

1909751

by Alex Williams

Submission date: 22-Dec-2023 04:32PM (UTC+0000)

Submission ID: 220151995

File name: 11778_Alex_Williams_1909751_182120_861709446.pdf (1.95M)

Word count: 8770

Character count: 52890

Course: BSc (Hons) Electrical and Electronic Engineering
Module: SGEL6000 Independent Project
Assignment 1: Project Definition, Research and Quality Planning
Name: Alex Williams
University number: 1909751
Date submitted: 22/12/2023
Word count: 3924

Table of Contents

1. Executive Summary	5
2. Introduction	6
3. Project Background and Problem Definition and Constraints	7
3.1 Background	7
3.2 Problem Definition	9
3.3 Constraints	10
3.3.1 Ethical Engineering	10
3.3.2 Environmental and Sustainability	11
3.3.3 Legal and Commercial	12
4. Functional Design Specification and Test Plan	15
4.1 FDS	15
4.2 Testing	17
5. Literature Review and Choice of Final Solution	21
5.1 Solution One	21
5.2 Solution Two	23
5.3 Solution Three	24
5.4 Comparison of Solutions	24
6. Project Planning, Work breakdown and Management Techniques	27
7. Conclusions and Recommendations	28
8. Citation List	29
9.1 Appendix 1 - Project Proposal	33
9.2 Appendix 2 - Risk Assessment for implementation phase	35
9.2.1 Appendix 2.1 – Project Risks and Mitigations	35
9.2.2 Appendix 2.2 – Implementation Risk Assessment	41
9.3 Appendix 3 - Scoring Matrix for Solutions	42
9.4 Appendix 4 - WBS Chart	43
9.5 Appendix 5 - Gantt Chart	44
9.6 Appendix 6 - Costing Spreadsheet	45

9.7 Appendix 7 - Log entries up the present time 46

9.8 Appendix 8 – Preferred Suppliers..... 75

Table of Figures

Figure 1: Customer Process Flow Chart.....	7
Figure 2: Corral Layout	9
Figure 3: Solution One Block Diagram	21
Figure 4: Solution Two Block Diagram.....	23
Figure 5: Solution Three Block Diagram.....	24
Figure 6: Solution Radar Graph	26
Figure 7: WBS Chart.....	43
Figure 8: Gantt Chart	44

Table of Tables

Table 1: Company Departments	8
Table 2: Corral Process Steps.....	10
Table 3: FDS Table.....	16
Table 4: Testing Table.....	20
Table 5: HMI Users	22
Table 6: Solution Comparisons.....	25
Table 7: Project Risk Management and Mitigation.....	35
Table 8: Implementation Risk Assessment	41
Table 9: Solution Scoring Table	42
Table 10: Solution One Cost.....	45
Table 11: Solution Two Cost	45
Table 12: Solution Three Cost.....	45
Table 13: Preferred Suppliers	75

This is a good summary that outlines most of the things done in the report.

1. Executive Summary

However, you haven't mentioned, risks and testing

The project is based at a local fulfilment centre in the company's Receive department to reduce manual sortation errors, improve efficiency and save costs on the Corral system. Analysis showed achievable annual savings of £60,996.00 in labour costs and £1,794 for re-processing miss-sorts.

Compliance with ethical engineering was deemed essential. To support sustainability, equipment could be re-used, waste minimised/recycled and parts sourced locally. Legally, the project required compliance with BS7671:2018 (IET Wiring Regulations 18th Edition), Supply of Machinery (Safety) Regulations 2008 and Health and Safety at Work etc Act 1974.

A function design specification demonstrated compliance with the company's agreed requirements and a testing plan devised to prove the outcomes. Solution 1 utilised a Sick high-resolution colour sensor to detect coloured stickers/labels on the box. Using a Siemens SIMATIC S7-1500 PLC controller, the colour then determined the box's routing destination. Solution 2 involved a SICK ICR890-4 8k pro-colour camera coupled with the MSC800 control unit. The camera reads the colour sticker. The controller then communicates with the PLC, making the routing decision based on the HMI settings. This solution was the most expensive as the conveyor required changing. Solution 3 utilised a Cognex DM303X camera to read different 2D barcodes that were assigned a destination via the HMI, with a Reflex-Array sensor used to trigger the camera and the signal sent via the control box. The camera subsequently connected the S7-1500s PLC via the Profinet connection.

All solutions were scored against set criteria and key risks identified. Solution 1 was chosen as the better option as it was more scalable, required least modifications, was cost-effective with less risk and was deliverable within the time-constraints. A work-breakdown structure was then implemented, and a Gantt chart utilised to monitor progress and keep the project on time and within budget.

Implement and utilise both mean to carry out, but the project is not done yet!

2. Introduction

This report will outline the company's background and problem definition on reducing sortation errors within the Receive department. It will also detail the FDS, testing plan, three solutions, solution analysis with costings and justification of the chosen solution.

Errors occur during the manual sortation of cartons, primarily due to incorrect barcodes being scanned or the packaged goods being sent into the incorrect destination lane. This leads to goods being sent to incorrect warehouse areas, resulting in missed orders and failed deliveries.

The report will demonstrate that automating the receipt of inbound goods into the dock before being decanted in the receive area reduces these errors, resulting in a reduction of labour costs and savings associated with re-processing miss-sorts.

It will involve the company's Fulfilment Technologies Team and Maintenance Engineering, Operations, Health and Safety, Learning and Development and Procurement Departments. The project budget is £70,000, it must provide a return of investment within 2 years and be completed by July 2024.

The project proposal is in appendix 1.

a good introduction to the report but some items from the FDS have crept in

3. Project Background and Problem Definition and Constraints

3.1 Background

The project will be based at a local fulfilment centre (FC) for an e-commerce and global distribution company.

The company has multiple departments as shown in Figure 1.

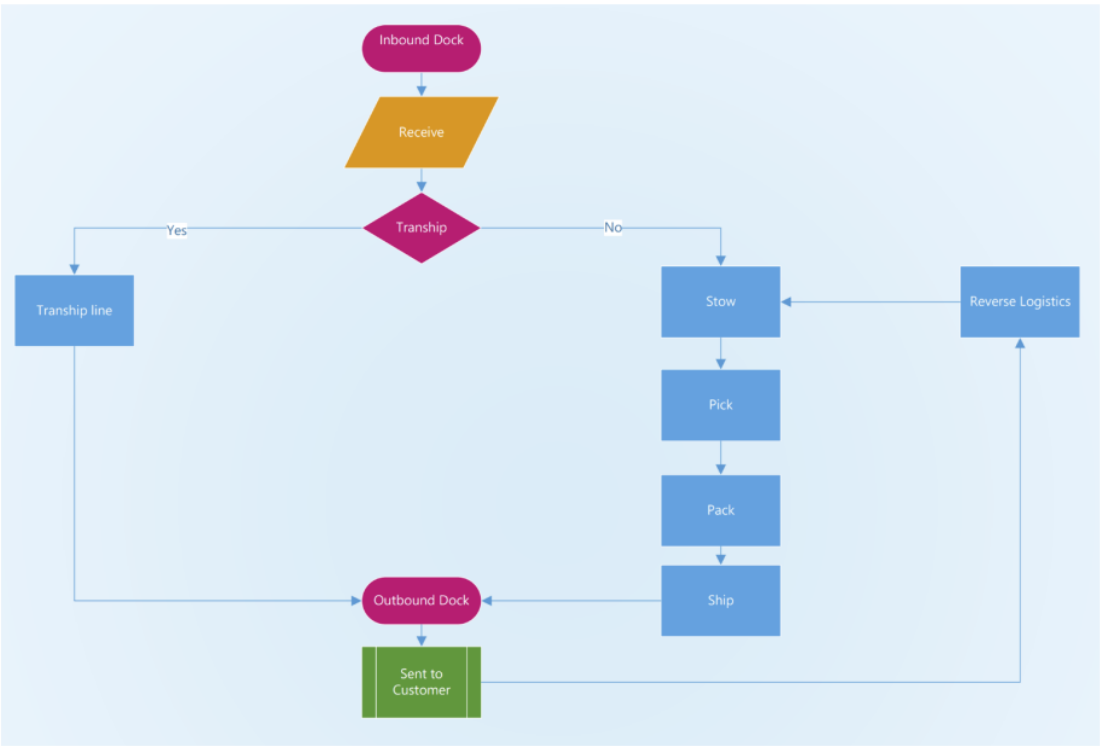


Figure 1: Customer Process Flow Chart

Table 1 summarises each department's role within the process.

*This table is a helpful key to understanding the above flow chart
However, you have not defined "tranship" though it can be deduce from your statement later*

Department	Information
Inbound Dock	Takes receipt of inbound goods and unloads cartons from HGVs from suppliers across the UK and EU.
Receive	Cartons are manually processed into the building from various suppliers, weighed and sent into a destination lane via a Corral system. Products from the cartons are sorted and units are processed to individual items.
Stow	Stows received items on shelves in a pick tower until it's ordered by a customer
Pick	Picks items for customer orders
Pack	Packs customer orders and applies shipping label.
Ship	Sorts the packages into carts via two different automated ship-sorters
Outbound Dock	Loads all carts into HGV's
Re-Lo	Re-Lo is reverse logistics which is a customer-returns department accepting and re-distributing returned customer orders.

Table 1: Company Departments

The project will be on the Corral system within the Receive Department comprising a series of roller-conveyors and a weigh-table. It's located within the inbound dock where cartons and

goods are processed into the building from various suppliers and separated into individual units to be stowed or transhipped to other FC's.

