CAPSTONE
SENIOR DESIGN PROGRAM

College of Engineering, Computer Science, & Technology
Expo: EE ME Programs (Spring Cohort)
Poster Session: EE ME ET Programs (Fall Cohort)
Friday, December 1, 2023 | 9:30 a.m. – 2:30 p.m.

AGENDA | EE ME Expo (Spring Cohort)

ACTION	TIME	LOCATION
Welcome and Kick-Off	10:00 a.m. to 10:15 a.m.	Community Room, Library North B-131
Team Presentations	10:15 a.m. to 1:15 p.m.	

AGENDA | EE ME ET Poster Session (Fall Cohort)
EE ME: 2023 Spring Cohort six teams **and** 36 EE ME ET: 2023 Fall cohort teams.

ACTION	TIME	LOCATION
Poster Session	1:00 p.m. to 2:30 p.m.	ET Courtyard

INFORMATION

Industry partners, faculty advisors, liaisons and students will gather for the Cal State LA College of Engineering, Computer Science, & Technology (ECST) Capstone Senior Design expo for the Electrical and Mechanical Engineering programs Spring cohort's projects and poster session for the Electrical, Mechanical, and Engineering Technology programs Fall cohort's poster session.

During this event, Capstone student teams will verbally and visually present their projects, discuss their research, address challenges, share their process and methods. In addition, student teams will answer questions and engage in discussions with the audience to further expand on their experience working on Capstone projects. Industry sponsors and partners take the opportunity to learn more about Cal State LA students and consider employment or internship matches.

COMPUTER SCIENCE PROGRAM | Project Review 8:30 a.m. to 10:30 a.m.
More information is available upon request

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PRESENTATIONS | EE ME Expo (Spring Cohort)

TIME	PROJECT NAME	STUDENTS
10:00 a.m. (TEAM 201)	*Video Extensometer* Advisor: Mathias Brieu, Ph.D.	Michael Cano, Manuel Haro Malik Moffet
10:45 a.m. (TEAM 202)	*On-Land Para Hockey Sled* Advisors: Chris Bachman, Ph.D., P.E., Everardo Hernandez	Jorge Madrid, Juan Perez Danny Soto
11:15 a.m. (TEAM 203)	Airborne Swarm Drone Deployment/Dispenser Advisor: Mike Thorburn, Ph.D.	Albert Calderon, Josue Luna, Patrick Hernandez, Erik Oganesyan Romy Herrera
11:45 a.m. (TEAM 204)	Airborne Swarm Drone Deployment/Dispenser Advisor: Kurt Sawitskas, Ph.D.	Marvin Garcia, David Samuel Sepnio, Marlon Pena Huezo Stefan Tchoubineh Jose Ramos
12:15 p.m. (TEAM 205)	Airborne Swarm Drone Deployment/Dispenser Advisor: Kurt Sawitskas, Ph.D.	Daniel Buonavita-Haag, Angel Sanchez, Nicholas Galvan Ashley Ly
12:45 p.m. (TEAM 206)	Thermo-plastic Injection Molding System Advisor: Mathias Brieu, Ph.D.	Neyda Bautista, Daniel Terrones, Maria Gonzalez Abdelrahman Mousafa

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Project 201: Video Extensometer for Tensile Testing of Soft Polymers

Advisor: Mathias Brieu, Ph.D.

Team Members: Malikk Moffet (EE), Michael Cano (ME), Manuel Haro (EE)

This senior design project presents a comprehensive solution for the precise measurement of strain in soft polymers during tensile testing. Bringing together the knowledge of Mechanical Engineering, Electrical Engineering, and Computer Science, this project integrates a mechanical gear system, electronics, and image processing software to form a Video Extensometer. Mechanical Engineering undergrad (Michael) developed a gear box system that is driven by a stepper motor, to displace a camera that is tracking a set of dots marked on the specimen throughout the longevity of the tensile test. Electrical Engineering undergrad (Manuel) programmed the hardware components, including the stepper motor driver, push buttons, and LED's, to enable real-time feedback control of the stepper motor, ensuring precise specimen tracking. The image tracking software written by Electrical Engineering undergrad (Malikk) measures the specimen's deformation to determine strain. This collaborative effort between mechanical, electrical, and computer science represents an innovative approach to materials testing and also showcases the interdisciplinary skills in tackling complex engineering challenges.

