as possible • understanding of budget that company has in which to implement the solution (£150,000 for this project) and when they expect to see a return on their investment (requirement is 2 years for automating line 8) • commercial availability of equipment, necessary down time anticipated to install proposed solution • understanding if there are likely to be any future requirements or alterations to the automated line at a later stage which may need consideration at the design stage when choosing the make and model such as PLCs and ASI slaves and their capability to be 'future proof' eg ASI slave required is VBA-4E4A-KE-ZE/R, as it will accept extended range addresses, 1 to 32A or B, utilising the full range of addresses available, thus maximising PLC resources. Siemens SIMATIC S7-1500 PLC to be installed for the new pack-line PLC as per the customers company policy due to

	its capability to adapt assemblies to suit the company's machine design due to its own modular design. This offers a flexible system with total scalability
Technical	• Need a good level of technical knowledge to understand the content and complexity of the project scope, design solutions and determine what existing technology is available to achieve the project objectives with a quality end process and the feasibility of doing it within budget and the time constraints given by the company • Ability to be able to properly cost out solutions, taking into consideration business needs and determining the most appropriate solution to deliver the project on time, within budget and with minimum disruption • Knowledge of contractors, manufacturers and suppliers with the appropriate level of skill set to fulfil project requirements during the manufacturing process, supply and installation of equipment • Knowledge to measure the success of the project by developing and completing a test plan to prove project objectives and FDS have been achieved.
Project Management	• Need the ability to successfully develop and implement project through all phases: Initiation, Planning and Design, Construction and Execution, Monitoring and Control, Completion • Need the ability to identify and assess the risks to the project • Need the knowledge to give productive guidance and the ability to effectively communicate with and provide supervision of the project team. The success of the project will be dependent on teamwork and working collaboratively. Effective communication will ensure that information and guidance is articulated in a clear and unambiguous manner so it is fully understood by everyone involved and conversely, will encourage constructive feedback where necessary. • To achieve the project's goal within the given constraints, all constraints need to be fully understood. This knowledge can then be used to develop a work breakdown structure and create target start and end dates for the project. • Knowledge of project management techniques such as use of Gantt chart are required to monitor the progress of the project against the baseline project plan. This allows problems to be identified and procedures and processes to be upgraded where necessary • Understand the importance of keeping complete and updated records and relevant documentation throughout all tasks • Need the ability to see the project through to completion and be able to successfully close down the project ie inform all interested parties, finalise documentation, carry out any necessary testing, conduct post project reviews and ensure that all contractual terms of the project have been met.

9.4 APPENDIX 4 – PREFERRED SUPPLIERS

Component	Preferred Manufacture / Specification
MCBs	Siemens/Schneider
PSUs	Siemens/Phoenix contact.
PLC	Siemens
AS-I Gateways, power supply units and Slaves	Pepperl&Fuchs.
Safety Relay	Pilz
General purpose relay	Phoenix contact, Siemens, Omron
Motor contactors	Siemens
Driven Rollers	Interroll
Operator controls (pushbuttons, pilot lights)	Siemens Sirius 22mm.
Photo-eyes	Sick/Omron
Proximity switches	IFM, SICK, Pepperl&Fuchs.
Terminals	Phoenix Contact STTB series
VFDs/Starters	Moeller-Eaton RASP or SEW Movimot.
Motors	SEW
Horns	Werma
Pneumatics	FESTO
Floor standing enclosures	Rittal TS range (or equivalent) maximum height of 1800mm, maximum width of 1200mm, minimum depth of 400mm and a 200mm plinth to enable bottom entry of cables.
Wall mounted enclosures	Rittal AE, AX and EB range (or equivalent)
Enclosure finishes	RAL7035 silicon grey (or equivalent)
Cable Idents	Phoenix Contact KM2

9.5 APPENDIX 5 – TOTE & SHIPMENT WEIGHTS AND DIMENSIONS

Table 4 Tote Dimension and weights

	Minimal	Maximal
Length	600 mm	600 mm
Width	400 mm	400 mm
Height	350 mm	350 mm
Weight	1.5 kg	30 kg

(Amazon Worldwide Design Engineering - Controls Engineering, 2020)

Table 5 Packages dimensions and weights

	Minimal	Maximal
Length	170 mm	600 mm
Width	120 mm	400 mm
Height	6 mm	375 mm
Weight	0.08 kg	31.5 kg

(Amazon Worldwide Design Engineering - Controls Engineering, 2020)

9.6 APPENDIX 6 – TELEGRAM STRUCTURES

PLCs will send a telegram message to AWCS server to deliver different status. Telegram 91 will inform the router of the line status to effectively load balance work between lines. Telegram 11 will reply to the router the result of a tote delivery to a line. To send a Telegram 11 a standard block will be used. To update the telegram 91, it will be important to confirm the order the router expects to see the destination in not to report incorrectly.