The Receive system is a manual process of unloading cartons from ^{HGVs} ^{they are} onto conveyance which transports them to an operator, where it is weighed and manually sorted into a destination lane via a manual rollerball table.

3.2 Problem Definition

The existing problem concerns the manual sorting of inbound goods and transhipments from suppliers/other FCs. The manual sortation allows for several errors to be introduced into the system. The Corral layout is shown in Figure 2. The steps are outlined in Table 2. Stages 1 and 2 are shown multiple times as they occur on each boom-conveyor.

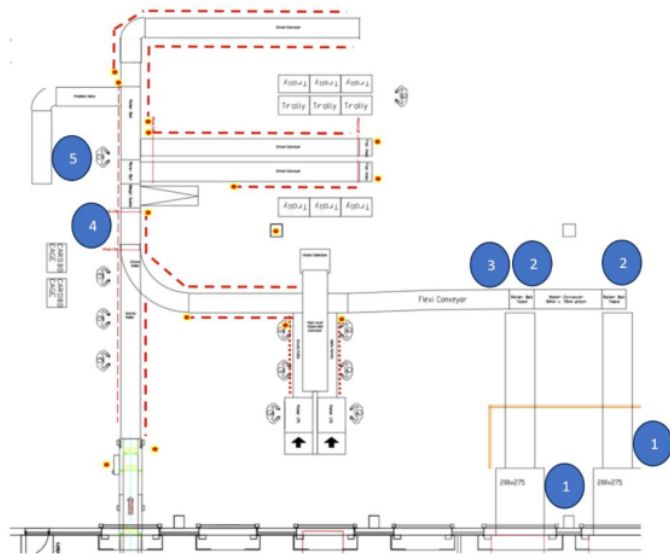


Figure 2: Corral Layout

Stage	Potential Errors
1. Carton unloaded from lorry on boom conveyor	Items being left unloaded.
2. Operator places barcode on carton, scans barcode then scans destination lane to assign a destination to the carton	Item does not scan Bad barcode Wrong destination assigned
3. Operator pushes the box from the boom conveyor onto the roller conveyor to transport it to the weight scale operator.	Does not place into scale correctly Leans on the side of the conveyor which adds inaccuracies to the box weight.
4. Scale operator weighs carton, places overweight label if required.	Fails to place label on carton, risking manual handling injuries.
5. Scans barcode and then pushes carton into destination lane via roller ball table.	Wrong barcode scanned or pushed box to wrong destination – incorrect lane leads to different warehouse areas. Missing cartons leading to failed customer orders and failed customer promises.

Table 2: Corral Process Steps

The primary and most costly issue for the business is errors occurring in manual sortation at stage 5. Whilst errors in stages 1-4 can be rectified within the department, incorrect sorting in stage 5 leads to cartons being sent to different warehouse areas, jeopardising customer orders. This results in financial losses and harm to the company's reputation due to missed orders, failed deliveries, and the expense of refilling/compensating orders.

An automated solution *would reduce* these errors, preventing cartons from going to the wrong destination lane. Automated systems are also less labour-intensive, enabling the company to reallocate labour to other internal departments.

3.3 Constraints

3.3.1 Ethical Engineering

Engineering ethics involves a set of principles and guidelines to ensure responsible and ethical practices are followed.

According to the Royal Academy of Engineering and the Engineering Council (2017), ethical principles are underpinned by:

- Honesty and integrity
- Respect for life, law, the environment and public good
- Accuracy and rigour
- Leadership and communication

Project participants will be expected to follow these ethical principles which are crucial to ensuring the safety, well-being, and trust of the public and stakeholders. In doing so, they must not knowingly mislead or allow others to Correctly cited in engineering matters and perform services in areas of current competence (IET, 2019). Accuracy and rigour are important as inaccuracies/carelessness can lead to the project failing, accidents and injury and strict compliance with legislation must be maintained. Competencies needed for each aspect of the project will be analysed and contractors/suppliers and the project team will be chosen based on those competencies and ethics.

Engineering solutions should ensure designs and decisions do not inadvertently discriminate against any group or individual and maintain compliance with the Equality Act 2010 (GOV.UK, Correctly cited 2015). An inclusive approach will therefore be adopted so that project solutions are accessible to all individuals, including those with usability, mobility or sensory conditions. This makes the project more successful and productive and prevents serious issues such as harassment, discrimination and bullying (Royal Academy of Engineering, 2023). The outcome will aim to re-utilise labour within the warehouse and not put jobs at risk. This retains talented and skilled employees and keeps them motivated and loyal to the company and maintains corporate reputation (acas, n.d.).

3.3.2 Environmental and Sustainability

Engineers have professional obligations in relation to sustainability as outlined in the UK Standard for Professional Engineering Competence (UK-SPEC) (Engineering Council, 2021).

Correctly cited

In order to support sustainability, this project will have regard to the following Engineering Council's principles.

- Contributing to building a sustainable society.
- Apply professional responsibility with sustainability.
- Doing more than just comply with legislation.
- Efficient use of resources.

(Engineering Council, 2021) Correctly cited

Therefore, any project solution will reuse materials, utilise existing systems instead of new installations and source parts locally wherever possible. This reduces the project's carbon footprint and ensures responsible, efficient and ethical sourcing. A multi-disciplinary team will be set up to deliver the project, including non-engineers and good practice shared and views sought to solve sustainability challenges. The waste hierarchy system of prevent, reuse, recycle, recover and dispose will be followed. Therefore, any waste material removed from existing systems or new waste generated by the project will be recycled or if not possible, disposed of responsibly via licensed waste management companies in compliance with the new Wales workplace recycling law that comes into effect on 6th April 2024 (Welsh Government, n.d.). Correctly cited A comprehensive risk assessment will be undertaken to identify the risks and benefits and a plan produced to manage those risks enabling early mitigation at the design stage.

The project is based around MHE (Material Handling Equipment) conveyance. It aims to be energy efficient and only run conveyance when required. If new conveyance is to be installed or existing MHE modified, ^{your reader may not know what is a VFD} a VFD will improve energy efficiency and soft starts will reduce mechanical stress on start-up (Jacott, 2016). Correctly cited

Up-to-date software in line with industry 4.0 will be utilised. Existing software will be examined and where possible developed to increase efficiency, improve user experience and have the capability to collect and analyse data. This enables system reviews and looks at future improvement, so all project engineering impacts are identified at an early stage (Grahams, 2023). Correctly cited

3.3.3 Legal and Commercial

3.3.3.1 Safety Requirements

Engineers must prioritise the safety and well-being of the public and the environment in their work (Engineering Council, 2020). All wiring will therefore conform to BS7671:2018 (IET Wiring

Regulations 18th Edition) (IET, n.d.) including the required MCBs and other circuit protection devices. Where there are interactions with the machine, appropriate machine guarding, safety interlocks and E-stops will be in place. All machine safety will [Correctly cited](#) the Supply of Machinery (Safety) Regulations 2008 (Office for Product Safety & Standards, 2023) requiring that machines are designed safely, a declaration of conformity is issued, and the machine is labelled UKCA compliant displaying the UKCA mark. These regulations are the UK implementation of the European Machinery Directive 2006/42/EC since leaving the EU (IET [Correctly cited](#) n.d.). Machine safety must also comply with The Provision and Use of Work Equipment Regulations 1998.

All project work must comply with the Health and Safety at Work etc Act 1974. Specifically, under Regulation 2, employers are required to safeguard the health and safety of their workforce. Regulation 3 places joint responsibility on both parties for conducting risk assessments, while Regulation 6 mandates manufacturers to guarantee the safety of their equipment.

3.3.3.2 Risk management

Risk management strategies will be undertaken to identify potential health and safety hazards and undesirable future events that may affect the project. The risks will then be analysed and evaluated to enable development of risk mitigation strategies to treat and monitor them.

Health and safety risks will be identified via a risk assessment conducted under the Management of Health and Safety at Work Regulations 1999 which is contained in Appendix 2.2. Identified risks include isolation of electricity. This also ensures the required control measures are in place for machine and operator safety (The National Archives, 2021). [Correctly cited](#)

Project management risks include scope and budget creep, lack of clarity due to poor communication, poor scheduling, external and internal risks and legal and technical constraints (KissFlow, 2023). [Correctly cited](#)

In order to minimise these risks, internal management of change processes will be followed where before installation, a buy-in procedure from Operations, senior site management, engineering management and the health and safety department needs approval. A detailed evaluation of project risks and mitigation can be found in Appendix 2.1.

Work contracts will be prepared between the company, suppliers and contractors. The company's legal team will review the contracts prior to being signed by an authorised senior manager which includes timelines, project-deliverables and non-disclosure agreements. This ensures health and safety, and environmental risks are carefully evaluated and controlled prior to implementing significant changes and limits commercial risk and liability (Gould, 2019).

[Correctly cited](#)

After the completion of the installation work, a testing and commission procedure must be completed including an internal company Safety Workstation / Equipment Handover (SWEH) document.

Work-breakdown structures and Gantt charts will also be utilised to manage project risks, ensuring that it's delivered within scope, on time and within budget. To reduce internal risks, training will be provided to operators on implementing the final solution and equipment will be standardised where possible for ease of maintenance and familiarity of operation.

3.3.3.3 Consideration of Intellectual Property

Any software used will have the appropriate licences to legally use it.

The intellectual rights for the PLC code in the Corral are already owned by the company so direct communication is possible during the project. The sortation code will be newly written and will require a PLC licence (already owned) and on completion the code will be owned by the company upon handover.

