

BUMES Optimization and Vision

BUMES Operation Guide and Supporting Documentation

ME500 Advanced Manufacturing Final Project

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Wednesday AM Lab Group

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Overview

This document contains all of the necessary information to operate the ADML as an automated manufacturing process. It will describe how to power on, run, and power down the system.

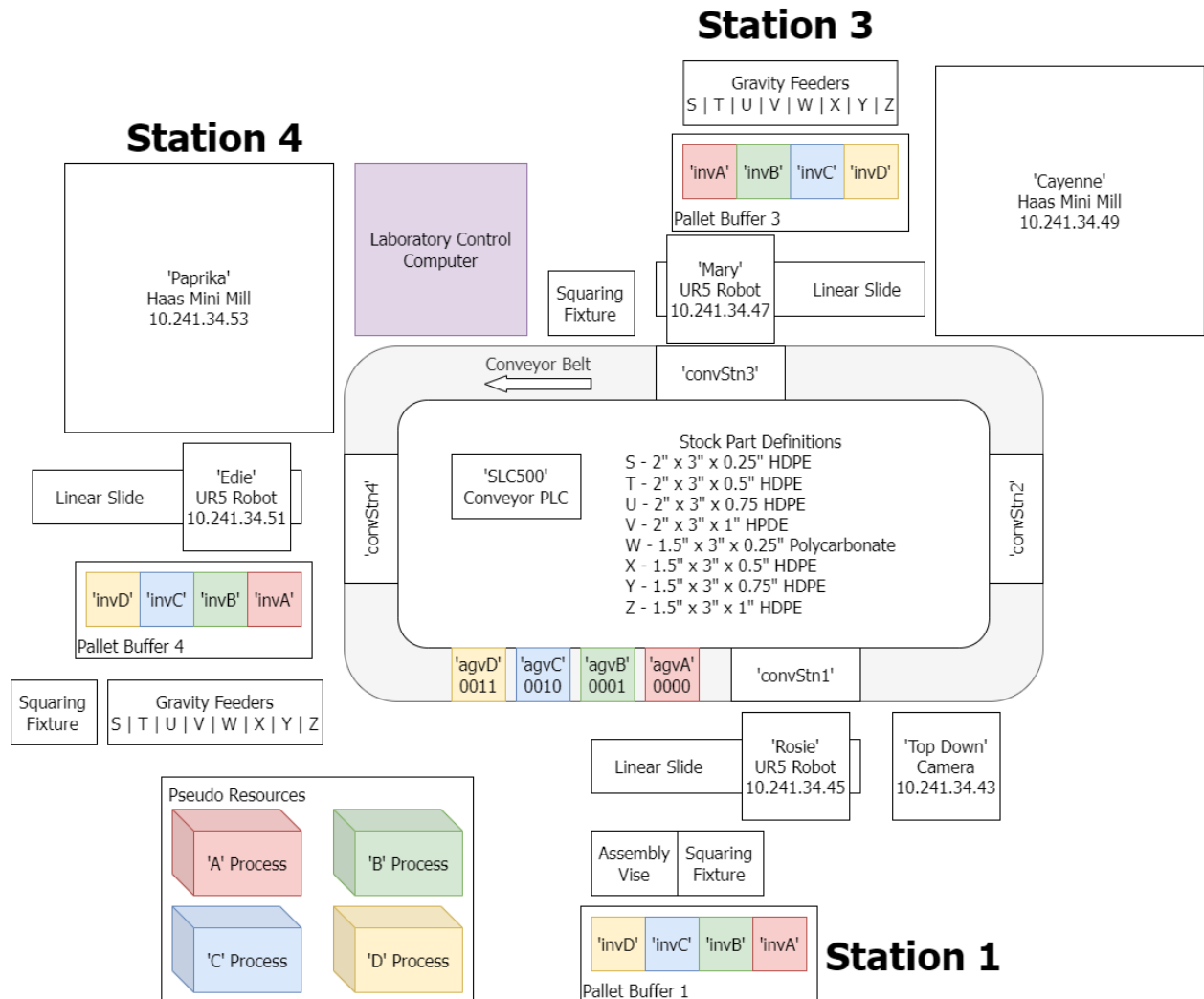


Figure 1. The ADML FMC Layout with labeled stations

Operations Guide

To operate the ADML with BUMES, start the system by turning on and initializing the following equipment according to their manuals:

- Universal Robotics (UR) arms (Rosie, Mary, Edie)
- Haas Mini CNC Mills

In addition to the above equipment, the pressurized air system (Figure 2, yellow valve by windows), and conveyor belt (Figure 3, I/O buttons near ADML Station 1) must be set to the “on” positions.

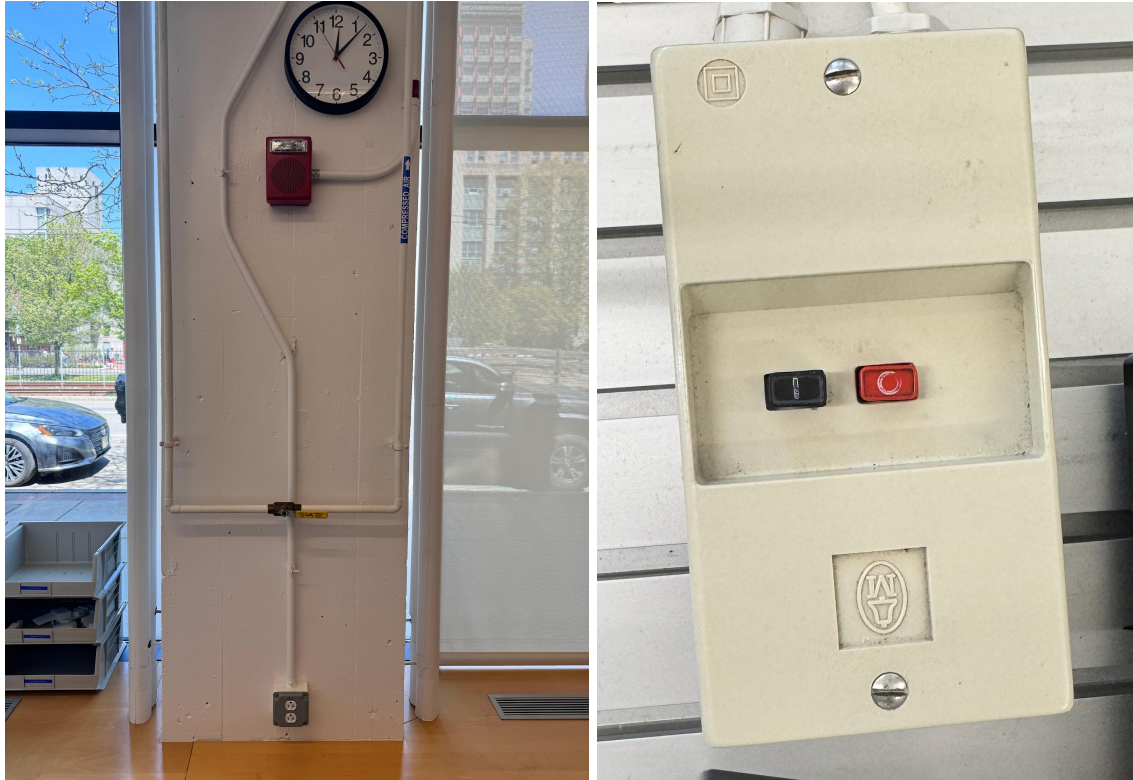


Figure 2 (left). Pressurized air valve in “on” position

Figure 3 (right). On/Off switch for system conveyor located at Station 1

Check that the Agv trays are in alphabetical order from A to D, with A being at the rightmost position and D at the left, and that the pallets are properly placed on the Agv trays, with the handle facing the outside.

Preparing the Robots for BUMES

To prepare the UR arms for BUMES, power on and initialize the arms according to the manual. Then, click the “Run Program” soft key on the touchscreen. The UR arm is now ready for BUMES operation.