No.	Amount Byte	No. Byte	Unit	Lower- Limit	Upper- Limit	Description
1	1	1	char	02 _{hex}	02 _{hex}	start of text
2	1	2	char	0	9	telegram counter
3	2	3-4	char	91	91	telegram ID
4	1	5	char	0	5	Feeding line SLAM 6 (SH11) '0' = operational, not (part) full '1' = lane full 30% '2' = lane full 70 % '3' = lane full 100% '4' = deactivated (switched off) '5' = error
5	1	6	char	0	5	Feeding line SLAM 7 (SH31) Status (see above)
6	1	7	char	0	5	Feeding line SLAM 8 (SH41) Status (see above)
7	1	8	char	0	5	Gifts (SH32) '0' = operational, not (part) full '1' = not used '2' = not used '3' = lane full 100% '4' = not used '5' = error
8	1	9	char	0	5	Gifts (SH42) Status (see above)
9	1	10	char	0	5	Overflow (SH33) '0' = operational, not (part) full '1' = not used '2' = not used '3' = lane full 100% '4' = not used '5' = error
10	1	11	char	0	5	Overflow (SH43) Status (see above)
8	54	12-66	char	5F _{hex}	5F _{hex}	Filler
9	1	67	char	5F _{hex}	5F _{hex}	Filler
10	1	68	char	03 _{hex}	03 _{hex}	end of text

Figure 9-1 Telegram 91 structure

No.	Amount Byte	No. Byte	Unit	Lower-Limit	Upper-Limit	Description
1	1	1	char	02 _{hex}	02 _{hex}	start of text
2	1	2	char	0	9	telegram counter
3	2	3-4	char	11	11	telegram ID
4	4	5-8	char	0000	9999	record-number
5	4	9-12	char	AA00	ZZZ9	ID-point of actual destination
6	11	13-23	char	0000000000 0	?????????? ?	tote barcode
7	4	24-27	char	AA00	ZZZ9	ID-point of commanded destination
8	2	28-29	char	00	07	sort code
9	37	30-66	char	5F _{hex}	5F _{hex}	filler
10	1	67	char	5F _{hex}	5F _{hex}	filler
11	1	68	char	03 _{hex}	03 _{hex}	end of text

Possible Sort codes:

- 00: Tote correctly sorted
- 01: Tote not sorted for unknown reasons
- 02: Tote without data
- 03: Tote is lost in tracking (not used)
- 04: Tote not sorted because gap error (not used)
- 05: Tote not sorted because lane full
- 06: Tote not sorted because lane is not operational
- 07: Tote not sorted because of invalid destination

Figure 9-2 Telegram 11 structure

9.7 APPENDIX 7 – COSTING EXERCISE

Table 6 contains the costings for each solution.

Table 6 Solutions costing

	Solution 1	Solution 2	Solution 3
Hardware	£ 136,739	£ 139,000	£ 215,000
Software	£ 1,000	£ 1,000	£ 15,000
Total	£ 137,739	£ 140,000	£ 230,000

9.8 APPENDIX 8 – SOLUTION COMPARISON

Table 7 Solution Scoring Table

Criteria	Solution 1	Solution 2	Solution 3
Cost	5	3	1
Deliverability	5	5	2
Complexity	5	4	2
Intrusiveness to operations	5	4	1
Number of resources/ stakeholders	5	5	1
Return on Investment <2 Years	5	5	5

a row should be added showing the total scores

Table 7 could then be displayed in a radar graph as shown in Figure 9-3 to visualise the weighting of each criterion. The aim is to have as distributed spread as possible, the wider the spread on the radar, the more of the scoring criteria has been met.

