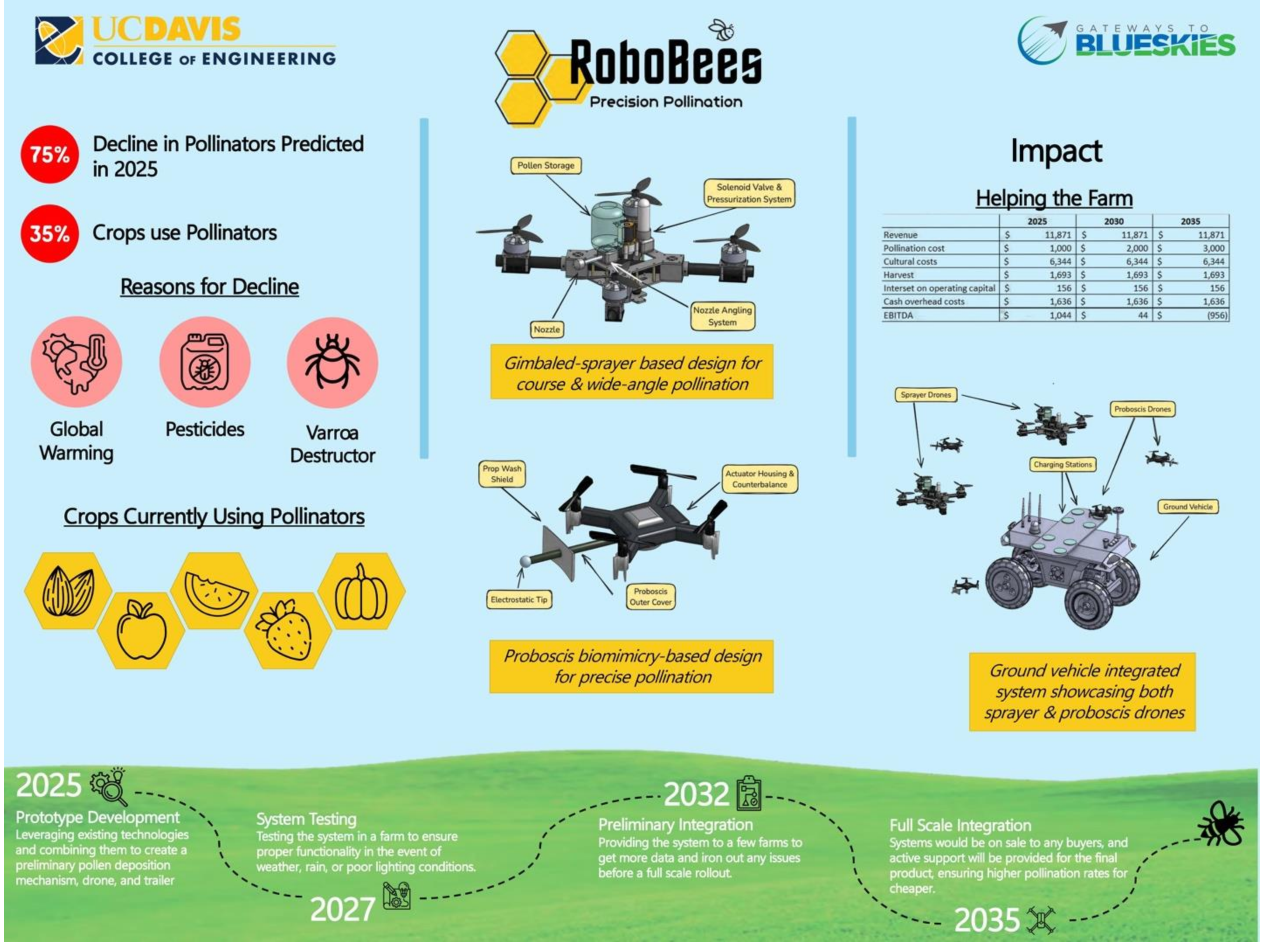
The University of California Davis

“RoboBees”



	2025		2030		2035	
Revenue	$	11,871	$	11,871	$	11,871
Pollination cost	$	1,000	$	2,000	$	3,000
Cultural costs	$	6,344	$	6,344	$	6,344
Harvest	$	1,693	$	1,693	$	1,693
Interset on operating capital	$	156	$	156	$	156
Cash overhead costs	$	1,636	$	1,636	$	1,636
EBITDA	$	1,044	$	44	$	(956)

The University of California, Davis Presentation will begin at 2:10 PM Pacific.
View the 2025 Finalists’ Infographics: **https://blueskies.nianet.org/finalists/**

GATEWAYS TO BLUESKIES

RoboBees

Precision Pollination

UCDAVIS
UNIVERSITY OF CALIFORNIA

RoboBees Team

Team Lead: Oliver Austin

Orfeas Magoulas

Achuth Jayasankar Kondoor

Horacio Contreras

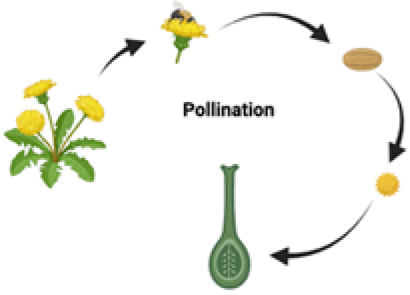
Het Satasiya

UCDAVIS COLLEGE OF ENGINEERING

UCDAVIS COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

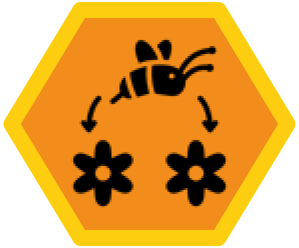
Situational Assessment

Pollination Overview



Global economic value of pollination is 161 billion

Provides countless ecosystem services



35% of crops need animal pollinators

The Humble Honey Bee

Extremely effective pollinator

Healthy bee population comes from healthy environment

Improves both quality and quantity of crops

Attracts pollen grains using weak electrostatic fields

The Western Honey Bee (Apis mellifera)

