# Robotic Automated Manufacturing

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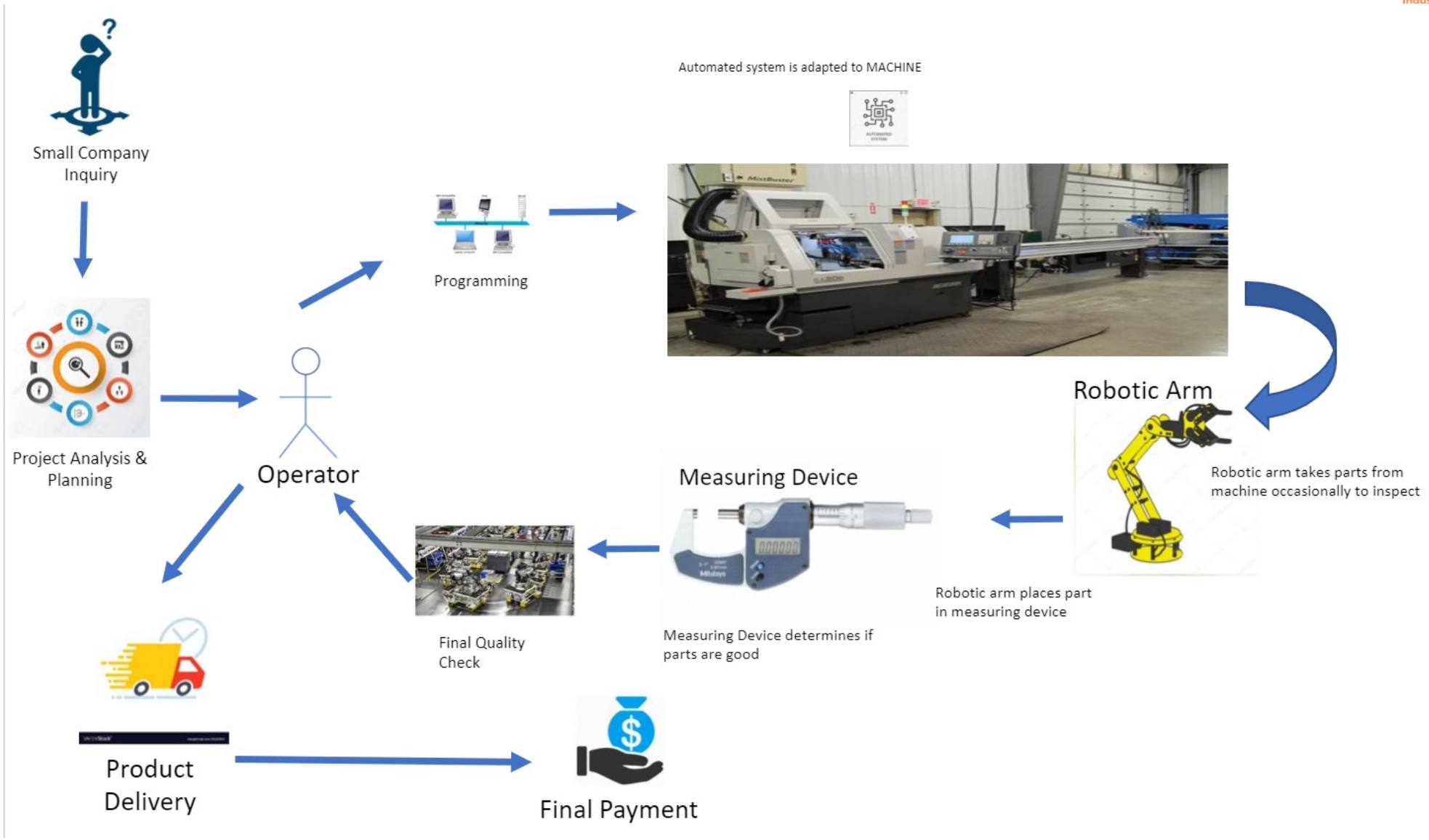
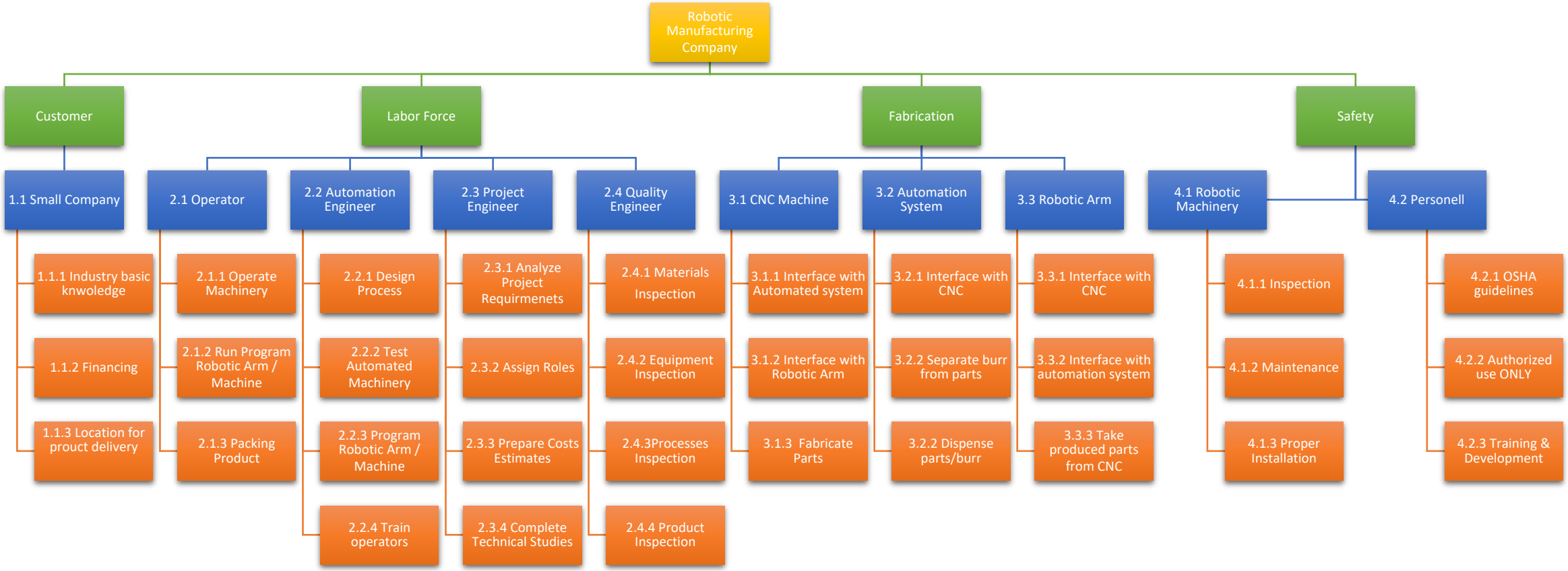
IE 4466 SENIOR DESIGN