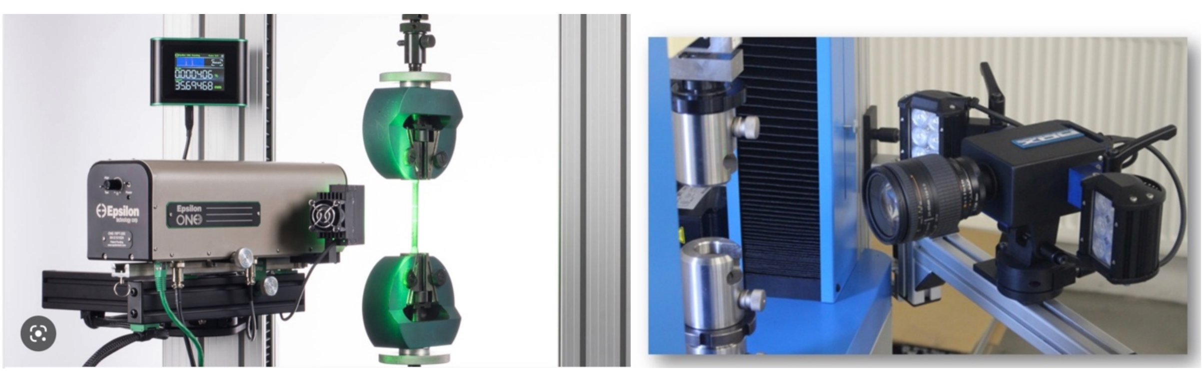

Fig.: Left-hand side Atomic Force Microscope, right-hand side: climatic chamber

Student Capabilities and Interests: Design, Matlab or python coding, and mechanism machining.

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Non-Contact Video Extensometer for Tensile Testing of Soft Polymers

Team Members: Michael Cano, Manny Haro, Malik Moffett
Faculty Advisor: Dr. Mathias Brieu
Liaison: California State University, Los Angeles
Department of Mechanical and Electrical Engineering
College of Engineering, Computer Science, and Technology

Project Background

This senior design project presents a comprehensive solution for the precise measurement of strain and yield strength of soft polymers during tensile testing. Combining Computer Science Mechanical and Electrical Engineering. This project integrates a mechanical gear system, electronics, and object detection and tracking software to build a Non-Contact Video Extensometer.

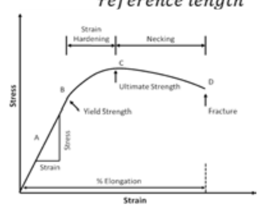
Objective

Build a mechanical gearbox driven by a stepper motor, to vertically displace a camera to accurately track a sample during a tensile test. Using python programming create an image tracking software to connect with a camera that measures the specimen's deformation to determine strain.

System-Level Requirements

Gear System	Minumum Torque Required (N*cm)	Output Torque onto rack (N*cm)	Input RPM	Output RPM
Simple	6.4	12.8	10	5
Compound #1	3.2	6.4	20	10
Compound #2	3.2	12.8	20	5

$$strain = \frac{deformation}{reference\ length}$$



Required Hardware					
ELEGOO MEGA2560 R3		Stepper Motor: Bipolar, 200 Steps/Rev 1.2 A/Phase 4.0V		Pushbutton X2	
DRV8834 Low-Voltage Stepper Motor Driver Carrier		Breadboard		100 uF Electrolytic Capacitor x1	
Portable Power Supply		Green and Blue LED		5V, 3A Power Supply	

Overall Design Approach

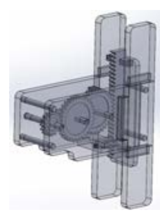
High resolution 4K USB camera mounted onto a 3D printed gearbox powered by a stepper motor for control. Camera is connected to a computer that provides the object detection and tracking algorithm for measurement. Strain can then be calculated using the measurements of length taken from the software.

$$\varepsilon = \frac{\Delta L}{L_0}$$

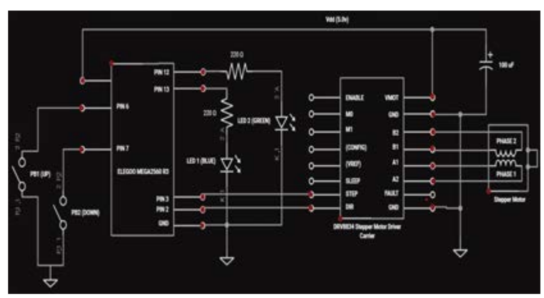
where

- ε strain
- ΔL total elongation [m]
- L_0 original length [m]

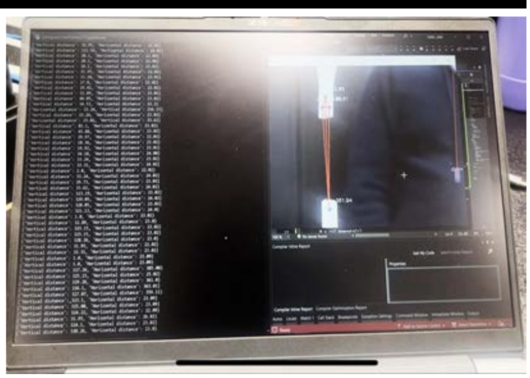
Gearbox Design



The gearbox is designed using SolidWorks to 3D print and assemble a prototype that can satisfy the camera-lift system requirements. Calculations are made to simulate different types of gear systems under similar conditions to determine the appropriate gear system for this project.



