Rutgers University

Department of Mechanical & Aerospace Engineering

2021-2022 Senior Design Projects

14:650:487/488 Aerospace Engineering Design I/II

Aerospace Engineering Projects

Table of Contents

AE PROJECT 1

UAV System for CO_2 Detection

Advisor: Prof. Xiaoli Bai

Email: xiaoli.bai@rutgers.edu

Project Abstract: The goal of this project is to develop a UAV system to detect carbon dioxide autonomously. The developed design can be used for general aerial monitoring of air quality. Furthermore, the grant vision is that such a system can be used for many other environment detection tasks.

Project Goals: Design and fabrication of a device that can fly like a bird

Project Envisioned Outcomes: Develop a UAV system that can detect carbon dioxide autonomously.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools			☑		
Traditional Machining			☑		
CNC machining		☑			
3D printing			☑		
Welding			☑		
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)				☑	
Bonding		☑			
Processing (e.g., vacuum bag, autoclave)		☑			

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol			☑		
Python		☑			
Ansys			☑		
SolidWorks				☑	
Other CAD packages					
Siemens NX			☑		
LabView				☑	
E-Calc			☑		
AVL			☑		
Xfoil			☑		
Machine vision program			☑		

Additional Requirements and Information:

- UAV flight experience and programming skills are highly desired.
- http://www.aretasaerial.com/products/uav-drone-co-carbon-monoxide-monitoring

AE PROJECT 2

Mechanical Bird

Advisor: Prof. Prosenjit Bagchi

Email: pbagchi@soe.rutgers.edu

Project Abstract: Building mechanical bird

Project Goals: Design and fabrication of a device that can fly like a bird

Project Envisioned Outcomes: Generation of aerodynamic thrust and lift using flapping wings.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design		☑			
Analysis		☑			
Hand tools		☑			
Traditional Machining		☑			
CNC machining	☑				
3D printing		☑			
Welding		☑			
Wiring		☑			
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)		☑			
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol			☑		
Python	☑				
Ansys	☑				
SolidWorks			☑		
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 3

Airplane Stability and Control Derivatives

Advisor: Prof. Haim Baruh

Email: baruh@soe.rutgers.edu

Project Abstract: Design of Airplane stability and control derivatives.

Project Goals: To build an aircraft whose stability and control derivatives are within desired ranges

Project Envisioned Outcomes: Construction of a plane

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis			☑		
Hand tools				☑	
Traditional Machining			☑		
CNC machining			☑		
3D printing	☑				
Welding			☑		
Wiring				☑	
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)			☑		
Bonding			☑		
Processing (e.g., vacuum bag, autoclave)			☑		

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol			☑		
Python			☑		
Ansys			☑		
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX		☑			
LabView			☑		
E-Calc		☑			
AVL		☑			
Xfoil		☑			
Machine vision program		☑			

AE PROJECT 4

Design Inflatable Deployable Lunar Habitat

Advisor: Prof. Haym Benaroya

Email: benaroya@soe.rutgers.edu

Project Abstract: Design Inflatable Deployable Lunar Habitat

Project Goals: Compare design options, analyze, build.

Project Envisioned Outcomes: the lunar habitat.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design			☑		
Analysis			☑		
Hand tools		☑			
Traditional Machining		☑			
CNC machining	☑				
3D printing	☑				
Welding	☑				
Wiring	☑				
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)	☑				
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab		☑			
Comsol	☑				
Python	☑				
Ansys		☑			
SolidWorks			☑		
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 5

Multi-Mode Hybrid Unmanned Delivery System: Combining Fixed-Wing and Multi-Rotor Aircraft with Ground Vehicles

Advisor: Prof. Onur Bilgen

Email: o.bilgen@rutgers.edu

Project Goals: The goal of this project is to investigate novel concepts for a multi-mode unmanned aerial system. For example, a VTOL vehicle attached (docked) to a fixed-wing (i.e. STOL) vehicle. In this case, the fixed-wing aircraft does the long-distance "cruising." Once the system within the vicinity of the delivery location, the multi-rotor will detach and will take care of the vertical movement for a controlled delivery to the ground. Navigation, planning, logistics, policy issues, docking/undocking, platforms etc. are all very interesting and relevant problems – such issues will be looked at by the design team.

Previous Success: The 2020 team received a research award from the highly competitive NASA USRC program. (https://mae.rutgers.edu/news/senior-design-team-captures-nasa-research-challenge).The new team will apply to the same program in June. In addition, the 2020 Team presented a paper at the AIAA 2021 Region I Conference, and received the 3rd place prize in the team category.