# Concept of Operations



# System Decomposition and Requirements



# Requirements Validation and Verification Plan

| Scenario Description | Subsystem/Part | Subsystem/Part Name | Requirement I | Reqmt Title | Requirement | Requirement Validation | | | | | Verification Plan | Verification Data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A small company initiates contact with the RoboticManufacturing Company to place an order. The small company and the Robotic company will exchange information about their current situations, and verify they are a good match, being able to continue the order process and eventually making an order | 1.1 | Small Company | 1.1.1 | Requirements for Project | The Customer (Small Company) shall be able to provide requirements of what they are looking for from the Robotic Company. | By requesting documentation from Customers, which includes product dimensions, specifications, and what they are looking for from the Robotic Company. | | x | | | Analyze the data requested from the potential customer, it will allow the Robotic Company to determine if the project being requested is viable or not, and whether the company can accomplish what is being required. | When a Customer shows interest, they will fill out a form, where they will provide specifics of the parts being requested such as; dimensions, material, color, weight, quantity, and timeframe. A Project Engineer will then go thorugh the specified project details, and verify if the current machine setup and capacities are able to take on such project. If it is viable, the Project Engineer will then meet with the customer to discuss the project ideas, manufacturability of drawings, tolerance requirements, to come to an agreement and sign a contract |
| | 1.1 | Small Company | 1.1.2 | Financing Capability | The Customer (Small Company) shall be able to come up with financing to cover project costs | The Customer would be providing official proof of funds to the Robotic Company. | | x | | | Confirm the proof of funds provided is from an official Financial Insitution. | The office staff / sales dept will request proof of funds or financing from an official bank statement or financial institution, which sall be provided by the customer before project begins, and no later than 5 business days after contract agreement has been signed. Request is performed via email . |
| | 1.1 | Small Company | 1.1.3 | Location for Product Delivery | The customer shall be able to take physical delivery of final product at a specified location by paying for transportation. | By requesting proof of physical address of where the final product will be shipped, in order for the Robotic Company to estimate shipping costs, and be able to deliver final product. | | x | | | Compare with tools such as googlemaps, and customer's company website if they have one. | Once the office staff /sales dept gets the physical addres where final product will be shipped, a verification of address will be made using a google search with the business name, googlemaps, and online directory to validate the existance of such address. |

