Testing Readiness Review

SIERRA NEVADA CORPORATION

University of Colorado Boulder

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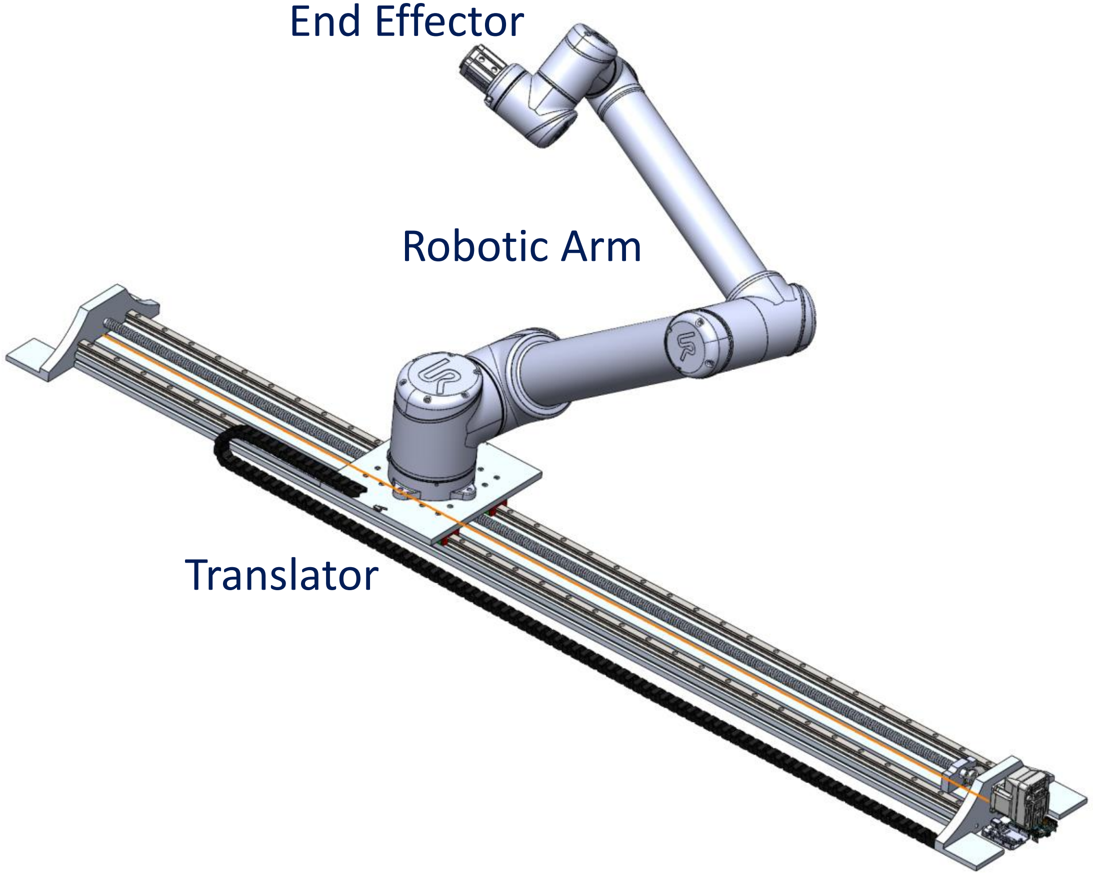
Section 1

Project Overview → Purpose → Objectives → CONOPS → FBD

Purpose

- Prove the feasibility of using Intra-Vehicular Robotics (IVR) to identify and distribute NASA cargo bags
- Demonstrate task management in an un-crewed environment
- Use robotics for cargo management tasks anticipated on a space habitat
- Use a robotic arm to capture and release bags in specified positions



Objectives

In Progress | Complete

Level	**Translator**	Robotic Arm	End Effector	
Level 1	Platform that is **capable of being mounted to the rail system** of size 2.15m x 0.3m.	Robotic arm can **move to a desired pose** under a given command without colliding with simulated LIFE module environment.	End effector is able to take a command to **operate the bag capture mechanism**.	Phase I Feb 22
Level 2	Translator is able to **integrate with the robotic arm** including power and communication systems.	Robotic arm can plan and **move to a specified pose while the base is being moved** by the translator.	**End effector can capture bag with operator input** and maintain hold while translating and rotating the arm.	Phase II Mar 19
Level 3	**Translate robotic arm up to 2 meters** in one direction given a control input with 1 cm of accuracy.	**Robotic system can capture a bag and release it at a specified location**, with a remote operator determining pick up and drop off location.	**End effector receives input from the robotic arm** to be aligned, capture, and control a bag instead of a remote operator.	Phase III Apr 16
Level 4	**Translation is automated** and repeatable; sensor suite returns position data to the system/user to refine position during operations.	The system will complete a cargo transportation task by **identifying, locating, capturing, and releasing a bag with no manual inputs** from an operator.	The end effector is **correctly aligned to capture a bag based on the coordinate location** returned by the imaging sensors.	Phase III Apr 16

CONOPS

Stage 1: Capture

A) Identify a cargo bag and return location coordinates

B) Position arm to attach to bag

C) Engage magnetic end effector

D) Rotate to required pose

Stage 2: Translation

A) Begin motorized translation

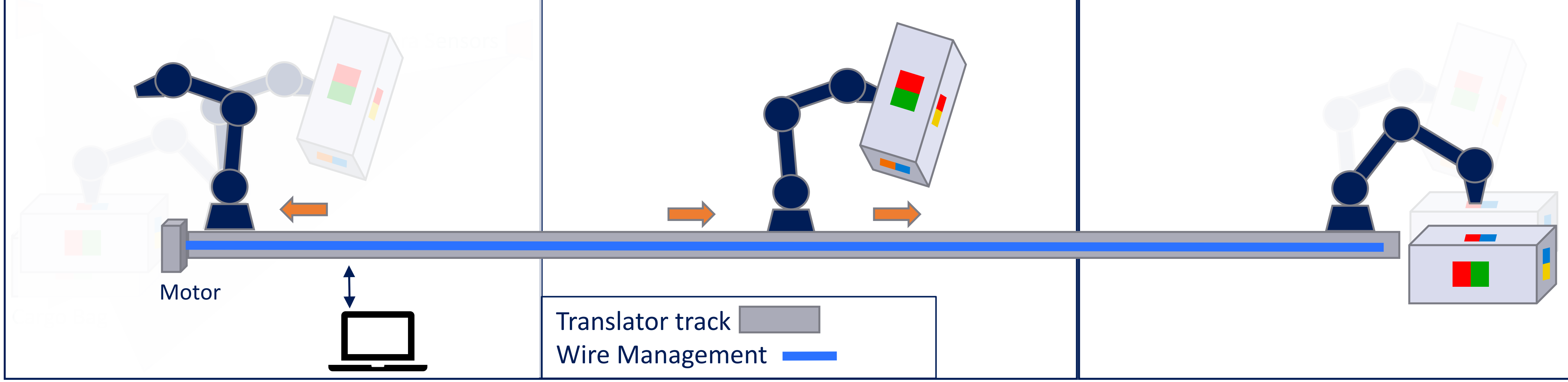
B) Stop translation at drop off location