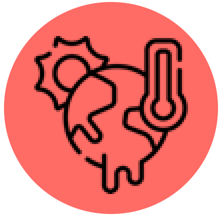
Pollinator Decline

Results

- Pollinator populations down by up to 75% in some regions.
- Loss of honey bee colonies predicted to reach a staggering 70% this year.
- Lack of pollination would lead to lower food production and mass food insecurity.

Causes

Pesticides



Global Warming

Insects and Disease

Artificial Pollination

Hand Pollination

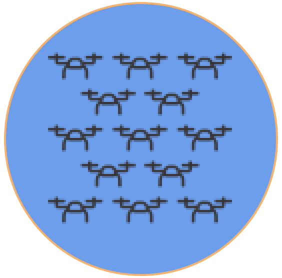
Brush Pollination

Spray Pollination

- Could help alleviate the workload of the bees, mitigate the effects of colony decline, preserve food production.
- With declining bee populations, it’s essential to have system in place to improve pollinator health and pollination.

What We Envision

- A system working alongside pollinators in farms to enhance yields, reduce food security, and improve pollinator health.
- Combine many different new and advancing technologies to create a UAV pollinator drone built to mitigate the effects of pollinator decline.



Drone Swarm

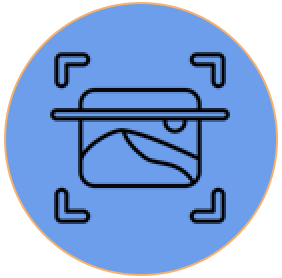
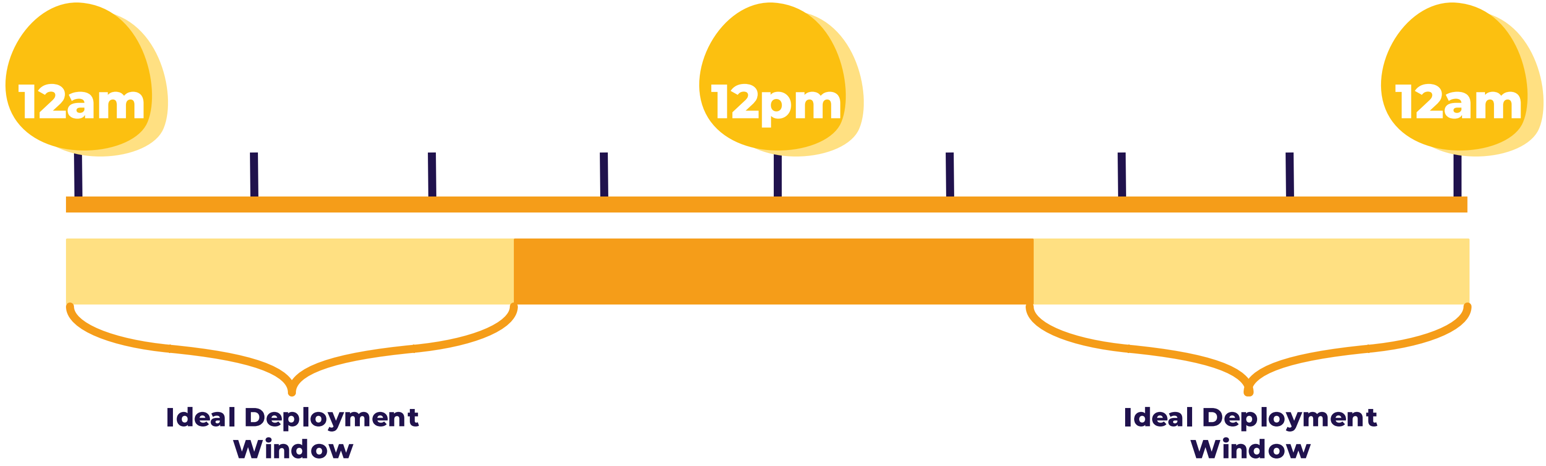