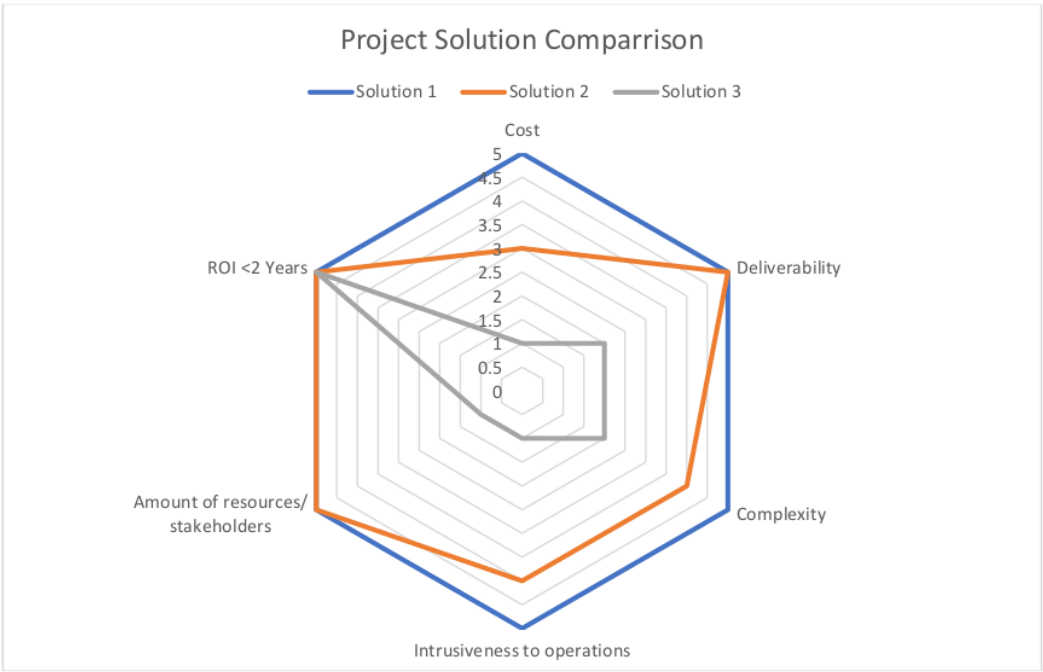
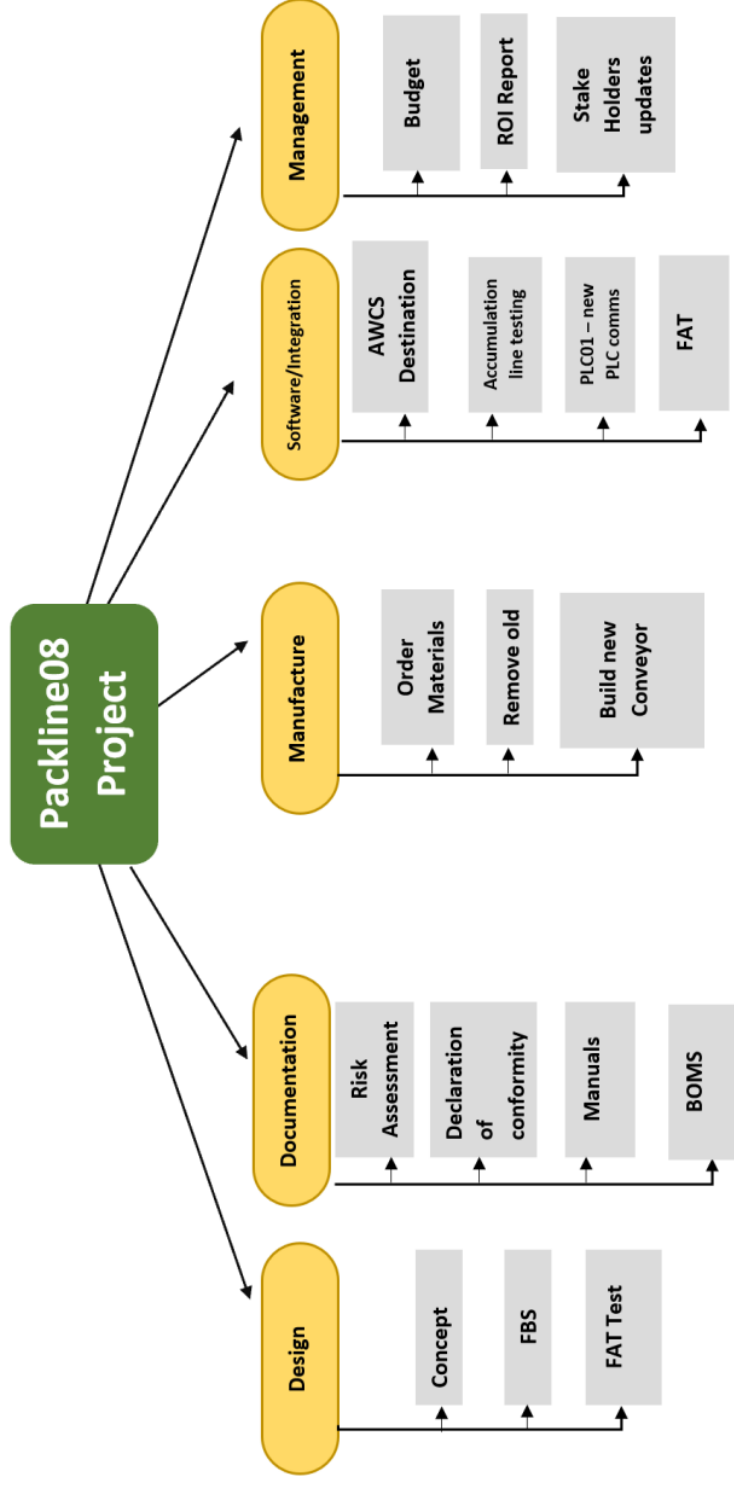