4. Functional Design Specification and Test Plan

4.1 FDS

requires

The FDS achieves proof of concept of automating the sortation process in the Corral system. It must meet the specification in Table 3 in relation to performance, safety, environmental, aesthetics, finance and technical constraints, and must be completed by July 2024 due to the company's operational requirements.

P- Performance

S – Safety

E – Environmental

A – Aesthetics

F – Finance

T – Technical

Reference	Outcome
P1	Must remove manual intervention at step 5 of the Corral system
P2.1	Must automate sortation to four destinations and a 5 th destination for kick outs/no reads/rejects.
P2.2	The system must show where the carton is being diverted to by means of pilot lights or HMI
P2.3	Be able to change routing destinations from the HMI
P3	Must highlight faults and be presented to the engineering team via pilot lights and/or the SCADA System.
P4	Should start automatically when incoming cartons are detected
P5	Must have a successful read rate of 99%
P6	Have a throughput of >7 seconds per unit
E1	Solution must be triggered by system on demand and not constantly on
S1	Must be able to isolate when demonstration not in use

A1	Proof of concept prototype must keep aesthetics, must fit on training rig within company workshop
F1	Project must be within budget of £70,000
F2	Project must provide a return of investment within 2 years.
T1	Parts used must be in line with the preferred suppliers list (Appendix 8)
T2	System must display and send healthy signal when system has no faults
T3	BOM, technical and operations manuals are provided
T4.1	HMI must have a view only mode
T4.2	HMI must have an operations mode where operations management can select the routing.
T4.3	Must have an engineering mode allowing access to all areas of the HMI such as read rates and maintenance settings.
T5	All cables are identified through cable ID's

Table 3: FDS Table

4.2 Testing

A testing plan is produced in Table 4 and will be completed at the end of the implementation phase to prove project outcomes, measure performance and gauge success.

Test Number	FDS Reference	Test Description	Expected outcome	Actual Outcome	Pass/Fail	Evidence
1.	A1	Check prototype fits within training area.	Prototype is within the training area in engineering workshop.			
2.	T5	Check all cables are identifiable with cable IDs.	All cable IDs are present.			
3.	T2	With no faults on the prototype, check healthy signal is shown via pilot lights or HMI	Healthy signal is displayed			
4.	T4.1	Attempt to set a routing destination in view only mode	HMI won't navigate to the required page due to permissions			

5.	T4.2	Attempt to set a routing destination in Operations mode	HMI will go to routing page and allow user to set routing destinations.			
6.	P1	Parcel moved under camera to simulate movement on a conveyor	Automated output is given on the destination			
7.	P2.1/P2.2	Test sample simulated to go to selected routing destination	Simulated output is seen to go to correct routing destination and intended destination shown on HMI			
8.	P2.3	Change routing destination on HMI	Routing destination changes.			
9.	S1	Engage isolator	All system shuts down.			
10.	P3	Place fault on system by using a bad shipment, e.g. Spoiled labels or upside down or interrupt the system	Fault light displays on pilot lights or HMI			
11.	P4	Sensor input will start the sortation system	System starts without manual intervention.			
12.	P5	Test 100 samples	Has a read rate of <99%			

should this be >99%?

13.	T4.2	Attempt to navigate to maintenance screen in operations mode	HMI won't navigate to the required page due to permissions			
14.	T4.3	Navigate to maintenance screen in engineering mode and reset read rate	HMI will go to the maintenance page and read rate will be reset.			
15.	E1	System triggers on demand	System operates only when called and turns off after use			
16.	P6	Time the process time for one unit	Process time has to be under 7 seconds.			
17.	T1	Check components used/BOM matches preferred suppliers	Parts used are preferred manufactures			
18.	T3	Check documentation list (FDS T3) for required documents	All required documentation is present.			
19.	F1	Project is within budget	Project is within budget of £			

20.	F2	Calculate ROI	Project will have an ROI <2 years				
-----	----	---------------	--------------------------------------	--	--	--	--

Table 4: Testing Table

5. Literature Review and Choice of Final Solution

Three solutions have been proposed and evaluated for proof-of-concept to meet the FDS for automated sortation in the Corral.

5.1 Solution One

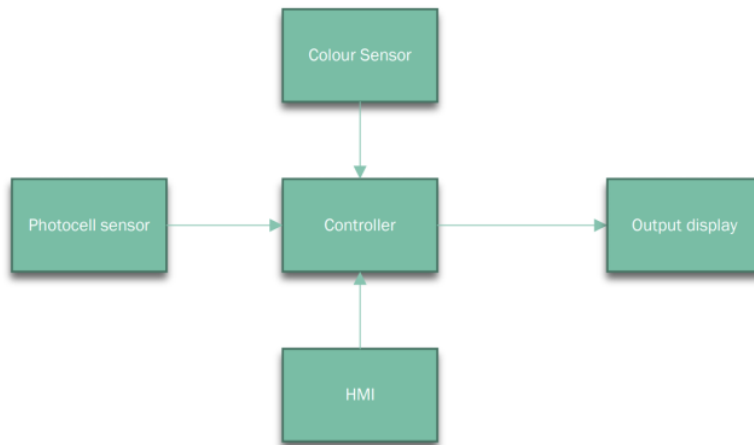


Figure 3: Solution One Block Diagram

This solution utilises a colour sensor to detect coloured stickers/labels on top of the box. Using a controller, the colour determines the carton's routing destination.

A photocell sensor gives a 24v signal to the controller which then triggers the colour sensor on demand. The results are subsequently sent back to the controller which processes the data and gives the required routable outcome. The outcome will be displayed on pilot lights and the HMI screen.

The Sick colour sensor CSS high resolution CSS-WBGAD4118AA10Z would be the chosen colour sensor. It has a sensing range of 50mm to 500mm making it suitable for different sized boxes that are processed. The 8-pin variant can output 15 colours or connected in IO-Link, allows the sensor to process up to 24 colours, resulting in multiple colours being used for routing (SICK, 2023). Correctly cited

The colour sensor needs triggering on demand. The SICK-RAY26 Reflex Array photocell will be used to achieve this and ensure standardisation across the site.

Due to the customer's company policy, the PLC to control the colour sensor and other project outputs will be a Siemens SIMATIC S7-1500 PLC (*Company* Worldwide Design Engineering

Correctly cited

- Controls Engineering, 2020). In addition, the 1500 series is adaptable to different assemblies and has functions to suit the machine's design due to its modular design. This offers a flexible system offering scalability (Siemens, n.d.).

Correctly cited

Once the solution is installed, the PLC needs to communicate to the existing PLC15 to perform a divert. The PLC for this project will be recycled from a previous project making this a sustainable option.

The output of the routing will be displayed on pilot lights and the overview of the HMI screen. The HMI screen allows for the routing to be changed as required by the operations team. It also allows 3 different user groups to be set up as shown in Table 5.

User	Description
View Only	Only allows the user to see the main screen where the routing results are shown
Operations Mode	Can see the main screen and allows users to set routing destinations.
Engineering Mode	Allows unrestricted access to HMI for maintenance and setting adjustments including resetting read rates.

Table 5: HMI Users

The chosen HMI screen would be a SIMATIC TP700 Comfort as it's of adequate size to suit both the training rig for proof-of-concept and when it's installed on the line. This gives the system the visualisation it needs during the sortation to indicate the required destination (Siemens, n.d.). The HMI can also be recycled from a previous project.

Correctly cited

5.2 Solution Two

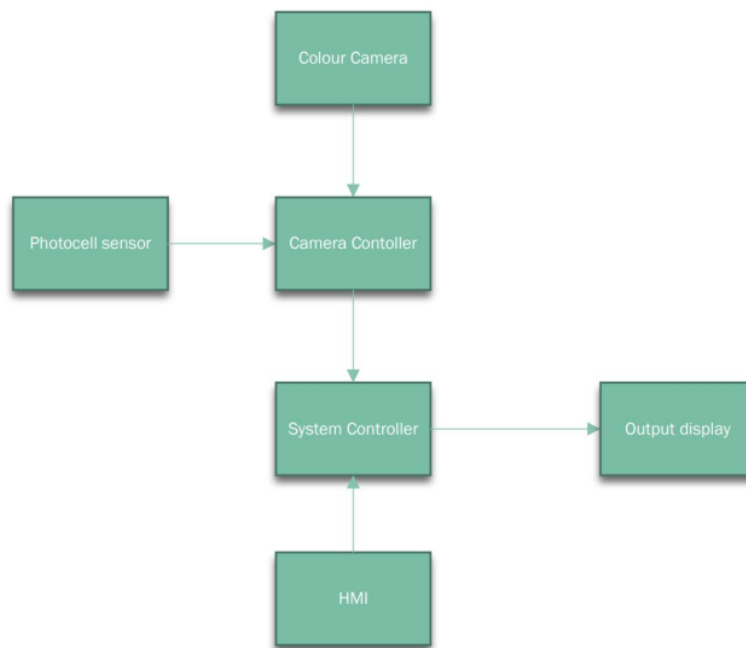


Figure 4: Solution Two Block Diagram

Solution two comprises a SICK ICR890-4 8k pro-colour camera coupled with the MSC800 control unit. The camera reads the colour sticker on top of the carton. The controller then communicates to the PLC and makes the routing decision based on HMI settings.

The HMI and PLC remain the same as solution one, having the same properties and requirements. The PLC and HMI would also be reused from previous projects for sustainability.

The SICK camera also needs triggering on demand using a SICK-RAY26 Reflex Array via the MSC800.

The SICK pro-colour camera has a built-in Single Item Verification Software to detect multireads and reject these packages. It also has recognisable warning signs such as hazardous material (Hazmat) warnings, has multi views of up to 45° so packages can be put down on multiple angles and a throughput of up to 21,000 pph.