Preparing the Haas Mini CNC Mills for BUMES

To prepare the mills for BUMES, power on and initialize the mills according to the manual. Press the “List Program” hard key, then toggle the CURSOR hard key arrows until the program numbered 9000 is highlighted in the list. Press the “Select Program” hard key, then press the “Memory” hard key. Once the Memory screen is highlighted on the system screen, press the “RESET” hard key, then the “Power up/Restart” hard key.



Figure 4. Haas CNC Mill controls with “Reset” and “Power Up/Restart” hard keys outlined in red

Check if the body and lid .nc codes are uploaded to both Paprika and Cayenne CNCs. To do this, press “List Program”, navigate to the .nc codes in the USB drive and hover over the lid and the body .nc codes, press F2 and copy to Memory for each. This saves the codes to the CNC’s local memory. Before initializing BUMES, check the Work Zero Offsets table, particularly the G54 row such that the offsets are -3.6512 for the X axis, -5.8119 for the Y axis, and -0.6000 for the Z axis. If these values are in the G54 row, then the mill is ready for BUMES operation*.

WORK ZERO OFFSET				
G CODE	X AXIS	Y AXIS	Z AXIS	
G52	0.	0.	0.	
G54	-3.6512	-5.8119	-0.6000	
G55	-4.1000	-9.3000	-2.0000	
G56	-4.2270	0.	0.	
G57	0.	0.	0.	
G58	-4.1585	-3.8156	-0.6313	
G59	-16.0000	-4.0000	0.	
G154 P1	0.	0.	0.	
G154 P2	0.	0.	0.	
G154 P3	0.	0.	0.	

Figure 5. Work Offsets table with the correct offset values put in the G54 row

***It is important to keep the mill from entering Sleep Mode before BUMES begins running.** If the mill enters sleep mode, press the “RESET” hard key, then the “Power up/Restart” hard key to exit sleep mode. If the Emergency Stop is engaged, turn it clockwise one-quarter turn or until it releases

Initializing the Vision System

To prepare the vision system for BUMES, first ensure that the camera on Station 1 is connected and actively running on the computer. Due to inconsistent lighting conditions in the ADML, the RGB values used for color classification must be calibrated before running the full vision system. This can be done using the `opencv.py` script, which isolates the vision functionality and allows for RGB calibration without activating the UR robot. When executed, the script detects the object's shape and displays its RGB values; if classification is successful, the main `vision_system.py` script can be run—otherwise, RGB thresholds should be adjusted and re-tested in `opencv.py` until the detection performs reliably, then updated accordingly in `vision_system.py`. Launch Visual Studio on the computer at Station 1 and open the following scripts:

- 1) `opencv.py`
- 2) `_mesProcess.py`
- 3) `_mesVision_test.py`
- 4) `Vision_system.py`

For a detailed explanation of each script and its corresponding `.py` file, please refer to the document titled *'ME500 Final Project WedsAM Vision Python Scripts Guide.'*

Note that `_mesProcess.py` is part of the original BUMES Python script and must not delete or edit its original script; **students should exercise extreme caution when making any additions or modifications.**

How is it connected to BUMES?

BUMES → `_mesProcess.py` → `_mesVision_test.py` → `Vision_system.py`

All commands are invoked from the `_mesprocess.py` script. To initiate the vision program from BUMES, a new function must be added to the `_mesprocess.py` script that calls the `Vision_system` script to run the vision process. Below is the sequence of this process:

```
1) Define the vision function in mes_process.py  
def Vision_test(self, mqttTopic)  
    exec(open('_mesVision_test.py').read())
```

```
2) _mesVision_test.py calls vision_system.py script  
runPythonScript('C:\git\ADML\Vision_system.py')
```

Running BUMES

Now that all of the equipment is powered on, BUMES can be utilized from the computer at ADML Station 1. Restart the computer prior to use, login, and access BUMES via the desktop shortcut. If needed, navigate to the “Process Editor” tab and create the programs by pasting the text from the **BUMES Scripts Text Files** section of this document and saving the individual programs. Navigate to the “FMC Overview” tab in BUMES and press the “Post Operations” soft key, add one instance of each script in order according to the **BUMES Scripts Order** section of this document, then pressing the “Add to Queue” soft key. Confirm the correct order of the queue, then press the “Real Run” soft key to start the system.