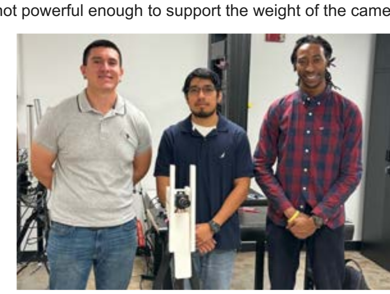
Results



The object detection and tracking algorithm was able to successfully track, follow, and display the changing vertical displacement of the sample. It was robust enough to track the sample at both a rapid and gradual pace without fail.

Major Findings and Conclusions

While testing, we observed that the algorithm was sensitive to detect any object that resembled the template used for tracking. In addition, to this it was revealed to us that the motor initially selected for use was not powerful enough to support the weight of the camera.



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Project 202: On-Land Para Hockey Sled

Client: Philip Bloom

Advisors: John "Chris" Bachman, Ph.D., P.E. and Everardo Hernandez

Team Members: Jorge Madrid, Danny Soto, Juan Perez, Danny Soto

The On-Land Para hockey sled is designed to emulate the performance and movement of a conventional para hockey ice sled. Our client faces challenges in practicing in southern California due to the limited availability of ice rinks. This project requires the team to design and develop a product that can be used on surfaces such as black tops, wooden floors, and concrete. The design is focused on implementing a chassis with wheels that will allow full maneuverability with minimal difficulty in cornering and turning.

Student Capabilities and Interests: Engineering design process, machine design, manufacturing

Industrial Sector/Technologies: Product design, machine design, manufacturing

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Para Hockey Sled

Team Members: Jorge Madrid, Danny Soto, Juan Perez
Faculty Advisor: Dr. Chris Bachman, Professor Everardo Hernandez
Liaison: Phillip Bloom
Department(s) of Mechanical Engineering
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

Project Background

Para Hockey, also known as sled hockey, is a version of the sport designed for those with physical disabilities. Players ride in specialized sleds, propelling themselves forward using a pair of shortened hockey sticks tipped with ice picks at the ends. The sleds themselves use a set of blades that can be adjusted with spacers to support beginners, intermediate and expert athletes. Unlike the traditional hockey, paraplegic hockey has no "on-land" equivalent.


System Level Requirements

Criteria/ Requirements Description	Requirement	Reason for Requirement	Method of Verification
Cost	cost < $800	To be competitive in the market	Analysis
Weight Capacity	500 lbs.	F.O.S = 2.5	Inspection
Material	Round Aluminum Tubing	Market Standard	Design
Weight	15 lbs. < weight < 25 lbs.	To be competitive in the market	Inspection
Rolling Resistance	<0.05	To provide similar movement as ice	Analysis
Impact Capacity	3G	To withstand forces during activity	Analysis

Final Product

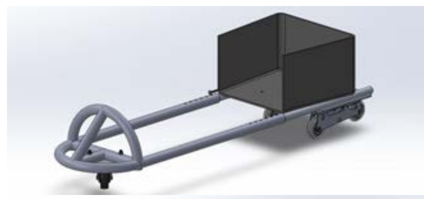
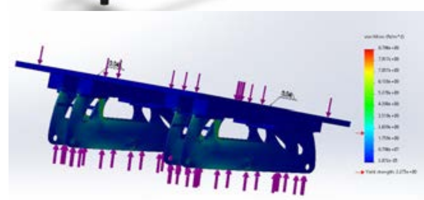

Acknowledgements

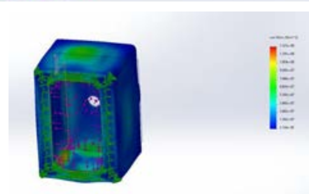
The team would like to thank the Makerspace staff for aiding us in the manufacturing process and answering all questions about machinery, with special thanks to Hector Vasquez for using his welding skills and waterjet knowledge to help complete the final product.

Objective

The client has shared that the limited availability of hockey rinks in their area has made it difficult to practice para hockey regularly. The objective of this project is to design and produce a hockey sled that can serve as a suitable practice unit that can be used on surfaces such as concrete, hardwood, and asphalt. This sled should be reasonably robust, while remaining both lightweight and maneuverable.