# Requirements Validation and Verification Plan

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| The Automation Engineer analyzed the process manufacture and decided to assigned the tasks to the operator, sourcing and project engineer for start working with the manufacture of the product and this use case ends when the person of quality control verify the product with the subject expert material and they proceed with the shipping. | 2.1.1 | Robotic manufacturing/Operator | 2.1.1 | Operate Machinery | The operator must monitor the parts produced by the CNC to make sure they are meeting the dimensions specifed in the print. | The operator must proof the efficiency of the CNC to produce the right dimensions of the products | | | X | | Operator must vaildate that the machinery used is balanced,checking the specific dimensions everyday at least once every 2 hrs. | The operator will entering the data twice and verify the data with the work order. |
| | 2.1.2 | Robotic manufacturing/Operator | 2.1.2 | Run Program Robotic Arm / Machine | The operator shall run the programs for the robotic arm with Sheetcam to generate the post process G-code | Demostrate how the robotic arm will work with theG-code | | X | | | The operator will confirm that the G-code is working doing some try and failure before beginning the project | The operator has to proof that the Code is working with the machines, working with the IT deparment to corroborate that the G-code us working well. |
| | 2.2.1 | Robotic Manufacturing/Automation Engineer | 2.2.1 | Design Process | The automation engineer shall design the automated system that will be integrated to the CNC swiss lathe. | Proof the results of the integration between the system and the CNC swiss lathe | X | | | | Corroborate the results of the machinary with the CNC swiss lathe. | The design process will proof that the CNC swiss lathe can work with the products asked by the customer. |
| | 2.2.2 | Robotic Manufacturing/Automation Engineer | 2.2.2 | Test Automated Machinery | The automation engineer shall test the automated machinery to make sure it does not collide with the CNC. | Requesting an automated test to corroborate that the machinery will not fail with the CNC. | | X | | | Develop the test for the machinery to verify if there is an error or not with the machinery and the CNC. | Testing the machinery with some doble check of the production and see if the CNC do not collide. |
| | 2.2.3 | Robotic Manufacturing/Automation Engineer | 2.2.3 | Program Robotic Arm / Machine | The automation engineer will program the robotic arm to interface with the automated system using customer specified dimensions. | The automation engineer will proof the right dimensions of the products | X | | | X | The automation engineer will confirm the dimensions checking the data entered in the machine with the requested of the customer | Double check with the dimension of the work order and taking use the right standards for the dimensions of the products. |