BUMES Scripts Order

This section contains the order in which to post the BUMES scripts for the ADML Manufacturing Cell to run the process as desired. If more than one instance of this process is desired, repeat the queue in the following order as desired:

1. A1CordganizerLid
2. B2CordganizerBody
3. C3CordganizerBody
4. MaryAssembleAtoB
5. D4CordganizerLid
6. F5CordganizerLid
7. G6CordganizerBody
8. EdieAssembleCtoD
9. H7CordganizerBody
10. J8CordganizerLid
11. MaryAssembleFtoG
12. EdieAssembleHtoJ
13. visiontest

Appendix A: Bumex Scripts Descriptions

This section contains descriptions of all of the required BUMES scripts

1. **A1CorganizerLid:** occurs at Station 3 (Mary, Cayenne). Produces Lid A.
 - a. Takes stock W from Gravity Feeder W
 - b. Squares Stock W on Squaring Fixture
 - c. Places Stock W into the mill
 - d. Mills Cordganizer Lid A
 - e. Removes Cordganizer Lid A from mill
 - f. Places Cordganizer Lid A into vertical vise to prepare for assembly
2. **B2CorganizerBody:** occurs at Station 4 (Edie, Paprika). Produces Body B.
 - a. Takes stock Z from Gravity Feeder Z
 - b. Squares Stock Z on Squaring Fixture
 - c. Places Stock Z into the mill
 - d. Mills Cordganizer Body B
 - e. Removes Cordganizer Body B from mill
 - f. Places Cordganizer Body B onto conveyor on pallet at AgvA
3. **C3CorganizerBody:** occurs at Station 3 (Mary, Cayenne). Produces Body C.
 - a. Takes stock Z from Gravity Feeder Z
 - b. Squares Stock Z on Squaring Fixture
 - c. Places Stock Z into the mill
 - d. Mills Cordganizer Body C
 - e. Removes Cordganizer Body C from mill
 - f. Places Cordganizer Body C onto conveyor on pallet at AgvB
4. **MaryAssembleAtoB:** occurs at Station 3 (Mary). Assembles Lid A to Body B. Occurs while Body C is being milled.
 - a. Removes Lid A from vertical vise by gripping from below
 - b. Flips Lid A
 - c. Squares Lid A at Squaring Fixture
 - d. Assembles Lid A to Body B on conveyor at AgvA
 - e. Uses robot gripper to press Lid A to complete assembly
5. **D4CorganizerLid:** occurs at Station 4 (Edie, Paprika). Produces Lid D.
 - a. Takes stock W from Gravity Feeder W
 - b. Squares Stock W on Squaring Fixture
 - c. Places Stock W into the mill
 - d. Mills Cordganizer Lid D
 - e. Removes Cordganizer Lid D from mill
 - f. Places Cordganizer Lid D into vertical vise to prepare for assembly
6. **F5CorganizerLid:** occurs at Station 3 (Mary, Cayenne). Produces Lid F