Limitations include the camera being read against a matt surface for the conveyor belt. Consequently, when the solution is installed, this section of conveyance would need to be changed from a roller-conveyor to a belt-conveyor (SICK, n.d.).

Correctly cited

The camera connects to the MSC800 via CANBUS (RS-232) to transmit the camera analysis output. In addition, Gigabit ethernet can be used to connect to an FTPC server to store the images for fault finding analysis.

5.3 Solution Three

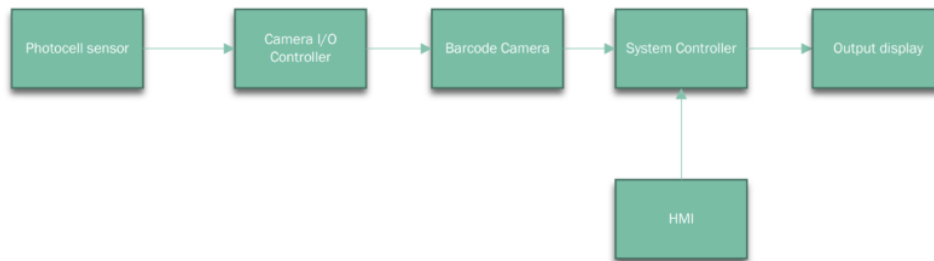


Figure 5: Solution Three Block Diagram

This solution uses a Cognex DM303X camera to read different 2D barcodes that would be assigned a destination via the HMI.

The camera is powered by the control box. A SICK-RAY26 Reflex Array sensor would be used as the camera's trigger with the signal sent via the control box. The camera then connects the S7-1500s PLC via the Profinet connection.

The PLC subsequently processes the barcode and gives the assigned routing output via the pilot lights and HMI as per the FDS like the other solutions.

The Cognex camera reads the barcode and then processes the data using a Cognex control box and sends the data to the PLC.

The Cognex DM303X is a part of the Cognex DataMan 300 series readers. They are fixed-mount ID readers that are high-performance and have the highest read rates on 2D barcodes, flexible optics, intelligent tuning and express set-up. It has advanced ethernet connectivity and has the ease-of-use tune-and-trigger button (Cognex, 2020). Correctly cited

5.4 Comparison of Solutions

The project aims to save labour and cost of miss-sort cartons through re-processing. The business savings amount to 10 hours labour per shift, of which the process runs for 102 hours in a week. Annually, that equates to £60,996 while re-processing miss sorts from the Corral system costs the business £1,794 a year. Therefore, the project must have a return on investment (ROI) on £ 62,790.00 (labour and processing costs combined) in under 2 years.

The scalability cost has been added to the ROI to estimate costs for conveyor modifications needed for post proof-of-concept implementation. Solution one is easier to scale due to the least modification required to the existing conveyor systems in comparison with the other two solutions.

All three solutions have their own advantages and disadvantages as discussed in Table 6.

Solution	Advantage	Disadvantage
Solution One	• Lowest Cost • Better scalability • Visual Representation with colour labels • ROI 25 Weeks	• Requires Carton justification on an alignment conveyor • Top scan only
Solution Two	• Visual Representation with colour labels • Boxes in any more orientation • ROI 45 Weeks	• Harder scalability due to conveyor change required • Higher Cost • More parts required
Solution Three	• Cameras already in use on site • ROI 24 Weeks	• Poor Visual Representation with colour labels • Requires Carton justification on an alignment conveyor • Top scan only

Table 6: Solution Comparisons

The three solutions were evaluated and scored against the following criteria:

- Cost
- Complexity
- Scalability
- Sustainability
- Deliverability
- ROI

Each category was scored out of 5, with 5 being the more preferable outcome e.g. A score of 5 is more sustainable, more scalable, lower cost and less complex than a score of 1.

The solution's scoring matrix is shown in Appendix 3 and radar diagram is in Figure 6.

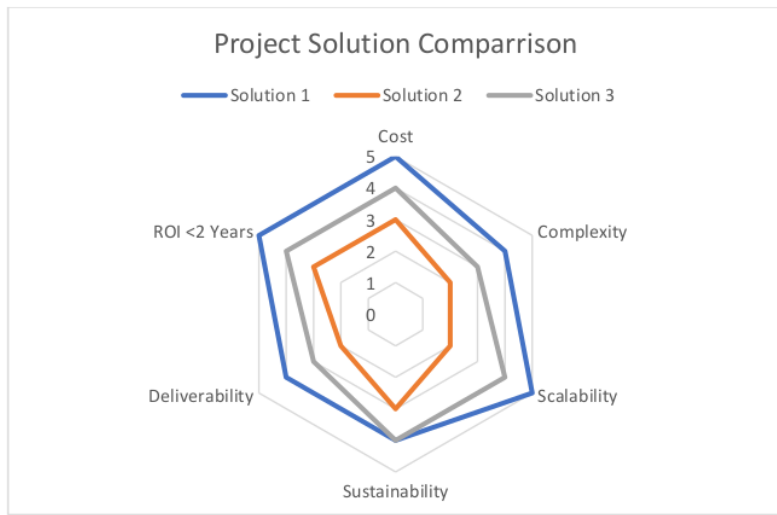


Figure 6: Solution Radar Graph

Solution 1 was the best scoring concept with a more rounded radar graph. It's also more visual to operators so any sortation errors are easier to spot if a miss-sort occurred.

Full costings for each solution are detailed in Appendix 6.

6. Project Planning, Work breakdown and Management Techniques

A work-breakdown structure (WBS) will be used to manage the project in stages. These are Design, Documentation, Manufacturing, Software/Testing and Management to make the tasks more manageable. This technique visually shows the subtasks in a chart to allow progress from each stage for project delivery.

The project will follow the WBS principle known as the 40-hour rule, a commonly used guideline for breaking down tasks (Project Manager, ND). Appendix 4 details this project's WBS.

Subsequently, a resource plan will be developed to efficiently oversee and acquire the necessary resources for project implementation. Simultaneously, a communication plan will be formulated to facilitate seamless communication amongst management, the project team, and all stakeholders. Potential risks have been identified, quantified, and strategies for risk mitigation developed as detailed in Appendix 2.1. These include prevention of scope and budget creep, internal and external pressures and legal risks due to regulatory, contractual and litigation matters.

Following the WBS, a Gantt chart will be generated and implemented. This effective management technique visually represents tasks against time, allowing for the monitoring and review of progress (Association for Project Management, 2019). Appendix 5 presents the Gantt chart used for scheduling task dates, along with a cost spreadsheet in Appendix 6 to ensure adherence to the budget. Regular project review meetings involving stakeholders will be conducted, during which the Gantt chart will be updated to track project progress against the baseline and allow for continuous improvement. Additionally, a logbook (appendix 7) will be maintained and referenced in review meetings.

7. Conclusions and Recommendations

The project aims to optimise efficiency, reduce labour costs, and reduce expenditure associated with miss-sorted cartons. The financial analysis revealed annual savings of £60,996 in labour costs and an additional £1,794 in re-processing expenses. The stringent requirement for a return on investment (ROI) within two years, amounting to £62,790, highlighted the project's financial viability. A Function Design Specification (FDS) was therefore agreed with the company, broken down into project outcomes, measurable performance parameters and features for incorporation into the final system. This resulted in three proposed solutions.

The comparative analysis of these solutions against set criteria showed solution one as the most favourable option, offering the lowest cost, better scalability, and a quicker ROI. Solution one's well-rounded radar graph and visual representation to operators further validated its selection.

The proposed solution offers an efficient method for carton-sortation by employing a colour sensing system. The integration of the Sick colour sensor CSS-WBGAD4118AA10Z with the capability to process a multitude of colours and sensing range, ensures adaptability to various box sizes and allows for the utilisation of multiple colours in routing. It is therefore recommended that solution one is implemented utilising the Sick colour sensor CSS-WBGAD4118AA10Z, together with the SICK-RAY26 Reflex Array photocell for triggering the colour sensor as it contributes to standardisation across the site, enhancing reliability and consistency.

The Siemens SIMATIC S7-1500 PLC, aligned with the customer's company policy, will serve as the controller for the colour sensor and other project outputs. Its modular design not only accommodates different assemblies but also provides scalability, offering a flexible system tailored to the machine's design. The decision to recycle the PLC and HMI screen from a previous project also aligns with the company's sustainability goals.

An assessment of project management techniques concluded that employing a blend of the Work-Breakdown Structure (WBS), coupled with the Gantt chart and a cost spreadsheet, was the most efficient approach to guarantee timely, budget-conscious, and scope-compliant project delivery. Following the implementation phase, testing will be conducted and compared against the FDS to validate the project's achievements and performance.

8. Citation List

Company Worldwide Design Engineering - Controls Engineering, 2020. *WWDE-CNTRL-STND-GLOBAL-SPEC-R214-121620*. s.l.:s.n.

acas, n.d. *Equality, diversity and inclusion - What they are*. [Online]

Available at: <https://www.acas.org.uk/improving-equality-diversity-and-inclusion>

[Accessed 8th December 2023].

Association for Project Management, 2019. *What is a Gantt Chart?*. [Online]

Available at: <https://www.apm.org.uk/resources/find-a-resource/gantt-chart/>

[Accessed 12th December 2023].

British Safety Council, n.d. *The Health and Safety at Work Act Explained*. [Online]

Available at: <https://www.britsafe.org/training-and-learning/informational-resources/the-health-and-safety-at-work-act-explained#:~:text=As%20a%20brief%20overview%2C%20the,operations%20within%20it%20are%20conducted>

[Accessed 17th November 2023].

