LABORATORY FOR
Computational
Sensing + Robotics
THE JOHNS HOPKINS UNIVERSITY

JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Automation of Mosquito Dissection for Malaria Vaccine Production

Computer Integrated Surgery II – Project Update
March 26, 2019

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Mentors:
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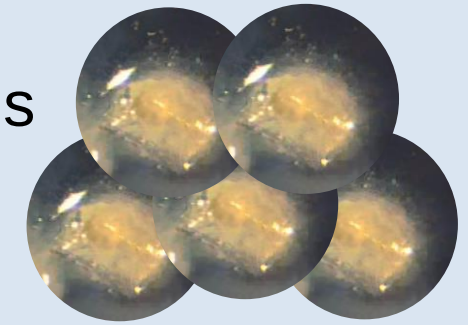
Statement of Confidentiality

This presentation includes information, designs, and plans for items that have not been publicly disclosed due to intention of pursuing intellectual property. This content, before that public disclosure, is only for the eyes of those who have signed a non-disclosure agreement.

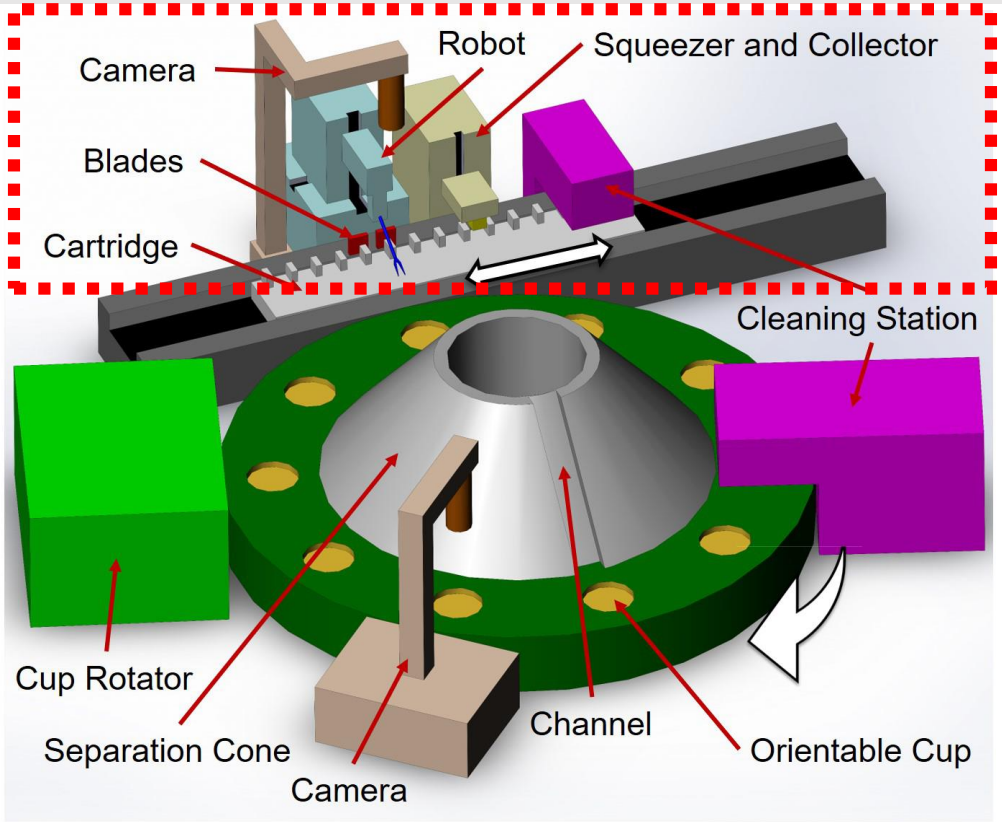
Project Summary

Staged Mosquitoes → Dissection System → Salivary glands



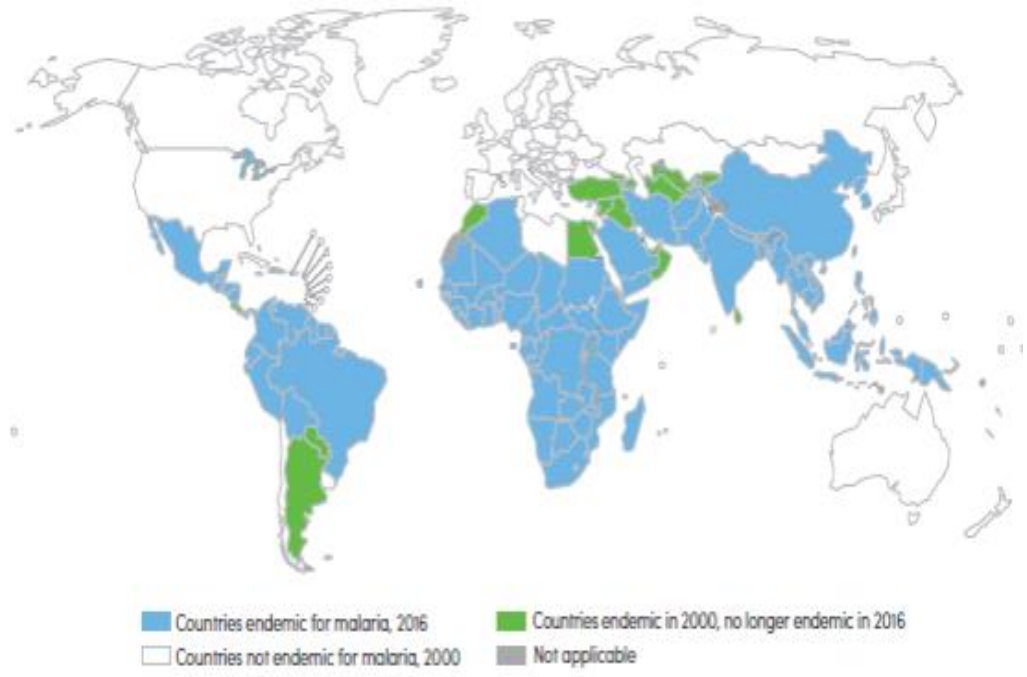
Within a Larger System:

1. Mosquito separation
2. **Mosquito pick-and-place**
3. **Mosquito dissection**
4. Mosquito recognition (throughout)



Refresher of Motivation

- Malaria is a **global** health problem



- Estimated malaria deaths 2015:
  - 438,000[1]
  - 666,000[2]
  - 730,500[3]
  - Estimated clinical cases 2015: 214,000,000[1]
- >$12B GDP loss in Africa alone[1,4]