Stage 3: Release

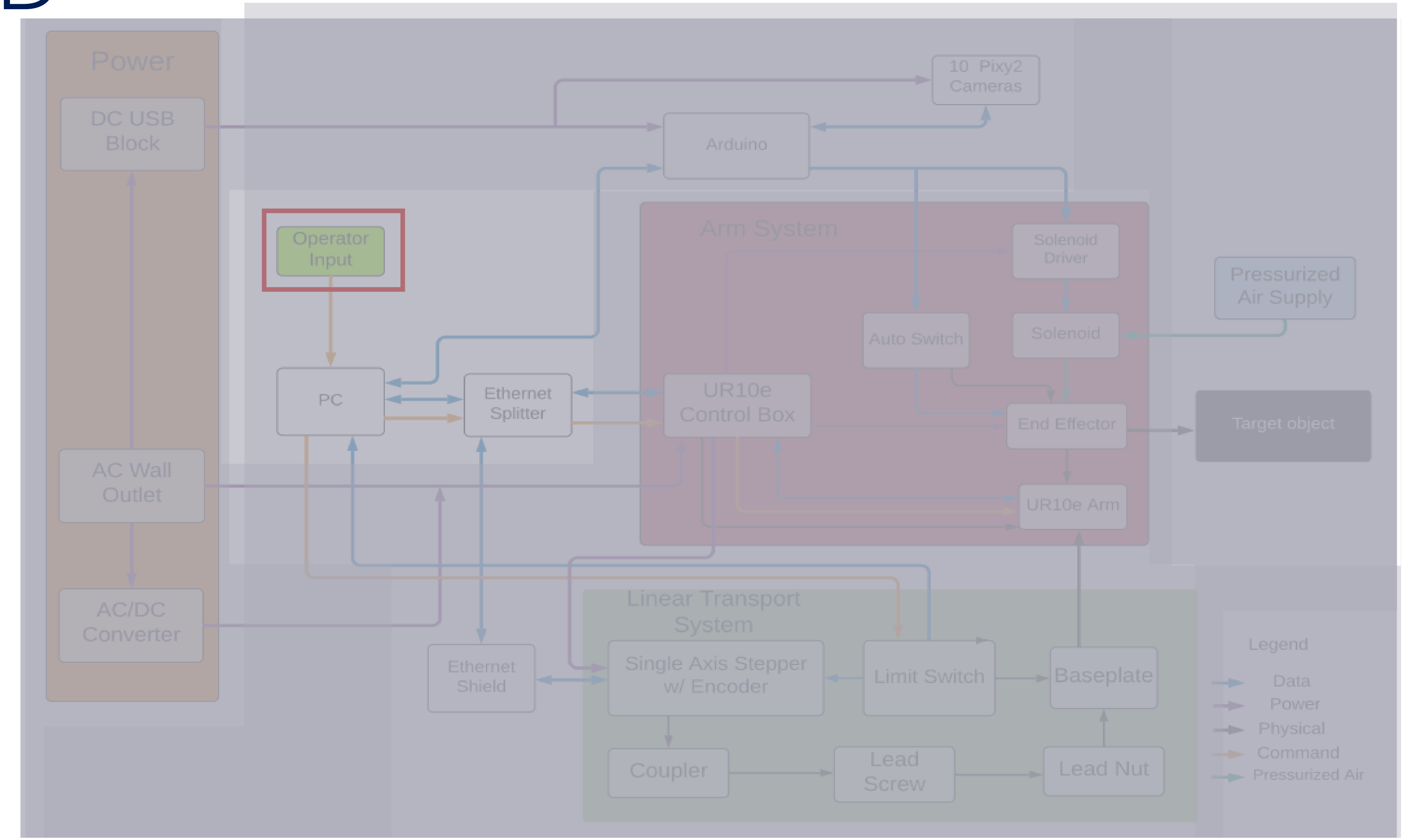
A) Rotate to drop off pose

B) Disengage end effector

C) Return to origin and restart process



FBD



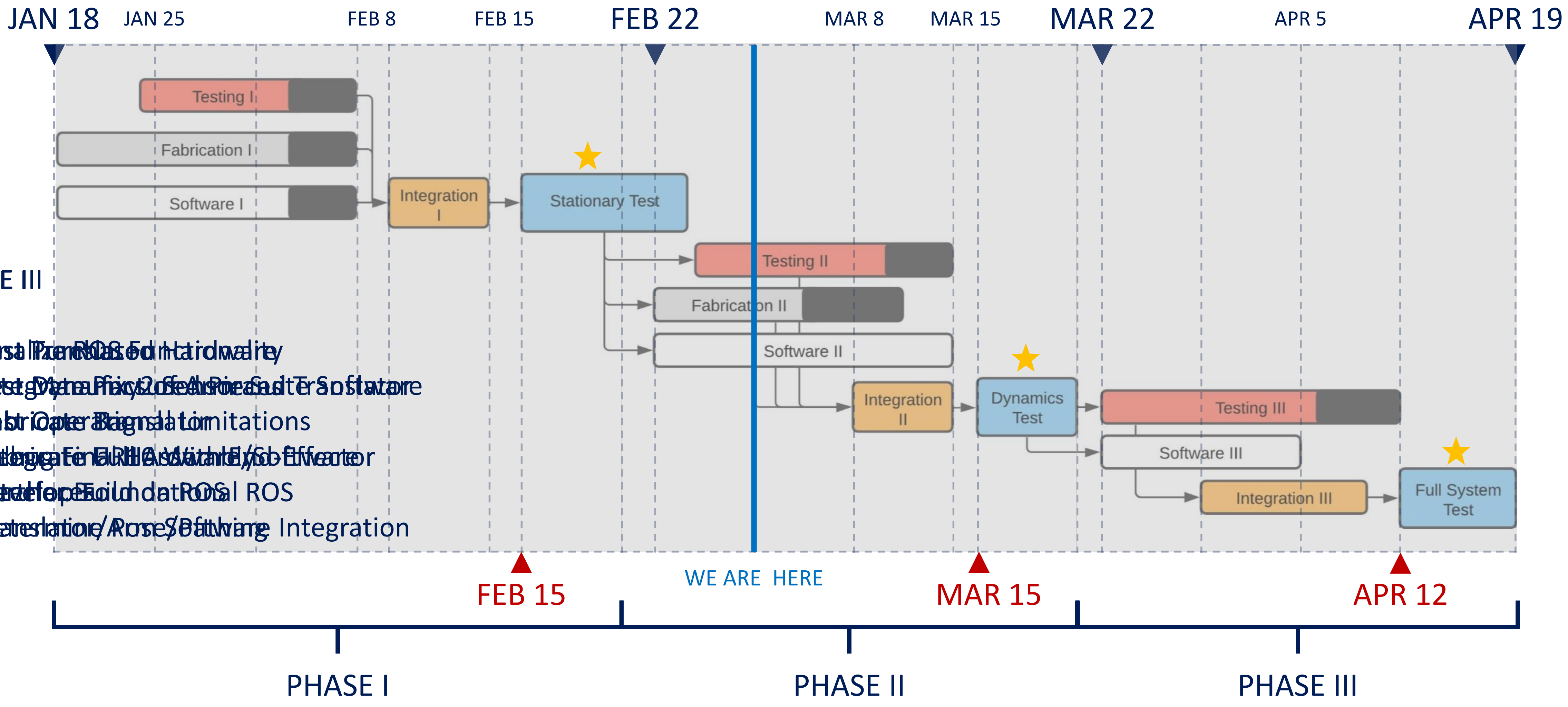
Power
DC USB Block
AC Wall Outlet
AC/DC Converter
10 Pixy2 Cameras
Arduino
Operator Input
PC
Ethernet Splitter
Ethernet Shield
Arm System
Solenoid Driver
Auto Switch
Solenoid
UR10e Control Box
End Effector
UR10e Arm
Pressurized Air Supply
Target object
Linear Transport System
Single Axis Stepper w/ Encoder
Limit Switch
Baseplate
Coupler
Lead Screw
Lead Nut
Legend
Data
Power
Physical
Command
Pressurized Air

Section 2

Schedule → Gantt Chart → Current Progress

Gantt Chart – Critical Path

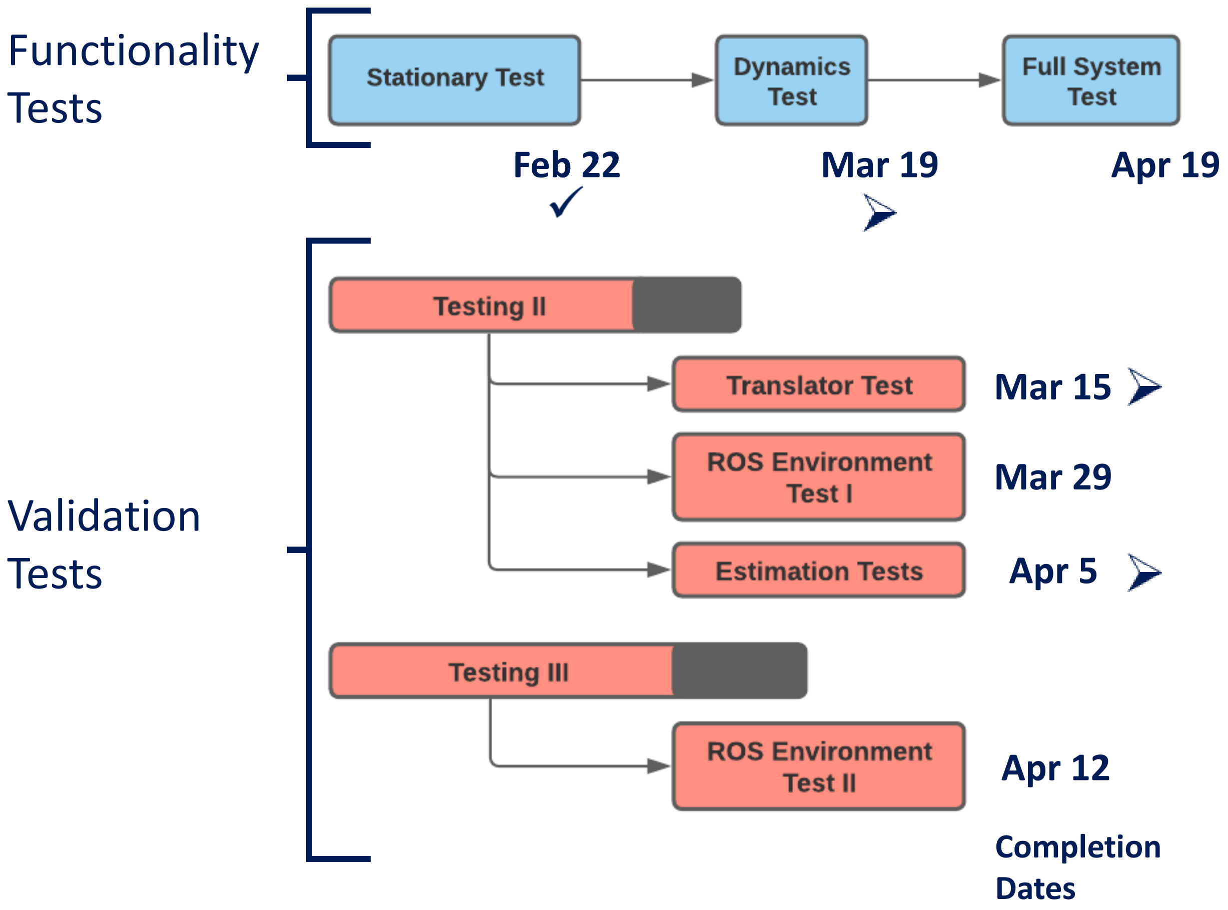
Milestones · Margin · Testing · Fabrication · Software · Integration



PHASE III

Current Progress - Testing

○ Incomplete ➢ In-Progress ✓ Complete



	Test	Sub-Test/Tasks	Date
FUNCTIONALITY	Stationary Test	✓ Assemble Test Components ✓ Actuate End Effector ✓ Waypoint Task Robotic Arm	✓ Feb 22 ✓ Feb 22 ✓ Feb 22
	Dynamics Test	➢ Assemble Translator ○ Test Limit Switches	➢ Mar 15 ○ Mar 8
	Full System Test	○ Assemble Full System ○ Integrate Control/Comms	○ Apr 12 ○ Apr 12
VALIDATION	Translator Test	➢ Acceleration/Mass Test	➢ Mar 15
	Estimation Tests	➢ End Effector Test ➢ Camera Test ○ Algorithm Test	➢ Mar 5 ➢ Mar 22 ○ Apr 5
	ROS Environment Test I & II	○ Sensor Data Read/Pkg Test ○ Real Time System Status Test ○ Task Planner Command Test	○ Mar 29 ○ Apr 12 ○ Apr 12

Section 3

Testing Readiness → Test → Equipment → Procedure

Testing Overview

Functional Test | Complete
Validation Test | In Progress | ★ In Presentation

RIVeR

Phase	Milestone	Hardware	Purpose	Status
Phase I	Component Testing	Various	Verify baseline parameters/operations	In Progress
	Stationary Test	Robotic Arm, End Effector and Cargo Bag	Test end effector and robotic arm interface and verify end effector is strong enough	Complete
Phase II	Translator Test ★	Translator Motor	Verify motor accuracy and strength	March 15th
	Estimation Tests ★	Pixy2, PC, End Effector	Test accuracy of cameras, end effector accuracy needs, and positional algorithms	April 5th
	Dynamics Test	Translator and UR10e	Test translator and robotic arm function in tandem	March 19th
Phase III	ROS Environment Test ★	PC, UR10e, Pixy2, End Effector, Translator	Test read/communication/command systems between components	April 12th
	Full System Test ★	Translator, Robotic Arm, and Camera Suite	Test entire system functionality	April 19th

Translator Tests

Complete: 15 March

Purpose: Verify the capability of the translator to move the UR-10 and meet design requirements.

Equipment: UR-10, Translator, Baseplate, Motor, Motor Power Supply, PC

Variables: carrying weight, motor torque, distance traveled, acceleration, accuracy.

Design Requirements Satisfied:

DR.1.1, DR.3.2, DR. 5.2

Backup Slides

In Presentation

Translator Tests

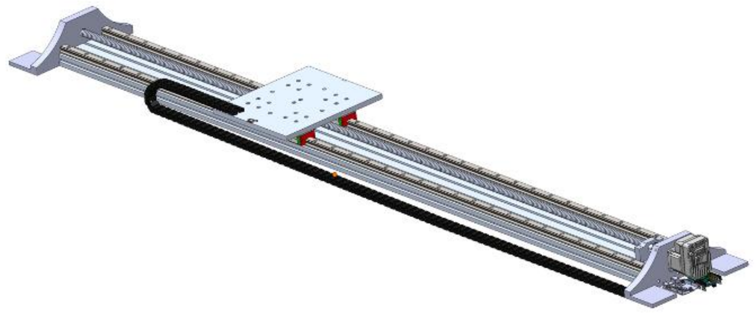
- Acceleration Test
- Accuracy Test
- Mass Test
- Torque Validation Test

Pass Conditions:

- **Acceleration:** 3 cm/s from DR 1.1
- **Mass:** 50 kg DR 3.2, robotic arm, end effector/ cargo bag combined mass
- **Accuracy:** 5 cm from DR 5.2

Fail Contingency:

- Run motor at a lower angular velocity
- Construct a gearbox between the stepper motor and coupler.
- Procure a higher voltage power supply



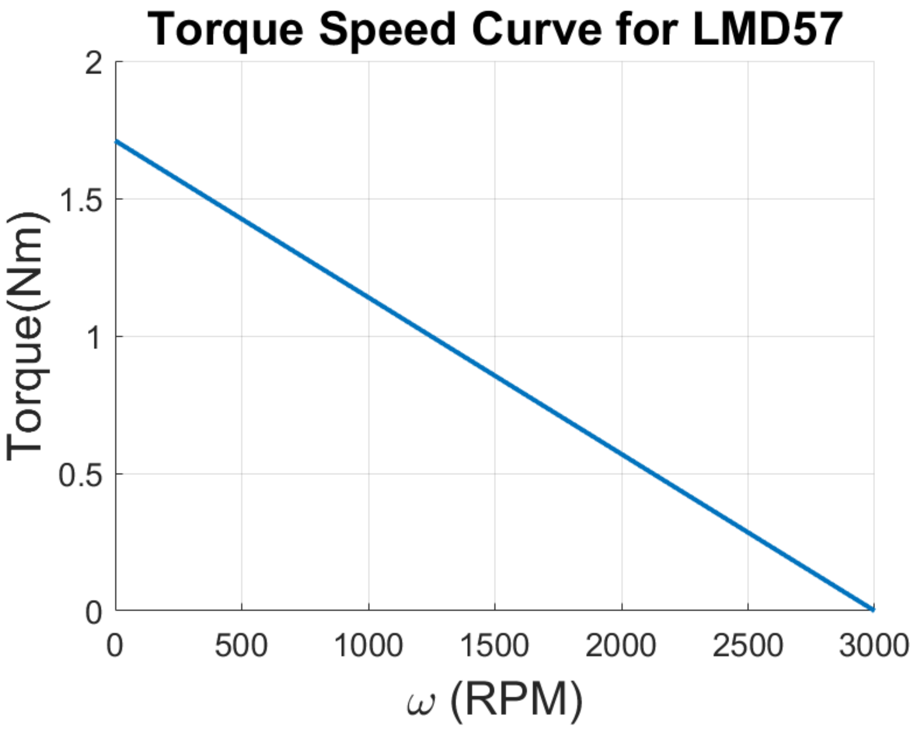
Translator Test

Complete: 7 March

Torque Model Validation

DR 3.2	The translation system shall be capable of translating the robotic arm, end effector, and cargo bag's combined mass

Holding Torque Required	Motor Rating
.652 Nm	1.71 Nm



Procedure

1. Setup translator without additional payload
2. Set acceleration to 1000 microsteps/(s^2) & run current to 100%
3. Test 10 angular velocity values ranging from .1 to 3000 RPM
3. Print motor torque to terminal with PR TD command after each angular velocity is reached
4. Compare results to expected motor torque-speed curve.

