

1302736

by Jason Booth

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Contents

1. Research	3
2. System Overview and Operation	5
2.1 Conveyor Tracking	9
2.3 Wagon Coding System	12
3. Health and Safety, Maintenance and Reliability Requirement	16
4. System Design Adaption	19
5. Conclusion and Recommendations	21
6. Team Working	22
7. Citation List	23
8. Appendix	24
VoT Testing	24
 Figure 1	 5
Figure 2	5
Figure 3	6
Figure 4	7
Figure 5	7
Figure 6	8
Figure 7	8
Figure 8	9
Figure 9	10
Figure 10	10
Figure 11	11
Figure 12	11
Figure 13	12
Figure 14	12
Figure 15	13
Figure 16	13
Figure 17	13
Figure 18	14
Figure 19	14
Figure 20	14
Figure 21	15
Figure 22	15
Figure 23	17
Figure 24	21

1. Research

Industry 4.0 is creating new and exciting ways companies manufacture, improve and ship their products. New technologies are being integrated by manufacturers such as Internet of Things (IoT), cloud computing and analytics, and AI and machine learning to their production houses and throughout their operations. (IBM, 2019) Correctly cited

Smart factoring that has fully adopted industry 4.0 technologies will be equipped with advanced sensors, embedded software and robotics collecting and analyse data to allow for better decision making, working in harmony together without the use of human involvement. (2019)

M2M is a broad term used to describe technology that can enable devices to send and receive data between two devices without any assistance by humans. M2M is the foundation for the IoT. (Shea, 2020)

M2M communications can be carried over mobile networks by cellular using 4G technology or they can be connected to the network or LAN. (CIO Wiki, 2020)

IoT and M2M both promises to fundamentally change the way the world operates. Because they are so similar, M2M virtually allows any sensor to communicate, which widens the possibility of systems carrying out constant monitoring of themselves and automatically responding to changes in the environment, with far less need for human involvement. This provides an almost autonomous system that is being monitored and altered by computer AI. (Link Labs, 2018)

M2M is among the fastest growing type of connected device technologies in the market right now, largely because M2M technologies can connect million devices within a single network. (2018) author is missing in your citation

A list of benefits that can be obtained by transitioning to industry 4.0 are:

- Real time response to customer request
- High performance optimization due to high level automation
- Malfunctions and errors are prevented thanks to real time monitoring and well in timed alerts
- Business intelligence which helps to prevent waste of resources and in result cutting costs

These are just some of many more benefits. (ISS, 2020)

There are some concerns surrounding M2M and industry 4.0 whereas more and more devices are connected to networks there runs the risk of information being leaked by hackers and intellectual property can be at risk so should be protected carefully. (2020)

M2M is used in lots of places where people are already familiar with. It is adopted in smart meters where devices measure the use of energy of water. It offers ^{explain?}realtime observation of how much commodity is being used and the cost associated with it. Using cellular or WiFi network, the smart meter can send the data to a database owned by the utility company. (TopConnect, 2020)

2. System Overview and Operation

The CIM system in the PLC classroom acts as an assembly line where it puts together a stamp and handle to result in a finished product. It includes material handling from the robot putting the parts together, vision and inspection by the IFM camera, and the process station.

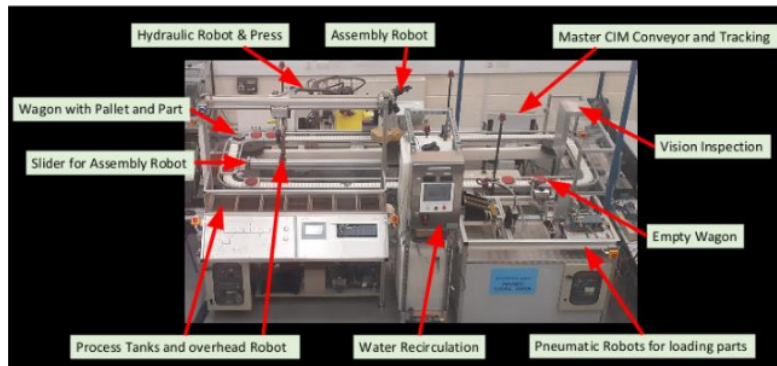


Figure 1

most of your images and figures should be in the appendix as stated in the brief

Figure 1 above shows the layout of the CIM system with arrows showing where each part of the system is such as vision inspection, assembly robot, etc. The main (master) PLC is 101 and is a S7-1511F safety PLC which is responsible for the conveyor and tracking. It comes with safety input and safety output module, along with a power supply and profinet switch for communication between PLCs.

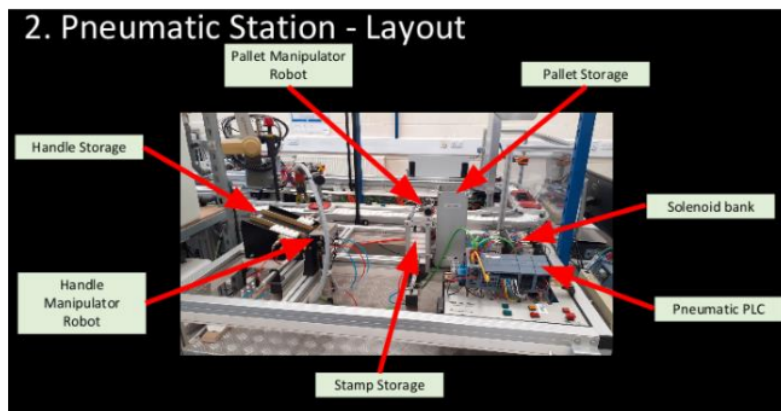


Figure 2

The pneumatic station is controlled by PLC 102 with extra digital input module and relay output module as well as a profinet switch. There is a bank of solenoids used to control the pistons to hold/release the parts. All parts are stored at this station and is placed onto the wagons. It

contains two manipulator robot that places the pallet on to the wagon and the handle on the pallet.