Cognex, 2020. *About the DataMan 300 Readers*. [Online]

Available at:

https://support.cognex.com/docs/dmst_616SR1/web/EN/DM300_Manual/Content/Topics/DM300_360_470_Manual/About.htm?tocpath=Getting%20Started%7C_____1

[Accessed 4th December 2023].

Engineering Council, 2020. *UK-SPEC*. [Online]

Available at:

[https://www.engc.org.uk/ukspec#:~:text=The%20UK%20Standard%20for%20Professional,or%20Chartered%20Engineer%20\(CEng\).](https://www.engc.org.uk/ukspec#:~:text=The%20UK%20Standard%20for%20Professional,or%20Chartered%20Engineer%20(CEng).)

[Accessed 15th November 2023].

Engineering Council, 2021. *Guidance on Sustainability*. [Online]

Available at: https://www.engc.org.uk/media/3555/sustainability-a5-leaflet-2021-web_pages.pdf

[Accessed 16th November 2023].

Engineering Council, 2021. *Guidance on Risk*. [Online]

Available at: <https://www.engc.org.uk/risk>

[Accessed 11th December 2023].

Gould, G., 2019. *The importance of a management of change (MOC) system*. [Online]
Available at: <https://www.wolterskluwer.com/en/expert-insights/the-importance-of-a-management-of-change-moc-system#:~:text=An%20MOC%20is%20used%20to,could%20result%20from%20these%20changes.>
[Accessed 17th November 2023].

GOV.UK, 2015. *Equality Act 2010: guidance*. [Online]
Available at: <https://www.gov.uk/guidance/equality-act-2010-guidance>
[Accessed 9th December 2023].

Grahams, B., 2023. *9 REASONS WHY SOFTWARE DEVELOPMENT IS IMPORTANT*. [Online]
Available at: <https://lobsterdigitalmarketing.co.uk/9-reasons-why-software-development-is-important/>
[Accessed 17th November 2023].

IET, 2019. *Rules of Conduct*. [Online]
Available at: <https://www.theiet.org/about/governance/rules-of-conduct/>
[Accessed 15th November 2023].

IET, n.d. *BS 7671 - 18th Edition*. [Online]
Available at: <https://electrical.theiet.org/bs-7671/>
[Accessed 17th November 2023].

IET, n.d. *Supply of machinery safety regulations 2008*. [Online]
Available at: <https://www.theiet.org/impact-society/factfiles/engineering-safety-factfiles/supply-of-machinery-safety-regulations-2008/>
[Accessed 23th November 2023].

Jacott, G., 2016. *VFD efficiency: Three best practices*. [Online]
Available at: <https://www.plantengineering.com/articles/vfd-efficiency-three-best-practices/>
[Accessed 17th November 2023].

KissFlow, 2023. *5 Major Project Management Risks and How to Mitigate them*. [Online]
Available at: <https://kissflow.com/project/project-risk-management/>
[Accessed 9th December 2023].

Office for Product Safety & Standards, 2023. *Supply of Machinery (Safety) Regulations 2008: Great Britain*. [Online]
Available at: <https://www.gov.uk/government/publications/supply-of-machinery-safety->

[regulations-2008/supply-of-machinery-safety-regulations-2008-great-britain](#)

[Accessed 24th November 2023].

Project Manager, ND. *Work Breakdown Structure*. [Online]

Available at: <https://www.projectmanager.com/work-breakdown-structure>

[Accessed 10th December 2023].

Royal Academy of Engineering, 2023. *Ethics*. [Online]

Available at: <https://raeng.org.uk/ethics>

[Accessed 16th November 2023].

Royal Academy of Engineering, Engineering Council, 2017. *Statement of Ethical Principles*.

[Online]

Available at: <https://www.engc.org.uk/standards-guidance/guidance/statement-of-ethical-principles/>

[Accessed 14th November 2023].

SICK, 2023. *Color sensors: CSS High Resolution*. [Online]

Available at: <https://www.sick.com/gb/en/catalog/products/detection-sensors/color-sensors/css-high-resolution/css-wbgad4118aa10z/p/p673397?tab=detail>

[Accessed 1st December 2023].

SICK, n.d. *ICR890-4 8k Pro Color*. [Online]

Available at: <https://www.sick.com/ag/en/catalog/system-solutions/track-and-trace-systems/icr-identification-system/icr890-4-8k-pro-color/p/p676165>

[Accessed 3rd December 2023].

Siemens, n.d. *SIMATIC HMI Panels – machine-oriented operation made easy*. [Online]

Available at: <https://www.siemens.com/global/en/products/automation/simatic-hmi/panels.html>

[Accessed 3rd December 2023].

Siemens, n.d. *SIMATIC S7-1500*. [Online]

Available at:

<https://new.siemens.com/global/en/products/automation/systems/industrial/plc/simatic-s7-1500.html>

[Accessed 1st December 2023].

The National Archives, 2021. *The Management of Health and Safety at Work Regulations 1999*. [Online]

Available at: <https://www.legislation.gov.uk/uksi/1999/3242/regulation/3/made>
[Accessed 23th November 2023].

Welsh Government, n.d. *Workplace Recycling, let's get it sorted*. [Online]
Available at: https://www.gov.wales/workplace-recycling?gclid=CjwKCAiAu9yqBhBmEiwAHTx5pxQdWTZg_MRWzGQ-nZSTCslfzuaHjPhJUPmckLC5AkjSXETKVx-WChoCqtEQAvD_BwE
[Accessed 17th November 2023].

9.1 Appendix 1 - Project Proposal

PROJECT PROPOSAL DOCUMENT

Student Name: Alex Williams

Project Title: Receive Automated Sortation

Date: 6/10/23

Budget: £70,000

Description of Project

The project is to be based at a local fulfilment centre for a global distribution company. The project will be in the Receive department where cartons are processed into the building from various suppliers across Europe and broken down to individual units to be stowed or transhipped to various other fulfilment centres across the EU.

The project aims to reduce the labour costs of the receiving process and to automate the process of receiving inbound goods into the dock before being decanted in the receive area. Proof of concept would be delivered on the training rig in the engineering workshop and would involve the Reliability Maintenance Engineering Team (RME) and the Automation Engineering team.

When the project goes into plant it would then involve multiple departments of the company including:

- Reliability Maintenance Engineering Team (RME)
- AFT - Fulfilment Technologies Team
- Health and Safety
- Operations
- Learning and Development
- Procurement

The budget is to be £70,000 but as per company policy it must have a return of investment in 2 years or would require high level approval.

Due to operational requirements within the company the project must have a completion date of July 2024. Proof of working concept and installation plans must be completed by April 2024 in order to meet the July 2024 deadline in readiness for full peak operation in November 2024.

Agreement for project proposal

Student Signature: _____AW_____ Date: 26/10/23

Industrial Supervisor Signature: _____JFC_____ Date: 26/10/23

Academic Tutor Signature: _____RD_____ Date: 27/10/23

9.2 Appendix 2 - Risk Assessment for implementation phase

9.2.1 Appendix 2.1 – Project Risks and Mitigations

Table 7: Project Risk Management and Mitigation

Identification of Risks	Risk Evaluation	Mitigation to Control Risk
External Risks due to : • Changes in stakeholder or company expectations /senior management decisions • Contractors/suppliers going bankrupt • Contractor, labour and material availability • Economic upheaval e.g. as a result of pandemic/war/recession	Can affect scope and budget creep and has additional financial implications for the company	-Identify exactly what the company/stakeholders require and include all details in a written request. -Agree functional design specifications (FDS) and test plans -Research the available technology to achieve project objectives -Identify alternative suppliers/contractors and make a reserve list
Project Management Risks due to: (i) Scope Creep -occurs if parameters are ill-defined from the outset. Pressures arise either internally from the project team or externally from customers/senior managers to take on tasks not part of the original project -plan due to evolving business needs -incorrect or insufficient collaborative contacts are established from the start	Incremental adjustments to the project plan can result in additional workload, delays, costs and even project failure due to the lack of time or resources necessary to complete the extra tasks	• Identify key personnel, suppliers, contractors and stakeholders with the necessary competencies and diverse backgrounds to be part of the project team and encourage strong working relationships between them • Evaluate the three solutions, ensuring that they meet the agreed FDS so that the project will be in scope • Set a baseline project plan to define the project's tasks and resource requirements

(ii) Budget Creep - Occurs where there are changes in project scope - Budget overrun due to overly optimistic cost estimates - unforeseen changes in material or labour costs. - Poor planning and communication	Budget creep has financial implications and can also result in project failure	• Develop work-breakdown structures (WBS) to implement the project's tasks and manage the project • Research carefully, estimate project expenditure, summarise the planned expenses and create a resource plan • From the WBS, develop a Gantt chart to assign timelines to each task and create target timelines to keep the project on target, within scope and within budget • Establish monitoring procedures to measure progress against the Gantt chart and manage any necessary changes • Project transparency can keep the project within budget if the project team/company client have all relevant information
(iii) Poor Communication/Lack of Clarity -Unclear requirements due to poor communication between the stakeholders, project team and company client can result incorrect project assumptions leading to incorrect deliverables -Can arise from language barriers, cultural differences, technological limitations, or lack of clarity in messages.	Can impact project and its delivery leading to delays, repeating the work, or project failure	• Decide on the best communication strategy that will serve everyone involved in the project, including communication between senior managers so there is a 'top to bottom' approach e.g. a combination of email/TEAMS/Chime/face-to face project meeting