# Requirements Validation and Verification Plan

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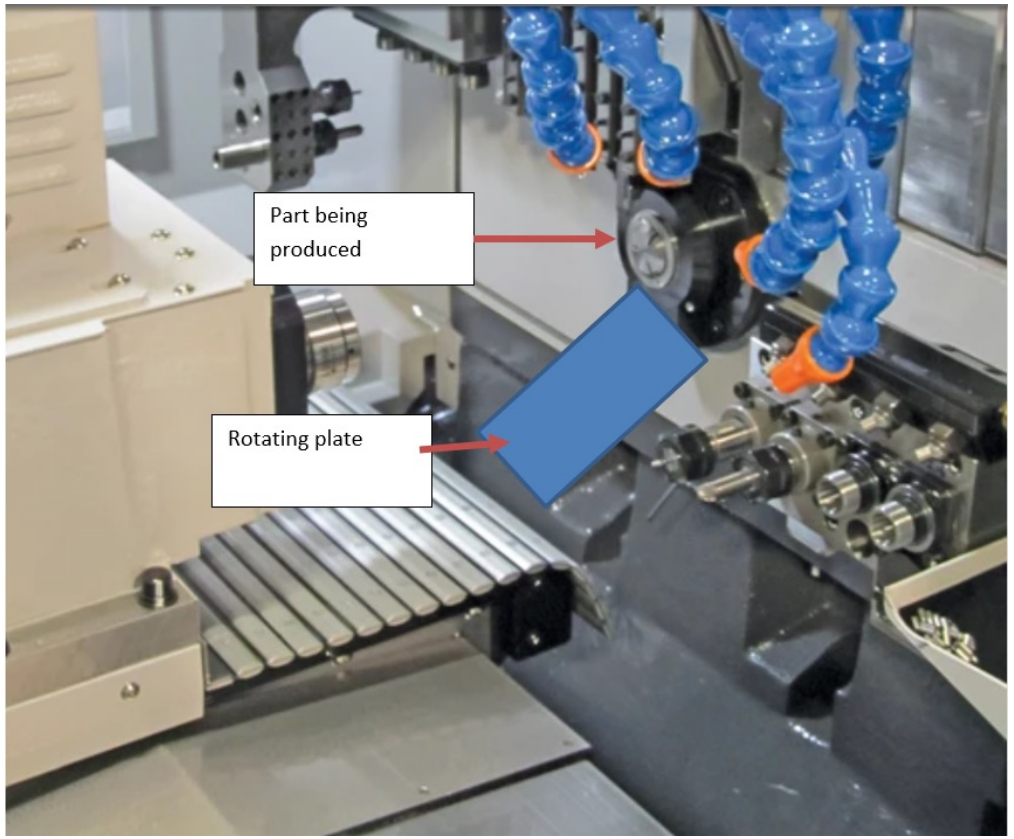
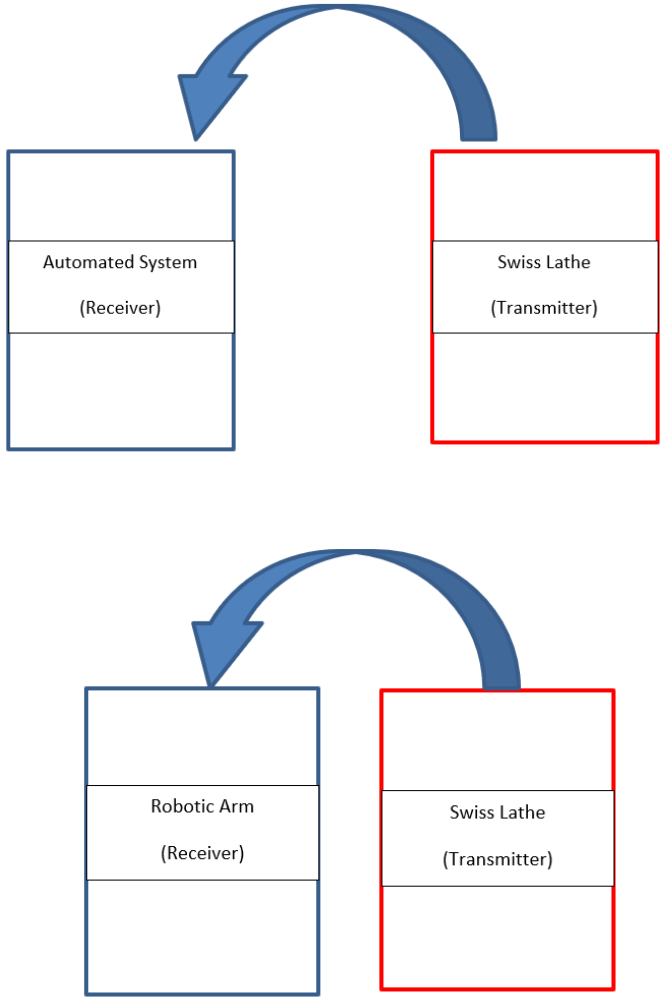
| The operator begins the program in the CNC. The CNC begins taking the material and fabricates it accordingly. The automated system separates finished parts from burr. The robotic arm scans parts periodically to assure quality assurance. Operator takes finished parts. This use case ends when the desired number of parts have been fabricated | 3.1.1 | CNC Machine | 3.1.1 | Interface with automated system | The CNC machine shall interface with the automated system | The CNC swiss machine and automated system will interface by connecting to the same network using wireless communication. | | | X | | Test that the CNC swiss machine and automated system are connected to the same network by simulating connection. | Similar applications of connecting CNC machines to a wireless network have shown that it is possible to communicate wirelessly from your computer to the CNC machine. A similar technology can be used to communicate between automated system and CNC. |
| | 3.1.2 | CNC Machine | 3.1.2 | Interface with Robotic Arm | The CNC machine shall interface with the robotic arm to notify when parts will be dispensed | The CNC machine and robotic arm will interface by connecting to the same network using wireless communication. | | | X | | Test that the Robotic arm can interface with the CNC by simulating connection. | The same technology used for the interfacing between CNC swiss machine and automated system will be used to communicate between Robotic arm and CNC |
| | 3.1.3 | CNC Machine | 3.1.3 | Fabricate Parts | The CNC machine shall fabricate parts in production with tolerance accuracy of at least 0.001 inches | The specifications of the CNC machine will indicate the tolerance accuracy. | | | x | | Will test that the CNC machine has the indicated tolerance accuracy by taking the dimensions of sample parts with measuring devices. | In order to take the dimensions of the produced parts in the CNC, measuring devices such as CMM (coordinate measuring machine) will be used to make sure that the CNC is giving the needed accuracy. |
| | 3.2.1 | Automation System | 3.2.1 | Interface with CNC | The automation system shall interface with CNC. | The automation system will interface with swiss CNC by connecting to the same network by using wireless communication. | | | X | | Test that the automation system and CNC are connected to the same network. | The same technology used for the interfacing between CNC swiss machine and automated system will be used to communicate since it is the same connection. |
| | 3.2.2 | Automation System | 3.2.2 | Separate burr from parts | The automation system shall separate parts from burr | The automated system will be able to be work inside the CNC to separate the unwanted leftover material(burr) from the produced part. | | | | X | Demonstrate that the automated system is separting parts from burr by doing test runs. | The automated system shall be designed in a way where it can separate the burr from the final product. The burr might still be present but it will be minimum so it will facilitate the separation the final product from the burr. |
| | 3.2.3 | Automation System | 3.2.3 | Dispense parts/burr | The automation system shall dispense parts in one bin and burr in another bin. | The automation system will have two conveyors. One conveyor will dispense the burr and the other conveyor will dispense the parts fabricated by the swiss CNC. | | | X | | Will test that one conveyor will dispense burr and the other conveyor will dispense the parts fabricated by the swiss CNC. | Given the limited space and the cutting oil being constantly used inside the CNC swiss machine, a conveyor system will not be possible to use. |