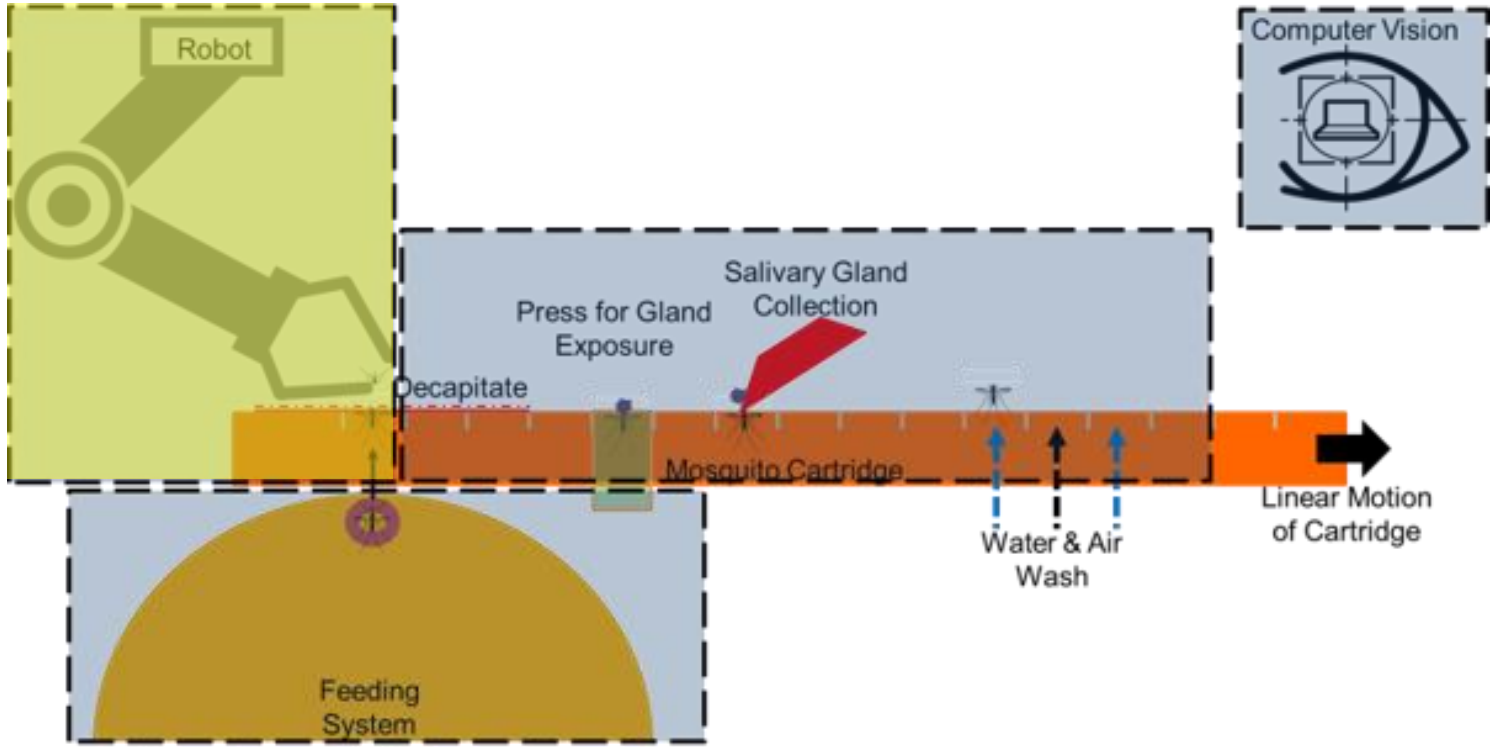
From WHO World Malaria Report 2016

1.World malaria report 2016. Geneva: World Health Organization; 2016.
2. Gething *et al. N Engl J Med* 375: 2435-2445, 2016.
3. GBD 2015 Mortality and Causes of Death Collaborators. *Lancet* 388: 1459-1544, 2016
4. Murray *et al*. *Lancet* 379: 413-431, 2012