Estimation Test

RIVeR

Complete: 5 April

Purpose: Verify that the cargo bag estimation process can estimate the position and orientation of the cargo bag within the uncertainty bounds required by the end effector

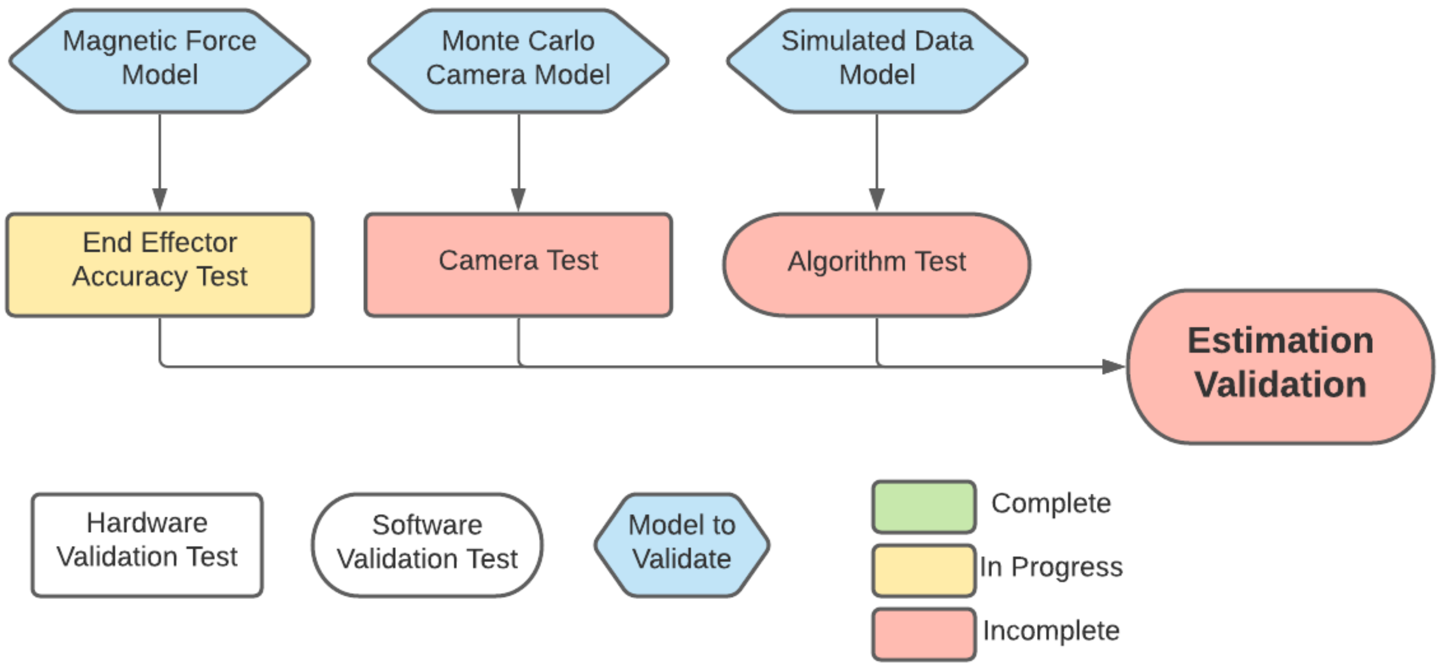
Equipment: Computer, Pixy Sensors, End Effector, Cargo Bag

Design Requirements Satisfied: DR 3.1, DR 3.2, DR 3.3, DR 3.4, DR 6.1

Pass Condition:

- Estimation errors for all markers remain within the accuracy bounds determined through end effector testing
- The sensor network can obtain the necessary data for estimation in at least 90% of bag configuration scenarios

Estimation Test



Estimation Test

Complete: 26 Feb

End Effector Accuracy Test

Purpose: Determine the placement accuracy of the end effector required to secure the cargo bag

Equipment: End Effector, Cargo Bag

Design Requirements Satisfied: DR 6.1

Fail Contingency:

1) Perform a weight vs holding force analysis of the magnetic plate to increase the accuracy necessary to secure the cargo bag

Procedure:

1) Set up the end effector with some measured displacement from the magnetic plate
2) Actuate the end effector to see if this relative placement can secure the cargo bag
3) Increase both the displacement and relative angle and repeat
4) Determine the required displacement and relative angle accuracy bounds

Estimation Test
End Effector Results

With Bag		
Distance (mm):	Secured:	Notes: -120 z-component = 11 mm
10	1	
11	1	
12	0	
11.5	0	
11.2	0	
11.1	1	
With Bag		
Angle (degrees):	Secured:	Notes: -90 degrees will be set as zero (wrist 2)
		Distance from centers (MHM and disk) is set to 11 mm
5 (or -85 on wrist 2)	0	
4	0	
3	0	
2	1	
With Bag	Secured:	Notes: -90 degrees will be set as zero (wrist 2)
Angle (degrees)		Distance = 6 mm
5	1	
6	1	
7	1	
8	1	
10	1	
12	1	
14	1	
15	0	

Estimation Test

RIVeR

Complete: 22 Mar

Camera Test

Purpose: Determine the minimum required number of cameras observing a target location such that the configuration determination algorithms can return a meaningful result

Equipment: Pixy2, Laptop, Bag

Design Requirements Satisfied: DR 3.1

Variables: Number of cameras observing the test location, random configuration of observed bag (bag must be in target location bounds) (unique for each trial)

Pass Condition: Given a data set of observations of N random bag configuration trials using 5 cameras, at least 90% of the N trials contain observations of at least 3 distinct markers each seen by at least 2 unique cameras

Procedure:

1. **Set up Cameras:** Configure desired number of cameras in assigned location
2. **Initiate Data Collection:** Start data collection of all cameras taking note of which markers are seen
3. **Re-configure Bag:** Change the orientation and position of bag (within target area bounds) during data collection

Fail Contingency:

1. Move locations of cameras, or move cameras closer
2. Increase the marker sizes
3. Increase number of cameras

Estimation Test

Complete: 5 April

Algorithm Test

Purpose: Validate the simulated estimation model with real Pixy sensor data

Equipment: Computer, Pixy Sensors, Cargo Bag

Design Requirements Satisfied: DR 3.1, DR 3.2, DR 3.3

Pass Condition:

- Estimation errors for all markers remain within the accuracy bounds determined through end effector testing

Procedure:

1) Collect sensor calibration data and calibrate each sensor
2) Set up the testing scenario such that the cargo bag position and orientation are known (ground truth)
3) Record live sensor data
4) Run the algorithms using the live data
5) Compare the results:
    1) Position: Estimation Error of measured markers
    2) Orientation: Estimation Error of unmeasured markers

Fail Contingency:

1) **Position:** Increase the data collection time or add additional cameras
2) **Orientation:** Increase the number of gradient descent iterations

ROS Environment Test

RIVeR

Complete: 12 April

Purpose: Verify all software & hardware components can correctly communicate through ROS

Equipment: Computer, UR10, Arduino, Sensors, Stepper Motor

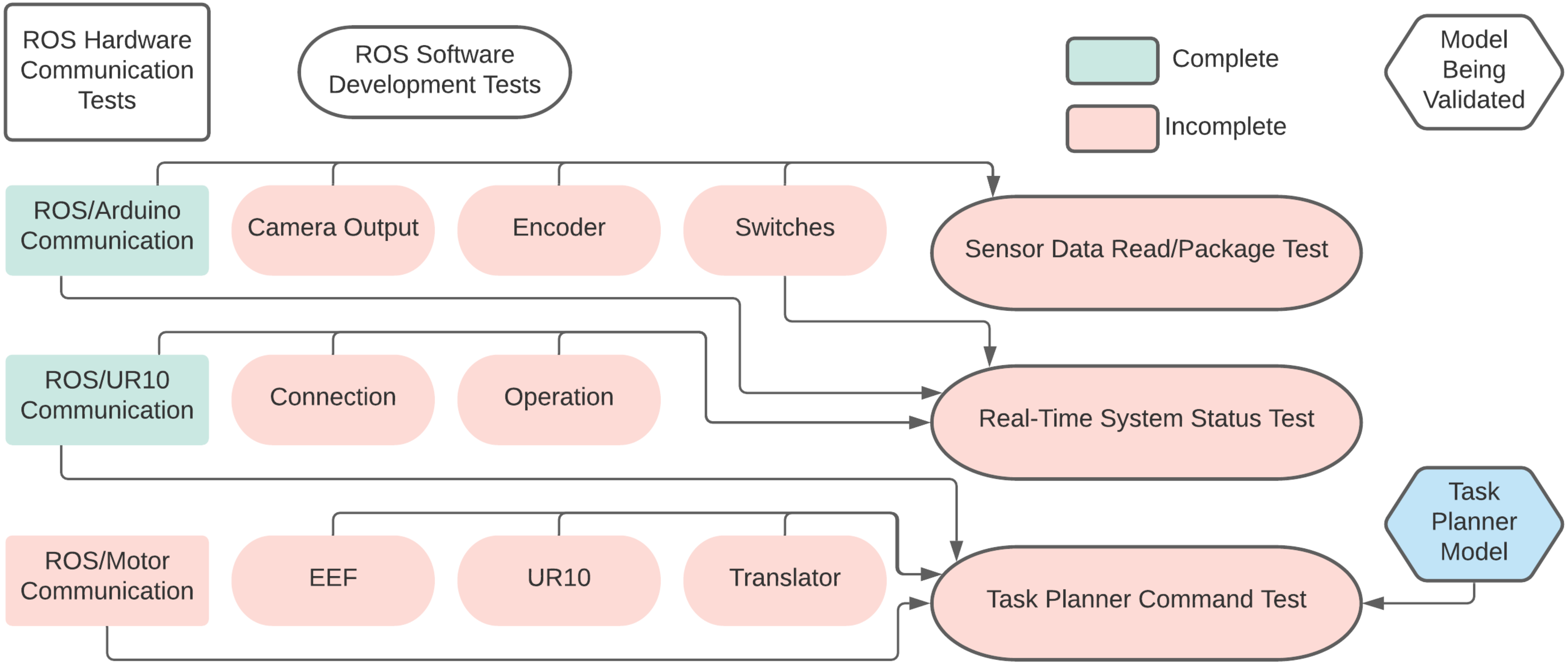
Design Requirements Satisfied: DR.2.2, DR.3.2, DR.3.3, DR.3.4, DR.7.1