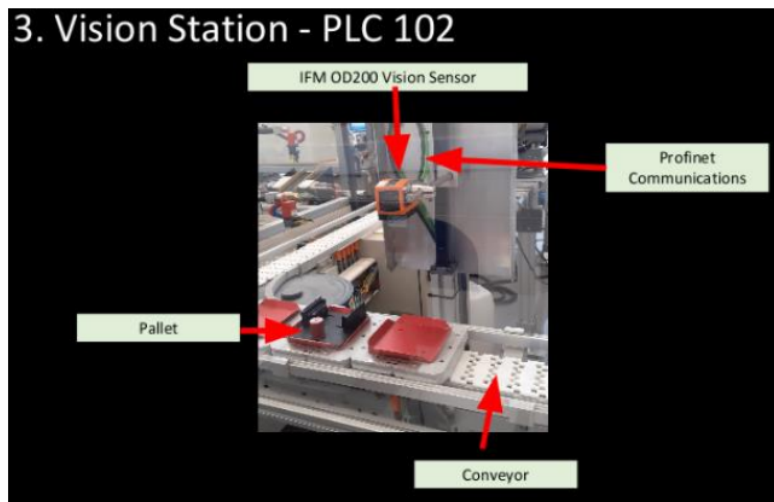


Figure 3

Incorrect, this should be PLC101

The vision station is also controlled by PLC 102. This station is primarily to inspect the wagon and its content to give feedback whether it has passed or failed. The inspection is done by the IFM OD200 vision sensor that has an image of a passed product stored in its memory that compares to the final product on the wagon. If it doesn't match its stored image, then the result is a fail.

5. Hydraulic Station - PLC 104

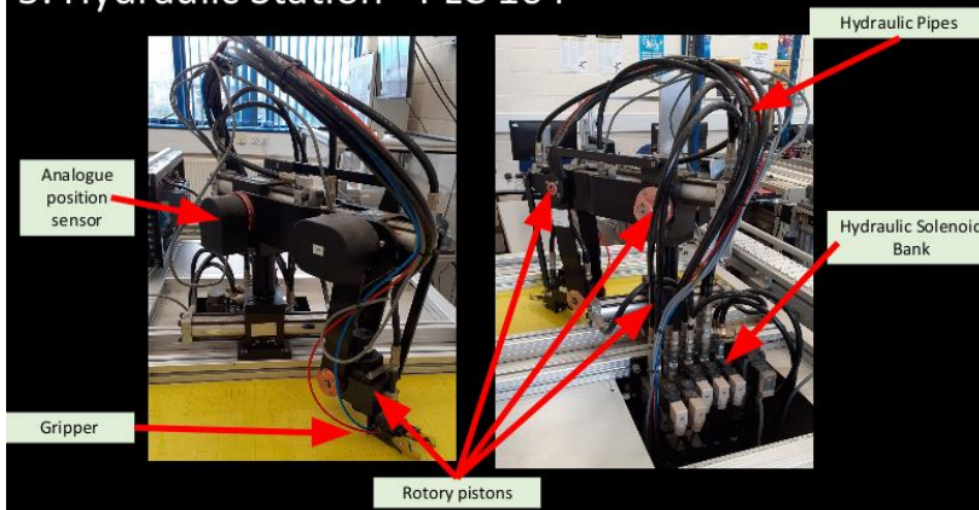


Figure 4

The hydraulic station's job is the storage of product. It is controlled by PLC 104 which is a S7-1214C with additional digital module and analogue module for position feedback. There are a series of manual switches connect to the PLC as well as a HMI screen (134).

7. Assembly Robot and Slider - PLC 106

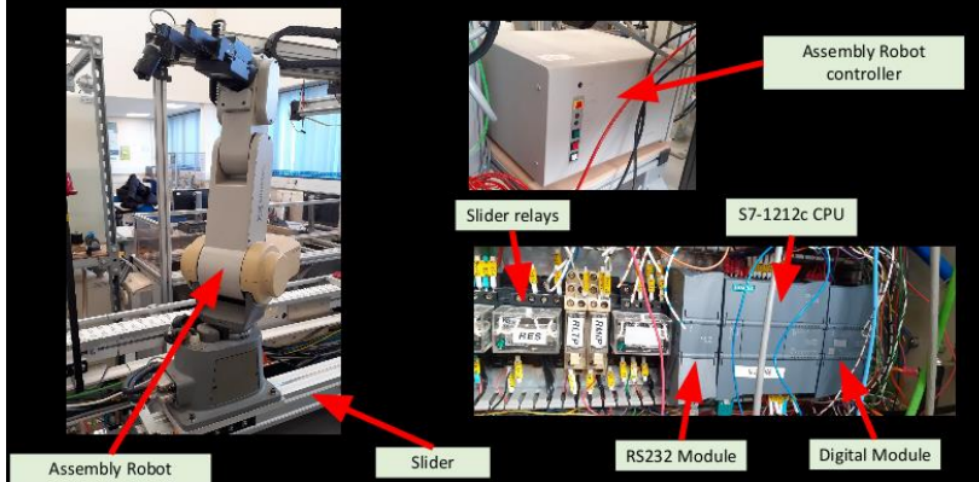


Figure 5

The assembly station assembles the parts together. It is controlled by PLC 106 (S7-1212c) with additional digital module and a RS232 module to control the assembly robot. There are also slider relays for the slider.

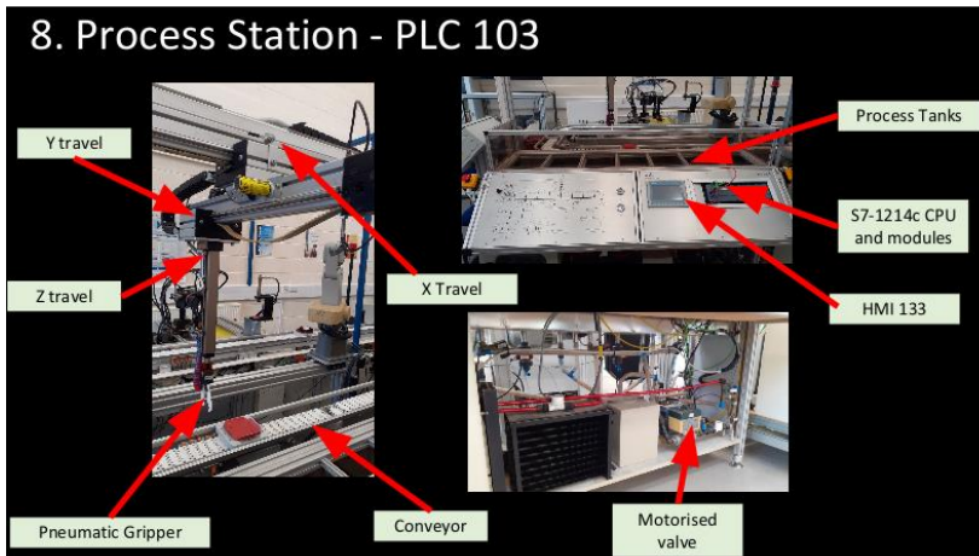


Figure 6

The process station processes the handle. It is controlled by PLC 103 (S7-1214c) with additional modules as well as a HMI (133).