# Requirements Validation and Verification Plan

| Subsystem/Part ID | Subsystem/Part Name | Requirement ID | Reqmt Title | Requirement | Requirement Validation | T | A | I | D | Verification Plan | Verification Data |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.1 | Robotic Machinery | 4.1.3 | Proper Installation | Machinery shall be installed in according to manufacturer's reccomendations. | Following installation procedure manuals and instructions from machinery's manufacturer. | x | | x | | Having the manufacturer's manuals and instructions available in computer's database for operator's access | Manufacturer's manuals shall be in every computer system, available to any operator, regardless of hierarchy. Manuals will also be in printed version, stored in safety dept. |
| 4.2 | Personell | 4.2.1 | OSHA Guidelines | Operators shall follow OSHA Industrial Robots and Robot System Section IV: Chapter 4. | Following OSHA's reccomendations in Industrial Robots and Robot System Section IV: Chapter 4 | | x | | | Having OSHA's reccomendations in Industrial Robots and Robot System Section IV: Chapter 4 availble in computer;s database for operator's access. | OSHA's reccomendations in Industrial Robots and Robot System Section IV: Chapter 4 will be available in the general computer system, where all operator shall have access to, in case information from it is required. |
| 4.2 | Personell | 4.2.2 | Authorized Use ONLY | Machinery shall be operated only by authorized operators who have completed training. | A security login and password will be promoted before machinery can be used for clearance. | x | | | | Clearance for machinery use will be assigned to operators who have taken the required training, and updated in the database. | Computer Database system will have credentials of both authorized and non-authorized operators. Whenever a machine is tried to be turned on, and tried to be operated, the operator will be promted to enter their personalized credentials to confirm they indeed are authorized, otherwise, the machinery will not run, and an emergency alert will be sent to the safety dept. |
| 4.2 | Personell | 4.2.3 | Training | Operators shall receive quaterly operations training. | Every quarter, operators will be required to attend training for each different machinery usage. | x | | | | If an operator does not complete a training, he or she wont be able to perform regular duty tasks until completed. | Trainings for different operations will be provided on a quaterly basis, where all operators have to attend to be able to contiue using the machinery. During the traiging, operators will go over machine funcitonaliy, operations, maintenance, and emergency procedures. Attendance will be monitored by operators scanning their employee badges by trainer, and be logged into a computer system to confirm they have completed the training. New hires will be given a training regardless of the quaterly trainings. |