Fail Contingency: Use manual write-to-file/read-from-file data sharing network

Pass Condition:

1. **Publishing:** Intended data is packaged in correct *rosmsg* and published to unique *rostopic*
2. **Subscribing:** Desired *rosmsg* is received and correct data is unpacked

ROS Environment Test



ROS Environment Test

Complete: 29 Mar

Sensor Data Read & Package

Purpose: Verify the following data are being packed and published correctly:

- Pixy2 marker positions
- Motor encoder/Translator position
- Limit switch engagement
- EEF grasp switch engagement

Equipment: Computer, Arduino, Sensors, Stepper Motor

Fail Contingency: Use manual write-to-file/read-from-file data sharing network

Pass Condition: All sensory data lines can be read off unique desired *rostopics* when Arduino is activated with hardware connected

ROS Environment Test

RIVeR

Complete: 12 April

Real-Time System Status Test

Purpose: Verify the real-time status of main dynamic components

Equipment: Computer, UR10, Arduino, Sensors, Stepper Motor

Variables: Connection, operation mode, limit switch/EEF grasp switch engagement

Fail Contingency: Environment status is visually monitored by user

Pass Condition:

- **Connection:** If connection is lost to pixy camera or motor, warning status is updated (*rostopic*)
- **Operation:** If bag placement succeeds, translator begins/ends moving, or arm trajectory execution begins/ends, respective status is updated
- **Switches:** If limit switch is activated, warning status is updated. If EEF grasp switch is activated, holding bag status is updated

ROS Environment Test

RIVeR

Complete: 12 April

Task Planner & Commands

Purpose: Verify the task planner commands are correctly sent to the hardware:

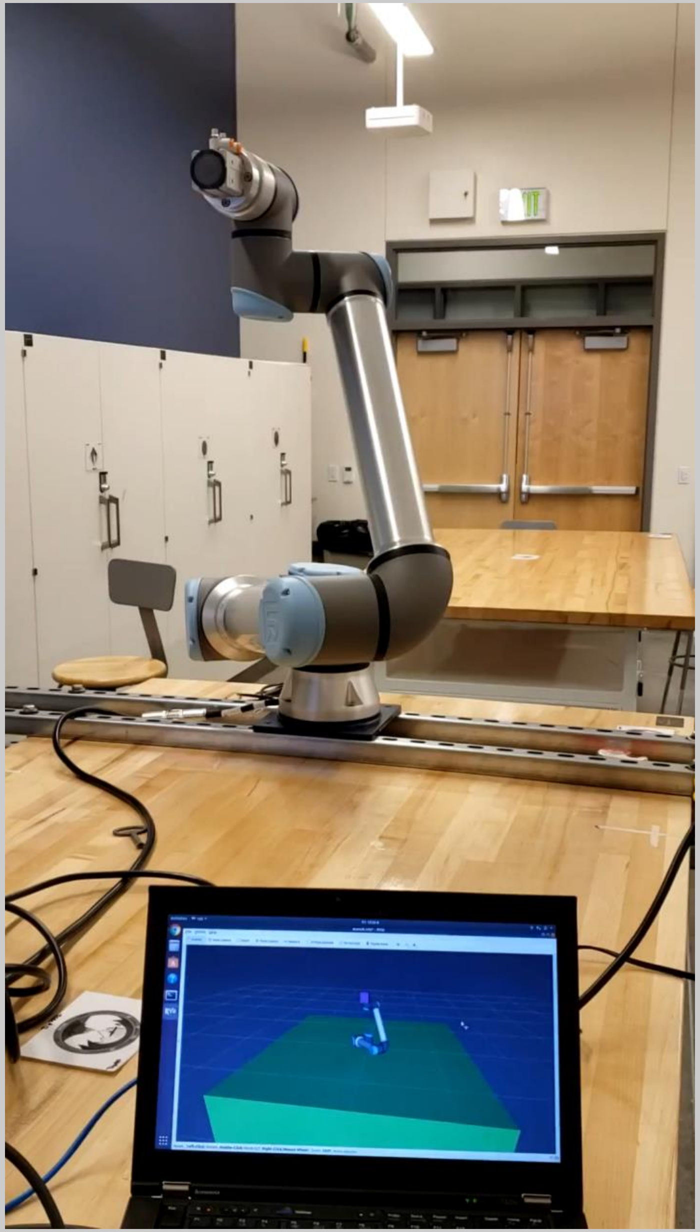
Equipment: Computer, UR10, Stepper Motor

Fail Contingency: Commands are manually executed by user (excluding UR10)

Pass Condition:

- **EEF:** When task planner sends engagement command, the EEF actuates
- **UR10:** Task planner calls motion planner with correct & safe start/end states. If motion plan succeeds, trajectory is executed on UR10
- **Translator:** When task planner sends desired translator position command, translator moves to commanded position to within 5cm

RIVeR



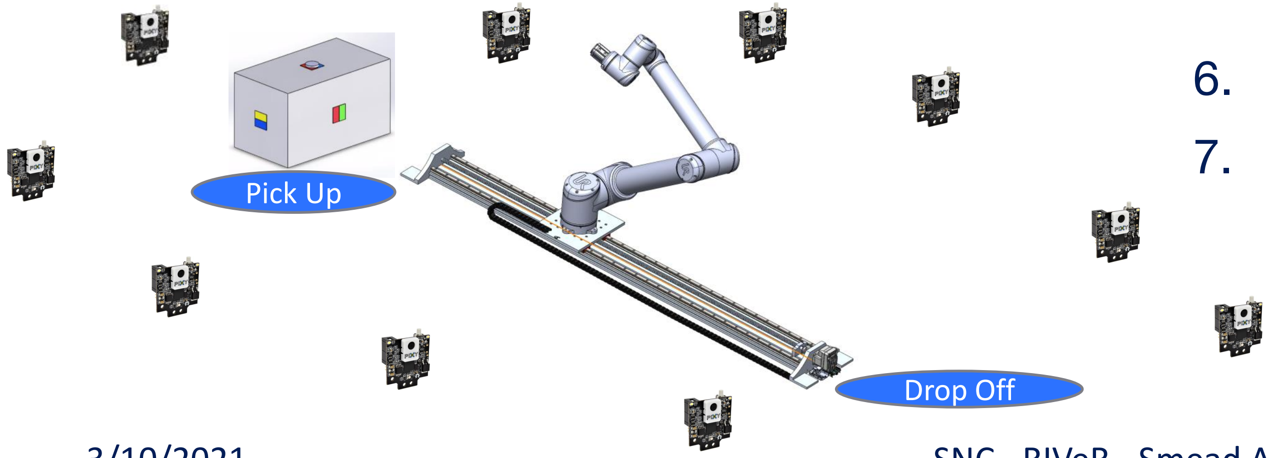
Full Systems Test

Overview: Use camera suite to identify a cargo bag and have the robotic arm/translator system capture and release a bag in the proper locations. No operator input.

Rationale: Verify complete operation of the system as an integrated process.

Location: Senior projects room

Equipment: Wall outlet, compressed air



Procedure:

1. Power on all components
2. Initiate program
3. Calibrate the sensor system
4. Cameras identify bag and send location to arm
5. Arm captures cargo bag, translator moves arm to drop-off side
6. Arm releases bag in drop off location
7. System resets for next bag

Section 4

Budget

Cost Plan

Actual Vs. Effective Budget

RIVeR

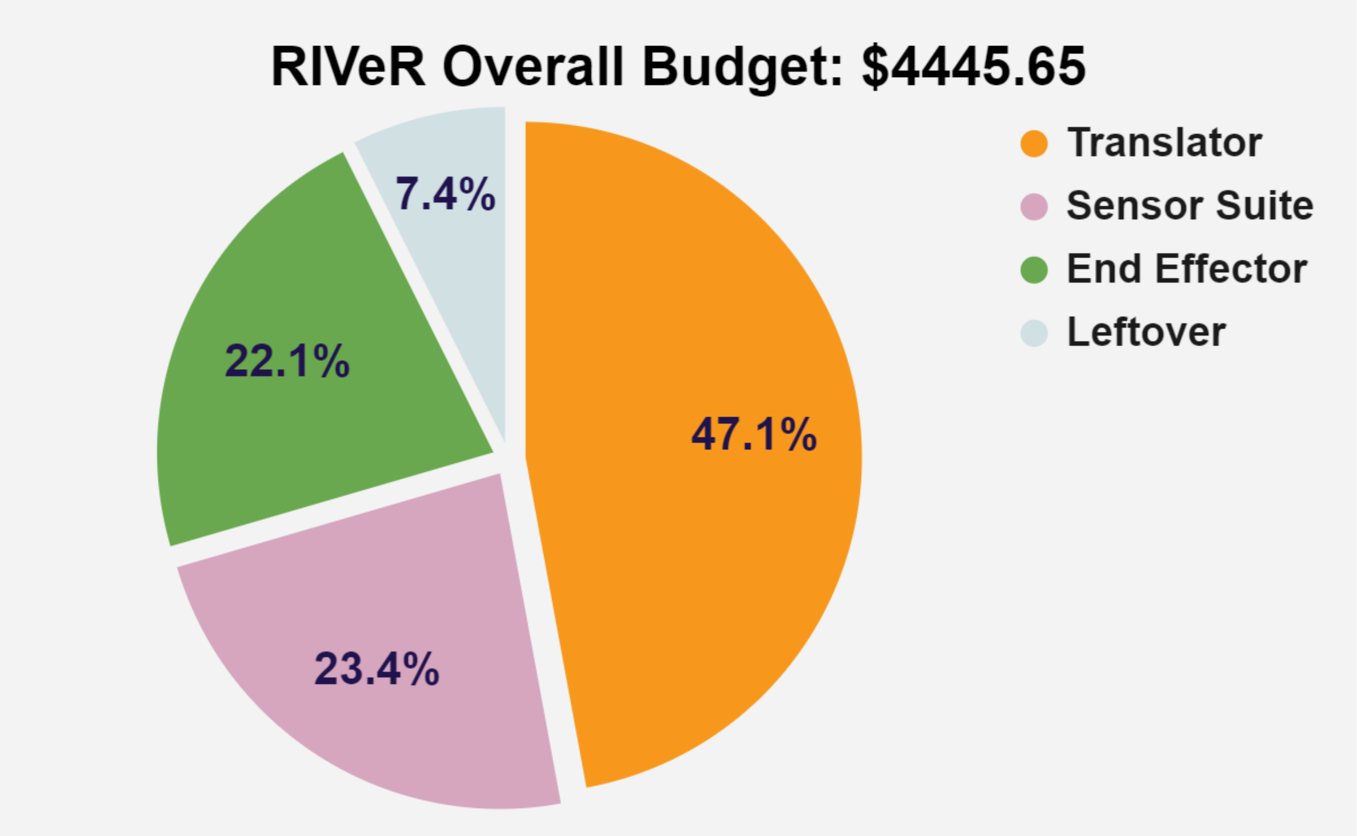
Actual Budget:	**$69.01**
1. Al 6061 Return	+ **$106.03**
2. PVC Shipping Refund	+ **$123.66**
3. Partial Ball Mount Return (x7)	+ **$55.65**

- **Effective Budget** $\boxed{\textbf{\$354.35}}$

Cost Plan

Subsystem	Effective Cost	Allocated Amount	Margin
Translator	2260.94	$2400	$139.06
End Effector	1122.30	$1250	$127.70
Sensors	1062.41	$1150	$87.59
Total	**$4445.65**	**$4800**	**$354.35**

Robotic Arm Provided by SNC ($40,000)



Procurement

All Items Delivered Except:

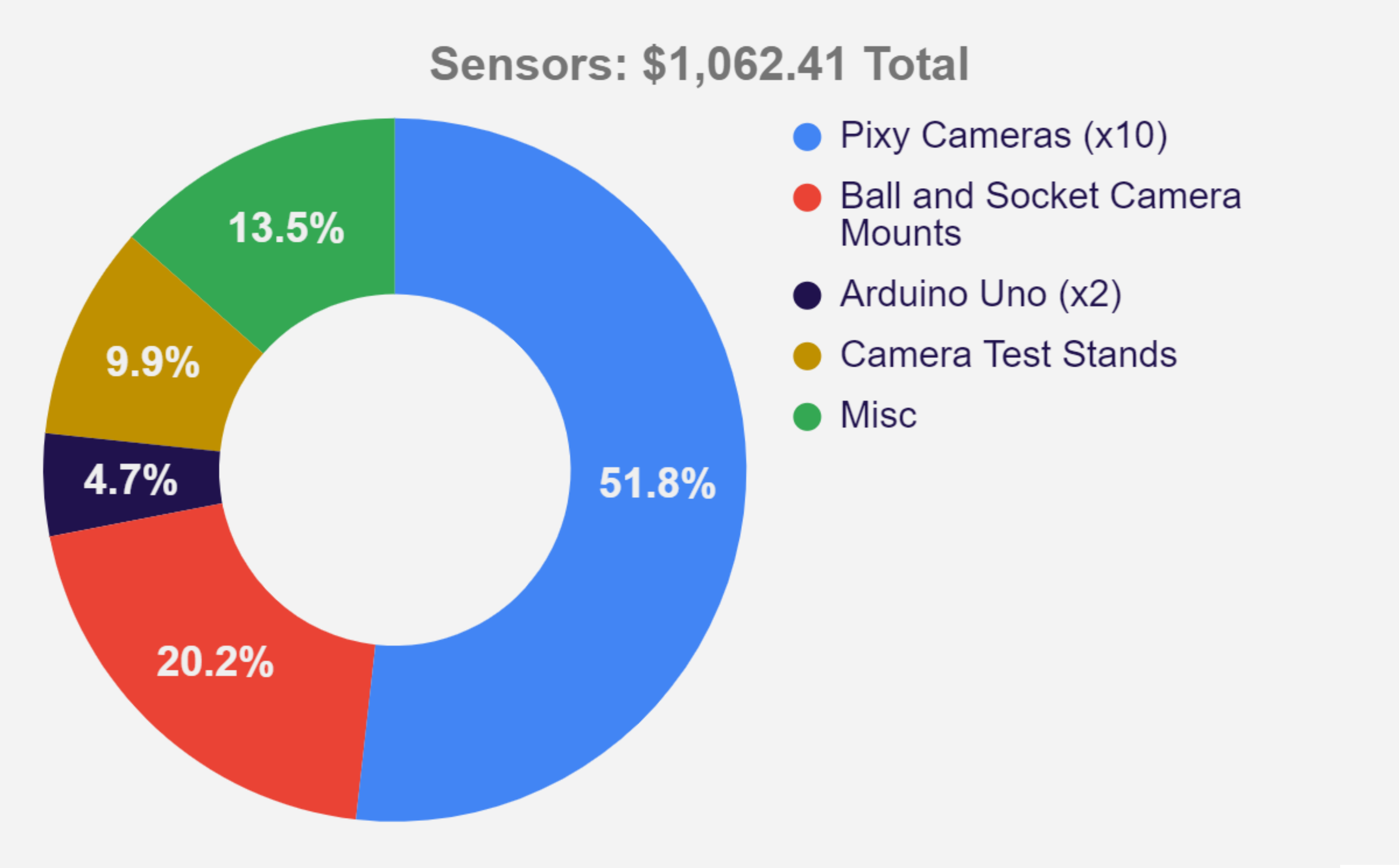
1. **Arduino Uno** (expected this week)
2. **Swivel Sockets** (expected today)
3. **Motor Shield** (expected this week)

Translator	Total	Total Cost	Vendor	Status
Motor	1	$660.45	MSITec	Delivered
Linear Stage	1	$749.99	Motion Constrained	Delivered
Limit Switch	2	$6.12	DigiKey	Delivered
Stepper Motor Power Supply	1	$19.99	Amazon	Delivered
Bumper Pads	1	$10.97	Amazon	Delivered
AL 6061 1/2"	1	$226.18	McMaster	Delivered
Al 6061 1.75"	1	$106.03	McMaster	Delivered
Rubber Washers	1	$6.07	McMaster	Delivered
Shaft Coupling	1	$26.62	McMaster	Delivered
UR10 Baseplate	1	$177.15	Vention	Delivered
Cable Carrier	1	$108.84	McMaster	Delivered
Cable Mounting Brackets	1	$8.44	McMaster	Delivered
Strut Channel - Zinc Plate Steel	4	$160.93	McMaster	Delivered
Hex Head Screw (x5)	1	$10.20	McMaster	Delivered
Hex Nut (x5)	1	$4.73	McMaster	Delivered
Grid Paper Roll	1	$16.99	Amazon	Delivered
Zinc Head Screw- 10 mm (x50)	1	$15.53	McMaster	Delivered
Steel Head Screw- 14mm (x25)	1	$5.73	McMaster	Delivered
Steel Head Hex - 1.75" (x5)	4	$33.02	McMaster	Delivered
NEMA 23 Mount Bracket	1	$12.99	Amazon	Delivered
		$2,366.97		

End Effector	Total	Total Cost	Vendor	Status
Manual Dump Valve	1	$50.85	SMC	Delivered
Filter/Regulation Combo	1	$32.20	SMC	Delivered
Electronic Dump Valve	1	$131.65	SMC	Delivered
Coupler w/ wall mount bracket	2	$12.80	SMC	Delivered
Pressure Gauge	1	$11.00	SMC	Delivered
Single Solenoid Valve	1	$64.52	SMC	Delivered
Solenoid Valve Silencers	2	$7.00	SMC	Delivered
Speed Controller Valve	2	$14.06	SMC	Delivered
1/4" Tube to 10-32 straight connector (internal hex)	10	$41.20	SMC	Delivered
1/4" Tube to 1/4 NPT Elbow	10	$28.20	SMC	Delivered
Magnetic Gripper	1	$491.45	SMC	Delivered
Solid State Sensors	2	$89.24	SMC	Delivered
1/4" Polyurethane Tubing, Black, 20	1	$24.00	SMC	Delivered
Solenoid Driver	1	$22.94	Digikey	Delivered
Manual Dump Valve Coupler	1	$5.49	Amazon	Delivered
Micro Switch for Bag Detection	3	$17.63	Adafruit	Delivered
Micro Switch Connection Wires	1	$4.95	Adafruit	Delivered
Brass Industrial Quick-Disconnect	2	$3.24	McMaster	Delivered
M8 3-Pin Connector	1	$9.99	Amazon	Delivered
		$1,062.41		

Sensors	Total	Total Cost	Vendor	Status
Tracking Camera	10	$550.00	RobotShop	Delivered
Microcontroller - Arduino UNO R3 (x2)	1	$49.99	Amazon	Transit
Arduino Ethernet Shield	1	$24.40	Amazon	Delivered
T Type Connector	3	$31.95	Amazon	Delivered
24 Gauge Wire	1	$13.99	Amazon	Delivered
USB Power	1	$39.99	Amazon	Delivered
High-Pressure Pipe	9	$13.41	McMaster	Delivered
PVC Pipe	6	$48.59	McMaster	Delivered
PVC Pipe Fitting	33	$14.85	McMaster	Delivered
RAM Double Socket	3	$28.47	Amazon	Delivered
RAM Swivel Socket	7	$74.91	OCMounts	Transit
iBolt Ball Mount	13	$103.35	Amazon	Delivered
1-1/4" Phillip Screw Pack	1	$7.86	Amazon	Delivered
Arduino Motor Shield	1	$13.49	RobotShop	Transit
Telemecanique Sensors	1	$25.74	Allied Electronics	Delivered
PLTC Cable	5	$14.64	ShowMeCables	Delivered
Belkin Ethernet Cable	1	$7.42	Amazon	Delivered
2x4 x 8ft	3	$18.45	Home Depot	Delivered
2x4 x 10ft	1	$9.62	Home Depot	Delivered
Corner Braces	1	$7.72	Home Depot	Delivered
Nylon Mason Line	1	$5.47	Home Depot	Delivered
Ethernet Tree	1	$17.99	Amazon	Delivered
		$1,122.30		

Critical Project Items



Special Thanks

Sierra Nevada Corportation and Loren McDaniel

Dr. Neogi

CU Boulder Aerospace Department

PAB

End Effector

Magnetic Force Model

$$F = \frac{k}{r^2}$$

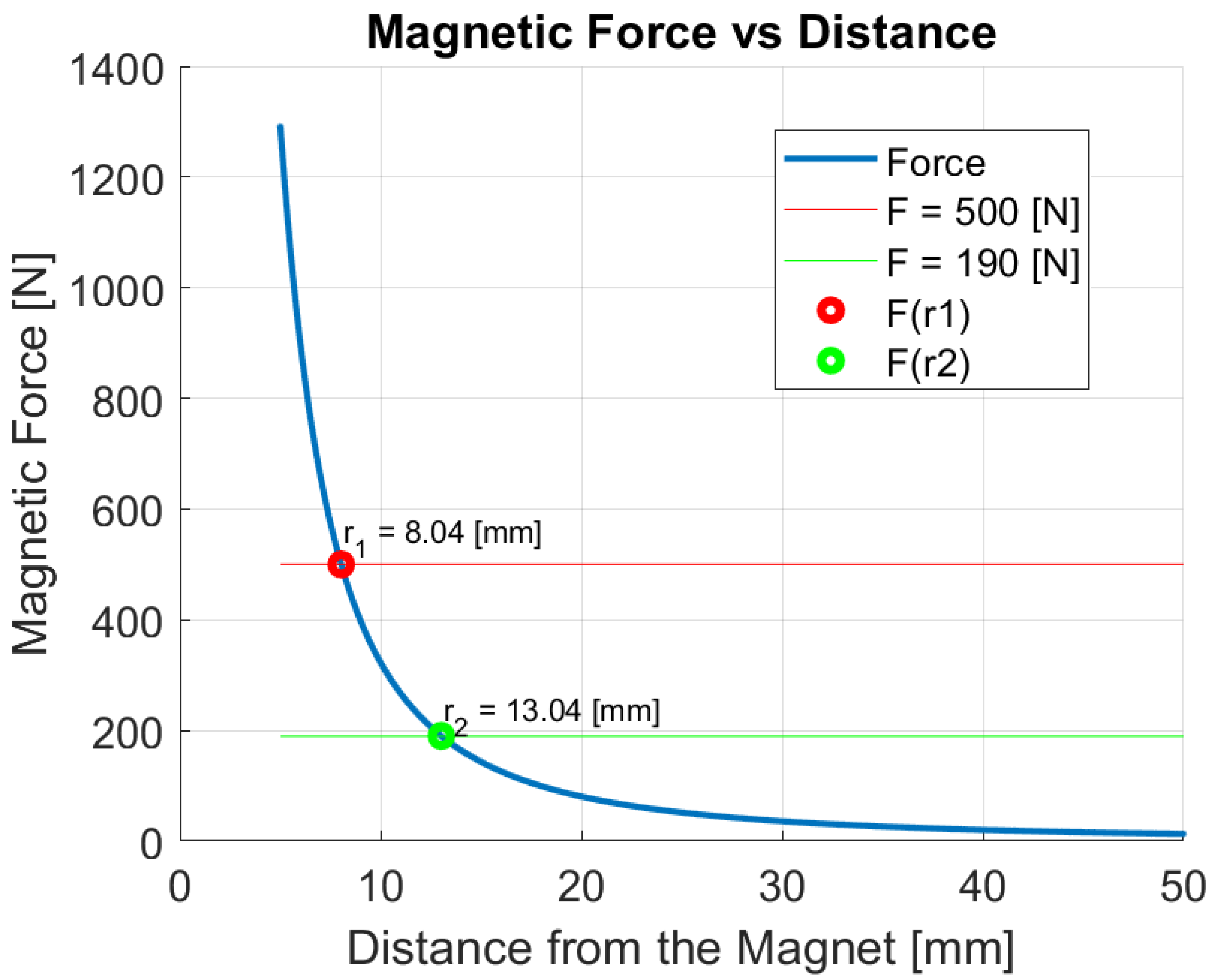
We know:

- $F_1 = 500$ N
- $F_2 = 190$ N
- $\Delta r = 5$ mm

$$\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2} = \frac{(r_1 + \Delta r)^2}{r_1^2}$$

$$k = 32287.183[Nmm^2]$$

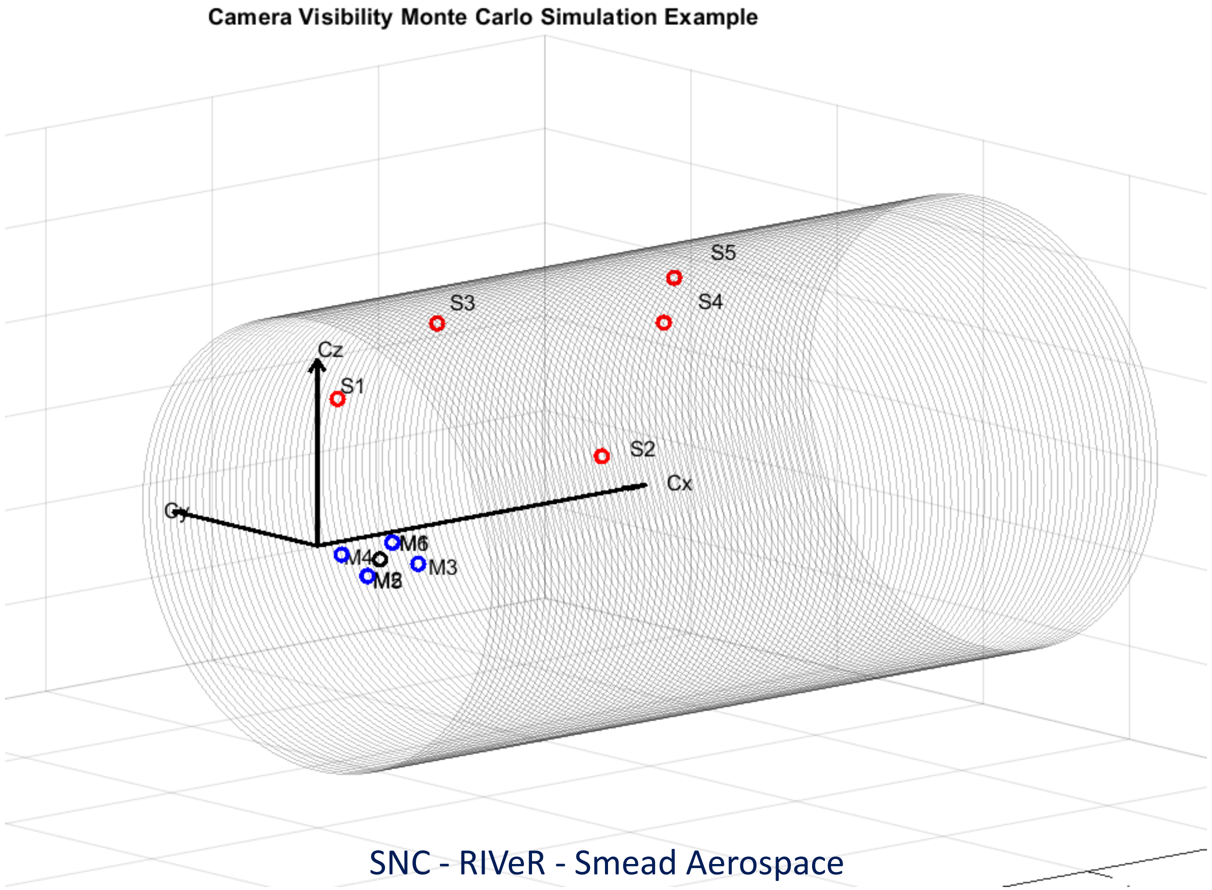
$$F(75[mm]) = 5.740[N]$$



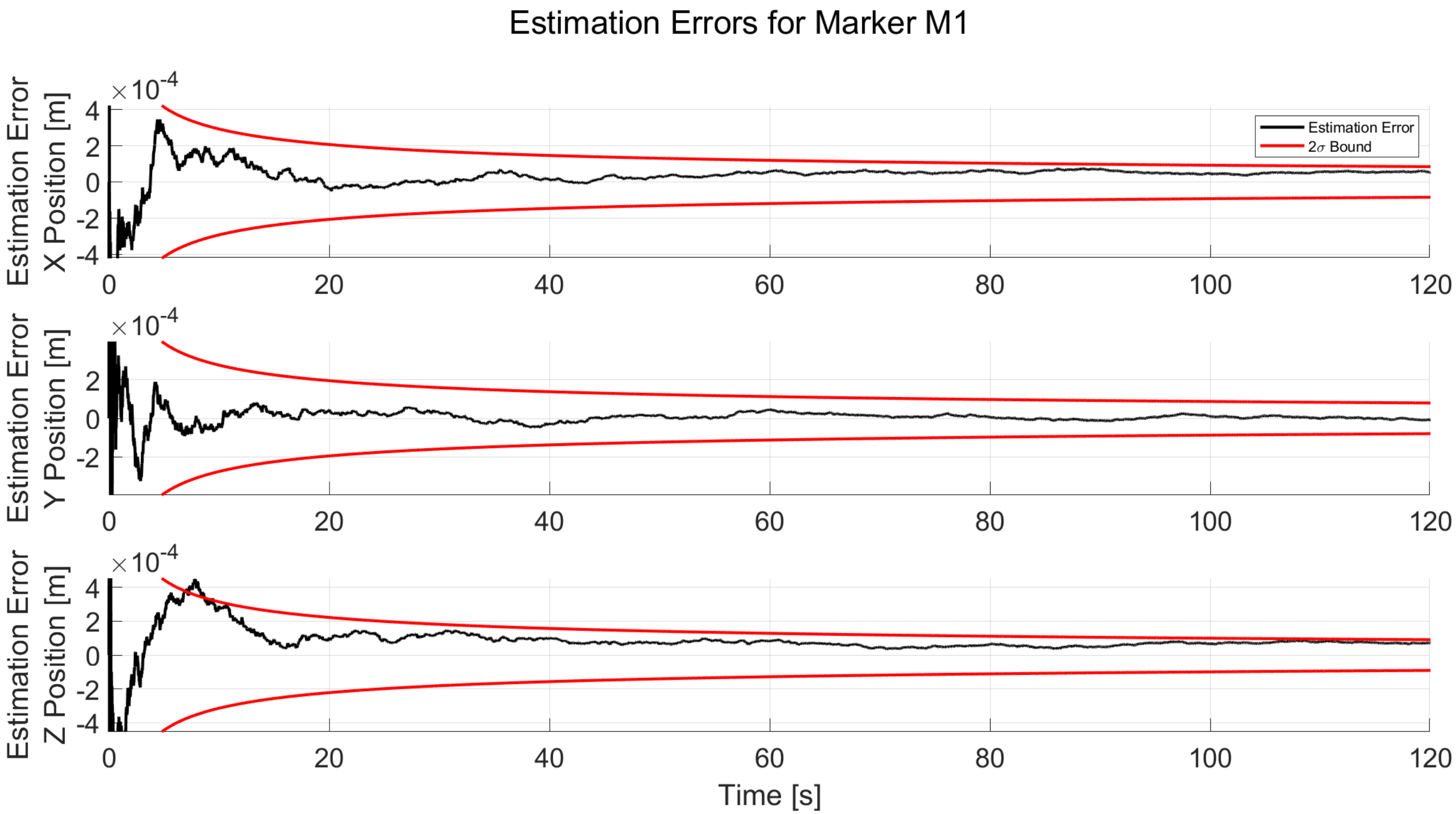
- SMC advertises a residual hol force of “0.3 [N] or less”

Camera Monte Carlo Simulation

- 5 Cameras are successful with 92% of random orientations



Estimation Simulation Model



Component Testing

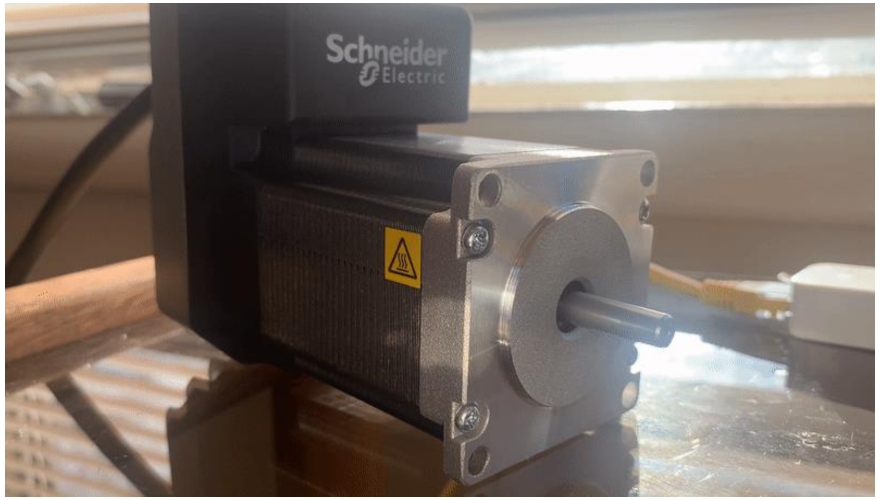
Translator Motor Test

Overview: Test Motor Functionality

Rationale: Verify basic motor functionality/ ability to receive commands

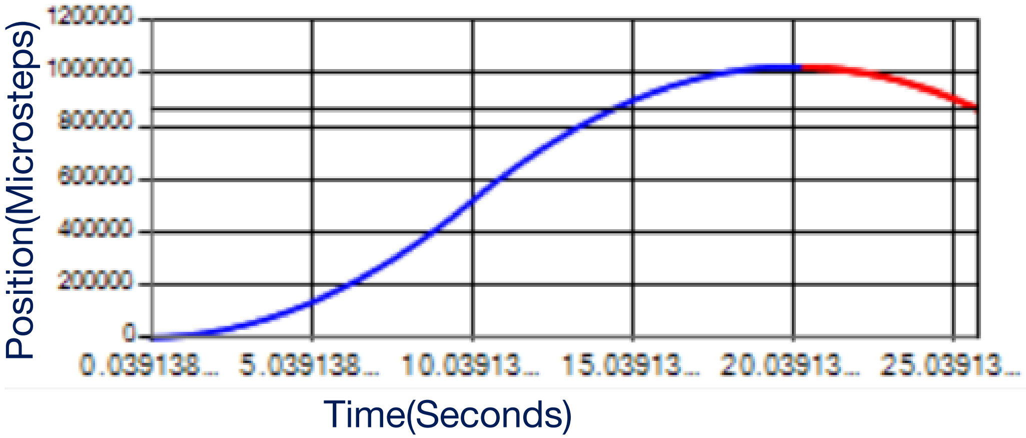
Location: Student home

Equipment: Lexium LMD 57 stepper motor, Power Supply, PC with Ethernet



Procedure:

1. Measure power supply voltages
2. Plug motor into power supply
3. Connect to PC using ethernet
4. Run sample command
5. Run sample program and read encoder signal
6. Confirm motion matches simulation shown below



Translator Test
Mass Test

Overview: Test Translator Accuracy
Rationale: Verify motor can carry the robotic arm, bag and end effector
Location: Senior Projects Room
Equipment: Linear Stage, Lexium LMD 57 stepper motor, Motor power supply, weights, tape measure

DR 3.2	The translation system shall be capable of translating the robotic arm, end effector, and cargo bag's combined mass

Procedure:
1. Connect stepper motor to linear stage using coupler
2. Zero the baseplate
3. Set maximum velocity to 358 RPM
4. Set motor to maximum torque mode
5. Set run current to 100%
6. Increment weights on baseplate from 5kg-40kg
7. Measure distance of travel and compare to expected distance

Translator Test
Accuracy Test

Overview: Test Translator Accuracy
Rationale: Verify motor compatibility with linear stage and encoder accuracy
Location: Senior Projects Room
Equipment: Linear Stage, Lexium LMD 57 stepper motor, Motor power supply, tape measure

DR 5.2	The translator shall be able to move to a prescribed location within a margin of 5 cm.