Progress Report

Mosquito pick-and-place

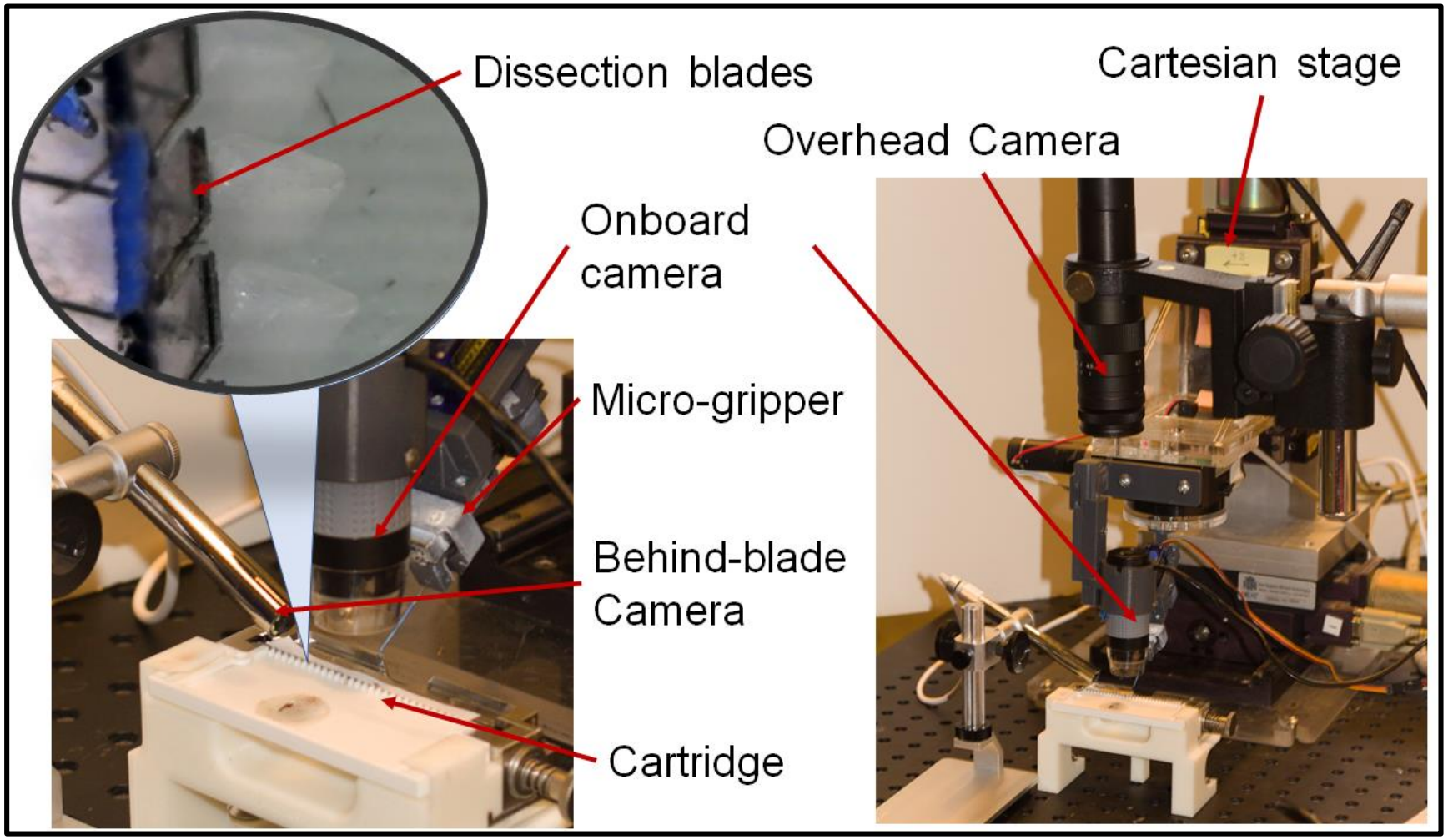
Mosquito dissection



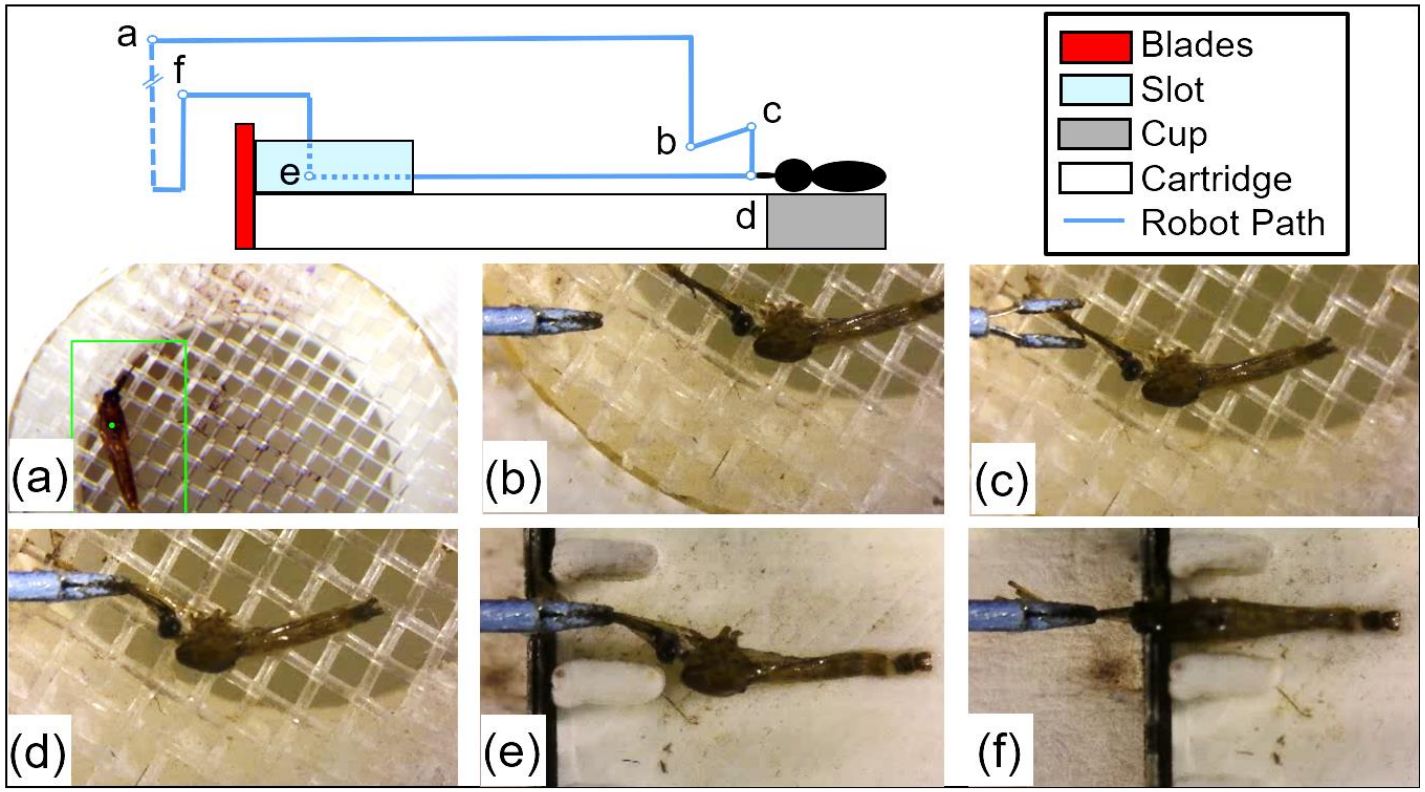
Pick-and-Place Robot Setup

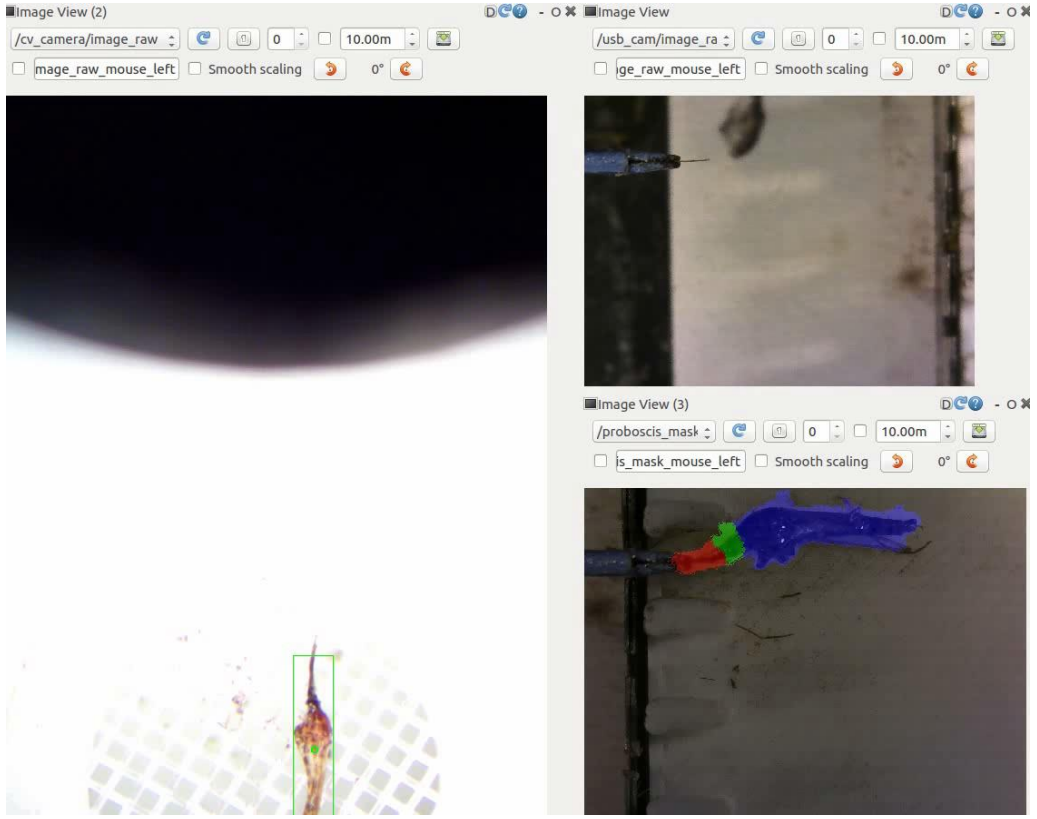
Improvements:

- Mounted and calibrated onboard camera
- Added behind-blade camera for visualization

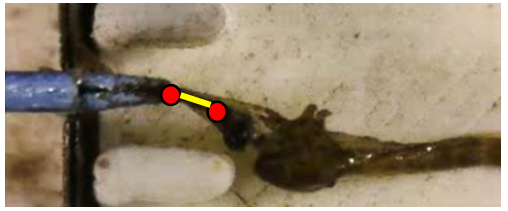


Robot & Vision Integration Method





a - overhead camera finds mosquito
b - robot moves near mosquito, onboard camera finds proboscis
c - move to proboscis
d - drop down and grasp
e - find tooltip-to-head offset using onboard camera
f - move based on offset and place in blades



Robot & Vision Integration Results

- N = 50 mosquitoes
- Mosquitoes manually placed
- All other action automated

Results:

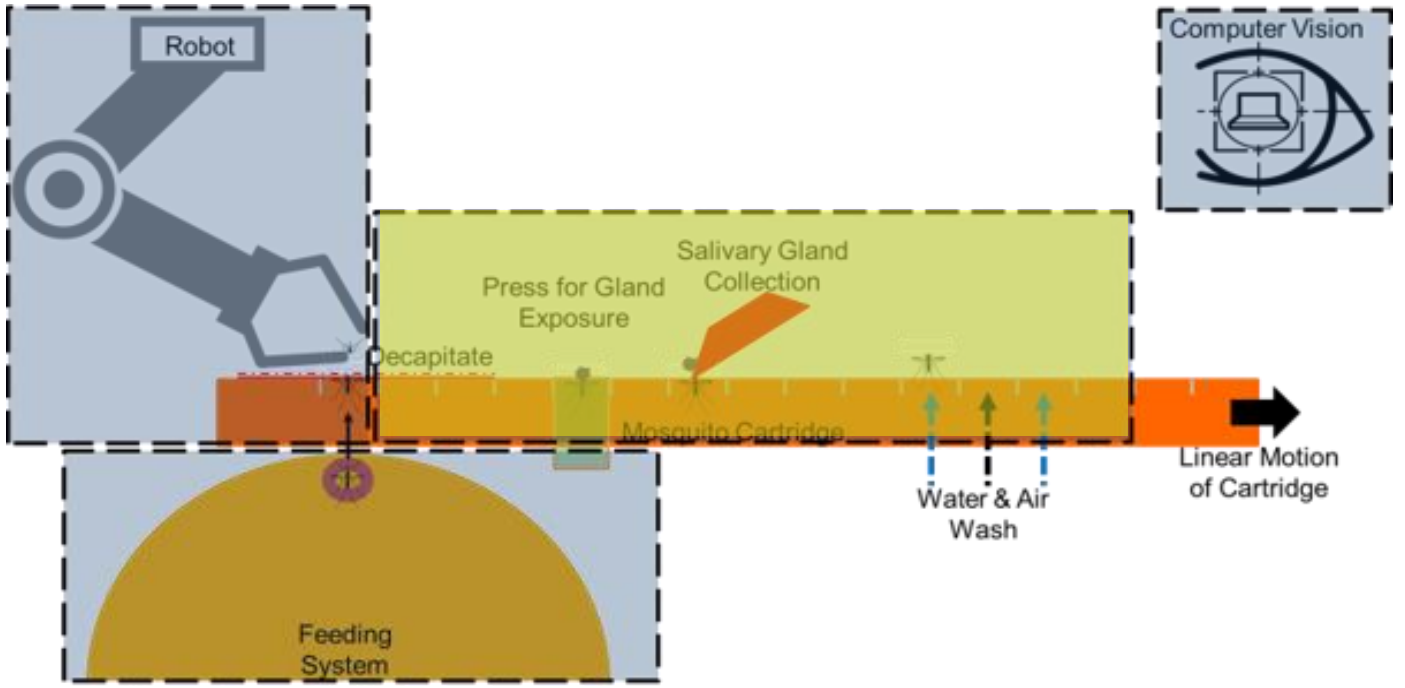
50/50 (100%) grasped & moved

45/50 (90%) placed with correct alignment

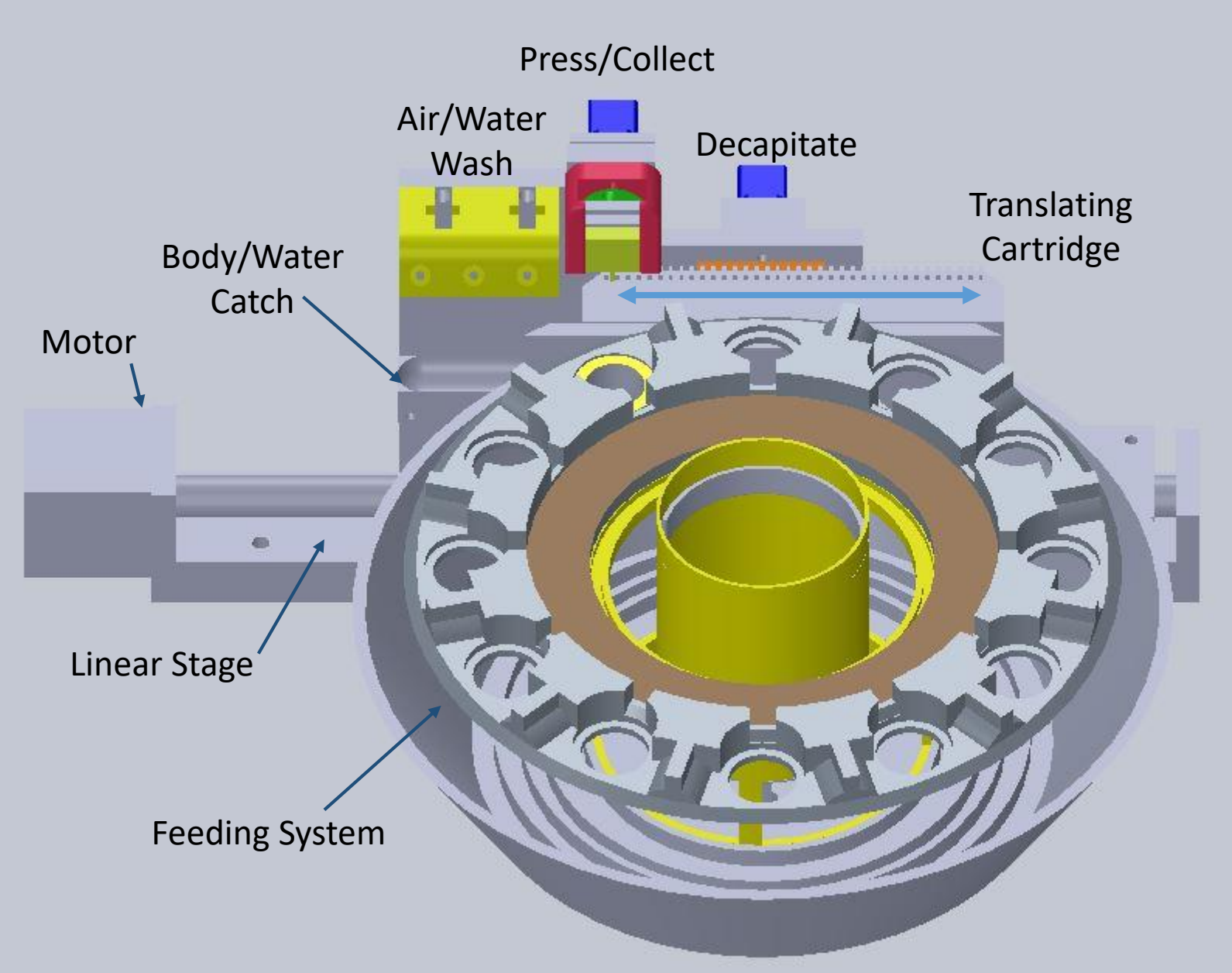
Progress Report

- Mosquito pick-and-place

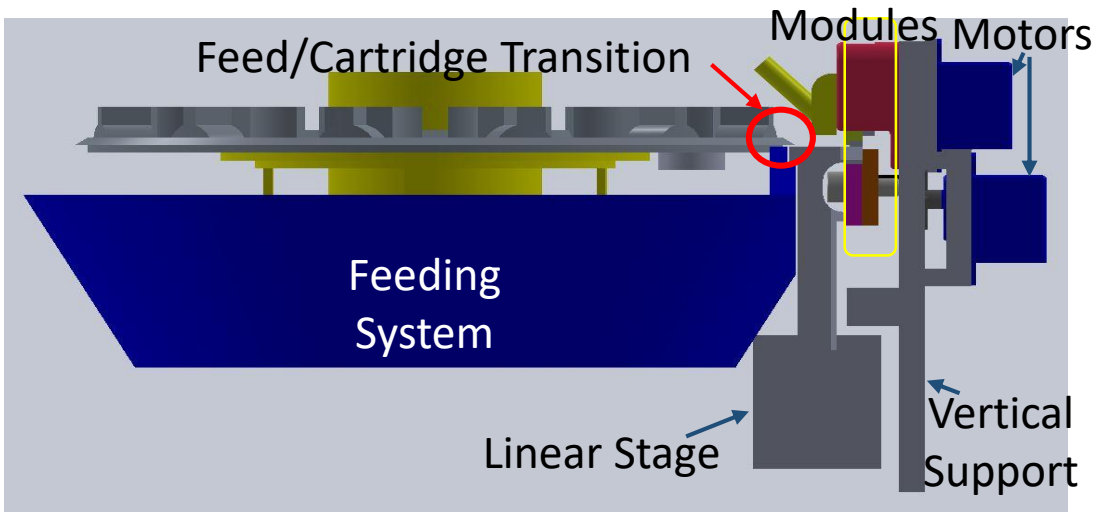
- Mosquito dissection

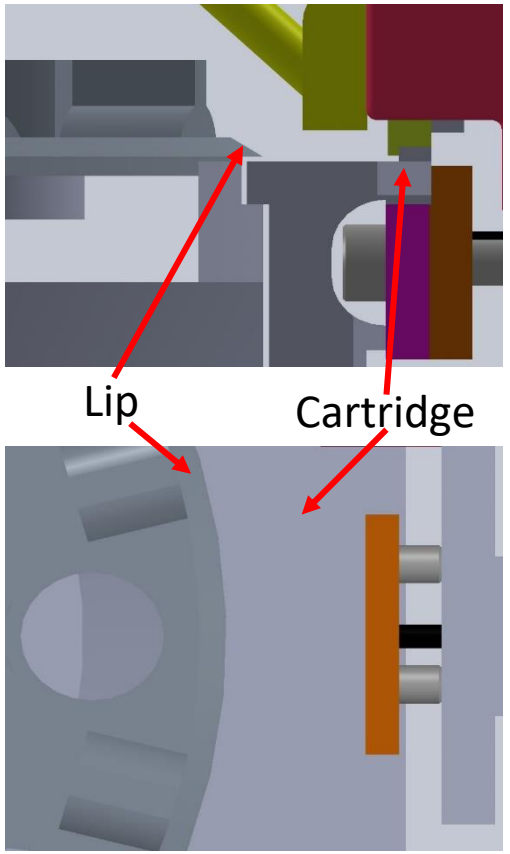


Current Linear System Concept



Intricacies of Mechanical Integration





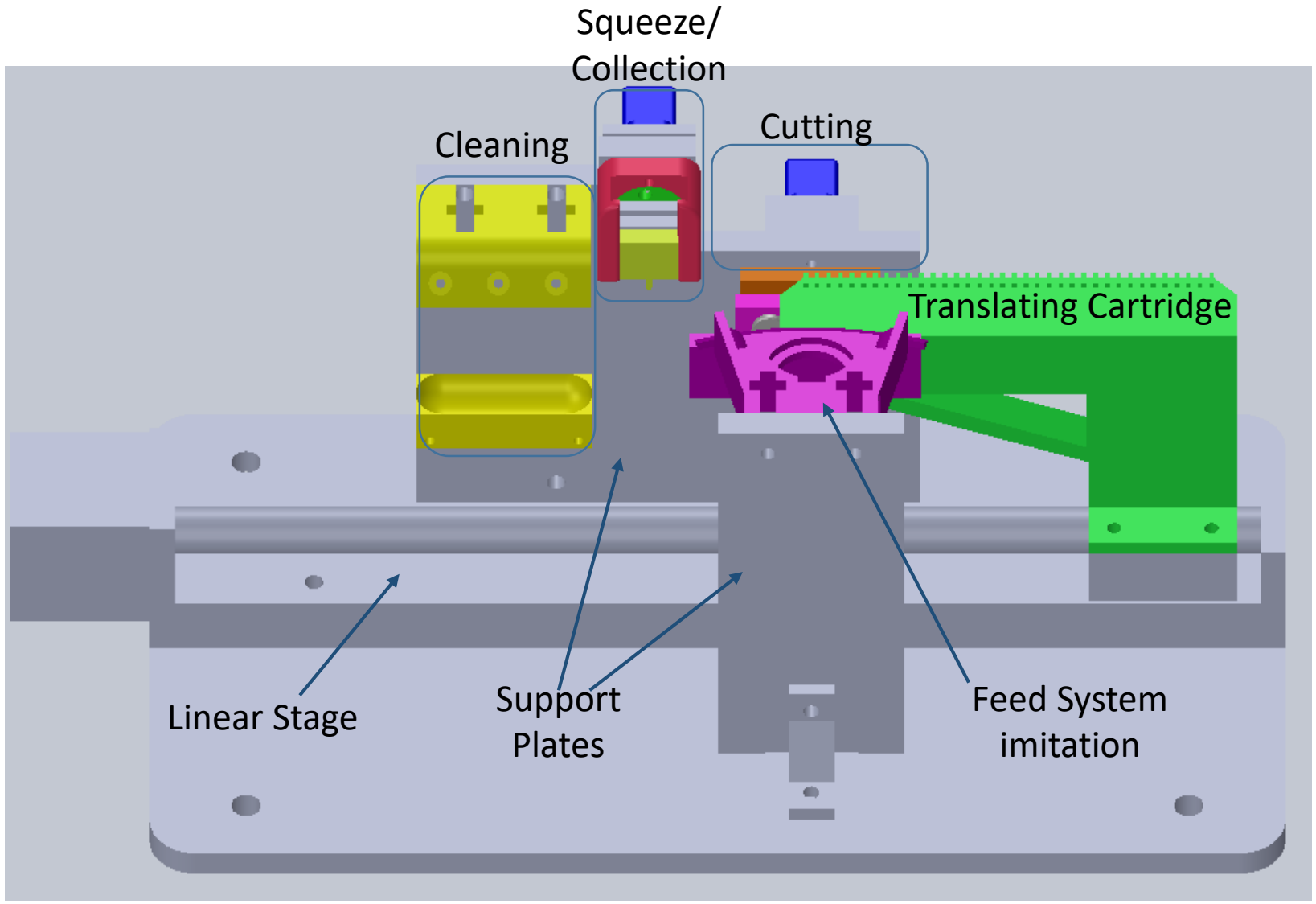