Image Detection

Precision Pollination

Daily System Deployment

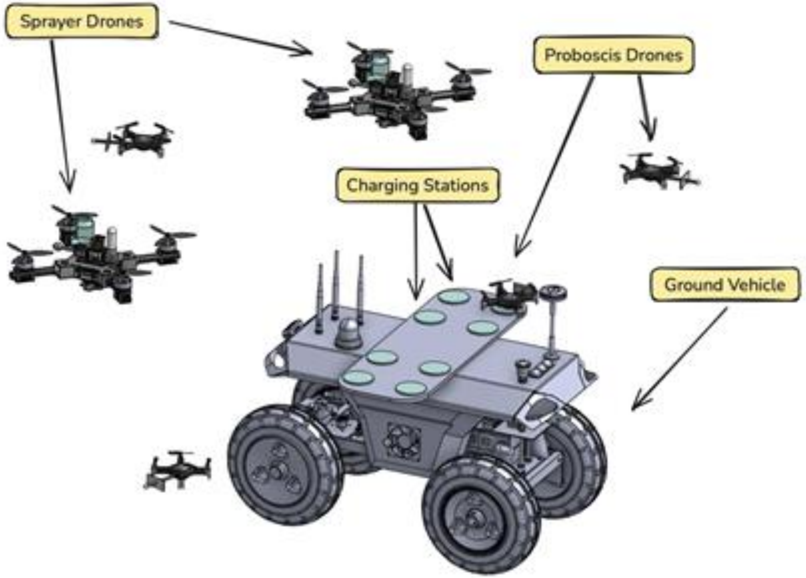


Technical Development

Mechatronics Design

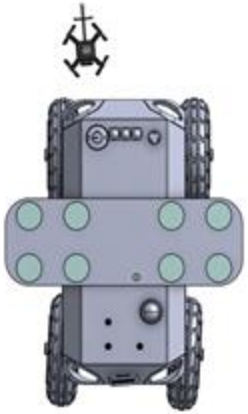
Areas Covered

- Bee-Hive / Ground Vehicle Features
- Proboscis Drone Design
- Sprayer Drone Design
- System Integration

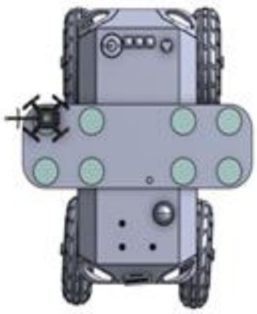


BeeHive Features

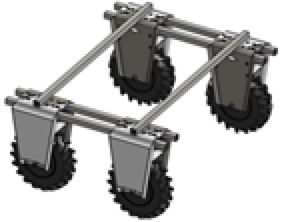
- Tractor-mounted & stationery configurations
- Vision-based localization & flower detection
- Autonomous charging
- Potential to support a tether to provide power & pressure