All team members are expected to have an exceptional work ethic and dedication to the project. Students from all backgrounds who are interested in continuing to graduate school are highly encouraged to join. Please contact Dr. Bilgen via email (o.bilgen@rutgers.edu) with the subject line starting with "Senior Design: Project Name – Your Name".

Project Envisioned Outcomes: See above.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools			☑		
Traditional Machining			☑		
CNC machining				☑	
3D printing				☑	
Welding				☑	
Wiring				☑	
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)				☑	
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol	☑				
Python			☑		
Ansys	☑				
SolidWorks				☑	
Other CAD packages				☑	
Siemens NX		☑			
LabView		☑			
E-Calc				☑	
AVL		☑			
Xfoil		☑			
Machine vision program		☑			

Additional Requirements and Information:

https://mae.rutgers.edu/news/senior-design-team-captures-nasa-research-challenge

AE PROJECT 6

Design and Testing of a Drone to Conduct Zero-G Experiments

Advisor: Prof. Onur Bilgen

Email: o.bilgen@rutgers.edu

Project Goals: The goal of this project is the design, analysis, fabrication and testing of a small quad-copter unmanned aerial vehicle (UAV) to act as a platform to conduct Zero-G experiments. The team will design, fabricate and test multiple iterations of the vehicle, as well as develop necessary control algorithms.

Previous Success: The 2020 Team presented a paper at the AIAA 2021 Region I Conference, and received the 1st place prize in the team category.

The new team will apply to the highly competitive NASA USRC program in June. If funded, students will be able to conduct funded research during the academic year, or during summer 2022.

All team members are expected to have an exceptional work ethic and dedication to the project. Students from all backgrounds who are interested in continuing to graduate school are highly encouraged to join. Please contact Dr. Bilgen via email (o.bilgen@rutgers.edu) with the subject line starting with "Senior Design: Project Name – Your Name" .

Project Envisioned Outcomes: See above.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools			☑		
Traditional Machining			☑		
CNC machining	☑				
3D printing				☑	
Welding				☑	
Wiring				☑	
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)				☑	
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol	☑				
Python			☑		
Ansys	☑				
SolidWorks				☑	
Other CAD packages				☑	
Siemens NX		☑			
LabView		☑			
E-Calc				☑	
AVL		☑			
Xfoil		☑			
Machine vision program		☑			

AE PROJECT 7

Modified R/C Transmitter with Haptic Joysticks

Advisor: Prof. Laurent Burlion

Email: laurent.burlion@rutgers.edu

Project Abstract: The students will modify a R/C transmitter and replace its joysticks by some haptic joysticks so that a human pilot can better learn and feel how to pilot a quadcopter drone.

Project Goals: Modify an R / C transmitter and design haptic joysticks. Design new control algorithms to send feedback to the human pilots via haptic joysticks. Use the new transmitter to train a few humans and analyze the results. Compare the learning process of several people and show that the learning process is faster when using haptic controllers.

Project Envisioned Outcomes: A great experience working on drones, control, machine learning and Arduino boards!

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools		☑			
Traditional Machining		☑			
CNC machining	☑				
3D printing				☑	
Welding			☑		
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)	☑				
Microcontrollers (e.g., Arduino)				☑	
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol	☑				
Python			☑		
Ansys	☑				
SolidWorks			☑		
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program		☑			

AE PROJECT 8

Satellite Testbed for Zero-G Flight

Advisor: Prof. Laurent Burlion

Email: laurent.burlion@rutgers.edu

Project Abstract: The students will design a satellite testbed that can be used to better mitigate the fuel sloshing disturbances onboard observation satellites.

Project Goals: Design a satellite testbed that could be used on a zero-G flight. Design some machine learning or control algorithms to reject the liquid sloshing disturbance.

Project Envisioned Outcomes: A great and exciting experience in control, satellites and test bench design!