Design: Modeling and FEA



Conclusion

- Total cost of materials was $669 (16.37% under desired amount)
- Final weight of 20.1lbs
- Sled reached a top speed of 11.4 ft/s (7.77 mph)
- Sled front can withstand an impact of up to 590lbs (2624N)
- Sled weight capacity is 635lbs (288kg)

Projects 203: Hyperion-Airborne Swarm Drone Deployment/Dispenser

Client: Cal State LA, ECST

Advisor: Mike Thorburn, Ph.D.

Team Members: Patrick Hernandez, Josue Luna, Erik Oganesyan, Albert Calderon, Romy Herrera

As drone technology has developed over time, it has benefited a variety of sectors, including agricultural, property management, and even military uses. Due to their superior dexterity over bigger drones, smaller drones may be required for a given purpose; however, their battery life and range are typically restricted. The team's job was to create a system that could safely deliver and deploy small drones needed to minimize such limits. Students have concentrated on mechanical, aerodynamic, and electrical elements while developing a system for a carrier drone that dispenses these smaller drones. To validate the idea, students carried out several analyses, experiments, and case studies. The team took into account different mission scenarios, flight dynamics, structural integrity, and the influence of physical constraints such as natural forces and aerodynamical anomalies. Multiple release mechanism designs were analyzed for tradeoffs such as weight, power consumption, aerodynamics, reliability, structural integrity and prototype production were all considered. Computer-aided design (CAD), simulation software, and coding software were used to analyze and determine the best design for our objective. Allowing these drones to cover more ground in tasks like aerial photography, surveillance, or remote sensing is one use case for this technology.

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Project Hyperion

Airborne Swarm Drone Deployment

Team Members: Erik Oganesyan, Patrick Hernandez, Rony Herrera, Josue Luna, Albert Calderon
Faculty Advisor: Dr. Michael Thorburn

College of Engineering, Computer Science, and Technology
California State University, Los Angeles

Project Background

The development and implementation of UAVs has become an integral component of modern tools used by various institutions and establishments to ensure maximum efficiency in their respective fields. Project Hyperion focuses on implementation of smaller UAVs (e.g. Quadcopters, Fixed Wings etc.) desired in surveillance, rescue and mapping missions that require tight space navigation.

Objective

The concept revolves around combining the capabilities of mini quadcopters and regular-sized quadcopters by designing a system where a larger drone acts as a carrier for multiple mini quadcopters. The large drone transports smaller drones to the desired location, providing an advantage of extended flight time and longer control range. Upon reaching the target area, carrier releases mini drones, allowing them to disperse and conduct surveillance in smaller areas with agility and precision. This combination offers a synergistic approach to aerial surveillance, leveraging the strengths of both mini and standard size quadcopters. As the mini navigate narrow spaces and collects data, larger carrier serves as a mobile command center, providing an overarching view of the entire operation.


Fig. 1: Complete Assembly

System-Level Requirements

- **Mechanical Design and Structure**
  - Weight/Size Constraints
  - Structural Integrity
  - Vibration and Oscillation Dumping
  - Compatibility
- **Aerodynamic Performance**
  - Aerodynamic Stability
  - Airflow Interference
- **Security and Reliability**
  - Secure Attachment
  - Mini Drone Frame
- **Operational Efficiency**
  - Controlled Release
  - Ease of Maintenance
  - Quick Assembly
  - Energy Consumption


Fig. 2: QAV 250 (Carrier) & DJI Tello (Mini Drone)

Design Approach

Servo Driven Linkage Mechanism

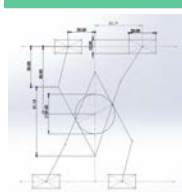


Fig. 3: Linkage Sketch


Fig. 4: Mechanism (Iter. 1)

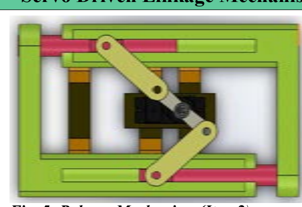


Fig. 5: Release Mechanism (Iter. 2)

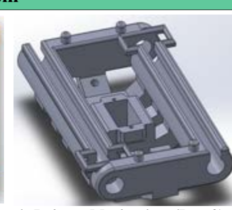


Fig. 6: Release Mechanism (Iter. 3)

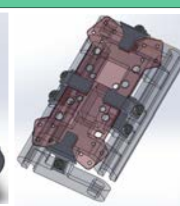


Fig. 7: Frame Attachment

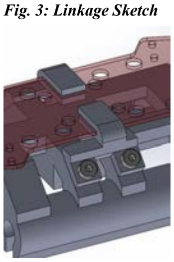


Fig. 8: Frame Attach.