Difficulties

- Various systems are not uniplanar
- Cup and Cartridge must be within robot workspace

Solutions

- Developed a lip for smooth transition from feed to cart
- Minimized robot distance of req. travel

Development of Simulation Setup



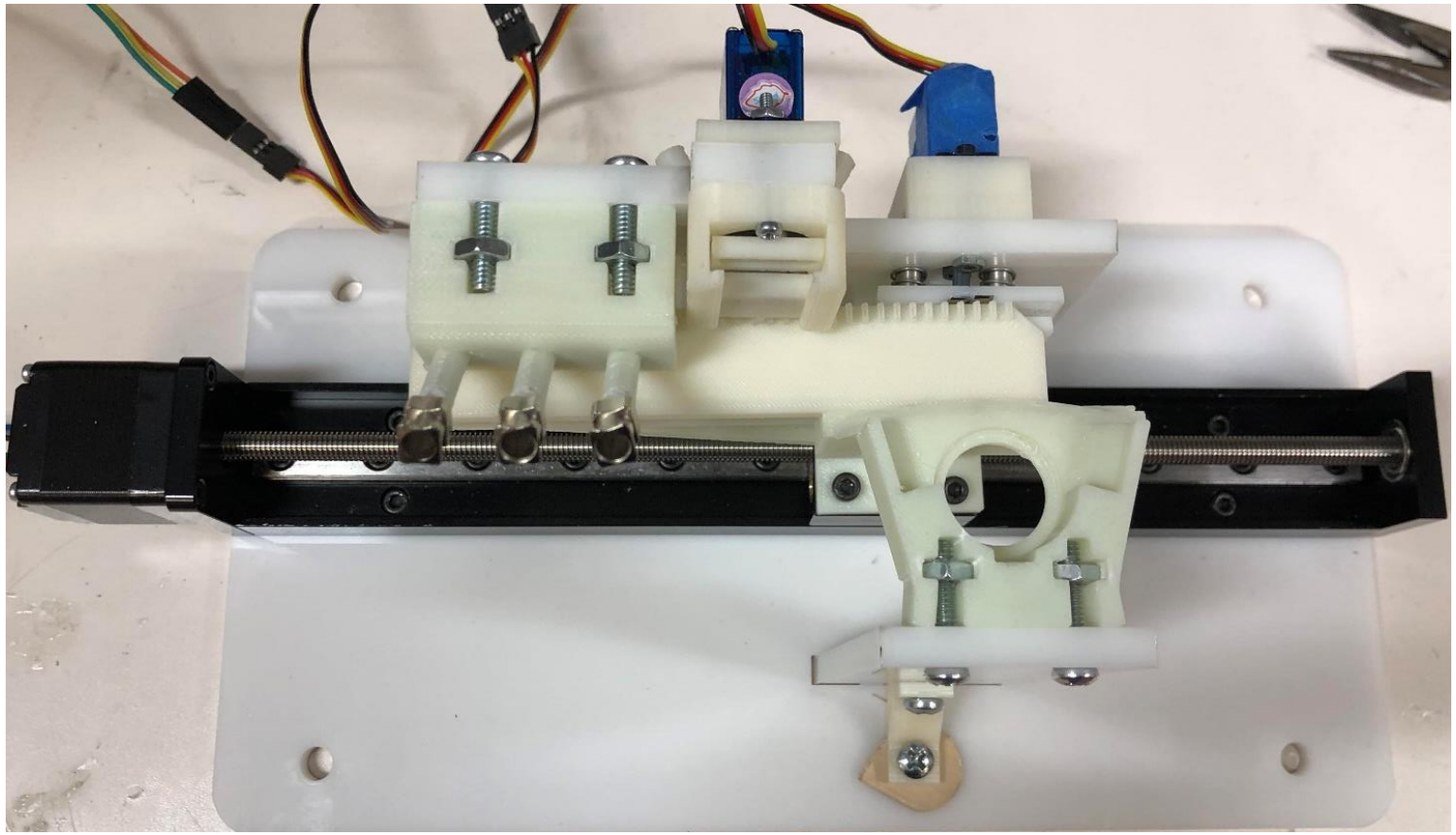
Difficulties

- Need robust way to test the setup with robot integration
- Don't want to redesign feeding apparatus, yet…