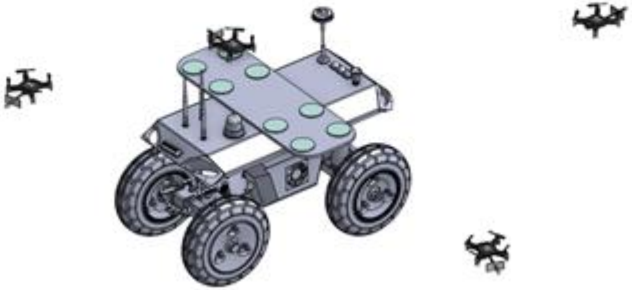


Undocked Micro-Drone

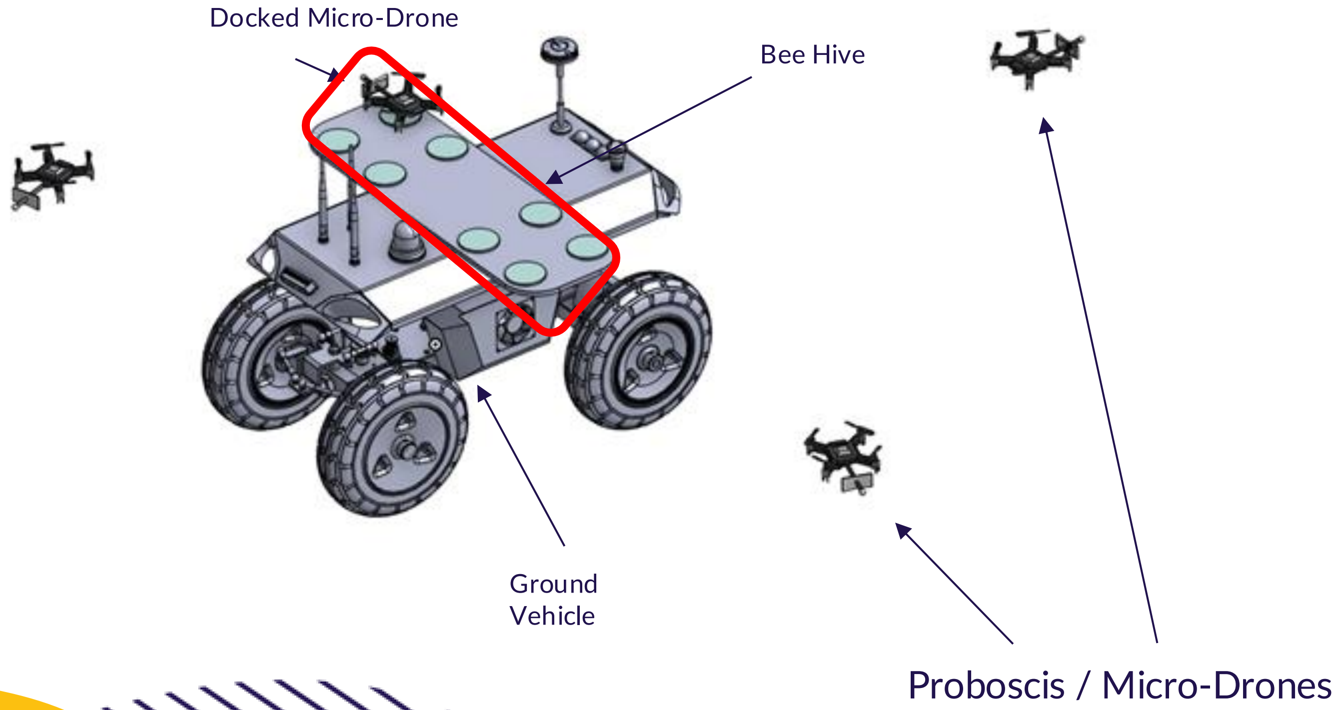


Docked Micro-Drone





Swarm Configuration



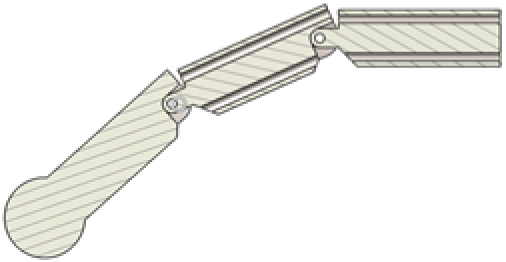
Proboscis / Micro-Drone Design

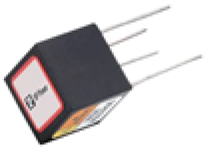
- Lightweight
- 10-20 minutes battery-life
- Contact-based pollination
- Electrostatic tip

- Avionics & camera for localization
- Wireless charging coil

Electrostatic Tip

- 5 kV charge, extremely low current
- Gold-plated polymer or carbon fiber tip
- Charge-reverses during deposition



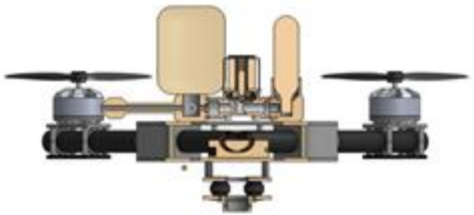


EMCO-Q Series or

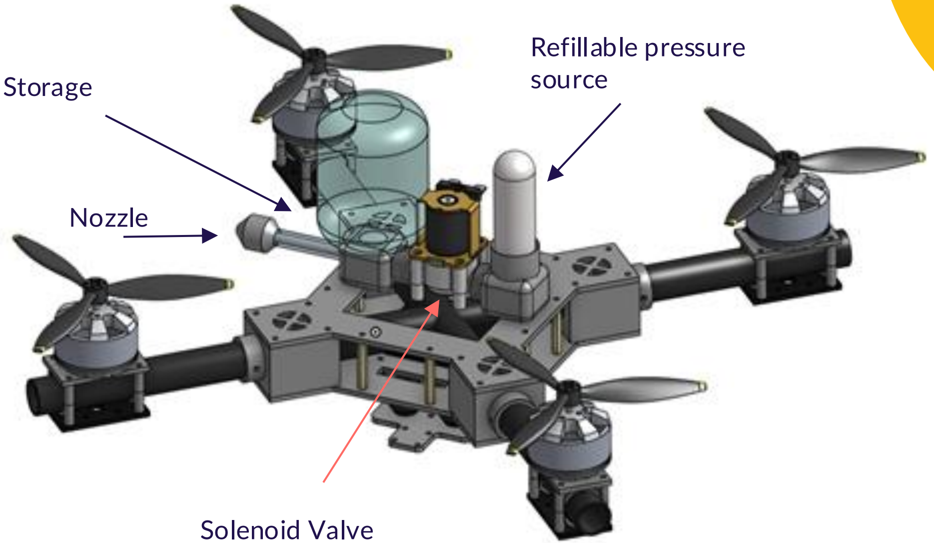
similar DC-DC Converter

https://www.xppower.com/portals/0/pdfs/SF_Q_Series.pdf

Sprayer Drone Design



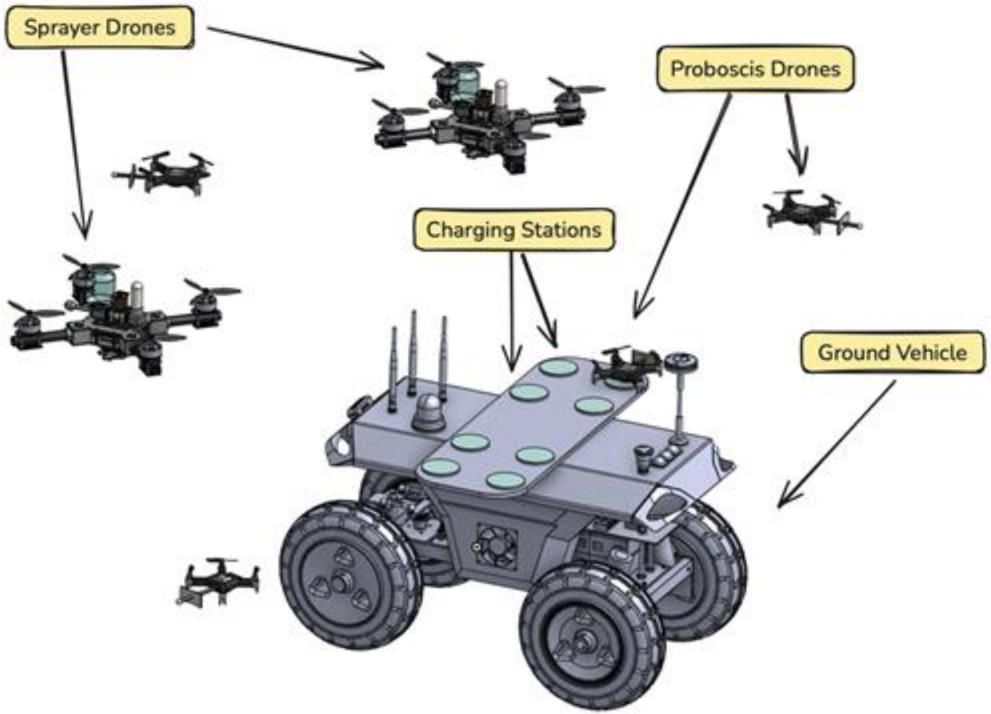
- Larger than micro-drone
- Broad pollination via spraying
- Refillable manually or automatically via a bee-hive facilitated docking