Procedure:
1. Connect stepper motor to linear stage using coupler
2. Zero the baseplate
3. Set maximum velocity to 358 RPM
4. Run the SEM terminal software for 5 different locations ranging 10cm-1m
5. Measure distance of plate trailing edge to origin
6. Compare to expected distance

Translator Test

Acceleration Test

DR 1.1	The translation system shall be able to accelerate the cargo bag and combined arm/end effector 3cm/s2

Overview: Test Translator Acceleration
Rationale: Verify motor can accelerate per design requirement
Location: Senior Projects Room
Equipment: Linear Stage, Lexium LMD 57 stepper motor, Motor power supply, stopwatch

Procedure:

1. Connect stepper motor to linear stage using coupler
2. Zero the baseplate
3. Set acceleration to 307200 microsteps/s^2(6 rev/s^2)
4. Set maximum velocity to 358 RPM
5. Run the SEM terminal software for 10 cm
6. Time the operation
7. Calculate V= d/t
8. Assume constant acceleration and calculate A = V/t

Component Testing

Overview: Test functionality of major components (arm, translator, end effector, cameras)

Rationale: Verify parameters of models

- Arm: position functionality
- Translator: motor accuracy
- End Effector: strength and actuation
- Cameras: accuracy and visibility

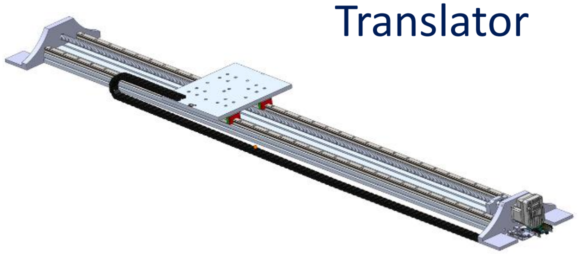
Location: Senior Project Room

Equipment: Power outlets, compressed air multimeter

Procedure:

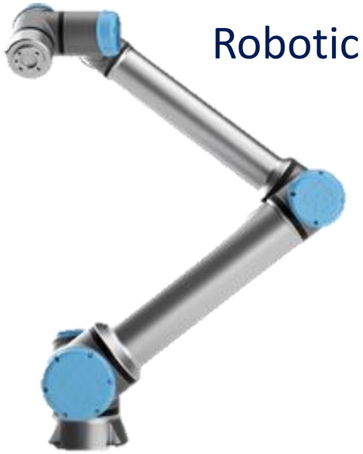
1. Power on hardware from appropriate source and voltage
2. Verify required parameter

Translator



Camera (x10)

Robotic Arm



End Effector

Component Testing

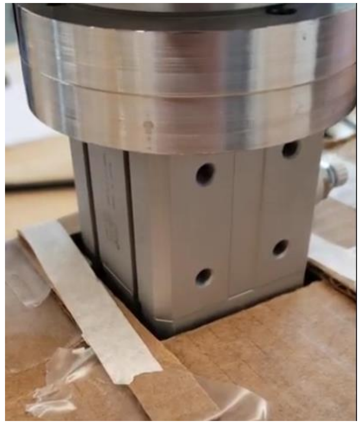
Robotic Arm Test

Overview: Test out-of-the-box functionality

Rationale: Verify arm can perform planned motions and at different speeds with repeating accuracy

Location: Senior Projects Room

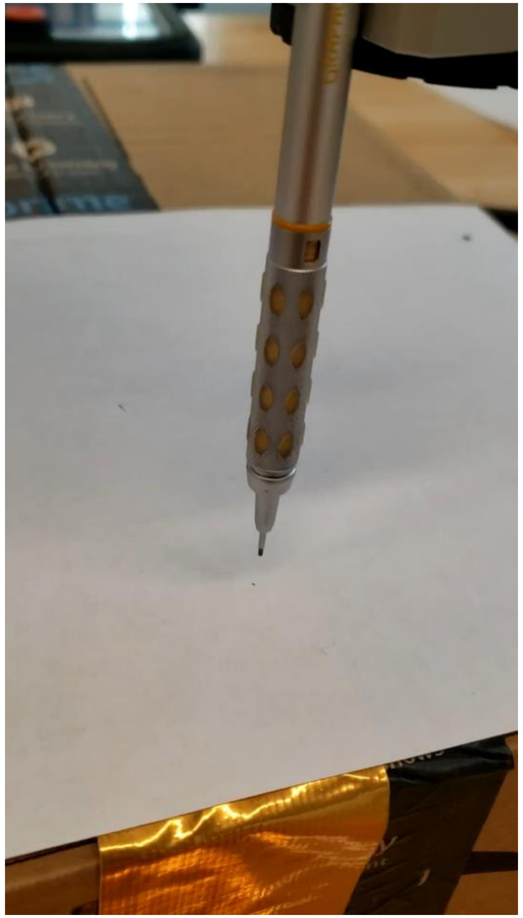
Equipment: UR-10, Control Box, Teach Pendant

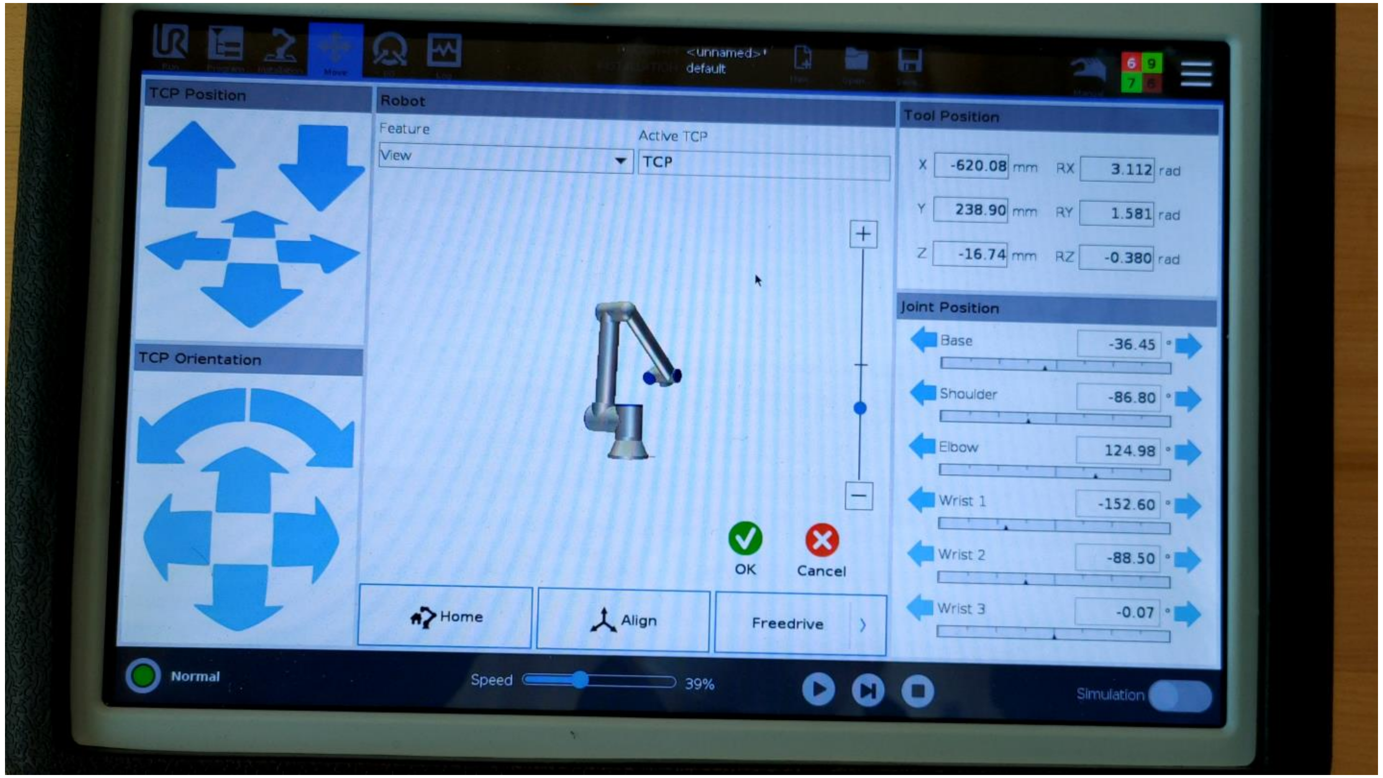


Procedure:

1. Turn on arm, verify mechanical breaks unlock
2. Create motion program to cycle between waypoints *(three methods).
    1. Align arm end-effector flush with hole
    2. Attach pencil to arm and contact a piece of paper
    3. Software defined Tool Positions
3. Verify arm position returns to the same marked location at the beginning of its motion plan

Testing Videos





Testing Videos

Component Testing

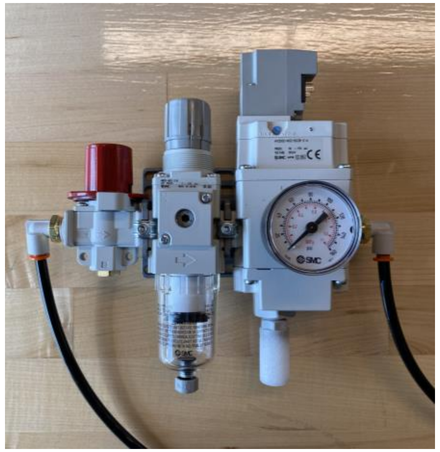
End Effector Test

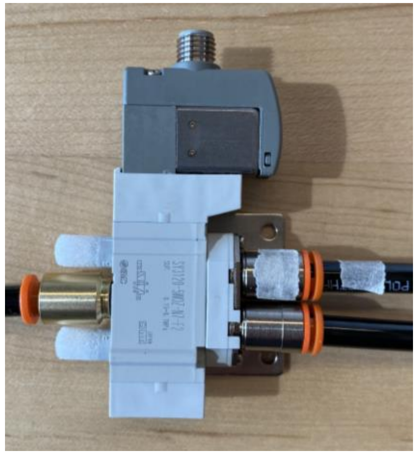
Overview: Test Actuation and Gripping Ability

Rationale: Verify End Effector can actuate, and grip simulated cargo bag

Location: Senior Projects Room

Equipment: MHM-32D, Filter/Regulator-Valve Assembly, Solenoid, Control Box





Procedure:

1. Set Manual Dump Valve to "SUP"
2. Connect Electronic Dump Valve to power and ensure indicator LED is on.
3. Connect End Effector Assembly to Pressurized Air Supply
4. Turn Air Supply on and ensure pressure gauge is reading at least 50 psi.
5. Test actuation using solenoid manual override button (MOB)
6. Test gripping in extreme orientations using MOB

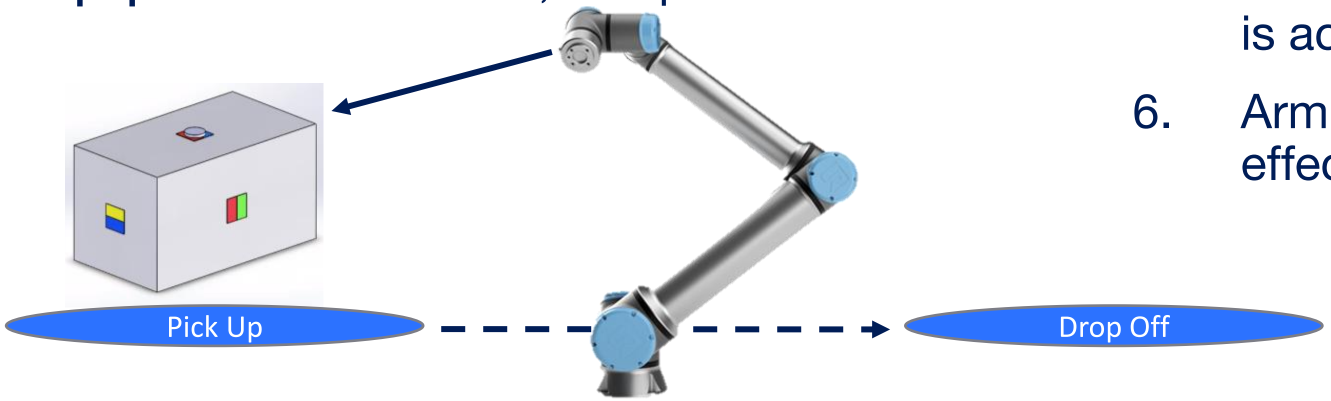
Stationary Test

Overview: Use robotic arm to capture, lift, rotate, and release cargo bag using the end effector.