- a. Takes stock W from Gravity Feeder W
 - b. Squares Stock W on Squaring Fixture
 - c. Places Stock W into the mill
 - d. Mills Cordganizer Lid F
 - e. Removes Cordganizer Lid F from mill
 - f. Places Cordganizer Lid F into vertical vise to prepare for assembly
- 7. G6CordganizerBody:** occurs at Station 4 (Edie, Paprika). Produces Body G.
- a. Takes stock Z from Gravity Feeder Z
 - b. Squares Stock Z on Squaring Fixture
 - c. Places Stock Z into the mill
 - d. Mills Cordganizer Body G
 - e. Removes Cordganizer Body G from mill
 - f. Places Cordganizer Body G onto conveyor on pallet at AgvC
- 8. EdieAssembleCtoD:** occurs at Station 4 (Edie). Assembles Lid D to Body C. Occurs while Body G is being milled.
- a. Removes Lid D from vertical vise by gripping from below
 - b. Flips Lid D
 - c. Squares Lid D at Squaring Fixture
 - d. Assembles Lid D to Body C on conveyor at AgvB
 - e. Uses robot gripper to press Lid D to complete assembly
- 9. H7CordganizerBody:** occurs at Station 3 (Mary, Cayenne). Produces Body H.
- a. Takes stock Z from Gravity Feeder Z
 - b. Squares Stock Z on Squaring Fixture
 - c. Places Stock Z into the mill
 - d. Mills Cordganizer Body H
 - e. Removes Cordganizer Body H from mill
 - f. Places Cordganizer Body G onto conveyor on pallet at AgvD
- 10. J8CordganizerLid:** occurs at Station 4 (Edie, Paprika). Produces Lid J.
- a. Takes stock W from Gravity Feeder W
 - b. Squares Stock W on Squaring Fixture
 - c. Places Stock W into the mill
 - d. Mills Cordganizer Lid J
 - e. Removes Cordganizer Lid J from mill
 - f. Places Cordganizer Lid J into vertical vise to prepare for assembly
- 11. MaryAssembleFtoG:** occurs at Station 3 (Mary). Assembles Lid F to Body G. Occurs while Body H is being milled.
- a. Removes Lid F from vertical vise by gripping from below
 - b. Flips Lid F
 - c. Squares Lid F at Squaring Fixture
 - d. Assembles Lid F to Body G on conveyor at AgvC

- e. Uses robot gripper to press Lid F to complete assembly
- 12. EdieAssembleHtoJ:** occurs at Station 4 (Edie). Assembles Lid J to Body H.
- a. Removes Lid J from vertical vise by gripping from below
 - b. Flips Lid J
 - c. Squares Lid J at Squaring Fixture
 - d. Assembles Lid J to Body H on conveyor at AgvD
 - e. Uses robot gripper to press Lid J to complete assembly
- 13. visiontest:** occurs at Station 1 (Rosie). Removes assembled Cordganizers from conveyor, places them under camera, and sorts based on the returned color value
- a. Stops AgvA
 - b. Removes Cordganizer assembly AB from AgvA and places under camera
 - c. Sorts Cordganizer
 - d. Releases AgvA, stops AgvB
 - e. Removes Cordganizer assembly CD from AgvB and places under camera
 - f. Sorts Cordganizer
 - g. Releases AgvB, stops AgvC
 - h. Removes Cordganizer assembly FG from AgvC and places under camera
 - i. Sorts Cordganizer
 - j. Releases AgvC, stops AgvD
 - k. Removes Cordganizer assembly HJ from AgvD and places under camera
 - l. Sorts Cordganizer

Appendix B: BUMES Scripts Text Files

This section contains all of the text files to create the BUMES scripts to run the system.

A1CordganizerLid

```
//Create a Cordganizer lid from raw material
```

```
//Initialize System
```

```
resourceSeize('A')
```

```
resourceSeize('C')
```

```
startupTasksComplete()
```

```
//Collect Lid raw material and manufacture
```

```
resourceSeize('Mary')
```

```
urDashboard('Mary','WED_9AM/gravityFeederW.urp')
```

```
urDashboard('Mary','WED_9AM/_adminCG-WXYZLoadMillMakeLid.urp')
```

```
resourceRelease('Mary')
```

```
//Unload lid from mill
```

```
resourceSeize('Mary')
```

```
urDashboard('Mary','WED_9AM/_adminCG-WXYZUnloadMillLid.urp')
```

```
//end
```

```
resourceRelease('Mary')
```

```
resourceRelease('A')
```

```
resourceRelease('C')
```