(iv) Poor scheduling -Can occur if the time or external resources required to complete the project are under-estimated or become unavailable or is influenced by external sources	Can impact the project due to delays, increased financial costs and possible project failure	• Ensure everyone involved is able to access any communication platforms that are chosen • Expectations about response times should be clear and set a good example of professional communication style and tone. • Make project schedule accessible to all involved and communicate any revisions to the plan or timelines to all parties so everyone understand how project is evolving • Ensure effective closing down of the project- notify everyone involved of its completion, finalise and review testing procedures to gauge success and identify any faults to be corrected. Check all contractual terms of the project have been met.
Internal Risks: • Insufficient staff with the necessary key skills • Staff shortage due to sickness or leave • Employment retention problems due to the company not fulfilling the needs of their staff	Untrained staff can cause financial problems due to incorrect equipment use, orders not being fulfilled, mistakes occurring. It may also have legal implications if not complying with legislation or breaching contracts Personnel shortages can cause project delays	• Identify training needs for new/ existing staff needing to use the equipment • Identify staff that can cover for each other during staff shortages, including senior managers who may need to authorise work or approve contingency plans and issue necessary work permits to external contractors • Ensure that all project work is undertaken ethically so staff remain motivated and key staff with the necessary competencies are retained

	resulting in financial loss for the company If staff feel unhappy/demotivated it can result in employees leaving the company and have financial implications as there is insufficient staff to complete the project. This can cause project delays and reputational harm for the company	• Ensure compliance with any technical documents and operational manuals. Where these are unavailable, write work procedures/instruction documents
Technical/ Equipment and System Risks- • Unavailability, delay or shortfall of equipment and system components • equipment failure; • Upgradability and complexity of equipment may cause future operational issues if incorrect equipment is used	Can result in project delays and budget creep, causing financial harm to the company Unfamiliarity with the equipment by the end user can result in accidents, problems with staff retention and staff becoming demotivated	• Prepare a list of alternative manufacturers, contractors and suppliers if the company's preferred ones are unable to complete the work/ supply the equipment on time • Draft instructions/procedures for end users • Consider each component, determine how it can fail, the effect of the failure, its severity, likely occurrence and methods of detecting failures and correcting defects • Test equipment prior to commissioning, • Have basic spare consumables on site in case of equipment failure • Research equipment to be installed and consider its upgradability to ensure the company's current and future needs are fulfilled, consider if software

		programmes are capable of upgrades and analysing data streams • Use equipment that is both cost effective , will perform the required functions and meets growth needs
Legal Risks due to: - • Regulatory- i.e. non-compliance with legislation, particularly environmental and health and safety legislation • Contractual- arising from any party not fulfilling contract terms or damage caused by poor performance. • Litigation due to negligence, non-compliance with licence agreements/commercial liability/ failure to consider intellectual property rights .	Non-compliance with legislation can result in prosecution by the relevant Regulator e.g. HSE/ breach of contracts and litigation Can result in civil penalties. These will all cause financial loss and reputational harm to the company	• Research and identify applicable legislation, codes of practice and industry standards. Ensure compliance with this regulatory framework, with particular reference to Health and Safety at Work etc Act 1974 and all umbrella legislation under this Act, The Supply of Machinery (Safety) Regulations 2008, Provision and Use of Work Equipment Regulations 1998, BS7671:2018 (IET Wiring Regulations 18th Edition . • Future proof project by researching if any new legislation is likely to be introduced or amended • Ensure that a declaration of conformity is signed by the machine manufacturer to demonstrate product safety • After the completion of the installation work, undertake testing and commissioning procedure including an internal company Safety Workstation / Equipment Handover (SWEH) document. • Protect intellectual property rights by knowing what they are, adhering to licence agreements, drawing up

	Unethical practices can result in discrimination against individuals or groups. This could have legal implications, cause damage to the company's reputation and result in staff retention problems Unsustainable practices can affect the environment, breach environmental waste legislation, have financial implications and result in reputational harm	contracts to include work schedules and contractors signing non-disclosure agreements . • All contracts to be signed by a Level 5 senior authorised manager and reviewed by the legal team • Carry out all project work professionally and ethically, ensuring compliance with the Engineering Council's guidance and the Equality Act 2010 • Project to be undertaken in a sustainable manner having regard to compliance with the Engineering Council's 6 principles on sustainability, environmental legislation, resources and the wider social implications. Where possible source products locally, minimise/ recycle waste, re-use equipment – re-use PLC and HMI screen, option chosen which works with existing conveyance
--	---	--

9.2.2 Appendix 2.2 – Implementation Risk Assessment

HAZARD		Risk Assessment (No Control)			CONTROL			Risk Assessment (With Control)				
		L	C	R				L	C	R		
General Site Hazards		3	5	15	- Basic PPE – safety boots, and high visibility clothing. - Specific PPE for particular tasks – Safety glasses, ear protectors, gloves - Access to all working areas controlled by barriers, tapes, cones, and signs.			2	3	6		
					- Personnel are trained and competent to use the power tools. - Power tools to be 110V or battery powered. - Daily power cable / extension lead inspection. - Portable electrical equipment to be suitably inspected (PAT where necessary), or new. - Hot work permit if grinding is required. - Specific PPE used.			1	2	2		
	Power Tools	4	5	20								
Vehicles		3	5	15	- No vehicles operating in the cordoned workshop area. - Construction debris cleared and disposed in designated waste skips. - Spillage cleaning materials and equipment available. - Chemicals used on site to be labelled and stored correctly. - No food or drink consumed in working areas. - Access routes free from tripping hazards.			1	5	5		
Housekeeping		3	5	15	- Personnel are trained and competent to use the hand tools. - Specific PPE used.			1	3	3		
Mechanical Hand Tools		3	2	6	- Use of caution to prevent entry of non-authorised personnel into work area. - Access permitted to the work area to non-authorised personnel only after handover is complete.			1	2	2		
Injury to other Personnel on site		3	5	15	Personnel are trained and competent in safe manual handling and lifting.			1	4	4		
Manual Handling		3	4	12	Electrical equipment inspected daily before use.			1	4	4		
Electrocution		4	5	20	- Strictly only competent personnel to use equipment. - Isolated and Lock out Tag out principle applied when not in use.			1	5	5		
Likelihood (L)		Consequence (C)			Action Levels based on risk:							
					L/C	1	2	3	4	5	Risk Range	Risk Status
1 = Very Unlikely (1 in a million)		1 = Insignificant (No injury)			1	1	2	3	4	5	1-2	Acceptable with the controls maintained.
2 = Unlikely (1 in 100,000)		2 = Minor (First aid required)			2	2	4	6	8	10	3-4	Acceptable, but consider control improvements.
3 = Fairly likely (1 in 10,000)		3 = Moderate (Up to 3-day absence)			3	3	6	9	12	15	5-9	Adequate, but discuss control improvements at project review.
4 = Likely (1 in 1000)		4 = Major (More than 3-day absence)			4	4	8	12	16	20	10-16	Tolerable, but improve controls in a fixed time scale.
5 = Very likely (1 in 100)		5 = Catastrophic (Death)			5	5	10	15	20	25	17-25	Unacceptable. Stop activity until control improvements are made.

Table 8: Implementation Risk Assessment

9.3 Appendix 3 - Scoring Matrix for Solutions

Criteria	Solution 1	Solution 2	Solution 3
Cost	5	3	4
Complexity	4	2	3
Scalability	5	2	4
Sustainability	4	3	4
Deliverability	4	2	3
ROI <2 Years	5	3	4