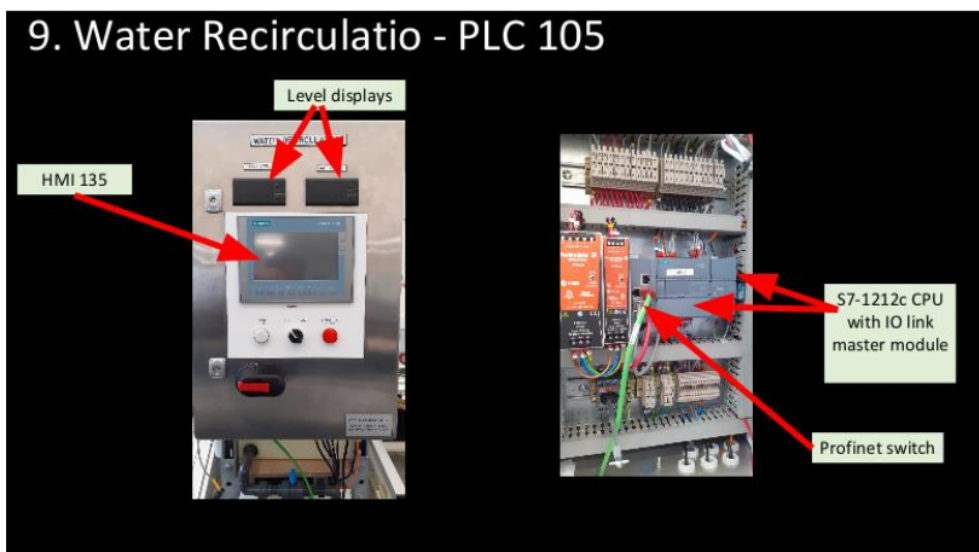
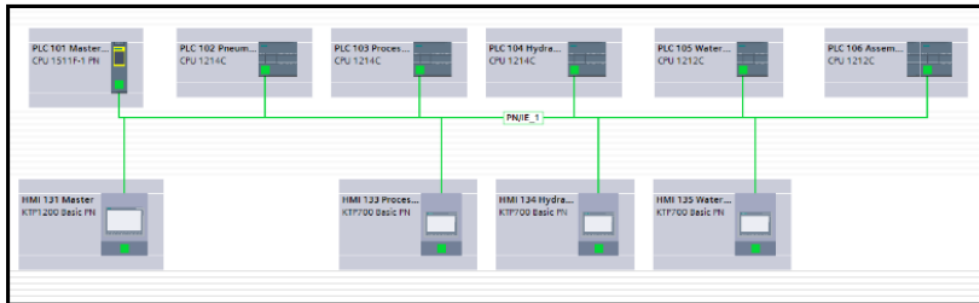


Figure 7

In figure 7 above, this station provides water recirculation and is controlled by PLC 105 (S7-1212c) with a profinet switch and an IO link master module.

The method of communicating between PLCs is by using profinet. The figure below shows the PLCs and HMI devices connected together through profinet with separate IP addresses.



should be figure numbered

2.1 Conveyor Tracking

The tracking of the wagons upon which there will be a pallet and on the pallet there will be 1 of 3 objects is controlled by the Master CIM PLC 1500 series.

In the CIM system contains a conveyor belt that transports the wagon and its contents to each of the stations in the system. The conveyor contains a tracking system that identifies each of the wagons which there are 7 in total. This is helpful to identify the wagon and where it is in the process which can be handy for maintenance and breakdown purposes.

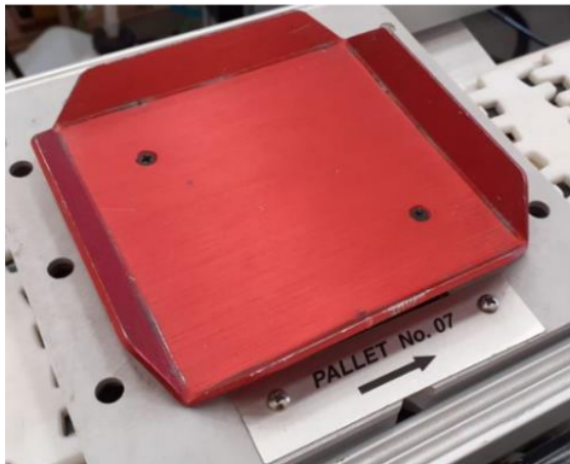


Figure 8

Figure 8 above is an example of an empty wagon. Underneath the wagon contains 5 circular recessed holes with a metal object fitted inside with each wagon having a different amount of metal objects.

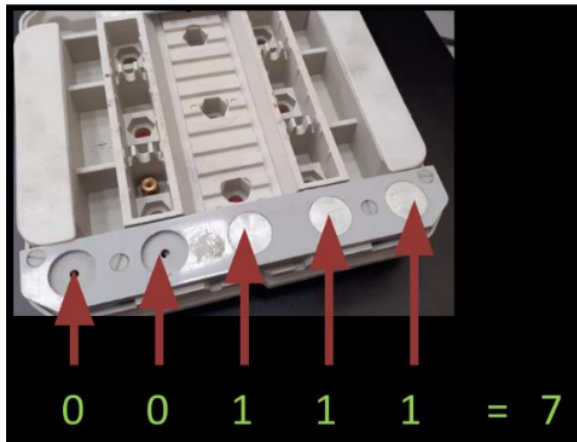


Figure 9

In figure 9 above shows the metal objects fitted into the holes. These metal objects make up a binary number which is used to identify what wagon it is. As can be seen in figure 11, the number for that wagon is 7 because it contains 3 metal objects. Theoretically using the same pattern on the wagons, the maximum number of wagons that can be used on the conveyor is 31 as that is the maximum digital number that can be produced using only 5 notches.

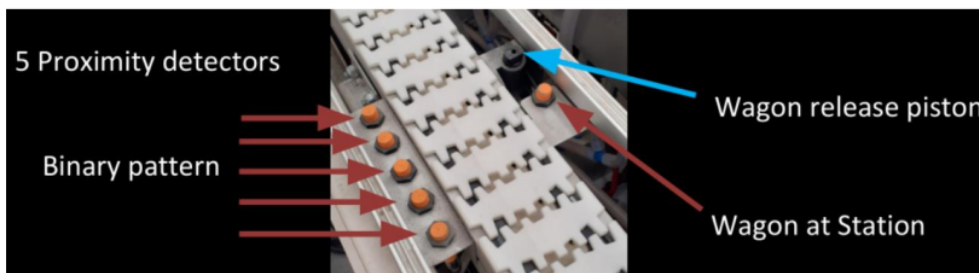


Figure 10

Figure 10 above shows 6 proxy sensors and a piston which are located right next to the conveyor belt at each of the stations. The 5 proxy sensors to the left will pick up the binary pattern underneath the wagon by detecting the metal objects and sending the binary pattern to the PLC to say that wagon is number 7. The piston will then drop and release the wagon. To limit the amount of I/O being used the proxy sensors are wired up in common taking up only 5 inputs which is a technique known as a multiplexing system. 24 Volts is sent to each

bank of proxy sensors and the PLC reads its state and stores it. This keeps jumping to each station removing power to the last all at high speed. The code for the CIM system scanning can be seen below.