Rationale: Verify the interface of the end effector and robotic arm. Verify end effector strength can carry the cargo bag.

Location: Senior projects room

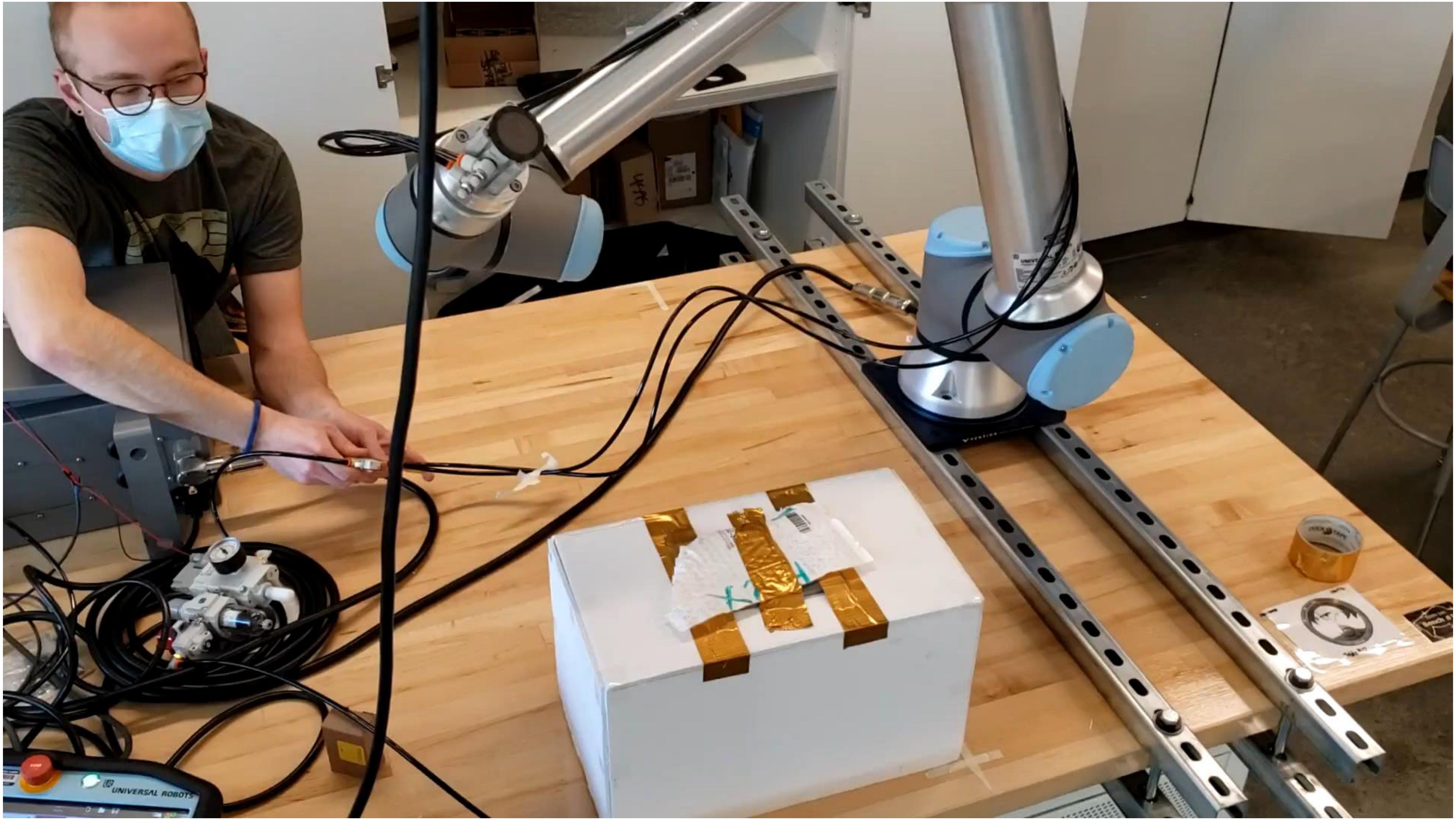
Equipment: Wall outlet, compressed air



Procedure:

1. Power on arm and end effector
2. Teach arm pick up and drop off location for the cargo bag
3. Place cargo bag in pickup location
4. Activate program
5. Arm moves to pick up position, end effector is actuated
6. Arm rotates to drop off location, end effector is disengaged

Complete


UNIVERSAL ROBOTS

Dynamics Test

Overview: Use robotic arm to capture and release bag while attached to the translator. Translate arm from one end of translator to the other.

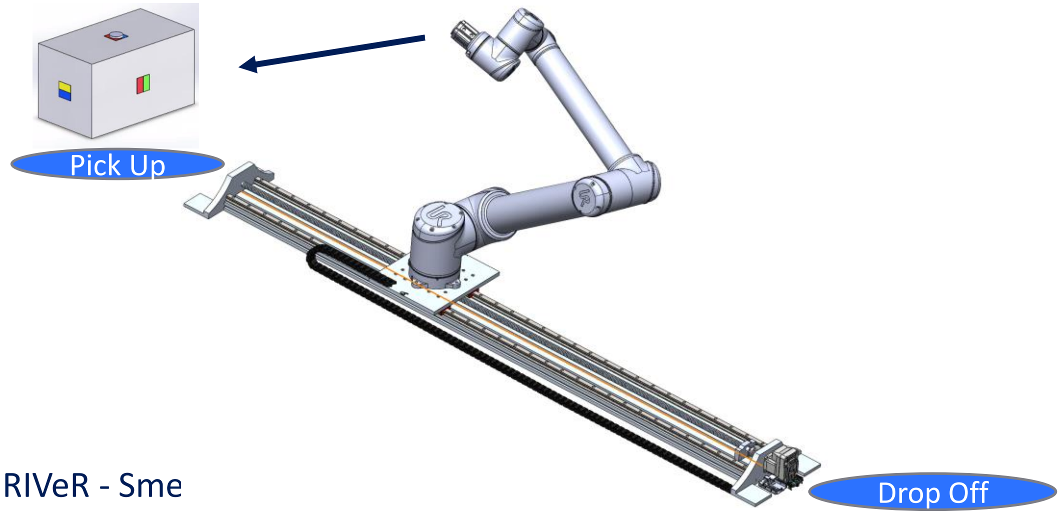
Rationale: Verify the interface the translator and robotic arm can operate in tandem.
Verify translator can support the arm

Location: Senior projects room

Equipment: Wall outlet, compressed air

Procedure:

1. Power on arm, end effector, and translator
2. Initiate capture and translate program
3. Arm captures cargo bag in pickup location
4. Arm is translated to opposite end of track
5. Arm releases bag in drop-off location



ROS Sim./Motion Planning Test

Overview:

Rationale: (what's being verified/validated)

Location:

Equipment:

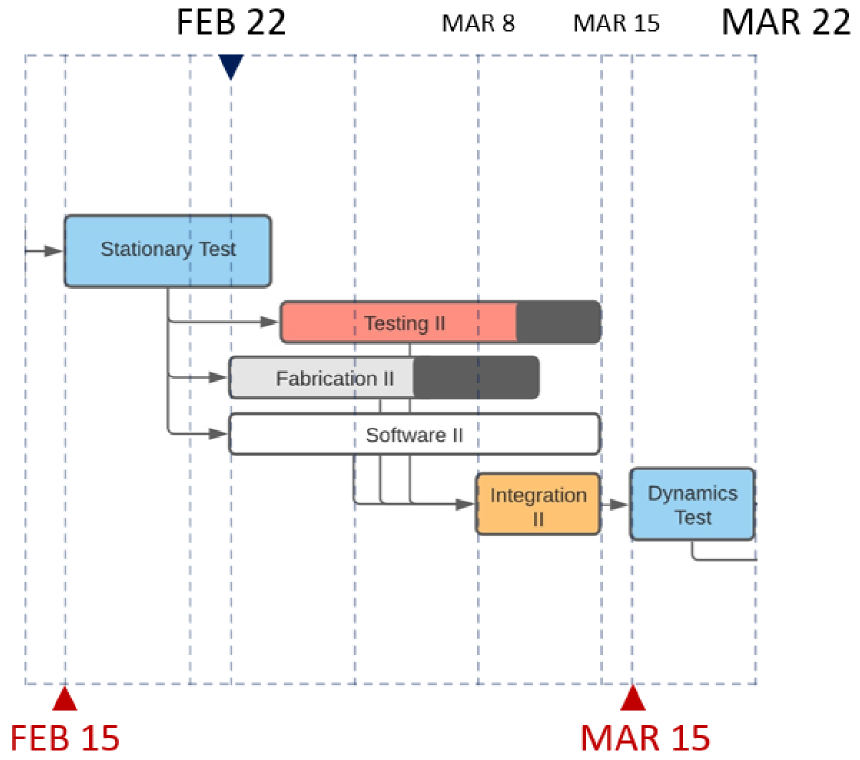
Procedure:

1. Step 1
2. Step 2

Pretty picture of hardware?

Current Progress

Testing



INTEGRATION II	NOT STARTED
DYNAMICS TEST	NOT STARTED

★ Milestones ■ Margin
Testing | Fabrication | Software | Integration
o Incomplete ➢ In-Progress ✓ Complete

TESTING	Task Type	Task	Date
	Translator	o Test Limit Sensors o Full Translator Test	o Mar 8 o Mar 15
	Robotic Arm	o Test Linux/ROS Connection o Test UR10e Motion Planning and Pose Determination o Test Pickup Accuracy	➢ Mar 5 ➢ Feb 26 ✓ Feb 26
	End Effector	o Grip Testing o Actuation Test o Actuation Sensor Test	✓ Feb 26 ✓ Feb 22 ➢ Feb 26
	Pixy Camera	o Sensory Output Sampling o Accuracy/Calibration Tests	➢ Mar 5 ➢ Mar 8

TESTING II	IN PROGRESS
FABRICATION II	IN PROGRESS, NO SIGNIFICANT CONCERNS, JOBS SUBMITTED
SOFTWARE II	IN PROGRESS, MAJOR CONCERN: ROS COMPLICATIONS

Lead Times

Average lead time: 7 days

Vendor	Lead Time (Days)
McMaster	~ 2-5
SMC Pneumatics	~ 7
Amazon	~ 6
DigiKey	~ 6
MotionConstrained	~ 8
MSITec	~ 9
Vention	~ 6

Vendor	Lead Time (Days)
Adafruit	12
OCMounts	~ 8
RobotShop	~ 7
Allied Electronics	~ 7
ShowMeCables	~ 8
Home Depot	~ 1 (in store pickup)

Red: Critical Project Items