Full Integration

- Most use-cases would use exclusive configuration

- System can support both configurations concurrently



Swarm Utility

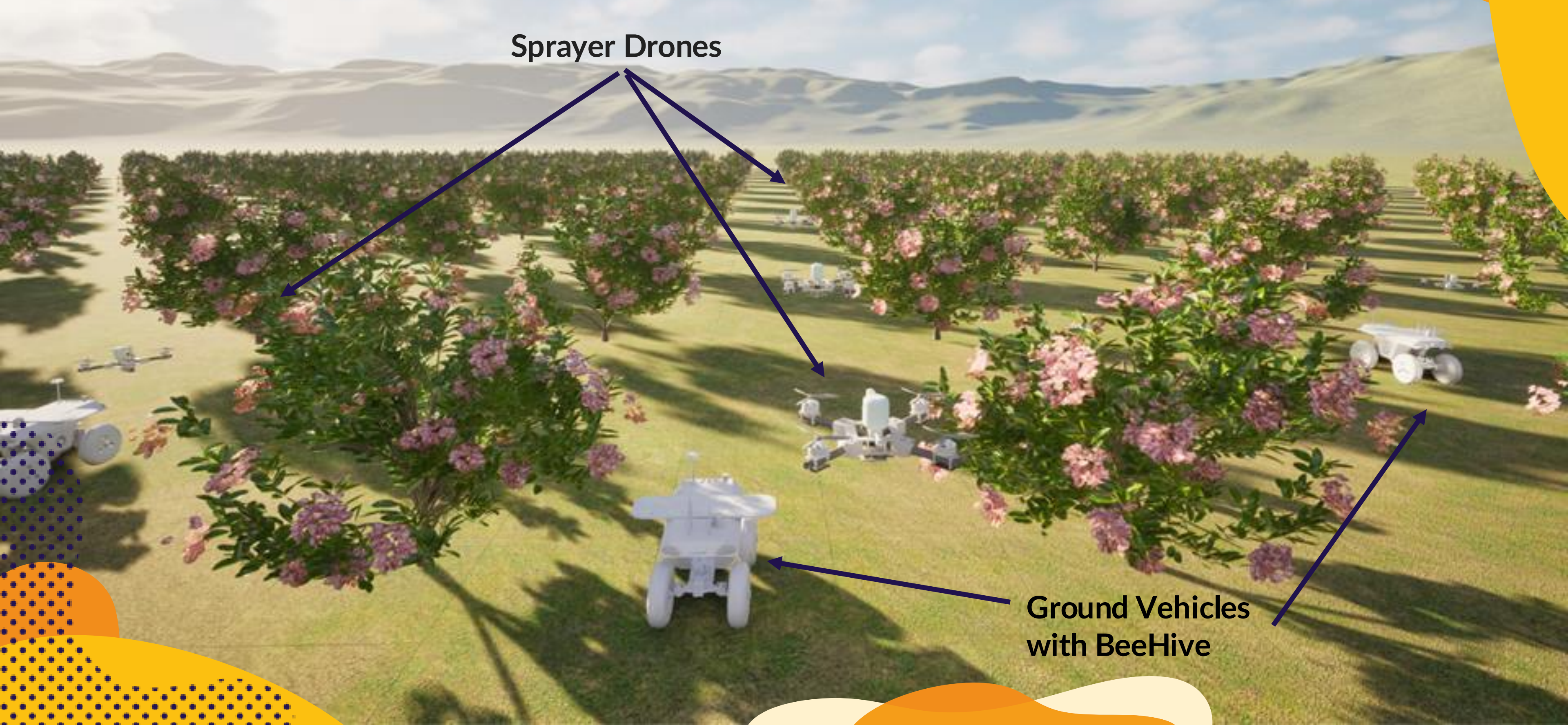
Contact Based

- Good for smaller plots, research, precise deposition of pollen with no waste, lack of already available pollen
- Good for smaller number of large flowers
- Pumpkins, Squash

Spray Based

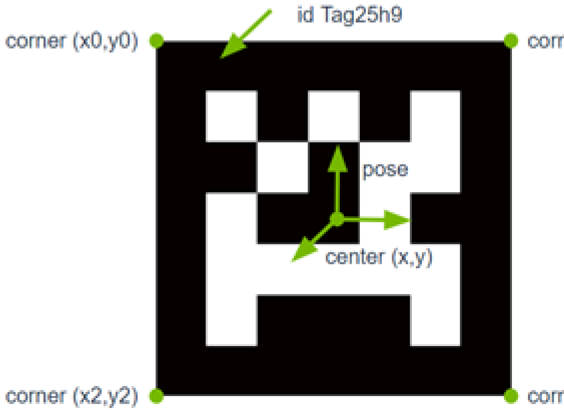
- Good for thousands of small flowers, spray helps cover many flowers fast
- Useful form mass pollination when pollination efficiency might not be an issue
- Almonds, Apples, cherries