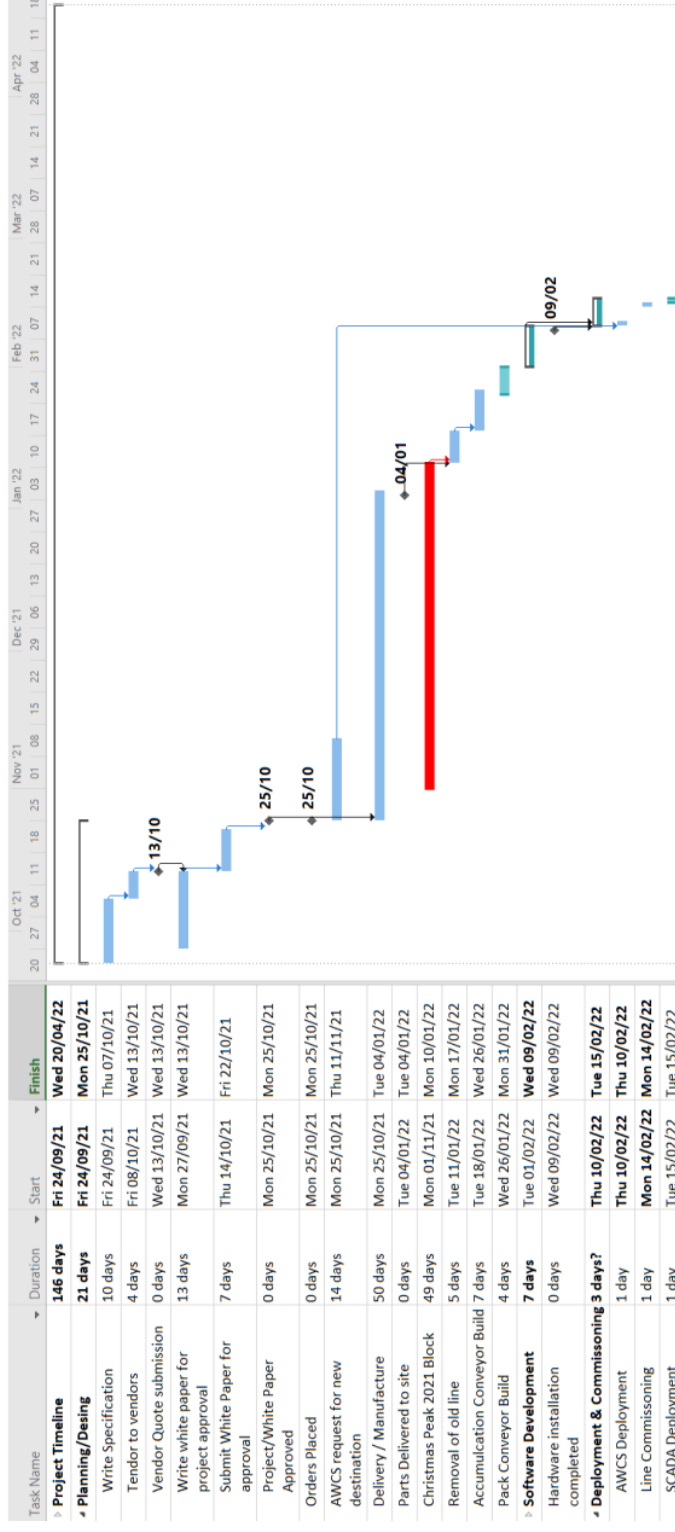