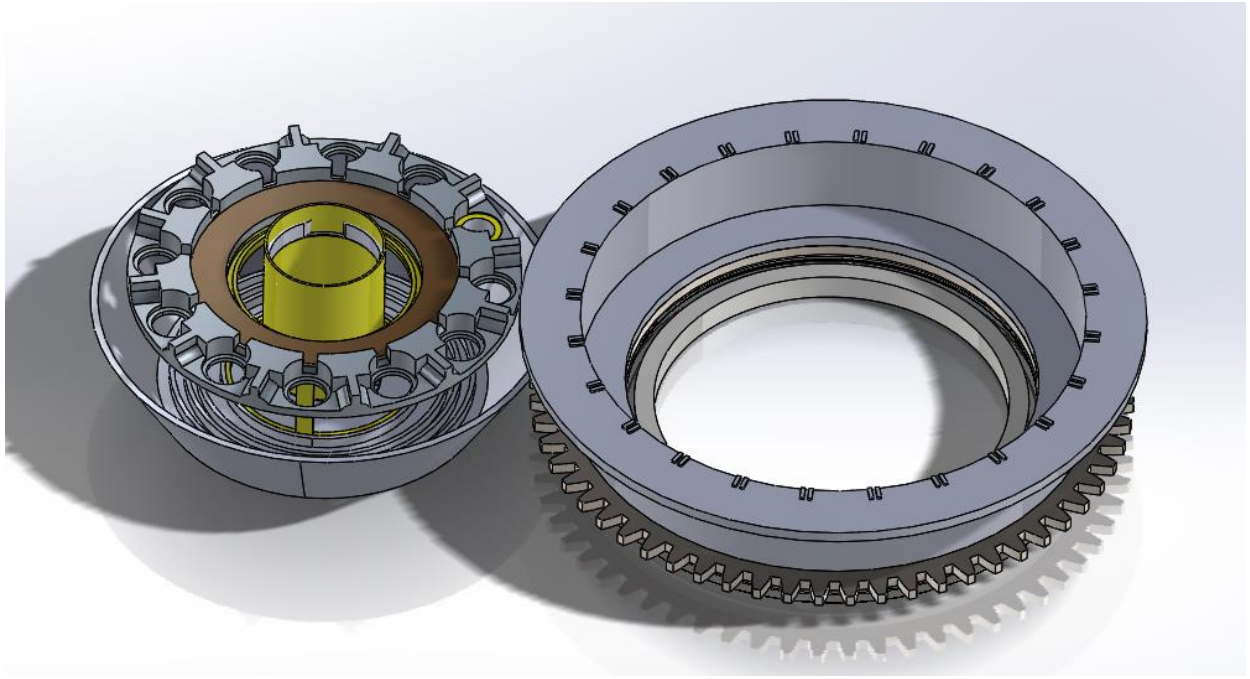
Solution

- Developed imitation setup to test linear system with robot
- Fabricated the system for implementation of Robot Setup