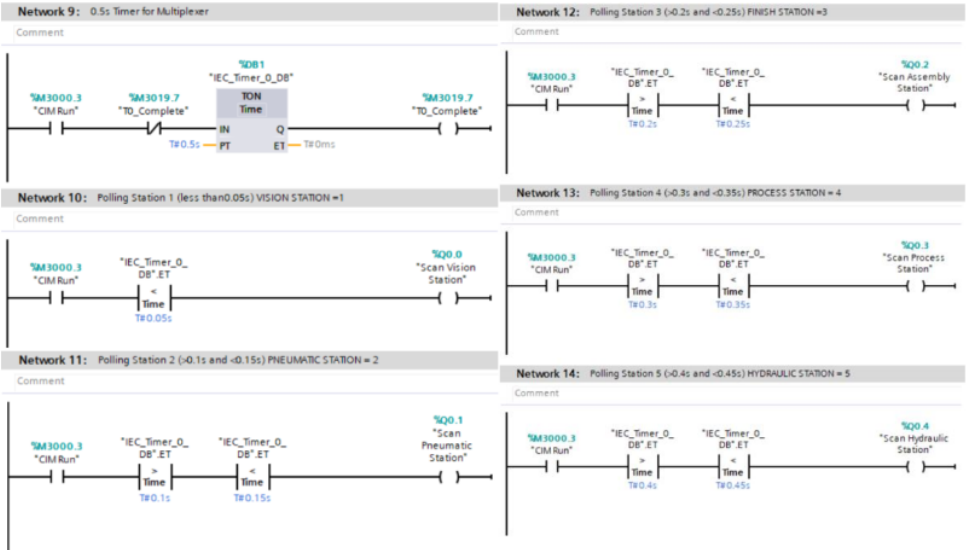


Figure 11

This can be demonstrated by analysing the figures below.

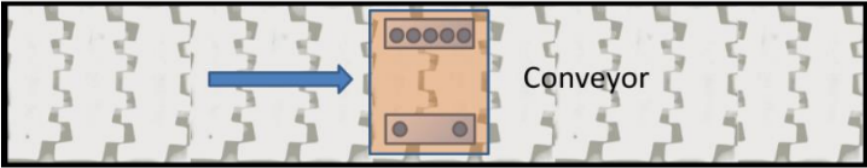


Figure 12

Figure 12 shows the station point containing the proxy sensors and piston, waiting to receive a wagon.

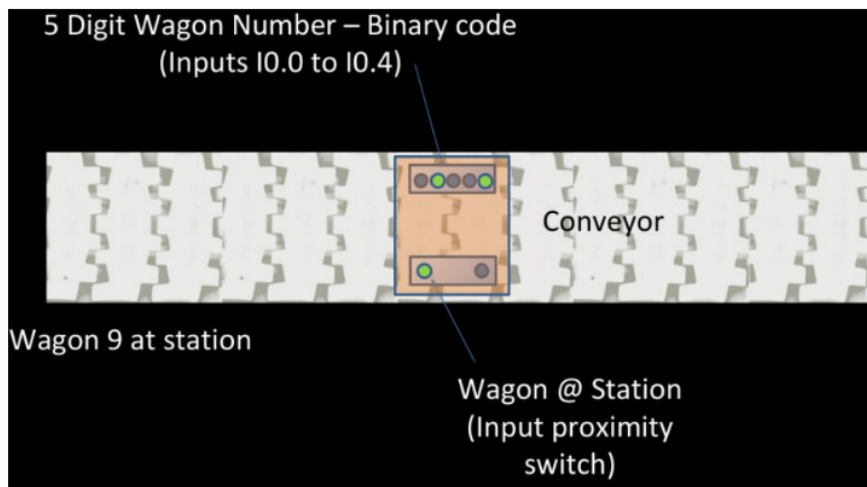


Figure 13

Figure 13 shows a station with proxy 1 and 4 on (counting from right to left on the binary pattern) along with wagon @ station sensor on. Proxy 1 and 4 being on would give a binary digit of 9 therefore wagon 9 is at the station.

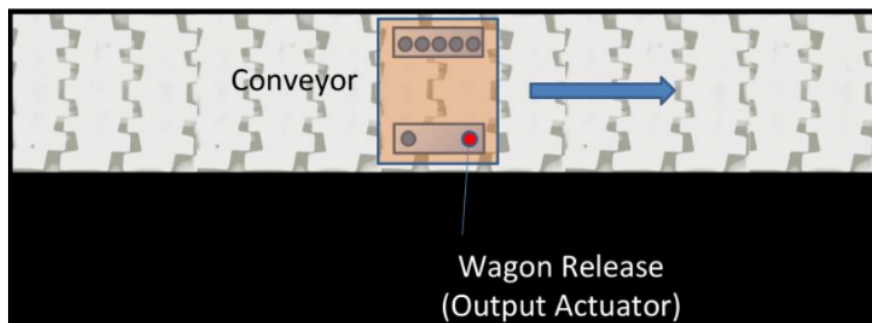


Figure 14

Once all the work is carried out at each station a signal is sent from the PLC to output an actuator to release the wagon so it can be sent to the next station.

2.3 Wagon Coding System

For the machine to know what to do, a setpoint must be made on the process variable on the wagon itself.

SP	PV	Description
0	1000	Empty Wagon (No work)
2000	2000	Wagon + Pallet (No work)
3000	3000	Wagon + Pallet + Stamp (No work)
3100	3000	Wagon + Pallet + Stamp (To be Inspected)
3100	3101	Wagon + Pallet + Stamp (Passed Inspection; To be Finished)
3100	3102	Wagon + Pallet + Stamp (Failed Inspection)
4000	4000	Wagon + Pallet + Round CH1 (No work)
4200	4000	Wagon + Pallet + Round CH1 (To be Inspected)
4210	4000	Wagon + Pallet + Round CH1 (To be Processed) (To be Inspected)
4200	4203	Wagon + Pallet + Round CH1 (Passed Inspection)
4210	4203	Wagon + Pallet + Round CH1 (To be Processed) (Passed Inspection)
4200	4204	Wagon + Pallet + Round CH1 (Failed Inspection) (To waste)
4210	4214	Wagon + Pallet + Round CH1 (Failed Inspection) (To waste)
5000	5000	Wagon + Pallet + Round CH2 (No work)
5300	5000	Wagon + Pallet + Round CH2 (To be Inspected)
5320	5000	Wagon + Pallet + Round CH2 (To be Processed) (To be Inspected)
5300	5305	Wagon + Pallet + Round CH2 (Passed Inspection)
5320	5305	Wagon + Pallet + Round CH2 (To be Processed) (Passed Inspection)
5300	5306	Wagon + Pallet + Round CH2 (Failed Inspection) (To waste)
5320	5306	Wagon + Pallet + Round CH2 (Failed Inspection) (To waste)
4210	4213	Wagon + Pallet + Round CH1 (To be Finished)
5320	5325	Wagon + Pallet + Round CH2 (To be Finished)
6000	6000	Finished Product to Store (To be Inspected)
6000	6007	Finished Product (Passed Inspection) (To Store)
6000	6008	Finished Product (Failed Inspection) (To waste)

Figure 15

Figure 15 above shows the list of potential setpoints and process variables that can be placed on the wagon along with the description.