Fig. 9: Mini attachment (FEA)

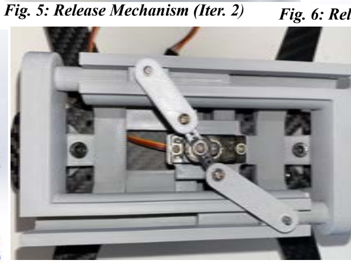


Fig. 10: Complete Mechanism (Final Iteration)

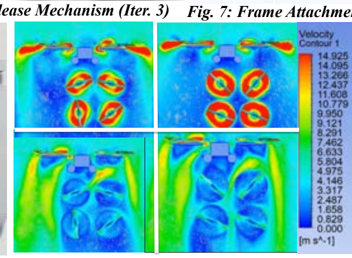


Fig. 11: CFD of Complete Assembly

Testing


Fig. 12: System Testing (Intact)


Fig. 13: System Testing (Detached)

Results

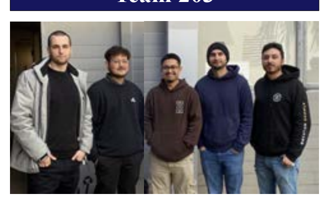
After testing phase, the results are the following:

- Mechanism is reliable and fully functioning
- Cost efficient manufacturing
- No system interfere with vehicles' aerodynamic performance
- Meeting power requirements imposed by the electric hardware
- Design is user friendly, easy to repair and adjustable to various quad. frames.

Conclusion

Project proved the concept of possible multivehicle surveillance that could potentially be dedicated to several applications including but not limited to: rescue, intelligence, defense etc.

Team 203



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Projects 204: Airborne Swarm Drone Deployment/Dispenser

Client: Cal State LA, ECST

Advisor: Kurt Sawitskas, Ph.D.

Team Members: Stefan Tchoubineh, Marvin Garcia, Jose Ramos, Marlon Pena, David Sepnio

Drones are unmanned aerial vehicles (UAVs) whose presence today are being used for various purposes from entertaining drone light shows, delivering distant medical supplies, or to aiding firefighters in monitoring a fire situation. In this project, students designed and developed a drone deployment system that can be attached to a "mothership" drone carrying a payload of smaller "daughter" drones with it which will be deployed while airborne.

The objective is to provide proof-of-concept of a mobile drone deployment system capable of distributing a swarm of smaller sized drones midair to perform a predetermined task. Utilizing 3D modeling software (SOLIDWORKS & OnShape), 3D Printing, and MATLAB, the team successfully developed and tested a working 3D printed prototype that was able to dispense two Tello EDU drones from a set height. While the concept is proven, the applications of such a system can be further explored.

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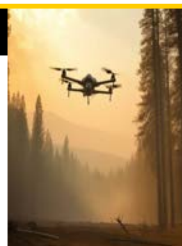
Drone Deployment System

Team Members: Stefan Tchoubineh, Marvin Garcia, Marlon Pena, Jose Ramos, David Sepnio
Faculty Advisor: Kurt Sawitskas
Departments of Electrical Engineering and Mechanical Engineering
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

Background

Drones are small unmanned aircraft that are easily piloted for various tasks such as search and rescue. They are maneuverable but have a limited battery life while large drones have longer battery life at the cost of weight and maneuverability. A small-drone deployment from a large drone delivers the best of both worlds for the right application.



Objective

The main objective is to design and develop a drone deployment system that is attached to a "mothership" drone and can deploy the "daughter" drones while airborne. The daughter drones must deploy without compromising the mothership's integrity. They must also fly independently after successful deployment.

System-Level Requirements

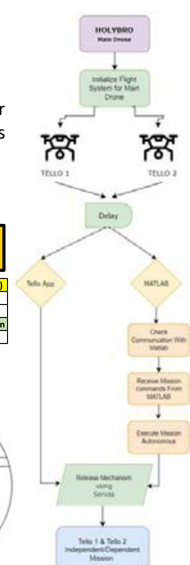
- **Mothership drone must be able to lift itself and the deployment system.**
- **Daughter drones must detach without compromising the mothership.**
- **Drones must deploy on command and hover without collision.**

<u>One Propeller at 75% power:</u>
906g = Thrust per manufacturer testing
3624g = Total thrust for four propellers
<u>Mass of drone and payload:</u>
610g = HolyBro Drone (mothership)
492g = Master Battery
97g (2x) = Tello Drone (daughter drone)
14.9g = fsia6b receiver
9.07g = Servo receiver battery
9g (2x) = Servos