B2CordganizerBody

//Create a Cordganizer body from raw material

//Initialize System

resourceSeize('B')

resourceSeize('D')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Edie')

urDashboard('Edie','WED_9AM/gravityFeederZ.urp')

urDashboard('Edie','WED_9AM/_adminCG-WXYZLoadMillMakeBody.urp')

resourceRelease('Edie')

//stop Conveyor

resourceSeize('convStn4', 'agvA')

//Unload Body from mill and load body

resourceSeize('Edie')

urDashboard('Edie', 'WED_9AM/_adminCG-WXYZUnloadMillBody.urp')

//end

resourceRelease('convStn4')

resourceRelease('Edie')

resourceRelease('B')

resourceRelease('D')

C3CordganizerBody

//Create a Cordganizer body from raw material

//Initialize System

resourceSeize('C')

resourceSeize('APrime')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Mary')

urDashboard('Mary','WED_9AM/gravityFeederZ.urp')

urDashboard('Mary','WED_9AM/_adminCG-WXYZLoadMillMakeBody.urp')

resourceRelease('Mary')

//wait for assembly A to B

resourceSeize('A')

resourceRelease('A')

//stop Conveyor

resourceSeize('convStn3', 'agvB')

//Unload Body from mill and load body

resourceSeize('Mary')

urDashboard('Mary','WED_9AM/_adminCG-WXYZUnloadMillBody.urp')

//end

resourceRelease('convStn3')

resourceRelease('Mary')

resourceRelease('C')

resourceRelease('APrime')

MaryAssembleAtoB

```
//Assemble a Cordganizer at Mary
```

```
//Initialize System
```

```
resourceSeize('A')
```

```
resourceSeize('B')
```

```
startupTasksComplete()
```

```
//assemble at conveyor
```

```
resourceSeize('convStn3', 'agvA')
```

```
resourceSeize('Mary')
```

```
urDashboard('Mary', 'WED_9AM/_adminCG-AssembleAtoB.urp')
```

```
//end
```

```
resourceRelease('convStn3')
```

```
resourceRelease('Mary')
```

```
resourceRelease('A')
```

```
resourceRelease('B')
```

D4CordganizerLid

//Create a Cordganizer lid from raw material

//Initialize System

resourceSeize('D')

resourceSeize('BPrime')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Edie')

urDashboard('Edie','WED_9AM/gravityFeederW.urp')

urDashboard('Edie','WED_9AM/_adminCG-WXYZLoadMillMakeLid.urp')

resourceRelease('Edie')

//Unload lid from mill

resourceSeize('Edie')

urDashboard('Edie','WED_9AM/_adminCG-WXYZUnloadMillLid.urp')

//end

resourceRelease('Edie')

resourceRelease('D')

resourceRelease('BPrime')

F5CordganizerLid

//Create a Cordganizer lid from raw material

//Initialize System

resourceSeize('APrime')

resourceSeize('CPrime')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Mary')

urDashboard('Mary','WED_9AM/gravityFeederW.urp')

urDashboard('Mary','WED_9AM/_adminCG-WXYZLoadMillMakeLid.urp')

resourceRelease('Mary')

//Unload lid from mill

resourceSeize('Mary')

urDashboard('Mary','WED_9AM/_adminCG-WXYZUnloadMillLid.urp')

//end

resourceRelease('Mary')

resourceRelease('APrime')

resourceRelease('CPrime')

G6CordganizerBody

//Create a Cordganizer body from raw material

//Initialize System

resourceSeize('BPrime')

resourceSeize('DPrime')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Edie')

urDashboard('Edie','WED_9AM/gravityFeederZ.urp')

urDashboard('Edie','WED_9AM/_adminCG-WXYZLoadMillMakeBody.urp')

resourceRelease('Edie')

//wait for assemble

resourceSeize('D')

resourceRelease('D')

//stop Conveyor

resourceSeize('convStn4', 'agvC')

//Unload Body from mill and load body

resourceSeize('Edie')

urDashboard('Edie', 'WED_9AM/_adminCG-WXYZUnloadMillBody.urp')