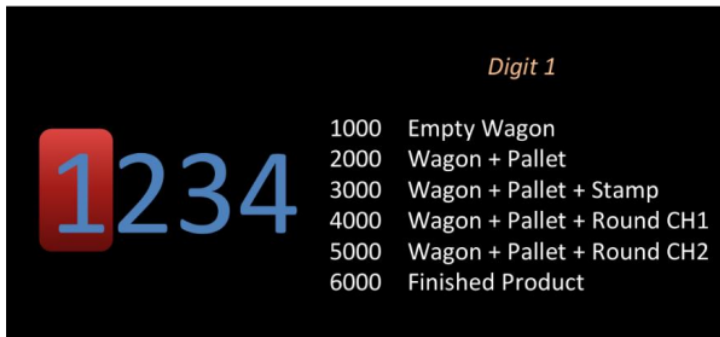


Figure 16

Figure 16 above shows what the first digit of the code represents. If the button, select pallet was pressed then 2000 would be put on the setpoint, as can be seen in the figure below.



Figure 17



Figure 18

The figure above shows what the second digit of the code represents. This digit is do you want to visually inspect. When visually inspect handle CH1 is pressed, 200 will be added to the setpoint which can be seen in the code below.

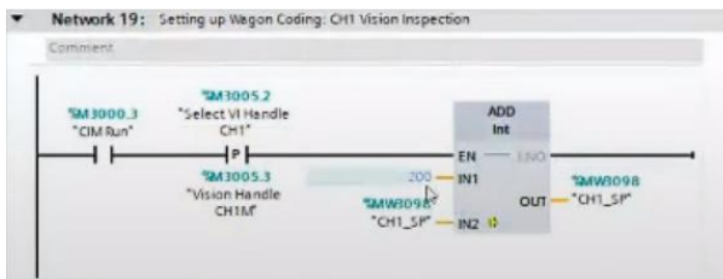


Figure 19



Figure 20

The figure above shows what the third digit represents. If processing for CH1 is selected, then 10 will be added to the setpoint.

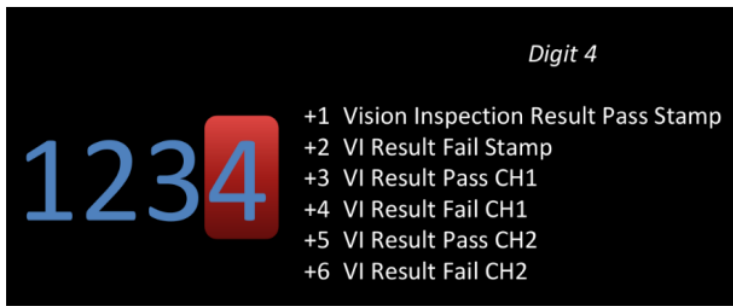


Figure 21

The figure above shows what the fourth digit represent. The last digit is for the results. When reset wagon codes is selected 0 is moved to each of the wagon setpoints and 1000 on the wagon process variable. The code for wagon reset can be seen below.



Figure 22

To provide description of what is on the wagon to the HMI the codes are placed in array of strings on the HMI.

3. Health and Safety, Maintenance and Reliability Requirement

RISK ASSESSMENT					
What is the hazard?	What is the risk?	What controls are in place?	Possibility of risk? (1-5)	Severity (1-5)	Additional Measures
Electricity	Electric shock	All electrical components are enclosed in a safety panel.	3	4	Routinely carry out insulation resistance checks to make sure there is no degradation or breakdown in the insulation of the system. Make sure all metal parts have a clear connection to earth.
Chemicals from the acid tanks	Cause irritation and burn to skin	Perspex guarding placed around the acid tanks.	3	4	Extend the current Perspex guarding vertically.
Running Cables	Slips, trips and falls - risk injuring yourself others and equipment.	Where necessary all cables should be hidden inside cable trunking, conduit, etc. Cables to be bundled together not	2	3	Run cables above head height on Unistrut, eliminating the risk of tripping over.

		separated and trailing.			
High Pressure Air	A dislodged pipe can leak high pressure air which can cause laceration if not tied down correctly.	All air tubes are to be securely cable tied in place and fittings and tube to be routinely inspected to check for any degradation.	2	3	A safety lock can be added that detects a sudden drop in air pressure that can switch the machine off.
Moving machinery - conveyor belt.	Body parts such as fingers or hair can be trapped and entangled in the belt and cause loss of flesh	Caution when machine is running. A limit of 1 person near the machine.	3	3	Perspex guarding to be placed around the perimeter of the belt.

Figure 23

The system utilizes a safety PLC which adds additional layers of protection to the program being run. It comes with extra security in the program requiring users to submit passwords to gain authorization. This helps prevent hackers getting into the system and potentially corrupting the program.

Regular maintenance of the system should be carried out by an engineer to maintain safety and reliability. Sensors over-time lose its calibration settings which can provide inaccurate results and make the overall system perform poorly, therefore it is vital that regular maintenance is carried out. The system provides a lot of information that can aid the engineer in carrying out maintenance tasks and predict if sensors are starting to perform poorly and needing calibration or replacing. This information can be found on the HMI screens.

Overall the CIM system is very safe with many interlocks in the program to safeguard the machine from destroying equipment. Another safety element of the CIM system is that the master PLC used in the system is a safety PLC which provides additional layers of safety and protection. The acid tanks could be made safer by extending the Perspex guarding vertically to further minimize the risk of contact.

4. System Design Adaption

GET and PUT commands were needed to be implemented to send and receive data between PLCs through profinet. It was needed to build the engineers screen on the main HMI as information on that HMI screen was from different PLCs so it did not exist on the main PLC.