<u>Remaining weight for deployment system</u>: 2286.03g

Operation

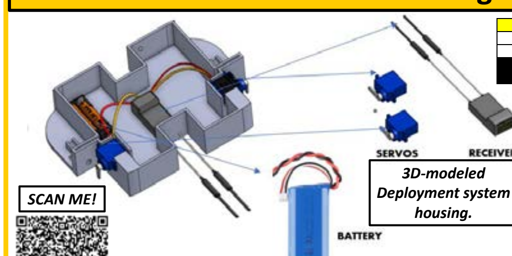
A mothership can be controlled through a Pixhawk 6c flight controller (dependent on model). Deployment drones are controlled via MATLAB programming for preconfigured operations or via smartphone connection for user-operated control. In both cases, there is a slight delay between the input and the output action. The release mechanism is triggered by a flight controller.



Design

no.	Electrical Component	Quantity	Current Draw (A)	Voltage Draw (V)	Power Consumption (W)
1	Servo Motors	2	3	5	15
2	Telemetry Radio	1	0.025	5	0.125
		Total	Total Current	MAX Voltage	Total Power Consumption
		3	3.025	10	15.125

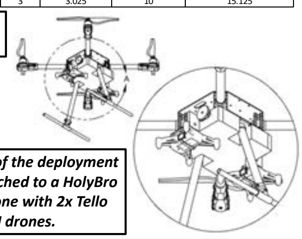
Electrical Components



3D-modeled Deployment system housing.

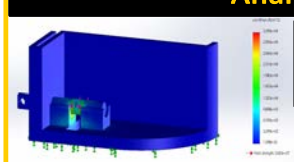
SCAN ME!

OnShape QR Code – View the model hands on!



Ideal model of the deployment housing attached to a HolyBro x500 V2 drone with 2x Tello EDU drones.

Analysis



(left) FEA of the cylindrical hook attachment indicates there is not much stress created by having a smaller drone hang from it.

(right) Simple CFD of the HolyBro Drone frame the design was built for. SCAN QR code for a quick animation!

Results

- ***Daughter drones detached without compromising the system/mothership.***
- ***Dropping one drone at a time can slightly affect the mothership's stability but is not significant.***

Simultaneously

Drop & Go!

The complete drone deployment system carrying two Tello EDU drones as the payload.

SCAN the QR codes to see flight tests in action!

Conclusion

The team successfully designed and developed a working prototype that dispensed two Tello EDU drones from a set height that would not compromise the mothership drone. Further development can be explored in creating tasks for the daughter drones to fulfill autonomously.

Project Team

left to right:
- [ME] Jose R.
- [ME] Marvin G.
- [EE] Leo P.
- [ME] Stefan T.
- [ME] David S.

Special thanks to Akram A. and Kurt S.!

Projects 205: Airborne Swarm Drone Deployment/Dispenser

Client: Cal State LA, ECST

Advisor: Kurt Sawitskas, Ph.D.

Team Members: Daniel Buonavita-Haag, Nicholas Galvan, Ashley Ly, Angel Sanchez

Anticipating a 66.8% surge in the demand for multirotor drones and workforce automation in 2024, a significant challenge emerges—the limited battery capacity of drones. In response, students from team 205, created a novel counter measure; the In-Situ Vertical Take-Off and Landing Aerial Deployment and Recovery (In-VADR) plane. This solution leverages a fixed-wing aircraft design to carry, release, and retrieve a drone, optimizing energy use and significantly expanding operational capabilities. The primary aim is to provide a highly efficient solution for industries requiring remote drone inspection, such as wind turbines, solar farms, oil and gas rigs, and construction sites.

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CAL STATE LA

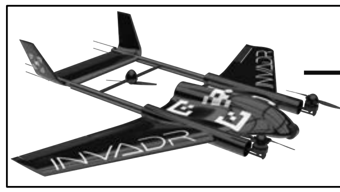
AIRBORNE SWARM DRONE DEPLOYMENT / DISPENSER

Team Members: Daniel Buonavita-Haag, Nicholas Galvan, Ashley Ly, Angel Sanchez
Faculty Advisor: Kurt Sawitskas
Department(s) of Mechanical Engineering
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

Introduction

Anticipating a 66.8% surge in the demand for multirotor drones and workforce automation in 2024, a significant challenge emerges—the limited battery capacity of drones. In response, students from team 205, created a novel counter measure; the In-Situ Vertical Take-Off and Landing Aerial Deployment and Recovery (In-VADR) plane. This solution leverages a fixed-wing aircraft design to carry, release, and retrieve a drone, optimizing energy use and significantly expanding operational capabilities. The primary aim is to provide a highly efficient solution for industries requiring remote drone inspection, such as wind turbines, solar farms, oil and gas rigs, and construction sites.