Table 9: Solution Scoring Table

9.4 Appendix 4 - WBS Chart

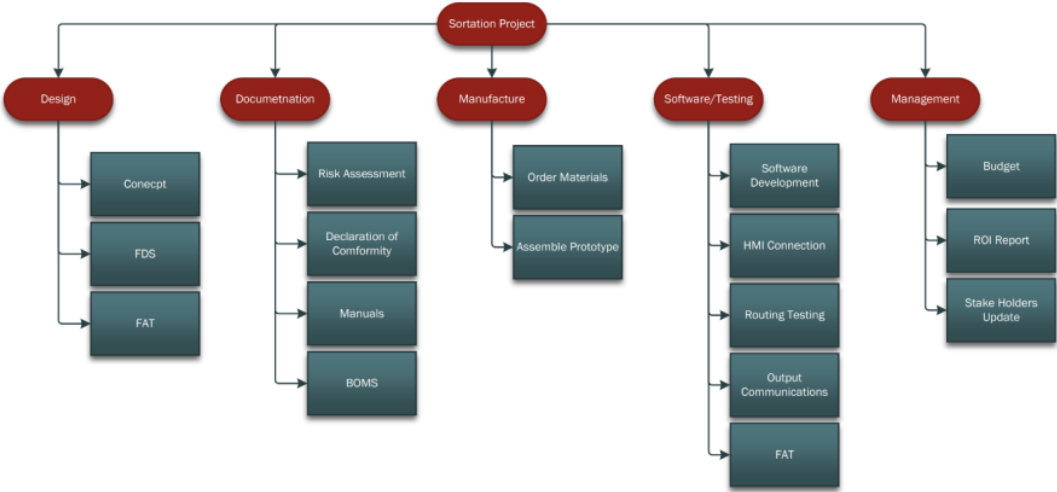


Figure 7: WBS Chart

9.5 Appendix 5 - Gantt Chart

Project Plan

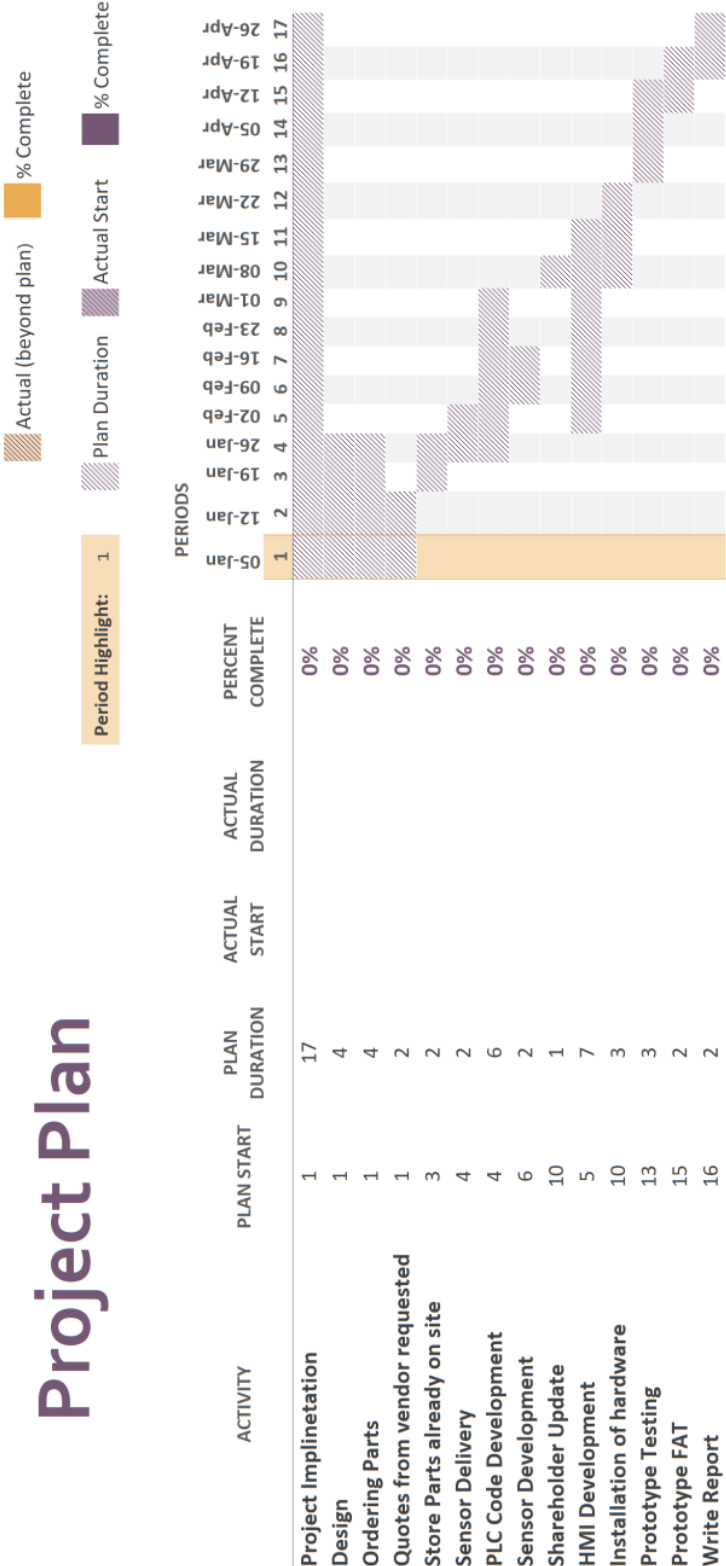


Figure 8: Gantt Chart

9.6 Appendix 6 - Costing Spreadsheet

Table 10: Solution One Cost

Item	Description	Part No	Units	Cost Per Unit	Line Cost
1	Colour Sensor	1120172	1	£ 558.14	£ 558.14
2	Plate K for universal clamp bracket, steel, zinc coated, Universal clamp (2022726), mounting hardware	2022718	1	£ 20.91	£ 20.91
3	Mounting bar, L-shaped, 150 mm x 150 mm, steel, steel, zinc coated, without mounting hardware	4056052	1	£ 8.85	£ 8.85
4	Sensor/actuator cable 5m	2095653	1	£ 20.84	£ 20.84
5	RAY26 Reflex Array	1221943	1	£ 132.51	£ 132.51
6	SIMATIC S7-1500, CPU 1511-1 PN	6ES7511-1AK02-0AB0	1	£ 560.80	£ 560.80
7	SIMATIC S7-1500 DI 32x24VDC HF	6ES75211BL000AB0	1	£326.00	£ 326.00
8	SIMATIC S7-1500 DO 32x24VDC/0.5A HF	6ES75221BL010AB0	1	£464.00	£ 464.00
9	SIMATIC S7-1500 Front connector Screw terminals For 35 mm modules	6ES75921AM000XB0	2	£ 37.00	£ 74.00
10	SIMATIC HMI TP700 Comfort	6AV2124-0GC01-0AX0	1	£ 926.00	£ 926.00
11	Siemens, SIRIUS ACT, Panel Mount Green LED Pilot Light, 22mm Cutout, IP20, Round, 24V ac/dc	3SU1102-6AA40-1AA0	1	£ 14.03	£ 14.03
12	Phoenix Contact QUINT-PS/1AC/24DC/5 Switch Mode DIN Rail Power Supply, 85 → 264V ac ac Input, 24V dc dc Output	2866750	1	£ 198.59	£ 198.59
13	RS PRO Blue 0.75 mm² Hook Up Wire, 24/0.2 mm, 100m	180-5922	1	£ 27.43	£ 27.43
14	Scalability Cost	-	-	-	£25,500.00
				Total	£28,832.10

Table 11: Solution Two Cost

Item	Description	Part No/Quote Ref.	Units	Cost Per Unit	Sub Cost
1	JCR890-4 8K Pro Colour - Line Scan Barcode Camera & Illumination	20230141-6	1	£14,968.22	£ 14,968.22
2	Associated Brackets & Cables				
3	MSC 800 & Firmware Upgrade				
4	Single Item Verification				
5	RAY26 Reflex Array	1221943	1	£ 132.51	£ 132.51
6	SIMATIC S7-1500, CPU 1511-1 PN	6ES7511-1AK02-0AB0	1	£ 560.80	£ 560.80
7	SIMATIC S7-1500 DI 32x24VDC HF	6ES75211BL000AB0	1	£326.00	£ 326.00
8	SIMATIC S7-1500 DO 32x24VDC/0.5A HF	6ES75221BL010AB0	1	£464.00	£ 464.00
9	SIMATIC S7-1500 Front connector Screw terminals For 35 mm modules	6ES75921AM000XB0	2	£ 37.00	£ 74.00
10	SIMATIC HMI TP700 Comfort	6AV2124-0GC01-0AX0	1	£ 926.00	£ 926.00
11	Siemens, SIRIUS ACT, Panel Mount Green LED Pilot Light, 22mm Cutout, IP20, Round, 24V ac/dc	3SU1102-6AA40-1AA0	1	£ 14.03	£ 14.03
12	Phoenix Contact QUINT-PS/1AC/24DC/5 Switch Mode DIN Rail Power Supply, 85 → 264V ac ac Input, 24V dc dc Output	2866750	1	£ 198.59	£ 198.59
13	RS PRO Blue 0.75 mm² Hook Up Wire, 24/0.2 mm, 100m	180-5922	1	£ 27.43	£ 27.43
14	Scalability Cost	-	-	-	£ 35,000.00
				Total	£ 52,691.58

Table 12: Solution Three Cost

Item	Description	Part No	Units	Cost Per Unit	Sub Cost
1	Cognex DM303X	DMR-303X-00	1	£ 990.00	£ 990.00
2	Cognex Control Box 820-9128-1RB	DMA-CC-4X	1	£ 880.00	£ 880.00
3	M12 Ethernet	CCB-84901-2001-10	1	£ 62.28	£ 62.28
4	Control Cable	IVSL-FSK-J5000	1	£ 20.00	£ 20.00
5	RAY26 Reflex Array	1221943	1	£ 132.51	£ 132.51
6	SIMATIC S7-1500, CPU 1511-1 PN	6ES7511-1AK02-0AB0	1	£ 560.80	£ 560.80
7	SIMATIC S7-1500 DI 32x24VDC HF	6ES75211BL000AB0	1	£ 326.00	£ 326.00
8	SIMATIC S7-1500 DO 32x24VDC/0.5A HF	6ES75221BL010AB0	1	£ 464.00	£ 464.00
9	SIMATIC S7-1500 Front connector Screw terminals For 35 mm modules	6ES75921AM000XB0	2	£ 37.00	£ 74.00
10	SIMATIC HMI TP700 Comfort	6AV2124-0GC01-0AX0	1	£ 926.00	£ 926.00
11	Siemens, SIRIUS ACT, Panel Mount Green LED Pilot Light, 22mm Cutout, IP20, Round, 24V ac/dc	3SU1102-6AA40-1AA0	1	£ 14.03	£ 14.03
12	Phoenix Contact QUINT-PS/1AC/24DC/5 Switch Mode DIN Rail Power Supply, 85 → 264V ac ac Input, 24V dc dc Output	2866750	1	£ 198.59	£ 198.59
13	RS PRO Blue 0.75 mm² Hook Up Wire, 24/0.2 mm, 100m	180-5922	1	£ 27.43	£ 27.43
14	Scalability Cost	-	-	-	£25,000.00
				Total	£29,675.64

9.7 Appendix 7 - Log entries up the present time

SGEL6000

Independent Project

Log Book

Alex Williams

Receive Automated Sortation

2023-2024

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	29/09/23	Introduction to project	2	4
2	06/10/23	Writing proposal - draft stage.	4	6
3	13/10/23	Project Proposal meeting with employer	2	8
4	20/10/23	Project Background and Problem Definition and Constraints	4	12
5	27/10/23	Project Background and Problem Definition and Constraints, proposal review with tutor,	4	16
6	3/11/23	Project Background	1	17
7	10/11/23	Problem Definition and timelines	3	20
8	17/11/23	Constraints completed and researching products	2	22
9	24/11/23	FDS and testing completed. Conversations with SICK.	2	24
10	1/12/23	Formatted report and block diagrams	4	28
11	8/12/23	Completed literature review and costing	6	34
12	15/12/23	Completed planning, WBS and management techniques	4	38
13	22/12/23	Formatting of report for submission	4	42
14				
15				
16				
17				

18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Log Entry Sheet

Log Number	1
Date	29/09/23
Duration (hrs)	2
Accumulated time (hrs)	2

Record of activities and achievements

Introduced to the project and discussed ideas with the college tutor. Meeting has been scheduled for during the week with my employer to replay the discussions of the requirements needed for the independent project.