Full Deployment Simulation

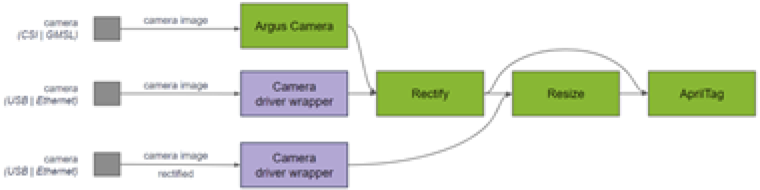


Computer Vision
&
Data Processing

CV-Based Localization

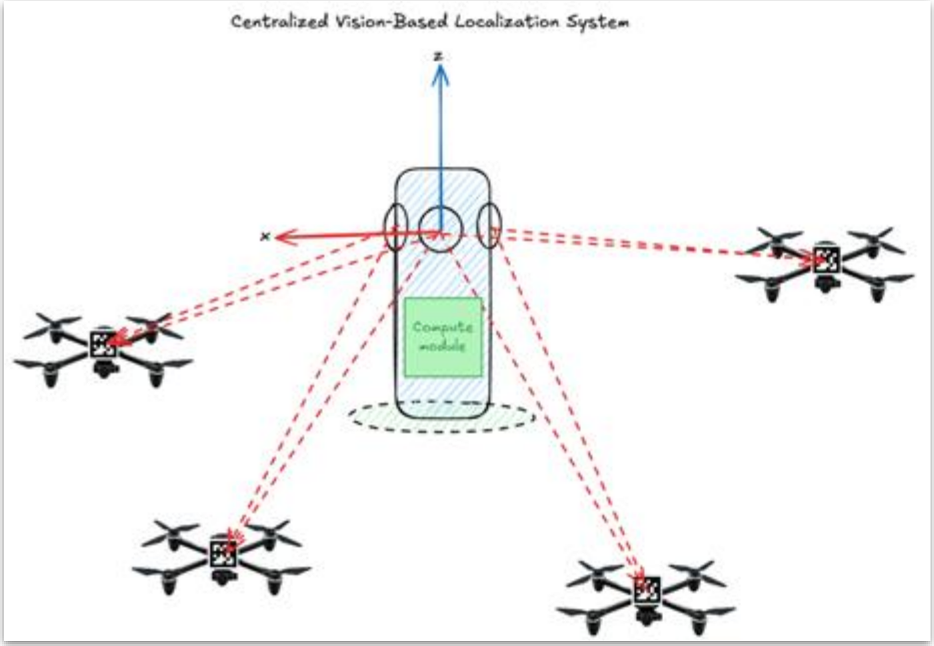


- In order to gain a 6DOF pose estimate in an edge environment, low cost, reliable, and fast detection of visual fiducials is a necessity.
- April tags are inexpensive to print and use in comparison to comparable solutions like an RTK GPS that provide a similar level of accuracy.



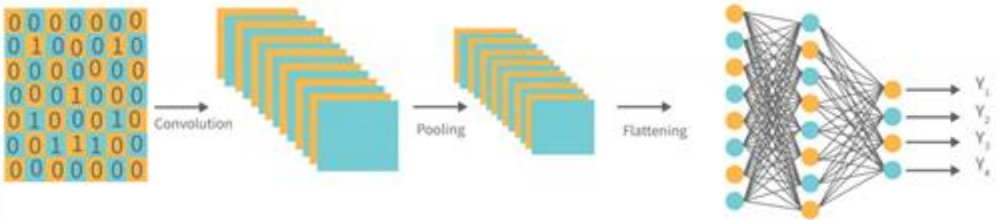
Centralized Data Processing

- Reduced overall cost and simpler structure
- Easier to upgrade and expand when needed