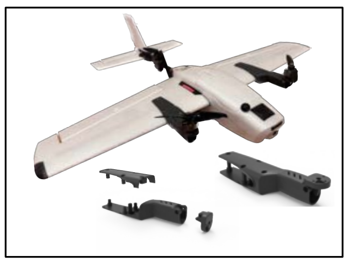
Design Approach



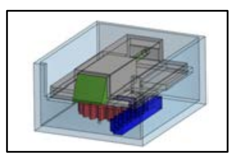
VTOL Concept Design

AprilTag

Inspection Drone

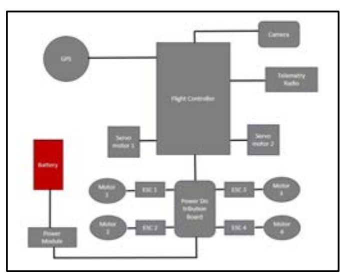


VTOL Foam Prototype

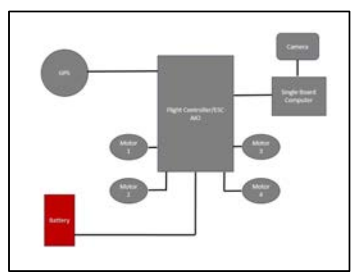


Release & Capture Mechanism

Inspection Drone Exploded view



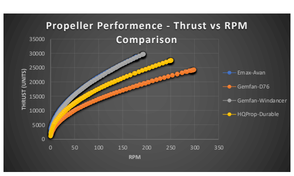
VTOL's Electronic Block Diagram



Inspection Drone's Electronic Block Diagram

Results

Thrust stand motor and propellor testing

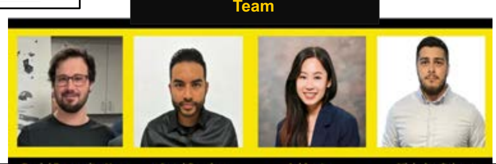


PX4 Control System

Software - Sources

TensorFlow Lite
Raspbian
pixhawk 4 mini
OpenCV
GitHub
python

Team



Conclusion

In conclusion, the In-VADR project, led by the team, features in-situ vertical takeoff and landing, offering a pioneering response to the challenge of limited drone battery capacity. The successful integration of computer vision on RPi, powered by OpenCV databases for object recognition, enhances its transformative potential across industries. Moreover, the aircraft's central role in deploying inspection drones marks a significant stride in bridging the gap between conceptualization and tangible, industry-ready solutions, promising to reshape drone applications.

CAPSTONE
SENIOR DESIGN PROGRAM

Project 206: Thermo-Plastic Injection Molding System

Client: Cal State LA, ECST

Team Members: Neyda Bautista, Maria Gonzalez, Abdelrahaman Moustafa, Daniel Terrones

Advisor: Mathias Brieu, Ph.D.

The thermo-plastic injection mold system senior design project focuses on the design and production of a heated pelletizer machine that shall allow the client to melt and mix several thermoplastic polymers, thereby creating homogeneous mixed pellets. These pellets will then be used in conjunction with an injection molding machine to manufacture different homogenous specimens, thus creating a comprehensive manufacturing chain that will assist ongoing research in the field of degradable or recyclable biopolymers for medical engineering or sustainable use of plastics. As the first-generation team working on this project, development of both the mechanical and electrical systems was mostly accomplished, some concrete testing was developed and verified for the electrical components. The mechanical part (mechanical system, and motor control) of the pelletizer is operational. The work done on the pelletizing system mainly consists of the mechanical structure, electrical system, coding, and commencement of electrical testing Further progress still needs to be made by future generations tasked with this complex project to control the heating of the chamber. This first-generation team has developed theoretical analysis to aid in further testing and analysis for future teams to continue testing and verification.

CAPSTONE
SENIOR DESIGN PROGRAM

Thermo-plastic Injection Molding Machine System

Team Members: Neyda Bautista, Maria Gonzalez, Abdelrahman Moustafa, Daniel Terrones
Faculty Advisor: Dr. Mathias Brieu
Departments of Mechanical and Electrical Engineering
College of Engineering, Computer Science, and Technology
California State University, Los Angeles

Project Background

The thermo-plastic injection mold system senior design project focuses on the design and production of a heated pelletizer machine that shall allow the client to melt and mix several thermoplastic polymers, thereby creating homogeneous mixed pellets. These pellets will then be used in conjunction with an injection molding machine to manufacture different homogenous specimens, thus creating a comprehensive manufacturing chain that will assist ongoing research in the field of degradable or recyclable biopolymers for medical engineering or sustainable use of plastics. As the first-generation team working on this project, development of both the mechanical and electrical systems was mostly accomplished, some concrete testing was developed and verified for the electrical components. The mechanical part (mechanical system, and motor control) of the pelletizer is operational. The work done on the pelletizing system mainly consists of the mechanical structure, electrical system, coding, and commencement of electrical testing. Further progress still needs to be made by future generations tasked with this complex project to control the heating of the chamber. This first-generation team has developed theoretical analysis to aid in further testing and analysis for future teams to continue testing and verification.