Assumptions and abbreviations:

Calendar week goes Sunday to Saturday.

WC - Week Commencing.

Plans for next week

Start drafting a project proposal to present to my tutor and employer when the meeting takes place. Meeting scheduled for calendar week 40, week commencing (WC) Sunday 1st October.

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	2
Date	06/10/23
Duration (hrs)	2
Accumulated time (hrs)	4

Record of activities and achievements

Meeting with my employer has been pushed back two weeks. One week for an internal company audit which takes precedence and a further week due to being asked to support another site during its launch.

Project proposal is in the draft stage. Tutor to review the proposal and revisions to be made as necessary. Proposal structure looked at and discussions took place regarding the needs for sustainable engineering and business requirements such as return of investment (ROI).

Plans for next week

Made any required amendments to the project proposal to ensure it is ready to present to my employer during a meeting that will take place in calendar week 42 (Week commencing Sunday 15th October).

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	3
Date	13/10/23
Duration (hrs)	2
Accumulated time (hrs)	6

Record of activities and achievements

Finished the draft of the project proposal and prepared to present it to my employer.
Discussed any potential vendors or people could reach out to technical support if needed during the project.

Plans for next week

Looking at potential constraints that could be encountered in the project. Constraints could fall into environmental, engineering, legal and commercial, financial and machine safety.

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	4
Date	20/10/23
Duration (hrs)	4
Accumulated time (hrs)	12

Record of activities and achievements

Gone through project constraints. Investigated different safety ratings of machines. Looked at risk exposure, risk rating, risk reduction, and performance level with the tutor.

Had an informal discussion with the company's automation engineer about ideas for the project and reached out to SICK to see what cameras and sensors are on the market.

Plans for next week

Finalise problem background, definition and constraints. Get a budget confirmed with my employer to have further guidance on the project to scope out products that will come within budget.

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	5
Date	27/10/23
Duration (hrs)	4
Accumulated time (hrs)	16

Record of activities and achievements

Budget confirmed with my employer. With a college tutor, I looked into constraints in more detail looking at different categories of constraints and how they can all have an effect on the project. Review of proposal with college tutor and adjustments made to include more specific deadlines.

Carried on with project background and problem definition.

Plans for next week

To complete constraints, background and problem definition.

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	6
Date	3/11/23
Duration (hrs)	1
Accumulated time (hrs)	17

Record of activities and achievements

Limited progress on report due to other commitments while in work with safety jobs taking priority. Project background section completed.

Plans for next week

Limited time projected for next week, aim to complete problem definition.

Signed *R. Davies*

Signed A. Williams

Log Entry Sheet

Log Number	7
Date	10/11/23
Duration (hrs)	3
Accumulated time (hrs)	20

Record of activities and achievements

Limited progress on report due to other commitments while in work with safety jobs taking priority. problem definition section completed. Discussed with tutor project timelines and where improvements can be made.

Plans for next week

Complete constraints section of task 4.

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	8
Date	17/11/23
Duration (hrs)	2
Accumulated time (hrs)	22

Record of activities and achievements

Constraints completed and started researching products that can sort products.

Plans for next week

Complete the FDS and testing to be able to find solutions.

Signed *R. Davies*

Signed A. Williams

Log Entry Sheet

Log Number	9
Date	24/11/23
Duration (hrs)	2
Accumulated time (hrs)	24

Record of activities and achievements

FDS and testing completed. Emails sent to SICK regarding potential product information to assist with solutions.

Plans for next week

Draft solutions in block diagrams and complete literature review.

Signed *R. Davies*

Signed A. Williams

Log Entry Sheet

Log Number	10
Date	01/12/23
Duration (hrs)	4
Accumulated time (hrs)	28

Record of activities and achievements

All previous sections have been compiled into one report and formatted. Literature review started. Discussion with tutor about flow charts vs block diagrams.

Plans for next week

Complete Literature review

Signed *R. Davies*

Signed A.

Williams

Log Entry Sheet

Log Number	11
Date	8/12/13
Duration (hrs)	6
Accumulated time (hrs)	34

Record of activities and achievements

Literature review completed. Three solutions proposed with each being cost and compared in a radar diagram.

Plans for next week

Complete Project Planning, Work Breakdown Structure and Management Techniques and conclusion of report.

Signed *R. Davies*

Signed *A. Williams*

Log Entry Sheet

Log Number	12
Date	15/12/23
Duration (hrs)	4
Accumulated time (hrs)	38

Record of activities and achievements

Completed planning, Work Breakdown Structure and management techniques. Near finished conclusion of report.

Plans for next week

Format final report ready for submission.

Signed *R. Davies*

Signed A. Williams

Log Entry Sheet

Log Number	13
Date	22/12/23
Duration (hrs)	4
Accumulated time (hrs)	42

Record of activities and achievements

Completed and formatted final report ready for submission.

Plans for next week

Research and start planning/preparing for presentation.

Signed *R. Davies*

Signed A. *Williams*

9.8 Appendix 8 – Preferred Suppliers

Table 13: 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

82/100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

PAGE 4

PAGE 5

Text Comment. This is a good summary that outlines most of the things done in the report.

Text Comment. However, you haven't mentioned, risks and testing

Text Comment. created

Text Comment. set out

Text Comment. Implement and utilise both mean to carry out, but the project is not done yet!

PAGE 6

Text Comment. a good introduction to the report but some items from the FDS have crept in

Text Comment. This table is a helpful key to understanding the above flow chart

Text Comment. However, you have not defined "tranship" though it can be deduce from your statement later

Text Comment. HGVs

Text Comment. they are

Text Comment. would reduce

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. your reader may not know what is a VFD

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 13

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 14

PAGE 15

Text Comment. requires

PAGE 16

PAGE 17

PAGE 18

Text Comment. should this be >99%?

PAGE 19

Text Comment. of £

PAGE 20



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.



Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

PAGE 37

PAGE 38

PAGE 39

PAGE 40

PAGE 41

PAGE 42

PAGE 43

PAGE 44

PAGE 45

PAGE 46

PAGE 47

PAGE 48

PAGE 49

PAGE 50

PAGE 51

PAGE 52

PAGE 53

PAGE 54

PAGE 55

PAGE 56

PAGE 57

PAGE 58

PAGE 59

PAGE 60

PAGE 61

PAGE 62

PAGE 63

PAGE 64

PAGE 65

PAGE 66

PAGE 67

PAGE 68

PAGE 69

PAGE 70

PAGE 71

PAGE 72

PAGE 73

PAGE 74

PAGE 75

GRADING FORM: NEW CSG-RUBRIC

ALEX WILLIAMS

82

1. ENGAGEMENT WITH LITERATURE



Sections 3 and 5: Engagement in research, judicial use and critical evaluation sources for project constraints and literature review of solutions
Excellent engagement with literature (8/10)
Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing
Wide range, correct use of Harvard (8/10)

16

2. KNOWLEDGE AND UNDERSTANDING



Section 3: Project background and problem definition
Briefly explained in a succinct way covering the main points. (4/5)
Section 3: Project constraints: Ethical.
Good coverage. (4/5)
Section 3: Project constraints: Sustainability
Good coverage. (4/5)
Section 3: Project constraints: Legal/Commercial
Good coverage. (4/5)

16

3. COGNITIVE AND INTELLECTUAL



Section 4: Functional Design Specification
A good list of outcomes with a useful referencing system of letters and numbers. (4/5)

16

Section 4: Test planning
A clear testing table that enables the FDS outcomes to be tested (4/5)

Section 5: Evaluation of solutions and justification of final solution

A good detailed section that explores all three solutions. Radar diagram identifies the best solution. (4/5)

Section 7: Conclusions and Recommendations

A very good set of conclusions with some recommendations. (4/5)

4. PRACTICAL APPLICATION



Section 6: Project Plan

A good planning system with milestone chart. However, each of the tasks and subtasks of the WBS should be included in the Gantt chart which should also contain contingencies. (4/5)

16

Section 6: Working breakdown structure, costing exercise and management techniques
Very detailed (4/5)

Appendix: Risk assessment for implementation phase
Excellent treatment (5/5)

Appendix: Planning phase log-book entries.
All entries present but many are very brief. (3/5)

5. TRANSFERABLE SKILLS



Section 1: Executive summary

18

A very good summary with a few things missing
(4/5)

All Sections: Presentation quality of the report,
diagrams, charts, tables, figure numbering, page,
and section numbering etc
Excellent (5/5)

All Sections: Quality of the writing style, use of
punctuation and grammar
Excellent (4/5)

Word count limit not exceeded
Not exceeded (5/5)