# Subsystem and Part Design



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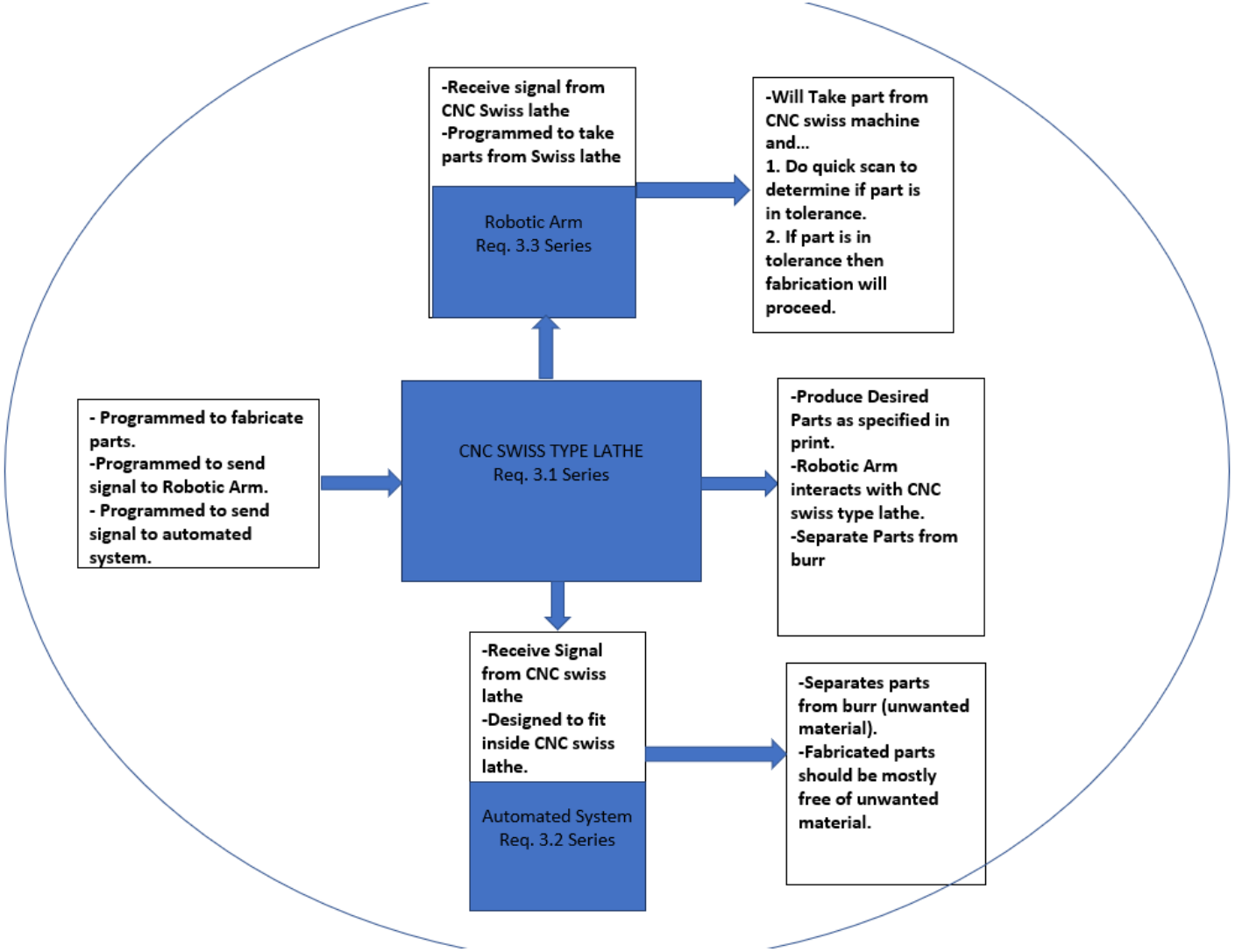
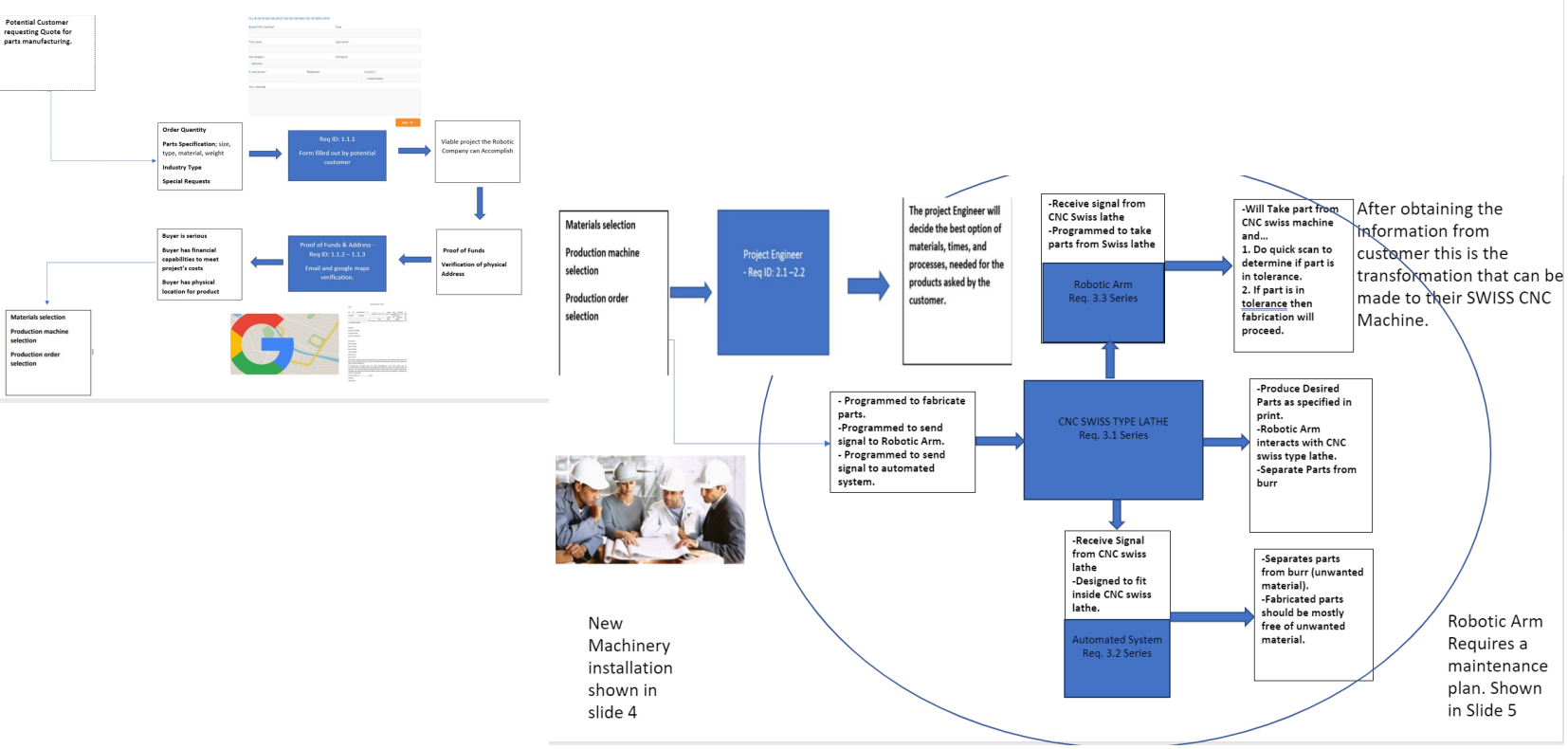
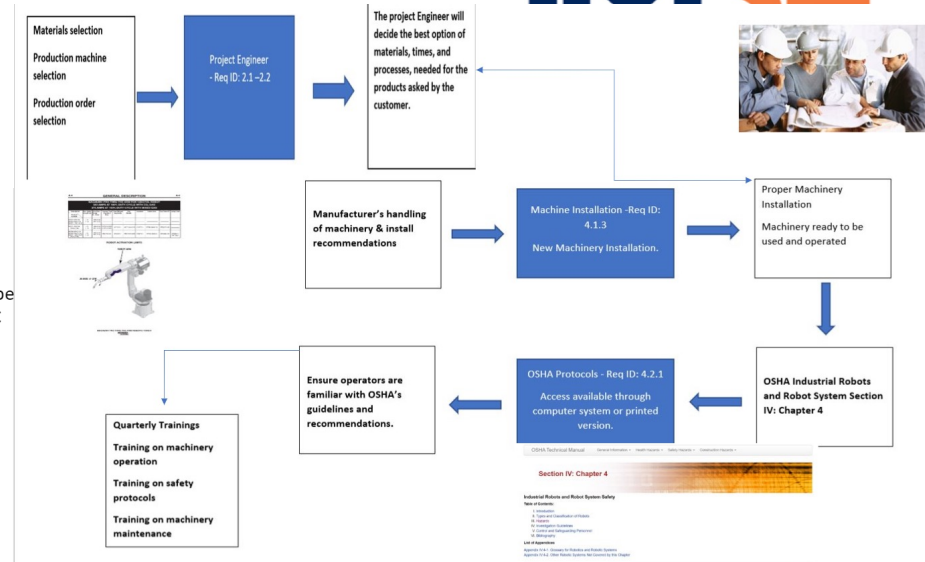
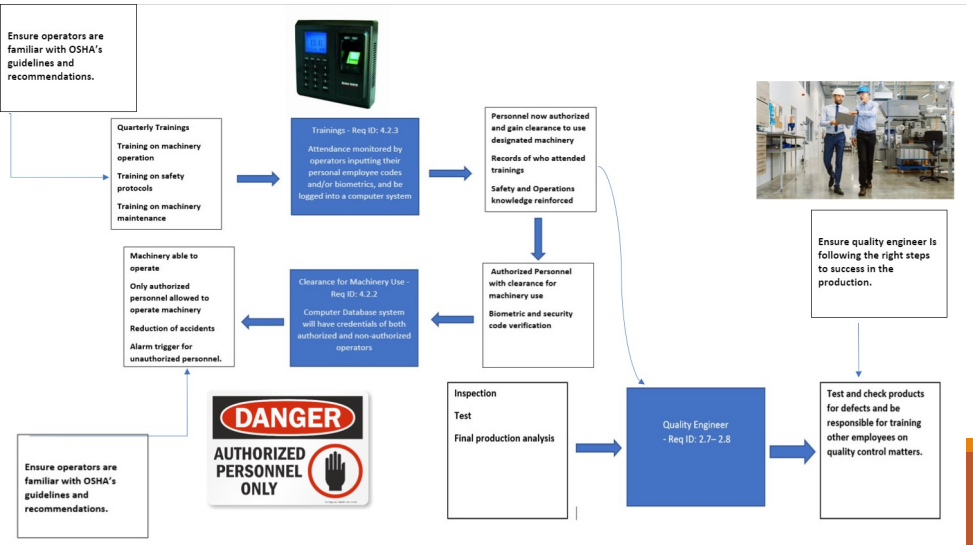
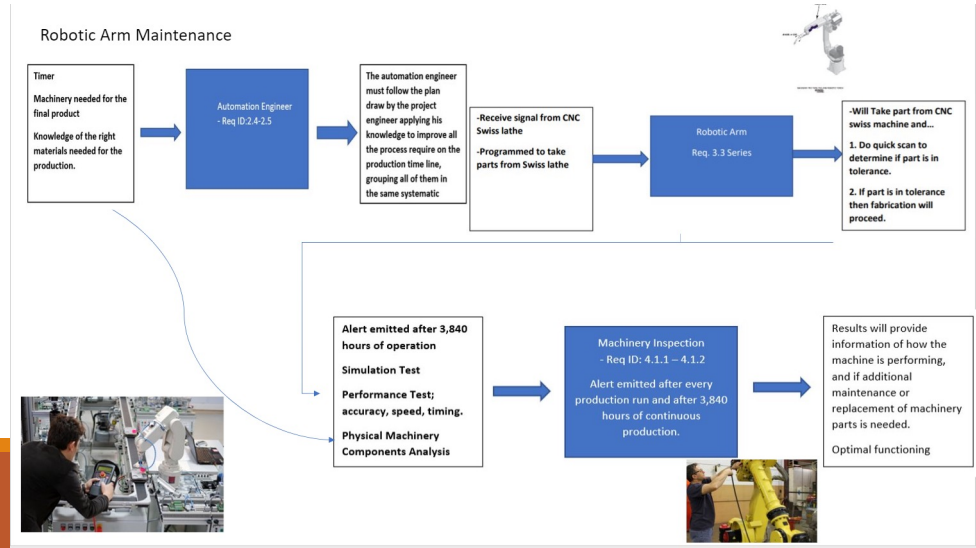


# Recomposing Parts into Final System



# Validating Overall System

- The system was validated by

- Ensuring that subsystem came together as a whole.

- The parts of each subsystem should work as planned since they were fully verified.

- The right system was built because the following were met:

- The four subsystems (customer, labor force, fabrication and safety) were able to come together and work as one system

- The requirements were met.

-The system should be working as intended if it were to be tested.

# Questions?