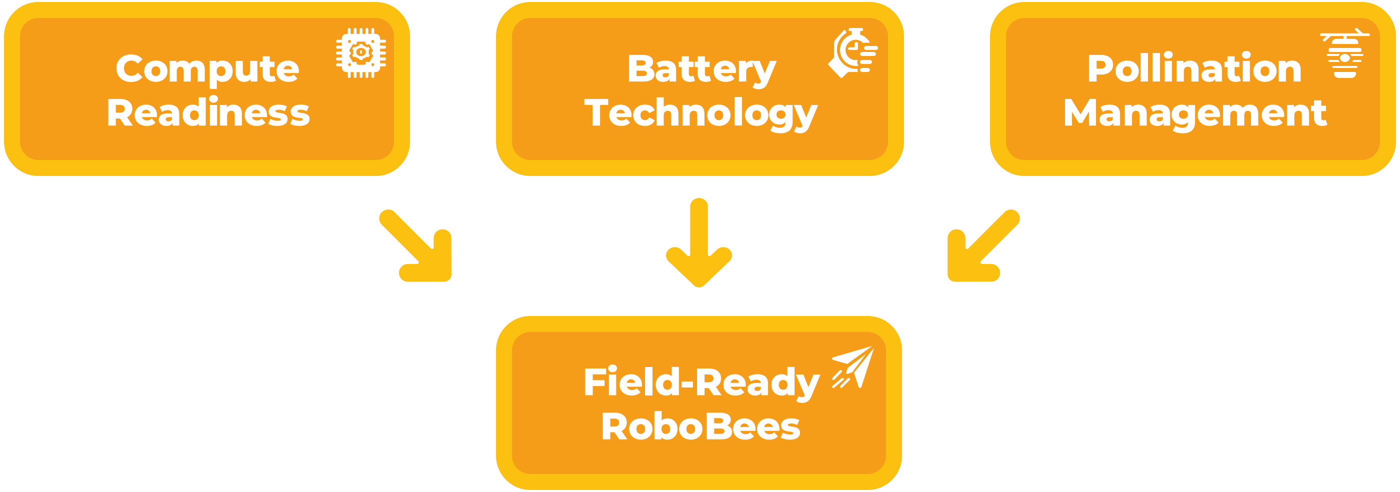
Flower Detection

- Mask R-CNN model for image segmentation and flower shape and location



System Implementation

High-Level Considerations



Technology Readiness (TRL) Analysis

TRL 8+
2032 → 2035

TRL 7-8
End of 2032

TRL 2-3
Current-Day

TRL 9
•Actual system "flight proven" through successful mission operations

TRL 8
•Actual system completed and "flight qualified" through test and demonstration (ground or space)

TRL 7
•System prototype demonstration in a space environment

TRL 6
•System/subsystem model or prototype demonstration in a relevant environment (ground or space)

TRL 5
•Component and/or breadboard validation in relevant environment

TRL 4
•Component and/or breadboard validation in laboratory environment

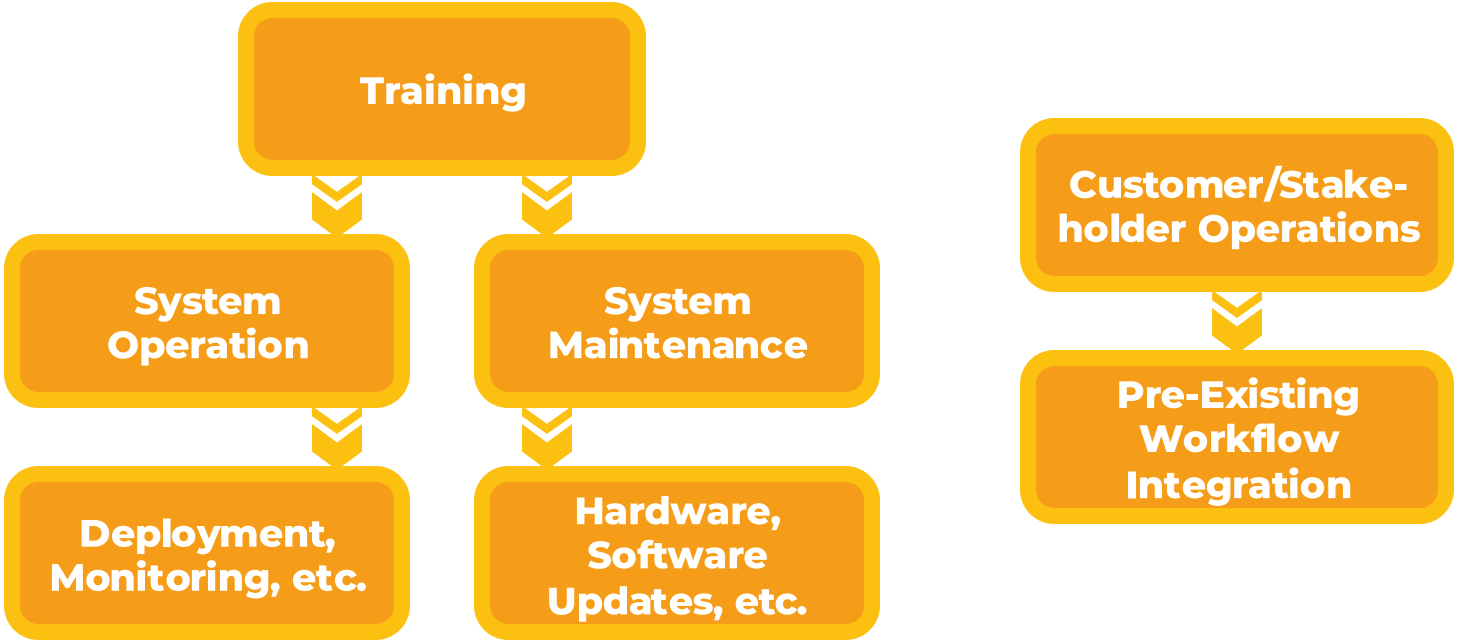
TRL 3
•Analytical and experimental critical function and/or characteristic proof-of-concept

TRL 2
•Technology concept and/or application formulated

TRL 1
•Basic principles observed and reported

https://www.nasa.gov/directorates/somd/space-communications-navigation-program/technology-readiness-levels/

Integration with the Farm



Protecting Natural Pollinators

Acoustic Disruption

Significance: Bees use sound cues for communication and navigation

Risk: High-frequency propeller noise may disorient or deter bees

Mitigation: Use of low-noise propeller designs and minimizing of drone weight

Operational Timing

Significance: Tractors already impact bee activity through vibration.