Figure 9-3 Solutions radar graph

9.9 APPENDIX 9 – WORK BREAKDOWN STRUCTURE



9.10 APPENDIX 10 – GANTT CHART



the planning chart should be for implementation only, starting in January 2022 and ending in April 2022

FINAL GRADE

GENERAL COMMENTS

Instructor

70/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

Text Comment. too much detail for a summary

Text Comment. the FDS should have been drawn up before the solutions were considered

PAGE 5

Text Comment. don't reveal your company name in a report

Text Comment. the company's

PAGE 6

Text Comment. colon instead of a semicolon

PAGE 7

Text Comment. this diagram is meaningless with labels

Text Comment. the diagram only shows 3, where is the fourth?

Text Comment. how does this relate to your project?

PAGE 8

Text Comment. what will they do? what specific legislation are you refering to?

Text Comment. which standards and which codes of practice

Text Comment. This does not need to be said as you are required to demonstrate this from the outset. Don't instruct your reader.

Text Comment. this is better and more specific

Text Comment. but now you are being general in your explanations again

PAGE 9

Text Comment. this is good

Text Comment. this is good because you are explaining how you implement these safety requirements

PAGE 10

PAGE 11

PAGE 12

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PAGE 14

PAGE 15

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PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

Text Comment. You could have added another row to your table for the totals

PAGE 22

Text Comment. the Gantt chart should be a plan for implementation not a look back to September

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

Text Comment. "has been considered". Don't preach at your reader

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

PAGE 37

Text Comment. a row should be added showing the total scores

PAGE 38

PAGE 39

Text Comment. the planning chart should be for implementation only, starting in January 2022 and ending in April 2022

JONATHON WILLIAMS**70****1. ENGAGEMENT WITH LITERATURE**

Section 5: Engagement in research, judicial use and critical evaluation sources, depth of literature review of solutions Good evidence of engagement with literature for the selection of the best solution. (RD) Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing Good evidence of a wider range of sources used in the selection of the project solution and in the consideration of wider issues and required standards of professionalism. (RD) (11/15)

11**2. KNOWLEDGE AND UNDERSTANDING**

Section 3: Project background and context, commercial, economic and social context A well-presented section in the report giving the reader a clear understanding of the context of the project (RD). Section 3: Project constraints, professional and ethical conduct, codes of practice, standards, security, intellectual property, legal requirements etc. Good consideration given to each of these issues. (RD) Section 3: Environmental and

18

sustainability limitations and promotion of sustainable development These issues have been addressed through the selection of the best solution by reusing existing equipment where possible. (RD Section 3: Project risks, health and safety etc. A comprehensive assessment of risk has been carried out and included in the appendix. (18/30)

3. COGNITIVE AND INTELLECTUAL



Section 3: Problem Definition Clearly defined with definite outcomes (RD). Section 4: Functional Design Specification Contains sufficient detail to allow solutions to be considered (RD). Section 4: Test planning All aspects of the FDS have been considered and planned for testing of deliverable outcomes. (RD) Section 7: Conclusions and Recommendations A very good set of conclusions and recommendations allowing the project to be implemented with clear direction and without delay (RD) (18/25)

18

4. PRACTICAL APPLICATION



Section 5: Critical choice and justification of final solution A scoring system and radar diagram provided a clear indication for the best choice of solution. Section 6: Project Planning, working breakdown structure and management techniques. Good evidence provided of a range of planning and management techniques. However, the logbook has not been kept up to date and you have left much of the reporting to the last minute.

11

You must manage your time better if this project is to be delivered on time and within budget. (RD)
(11/15)

5. TRANSFERABLE SKILLS



Section 1: Executive summary This covers most things. However, it is too long and too detailed, should be around 300 words. Report contains an interesting introduction but your company name should have been omitted for confidentiality reasons.(RD) All Sections: Quality of the report Excellent quality of presentation and generally, well written. (RD) Word count Kept with 10% of the required 3500 words (RD) (12/15)

12