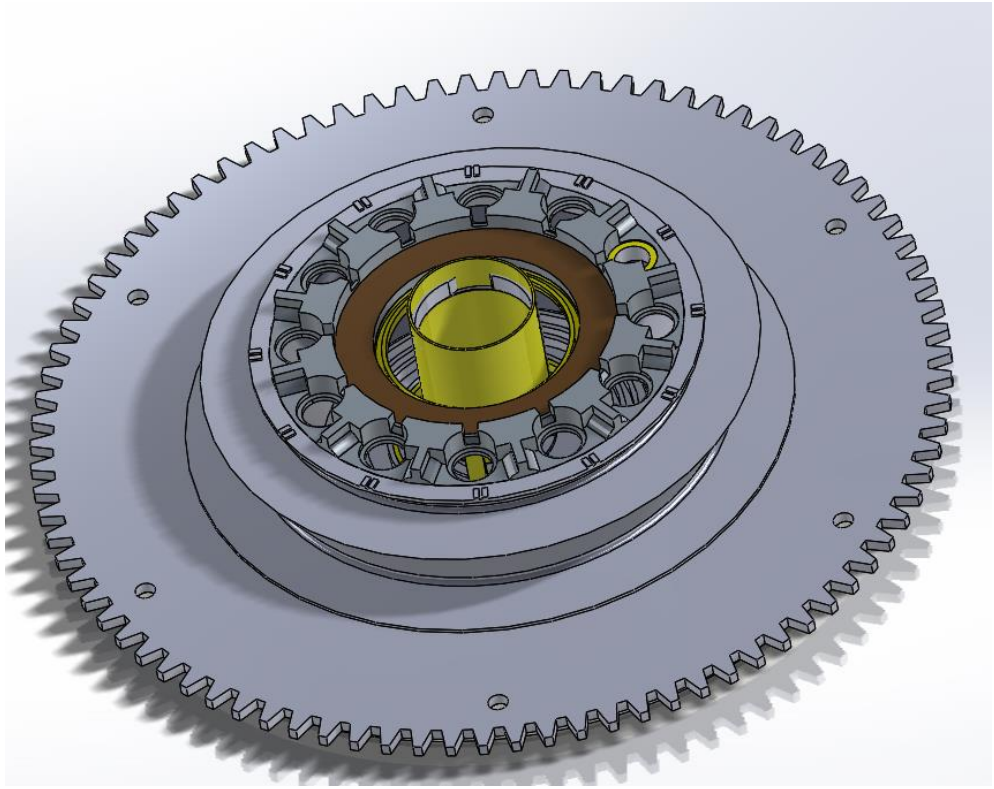
Next: Robot-Dissection Integration



Rotary Stage Design

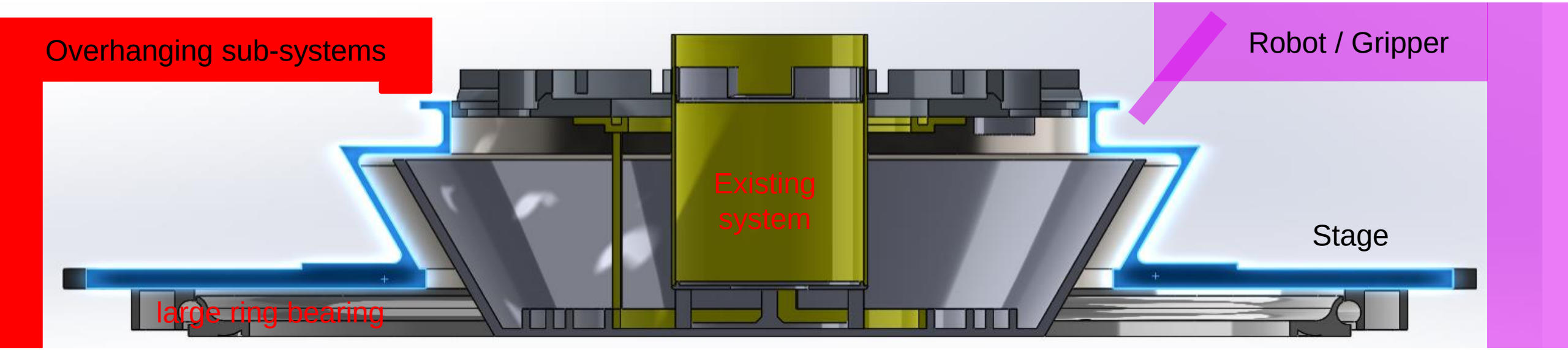


Tangent



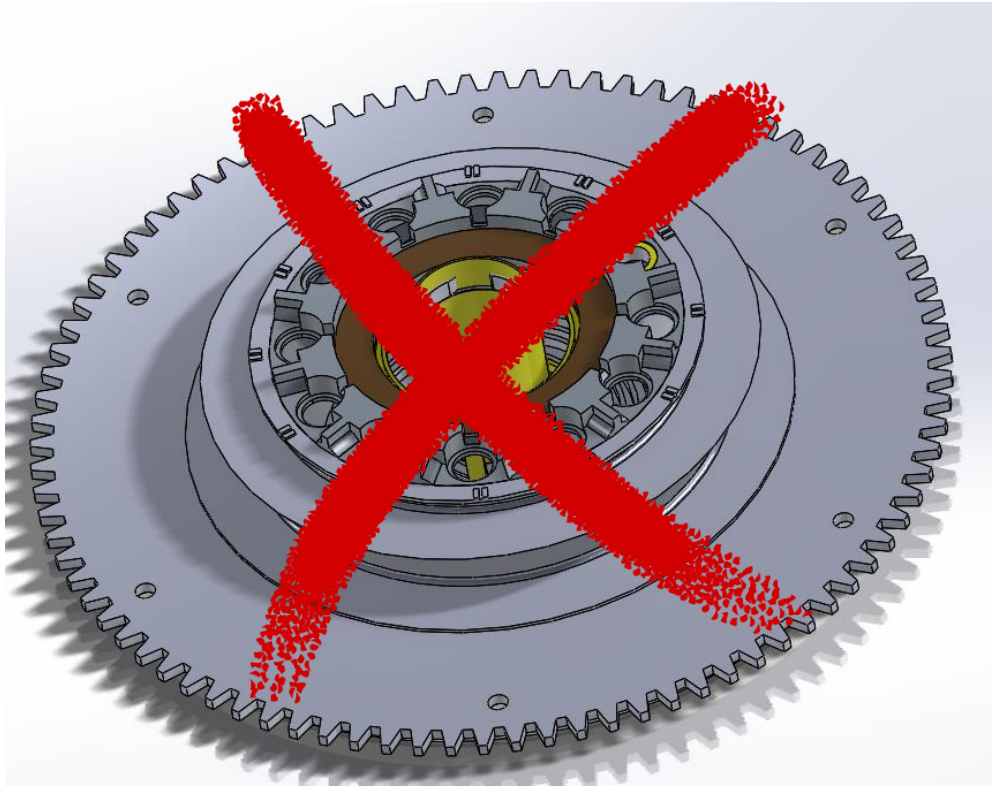
Concentric

Rotary Stage: Concentric

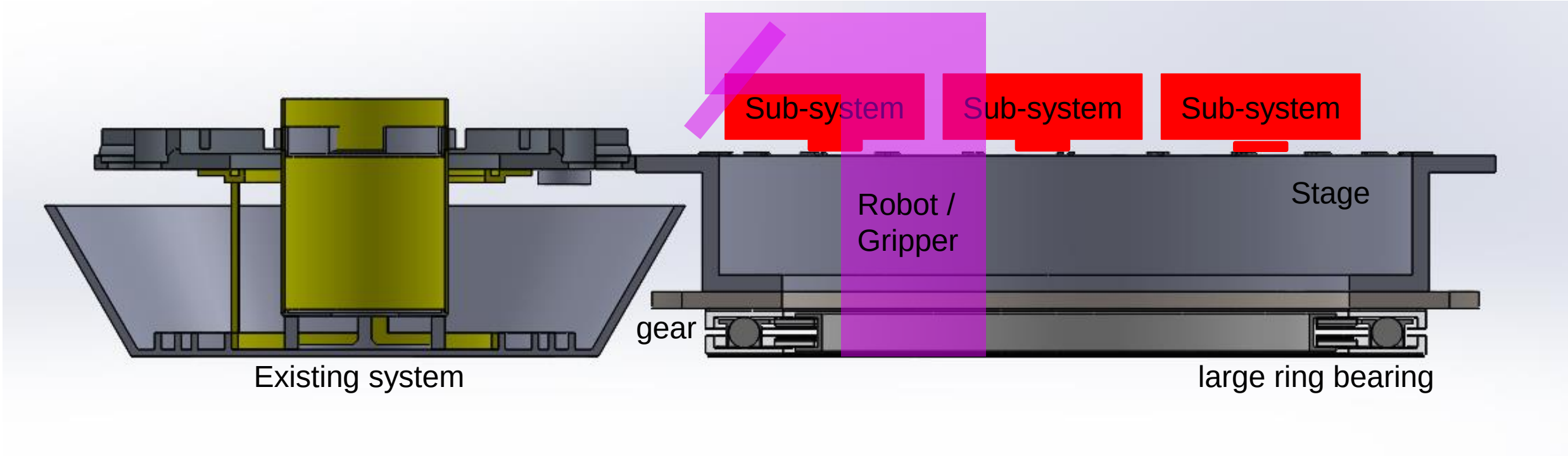


Rotary Stage: Concentric

- This design was constructed to lessen the footprint of the overall design
- Dissection subsystems and robot would overhang the design
- Size-constrained to large diameters due to rotary stages
- This design has several technical challenges that would result in the redesign of several existing systems

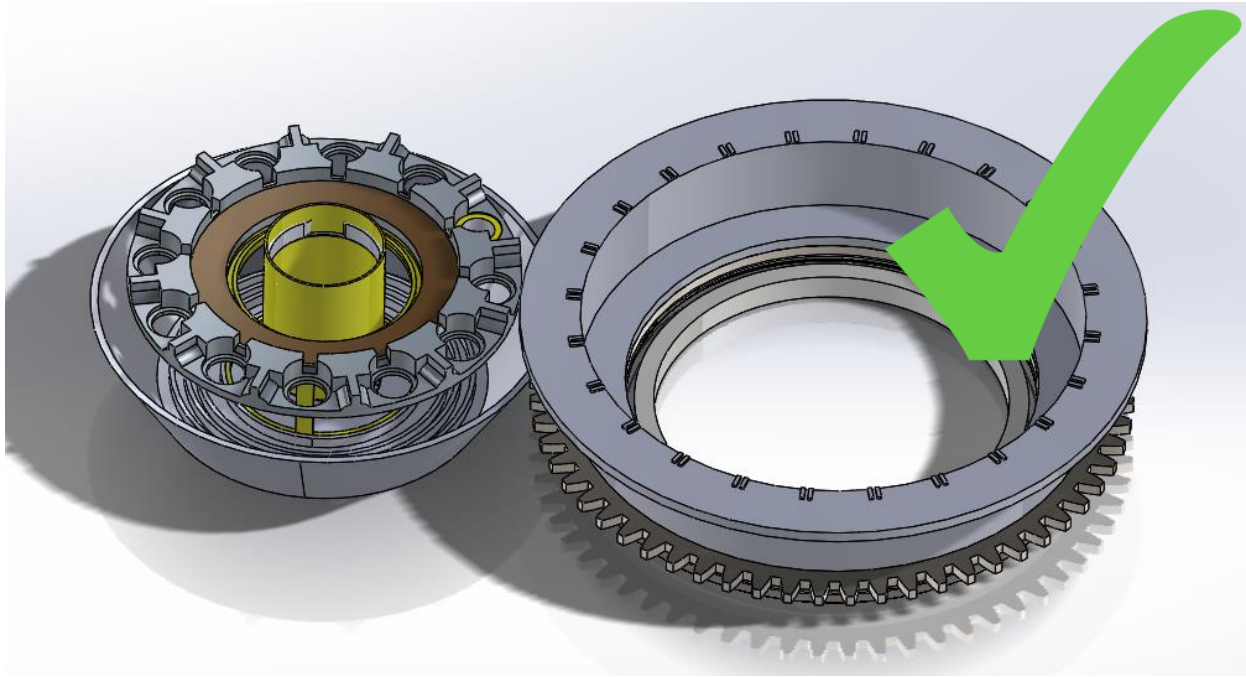


Rotary Stage: Tangent



Rotary Stage: Tangent

- Moving forward with this concept
- More modular, more independent of other still-changing subsystems
- Robot and dissection subsystems will sit inside of the ring
- Still a concept, some design challenges to discuss with mentors, on track for later-stage deliverable



Reprioritization of Deliverables

After our proposal, there was a change in priorities at the larger project level:

- To meet a paper deadline, vision was integrated with the robot before dissection

Prior Deliverables:

MIN

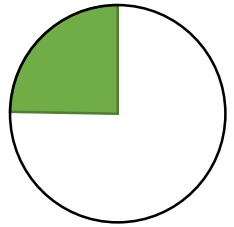
Video of a mosquito processed from presentation to body disposal, specifically:
Presentation → Pick & Place → Decapitation → Squeeze → Gland Collection → Body Disposal

03/26/19

IDEAL

Written report detailing system integration (no vision), automated dissection of 50+ mosquitoes
Written report of design concept of rotary stage

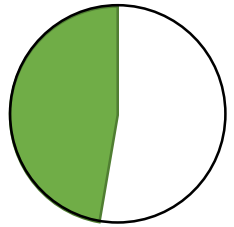
04/23/19



MAX

Written report on system integration (with vision), automated dissection of 100+ mosquitoes
Physical prototype of rotary stage concept

05/07/19



This resulted in a restructuring to what we believe are more reasonable deliverables:

New Deliverables

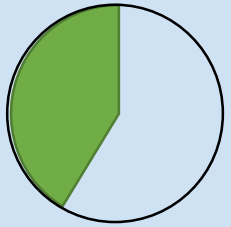
MIN

Video and Report of Pick-and-Place of 50 Mosquitoes integrated with vision system (no dissection)