Risk: If operated independently, RoboBees could double ecological stress

Mitigation: Development of field schedules to “hide” inside tractor noise

Key Deployment Challenges

Regulatory Hurdles

- FAA Part 107 Certification
- Beyond Visual Line of Sight (BVLOS) Approvals

Adoption Resistance

Low uptake of autonomous systems due to:

- High initial costs
- Disruption to existing workflows
- Limited understanding of long-term value

Strategies to Overcome

Demonstrations: Real-world use cases to build trust

Incentives: Subsidies or financial support to reduce entry cost

ROI Evidence: Cost-benefit studies to show profitability

Return on Investment

Key Assumptions

Standard nitrogen application and herbicides

Micro sprinkler irrigation and fertilization

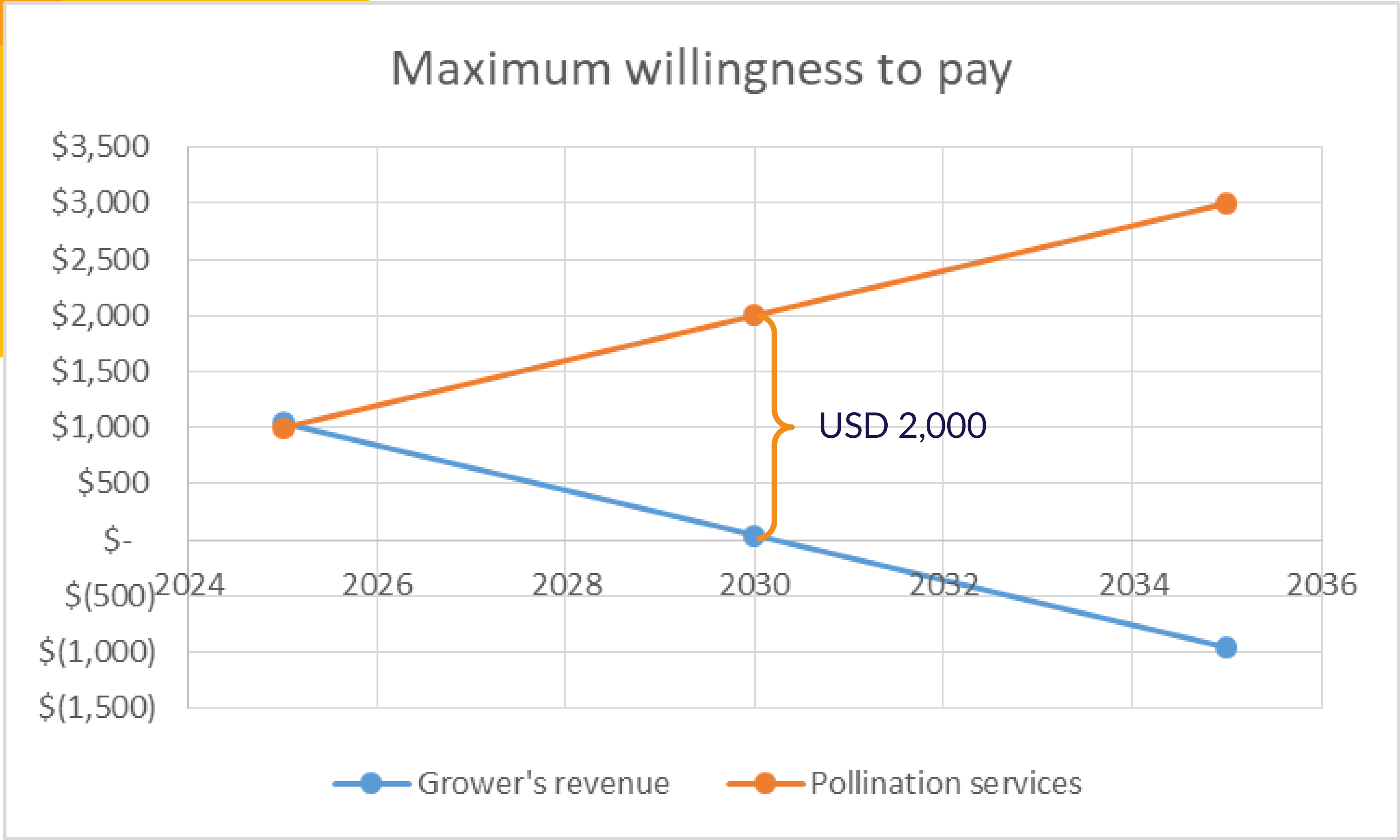
USD 3.53

1,361 Kg

Harvest, pruning and field operations

Long-term financial outlook

Item	2025	2030	2035
Revenue	USD 11,871	USD 11,871	USD 11,871
Pollination cost	USD 1,000	USD 2,000	USD 3,000
Cultural costs	USD 6,344	USD 6,344	USD 6,344
Harvest	USD 1,693	USD 1,693	USD 1,693
Interest on operating capital	USD 156	USD 156	USD 156
Cash overhead costs	USD 1,636	USD 1,636	USD 1,636
EBITDA	USD 1,044	USD 44	USD (956)


Maximum willingness to pay
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$-
$(500)
$(1,000)
$(1,500)
2024
2026
2028
2030
2032
2034
2036
USD 2,000
Grower's revenue
Pollination services

Potential for the Future

Multi-Function Payloads Beyond Pollination

Integrated Sensor Suite for Data-Driven Pollination

Modular Drone Fleet for Diverse Farming Needs

Acknowledgements

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Dr. Christina Harvey - Campus Contact

NASA's Gateways to Blue Skies for covering travel expenses

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NASA'S GATEWAYS TO BLUESKIES

2025 AgAir: Aviation Solutions for Agriculture Forum

NASA'S

GATEWAYS TO

BLUESKIES

2025 AgAir: Aviation Solutions for Agriculture Forum

THE 2025 GATEWAYS TO BLUE SKIES FORUM WILL RESUME AT 8:00 AM PACIFIC TIME ON Wednesday, MAY 21, 2025