Objectives

Design and produce a machine that shall allow the user to:

- Mix several thermoplastic polymers, thereby creating **homogenous mixed pellets.**
- Pellets will be used in conjunction with an **injection molding machine** to manufacture different homogenous specimens
- Create a **comprehensive manufacturing chain** that will assist ongoing research in the **biomedical field.**

System Requirements & Materials

No.	Requirement Name	Requirement Objective The machine shall	Requirement Met
1	Homogeneous Mixture	Mix several thermoplastic polymers to create homogeneous pellets	TBD
2	Even Heating	Apply even heating to the thermoplastic polymers as they mix	TBD
3	Table-top size	Be able to fit in a table of length: 7ft and width: 4ft	Yes
4	Low Cost	Have a total cost below $2,000	Yes
5	Thermoplastic Material Test	Be able to heat materials without risking any degradation. Lab procedures must be conducted.	Yes
6	Machinable	Be able to have components that are manufactured by the team	Yes
7	Systems Integration	Be made of electrical components that meet the required complex functions and safety regulations	Yes

Property	PCL	PLA	PGA
Glass Transition Temp.	$30 - 35^oC$	60^oC	$60 - 65^oC$
Melting Temp.	$55 - 65^oC$	175^oC	$220 - 240^oC$
Degradation Temp.	$300 - 380^oC$	320^oC	-
Conduction Coefficient $(\frac{W}{mK})$	0.5	0.13	0.35
Specific Heat Capacity $(\frac{J}{kg^oC})$	1,900	1,750	1,200
Viscosity (Pa*s)	25	-	15
Density $(\frac{g}{m^3})$	1.14	1.27	1.6

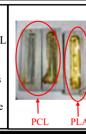
Procedure 1

- Degradation of PCL at 260ºC:
- impurities (?)

Procedure 2

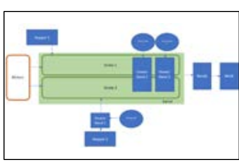
- No degradation of PCL at 200ºC:
- Brittle, highly viscous
- Silicone Mold Release Damage (?)

Procedure 3

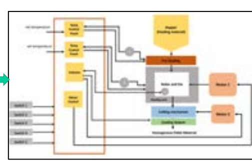


- Degradation of PCL at 240ºC
- Boiling & degradation of PLA at 230ºC
- Acetone Damage (?)

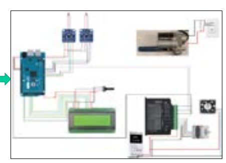
Electrical Evolution



- Phase 1: Preliminary System Block Diagram

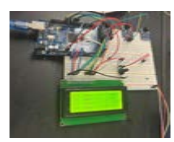


- Phase 2: Theoretical System Block Diagram



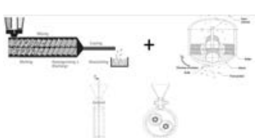
- Phase 3 & 4: Experimental System Block Diagram developed while testing

Electrical Testing

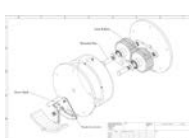


- Phase 4: Circuit and component testing and verification

Mechanical Evolution



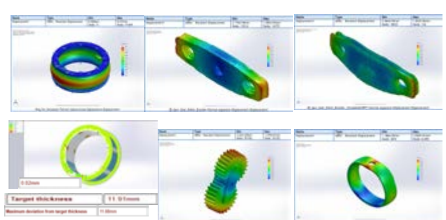
•Phase 1:Research and Development between a Twin-Screw Injector and Pelletizer, culminating in the creation of a new machine that prioritizes Pelletizer functionality by incorporating the best features from both options.



•Phase 2: Detail Desing and Development of Mechanism Involved

Phase 3: Manufacture and Tolerance Check

Thermal Analysis



Conclusion

- Circuit integration and software was accomplished
- Electrical systems accomplished vast testing
- Thermal analysis was performed
- Major manufacturing was accomplished
- Next generation must work on the integration of the heat band to safely include in the system
- Theoretical analysis is documented for the next generation to expand on further CAD, circuit integration, software, and manufacturing

Team

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Maria Gonzalez

Neyda Bautista

Daniel Terrones