The system was re-designed to include a webserver using VoT (Visual of Things) to act like a HMI screen. Successfully creating an interactive replicant of the HMI on a webserver can eliminate the need of a SCADA system resulting in less money spent. This is also very beneficial as any device that is connected to the network can access the webserver providing it has authorized access. This is helpful because if an engineer was reporting to a breakdown of a machine, they can log in to the network, bring up the webserver and monitor the sensory information for that machine.

To create the webserver, buttons, texts, counters, etc were placed onto the screen to replicate the HMI screen. A background photo of the HMI screen was placed on the webserver as aid to what is needed to replicate the HMI screen.

A testing table was produced the VoT to prove the functionality of the buttons, lamps and displays work correctly. To prove it worked, pictures were taken of the VoT and the HMI screen to show they both match and correspond. The testing table can be seen on the next page.

You have not included any evidence of individual work with the simulation of the HMI screens

Test	Expected	Result	Pass/Fail	Evidence
Start CIM by pressing start button - indication light should illuminate green	CIM to start operating	The CIM turned on when the button was pressed	Pass	Appendix 1 & 2
Start Conveyor by pressing start button - indication light should illuminate green	Expect conveyor to start running	The conveyor turned on when the button was pressed	Pass	Appendix 1 & 2
Switch to all 6 substations screens on VoT main engineer screen.	Pressing each of the substations should take you to its page.	The screen switched when the button was pressed	Pass	N/A
All substation PUT counter should read the same as the HMI	To read the same as the HMI screen	The VOT screen displayed the same values as the HMI screen	Pass	Appendix 3 & 4
Test for correct operation of the wagon numbering for each station	Wagon numbering changes as different wagons arrive at different stations.	Wagon numbers changed corresponding to what number wagon they were. VoT screen mirrored the HMI.	Pass	Appendix 3 & 4
Each stations SP displaying correct values	Setpoints on VoT should match the HMI screen.	The correct values were displayed and matched the HMI	Pass	Appendix 1 & 2
Each stations PV displaying correctly	Process variable on VoT should match the HMI screen.	The correct values were displayed on both VoT and HMI.	Pass	Appendix 1 & 2
Photo beam light shows green when working	When the CIM system is switched on and start button is pressed, the photo beam light should illuminate.	The photo beam light turned on	Pass	Appendix 3 & 4
The green light beneath each station to show online illuminates.	The CIM will be turned on and off to see if the stations lights function	The lights for each station turned on and off at the correct time	Pass	Appendix 3 & 4
Stop the CIM by pressing stop	When the stop CIM button is pressed the CIM will turn off and the online light will also turn off	The CIM switched off as well as the light.	Pass	Appendix 5 & 6
Stop the conveyor by pressing stop	When the stop conveyor button is pressed the conveyor will stop, the light will also turn off.	Conveyor stopped and the light switched off.	Pass	Appendix 5 & 6

Figure 24

5. Conclusion and Recommendations

From researching the concepts of industry 4.0 it is gathered that the world is in a fourth industrial revolution through the use of smart sensors and IoT. Industry 4.0 connects machines together using smart sensors with M2M technology. This technology provides machines to interconnect to each other and allow data to be sent and receive so the machines can operate and adapt.

Making the master PLC the slave and the substation PLCs masters was crucial for the PUT and GET coding to work, as there can only be one slave but multiple masters. The PUT and GET allowed the PLCs to communicate to each other via profinet to send and receive data. This enabled to build the engineers screen on the main HMI.

Creating VoT screen proved to be very beneficial as it would act and behave exactly the same as a HMI screen. This can easily replace the need for a SCADA system in industry which provides a vast reduction in costs to licensing. Because VoT is built on a webserver with it's own IP address, any device that can access the internet and is connected to the same network can access the webserver providing it has authorization. This can be helpful for engineers that are inspecting a machine on the shop floor, they can bring up the webserver on their phone and read the sensory information on that machine to determine what is wrong.

A recommendation can be made to remove the emergency stops from the system as all of them does the same job and cuts power to the whole system. A different approach would be to wire the emergency stops in such a way that each emergency stops cuts power to different substations and leaving the PLCs running. Additional code will have to be made in the program to accommodate this change.

A recommendation can be made to improve the wagon scanning system by instead of using proxy sensors to determine the wagon, each wagon will have a QR code placed underneath and cameras at each station will scan the QR code to determine the wagon. Using this system, the overall inputs will be less.

6. Team Working

As part of this project, team working was carried out by groups of three. Each person had their own responsibility and task to complete. The three members were Steffan Davies, Jason Booth & Daniel Outen. Steffan Davies was responsible for making sure the HMI and VoT screens had matching data for testing the VoT. Jason Booth was responsible for building the VoT page to mirror the HMI. Daniel Outen was responsible for producing the testing table and tableting the results.

Correct method of listing.

7. Citation List

CIO Wiki, 2020. *Machine-to-Machine (M2M)*. [Online]

Available at: [https://cio-wiki.org/wiki/Machine-to-Machine_\(M2M\)](https://cio-wiki.org/wiki/Machine-to-Machine_(M2M))

[Accessed 24 April 2022].

IBM, 2019. *How Industry 4.0 technologies are changing manufacturing*. [Online]

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[Accessed 25 04 2022].

Link Labs, 2018. *What is M2M? [2018 Update]*. [Online]

Available at: <https://www.link-labs.com/blog/what-is-m2m>

[Accessed 24 April 2022].

Shea, S., 2020. *machine-to-machine (M2M)*. [Online]

Available at: <https://www.techtarget.com/iotagenda/definition/machine-to-machine-M2M>

[Accessed 24 04 2022].

TopConnect, 2020. *What is M2M Technology?*. [Online]

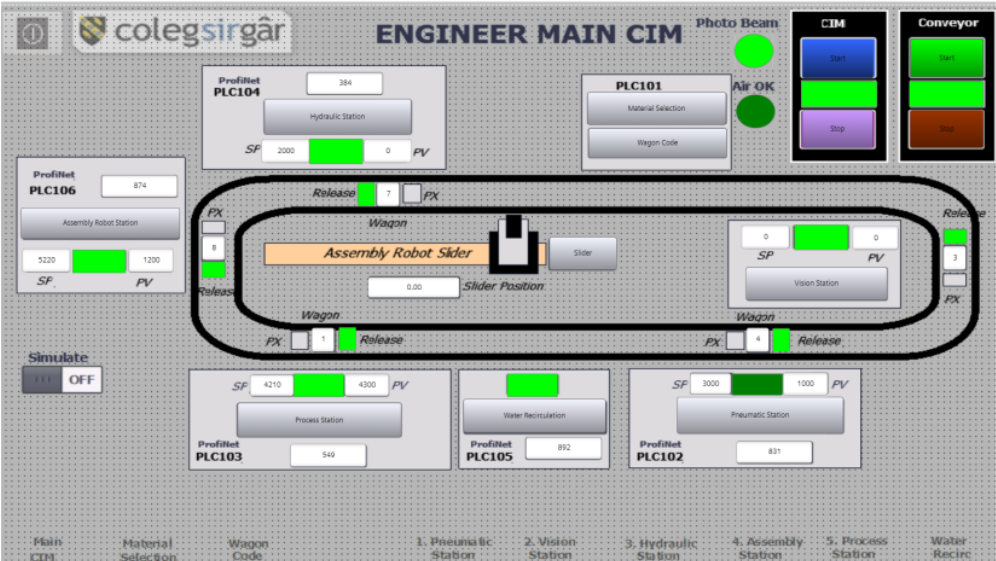
Available at: <https://topconnect.com/m2m-iot-connectivity/what-is-m2m-technology/>

[Accessed 24 April 2022].