//end

resourceRelease('convStn4')

resourceRelease('Edie')

resourceRelease('BPrime')

resourceRelease('DPrime')

EdieAssembleCtoD

//Assemble a Cordganizer at Mary

//Initialize System

resourceSeize('C')

resourceSeize('D')

startupTasksComplete()

//assemble at conveyor

resourceSeize('convStn4', 'agvB')

resourceSeize('Edie')

urDashboard('Edie', 'WED_9AM/_adminCG-AssembleCLidToD.urp')

//end

resourceRelease('convStn4')

resourceRelease('Edie')

resourceRelease('C')

resourceRelease('D')

H7CordganizerBody

//Create a Cordganizer body from raw material

//Initialize System

resourceSeize('CPrime')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Mary')

urDashboard('Mary','WED_9AM/gravityFeederZ.urp')

urDashboard('Mary','WED_9AM/_adminCG-WXYZLoadMillMakeBody.urp')

resourceRelease('Mary')

//stop Conveyor

resourceSeize('convStn3', 'agvD')

//Unload Body from mill and load body

resourceSeize('Mary')

urDashboard('Mary','WED_9AM/_adminCG-WXYZUnloadMillBody.urp')

//end

resourceRelease('convStn3')

resourceRelease('Mary')

resourceRelease('CPrime')

J8CordganizerLid

//Create a Cordganizer lid from raw material

//Initialize System

resourceSeize('DPrime')

startupTasksComplete()

//Collect Lid raw material and manufacture

resourceSeize('Edie')

urDashboard('Edie','WED_9AM/gravityFeederW.urp')

urDashboard('Edie','WED_9AM/_adminCG-WXYZLoadMillMakeLid.urp')

resourceRelease('Edie')

//Unload lid from mill

resourceSeize('Edie')

urDashboard('Edie', 'WED_9AM/_adminCG-WXYZUnloadMillLid.urp')

//end

resourceRelease('Edie')

resourceRelease('DPrime')

MaryAssembleFtoG

//Assemble a Cordganizer at Mary

//Initialize System

resourceSeize('APrime')

resourceSeize('BPrime')

//assemble at conveyor

resourceSeize('convStn3', 'agvC')

resourceSeize('Mary')

urDashboard('Mary', 'WED_9AM/_adminCG-AssembleAToB.urp')

//end

resourceRelease('convStn3')

resourceRelease('Mary')

resourceRelease('APrime')

resourceRelease('BPrime')

EdieAssembleHtoJ

//Assemble a Cordganizer at Mary

//Initialize System

resourceSeize('CPrime')

resourceSeize('DPrime')

startupTasksComplete()

//assemble at conveyor

resourceSeize('convStn4', 'agvD')

resourceSeize('Edie')

urDashboard('Edie', 'WED_9AM/_adminCG-AssembleCLidToD.urp')

//end

resourceRelease('convStn4')

resourceRelease('Edie')

resourceRelease('CPrime')

resourceRelease('DPrime')

visiontest

```
//First Pallet
resourceSeize('convStn1', 'agvA')
//call the python script from mesprocess
Vision_test()
resourceRelease('convStn1')

// Second Pallet
resourceSeize('convStn1', 'agvB')
Vision_test()
resourceRelease('convStn1')

//Third Pallet
resourceSeize('convStn1', 'agvC')
Vision_test()
resourceRelease('convStn1')

// Fourth Pallet
resourceSeize('convStn1', 'agvD')
Vision_test()
resourceRelease('convStn1')
```

Appendix C: Reference Documents

Reference the other documents listed here to learn more about each individual component.

Document Topic	Document Title	Document Description
Universal Robotics Arms	ME500 Final Project WedsAM UR Program Guide	Contains descriptions of each individual .urp file required to run the system
Vision Python Scripts	ME500 Final Project WedsAM Vision Python Scripts Guide	Contains descriptions and the complete text scripts
CAD/CAM	ME500 Final Project WedsAM CAD_CAM Guide	Contains instructions to replicate/change the CAD and CAM assemblies, and descriptions of the relevant files