03/26/19

IDEAL

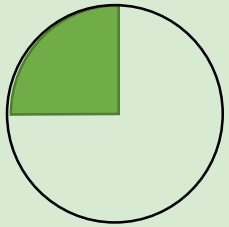
Video of a mosquito processed from:
Presentation → Pick & Place → Decapitation → Squeeze for 50+ mosquitoes
Written report of design concept of rotary stage



04/23/19

MAX

Video of a mosquito processed from presentation to body disposal, specifically:
Presentation → Pick & Place → Decapitation → Squeeze **→ Gland Collection**
for 100+ mosquitoes
Physical prototype of rotary stage concept

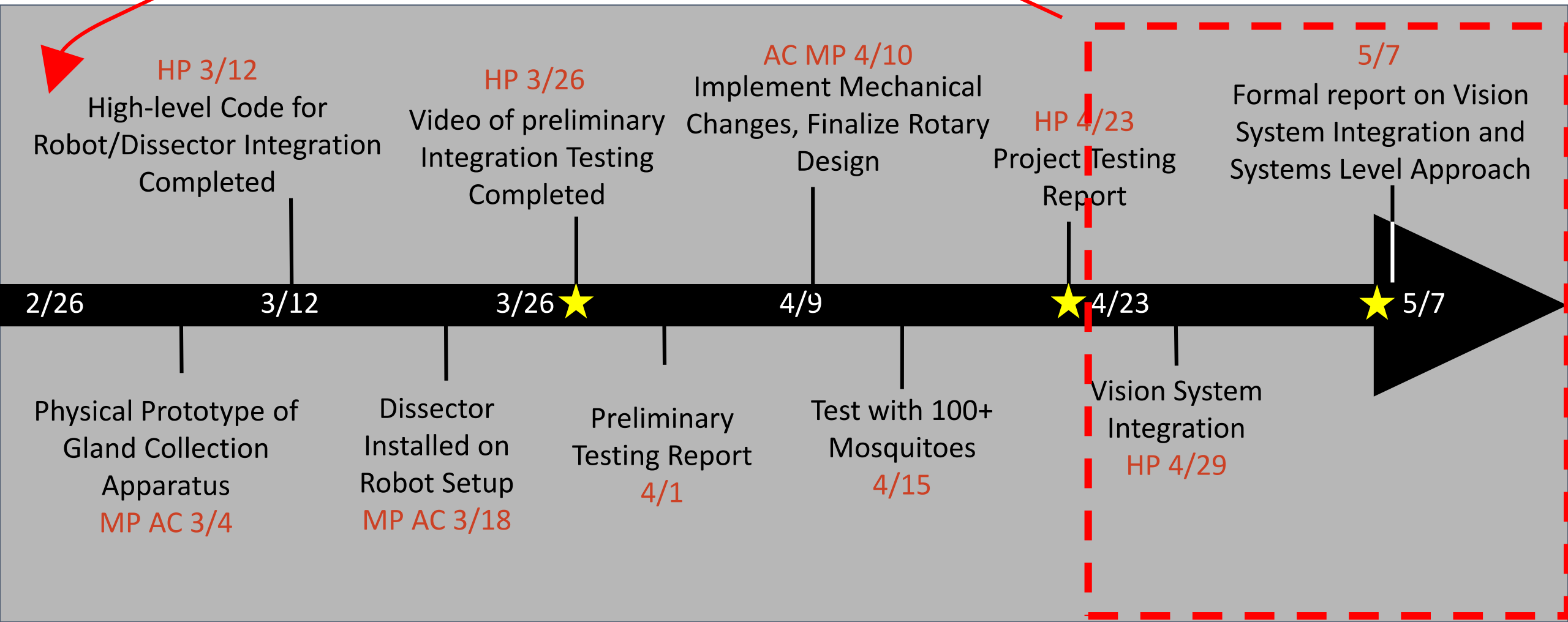


05/07/19

Prior Milestones

Responsible Member's Initials

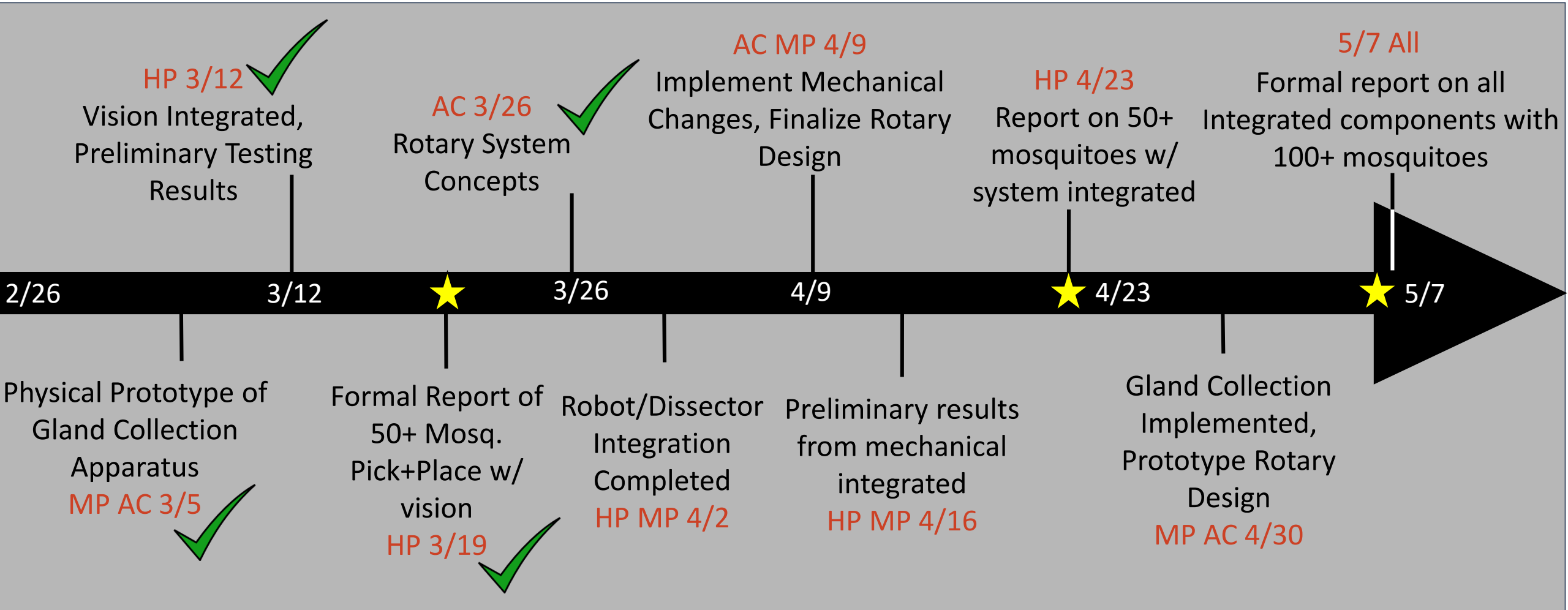
★ Key deliverable



New Milestones

Responsible Member's Initials

★ Key deliverable



Dependencies

Dependency	Solution	Date Expected	Date Required	Mitigation
Access to shared setup, computer, robot in Robotorium	Coordinate with collaborators	2/26	2/28	Perform testing in off-hours
Access to Lab Pod, JH Box (Alex)	Ask Dr. Taylor for Access	2/28	2/28	N/A
Access to mosquitos (weekly basis)	Email colleagues and Sanaria to coordinate pickup	Weekly	Weekly	No testing that week, or unofficial testing with old mosq's or those in ethanol
Interface with computer vision system	Rely on collaborators to continue development	3/15	4/23	Continue to use manual user-click commands
Interface with upstream mosquito staging system	Rely on collaborators to continue development	4/1	4/23	**Dissection system can be demonstrated with human-staged mosquitoes**
Money for mechanical development (e.g. new stage, fabrication costs, etc)	Ask mentors as needed - grant has funding	As needed	As needed	Use what resources are available
Continued functionality of recently re-designed micro gripper	Rely on collaborators to continue ongoing improvements	2/26	2/28	Complete redesign ourselves, possibly adjust project goals

Continuing

Continuing

Continuing


Questions?