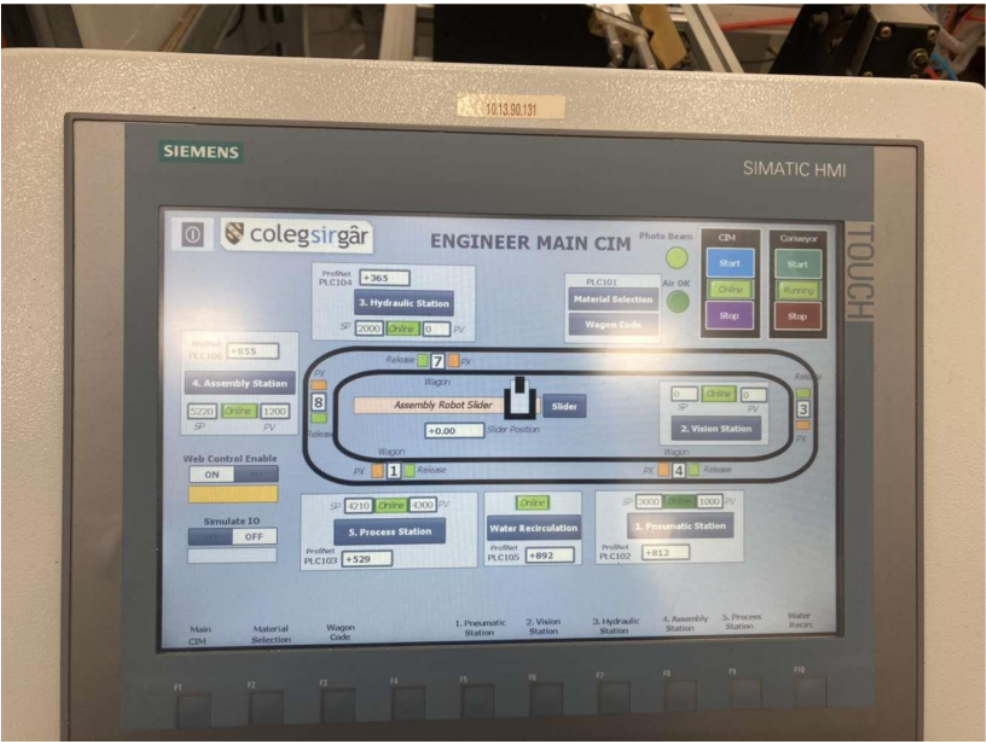
Moderate range of sources

8. Appendix

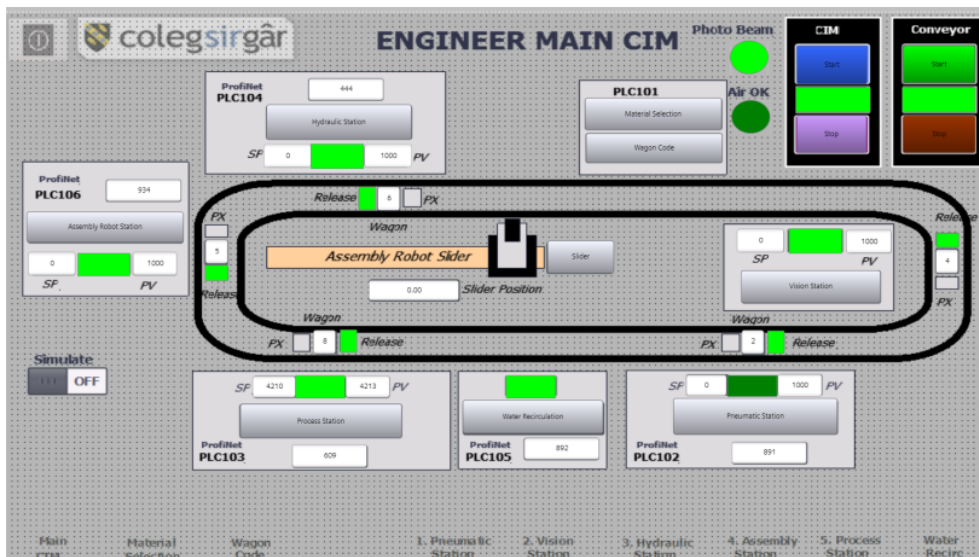
VoT Testing



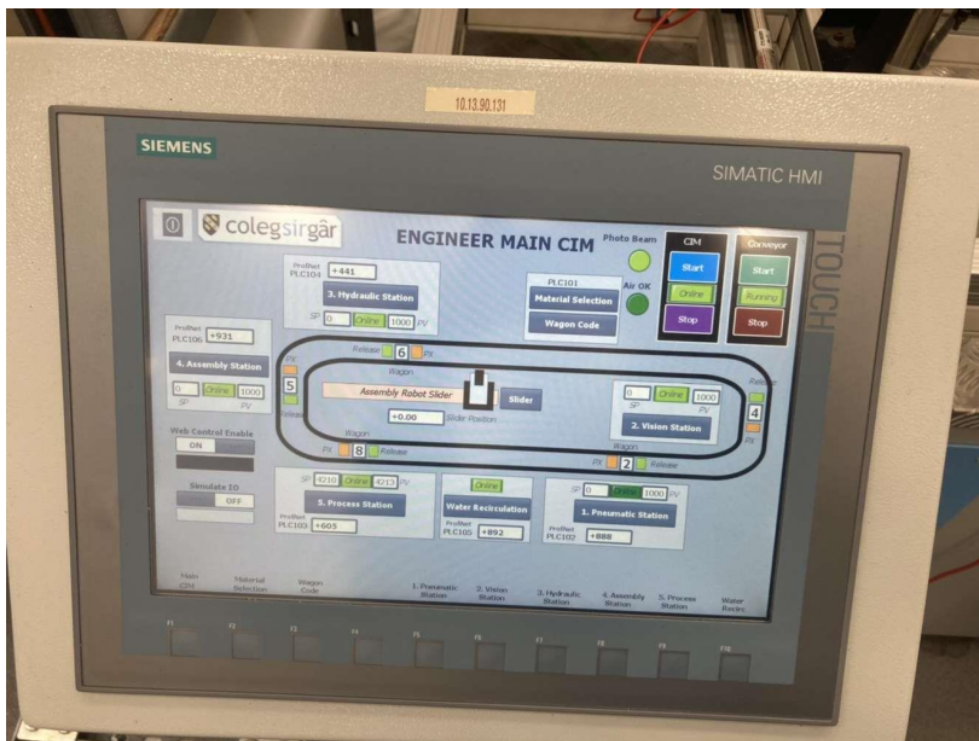
Appendix 1



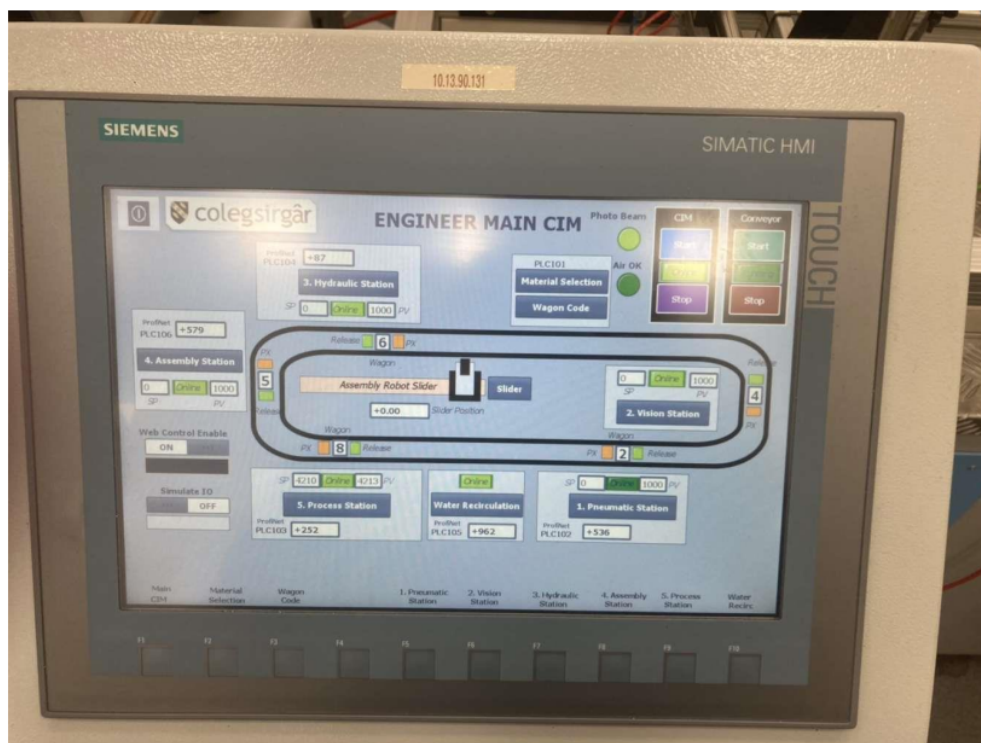
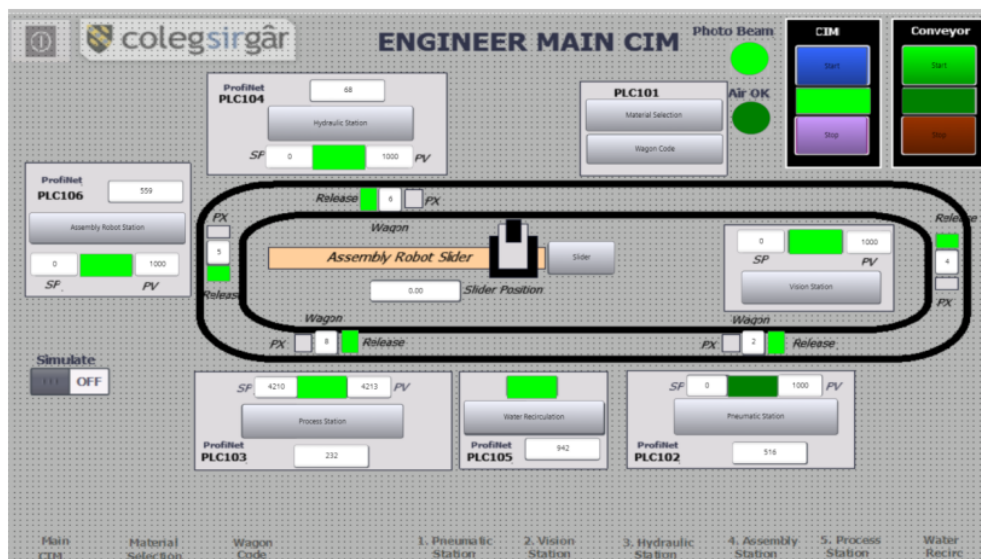
Appendix 2



Appendix 3



Appendix 4



Instructor

68/100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. author is missing in your citation

PAGE 4

Text Comment. explain?

PAGE 5

Text Comment. most of your images and figures should be in the appendix as stated in the brief

PAGE 6

Text Comment. Incorrect, this should be PLC101

PAGE 7

PAGE 8

PAGE 9

Text Comment. should be figure numbered

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

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PAGE 19

Text Comment. You have not included any evidence of individual work with the simulation of the HMI screens

PAGE 20

PAGE 21

PAGE 22

PAGE 23

QM

Correct method of listing.

You have listed your sources correctly according to the Harvard method.

Text Comment. Moderate range of sources

PAGE 24

PAGE 25

PAGE 26

JASON BOOTH

68

1. ENGAGEMENT WITH LITERATURE

 Good evidence of reading, information is relevant from a moderate range of sources cited and listed correctly using the Harvard method. 12/20

12

2. KNOWLEDGE AND UNDERSTANDING

 Very good evidence of knowledge and understanding. Good explanation given of the safety and maintenance aspects of the machine. 16/20

16

3. COGNITIVE AND INTELLECTUAL

 Good assessment of risk and excellent evidence of testing including the VoT. Very good conclusions and recommendations. 14/20

14

4. PRACTICAL APPLICATION

 Good evidence of practical working for the VoT but your individual work on the HMI and data transfer

10

has not been included. Hence your mark is lower in this section. 10/20

5. TRANSFERABLE SKILLS



A well written, presented and formatted report with good evidence of team working. 16/20

16