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools			☑		
Traditional Machining			☑		
CNC machining			☑		
3D printing				☑	
Welding		☑			
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)				☑	
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol	☑				
Python			☑		
Ansys	☑				
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program				☑	

AE PROJECT 9

NASA University Student Research Challenge

Advisor: Prof. Edward DeMauro

Email: ed451@soe.rutgers.edu

Project Abstract: University Student Research Challenge (solicitation NNH20ZEA001N-USRC) seeks to challenge students to propose new aeronautics ideas/concepts that are relevant to NASA Aeronautics. USRC will provide students, from accredited U.S. colleges or universities, with grants for their projects and it includes the challenge of raising a modest amount of cost share funds through crowdfunding platform. The process of creating and preparing a crowdfunding campaign acts as a teaching accelerator - requiring students to act like entrepreneurs and taking action. Crowdfunding also raises awareness about students' research among the public. The solicitation goal can be accomplished through project ideas such as advancing the design, developing technology or capabilities in support of aviation, by demonstrating a novel concept, or enabling advancement of aeronautics-related technologies. Notices of Intent (NOIs) are not required for this solicitation. Three-page proposals for the next USRC cycle are due June 24, 2021.

Project Goals:

(1) Submission of a proposal according to NASA's requirements (June 24, 2021)

(2) Identification of an engineering solution to commercial supersonic air travel, tackling issues associated with sonic boom generation

(3) Proof of concept through theoretical, empirical, and/or computational means

(4) Assessment of current competing technologies and how our concept compares

Project Envisioned Outcomes: I envision that the team will produce a detailed engineering design assessment, proven using theoretical, empirical, and/or computational tools, detailing a planned methodology for manipulating the sonic boom on a supersonic aircraft. This is a NASA proposal, which means that there is a great deal of work to be accomplished by June 24th. Therefore, I will need students ready to start ASAP.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design			☑		
Analysis			☑		
Hand tools			☑		
Traditional Machining				☑	
CNC machining				☑	
3D printing			☑		
Welding		☑			
Wiring					☑
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)		☑			
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol			☑		
Python		☑			
Ansys			☑		
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX			☑		
LabView			☑		
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

Additional Requirements and Information:

https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=813834/solicitationId=%7BC9CC1B80-9F50-7B37-2A9B-33CC623FA556%7D/viewSolicitationDocument=1/3.%20ROA-2020%20ULI%20Amendment%203%20Final_108p.pdf

AE PROJECT 10

Persistent Drone Weather Monitoring

Advisor: Prof. F. Javier Diez

Email: diez@soe.rutgers.edu

Project Abstract: Persistent drone weather monitoring

Project Goals: Develop a drone that can flight tethered continuously for 24hrs for weather monitoring

Project Envisioned Outcomes: Demo a drone that can achieve the project goals.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis		☑			
Hand tools			☑		
Traditional Machining		☑			
CNC machining		☑			
3D printing		☑			
Welding		☑			
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)				☑	
Bonding		☑			
Processing (e.g., vacuum bag, autoclave)		☑			

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol		☑			
Python				☑	
Ansys		☑			
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX		☑			
LabView			☑		
E-Calc			☑		
AVL		☑			
Xfoil			☑		
Machine vision program			☑		

AE PROJECT 11

Table Top Subsonic Wind Tunnel

Advisor: Prof. Doyle Knight

Email: ddknight@rutgers.edu

Project Abstract: The project is the design, fabrication and demonstration of a table top subsonic wind tunnel measuring the lift and drag on an airfoil, air velocity, temperature and pressure.

Project Goals: Completion and demonstration of the table top subsonic wind tunnel.

Project Envisioned Outcomes: Demonstration of ability to design, manufacture and validate table top subsonic wind tunnel.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design	☑				
Analysis			☑		
Hand tools			☑		
Traditional Machining			☑		
CNC machining		☑			
3D printing			☑		
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)			☑		
Bonding			☑		
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol			☑		
Python	☑				
Ansys			☑		
SolidWorks			☑		
Other CAD packages	☑				
Siemens NX	☑				
LabView			☑		
E-Calc			☑		
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 12

High Strength, Light Weight Spherical Pressure Vessel with Fiber-Reinforced Composites

Advisor: Prof. George Weng

Email: gjweng@rutgers.edu

Project Abstract: Use carbon fibers and epoxy resin to make polymer composites, and use the composites to build a spherical pressure.

Project Goals: To build a light-weight composite spherical pressure vessel that can sustain high pressure without failure.

Project Envisioned Outcomes: A hardware composite spherical pressure vessel.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design		☑			
Analysis		☑			
Hand tools		☑			
Traditional Machining		☑			
CNC machining		☑			
3D printing		☑			
Welding		☑			
Wiring		☑			
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)		☑			
Bonding			☑		
Processing (e.g., vacuum bag, autoclave)			☑		

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol	☑				
Python	☑				
Ansys	☑				
SolidWorks	☑				
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 13

A Multi-dimensional Fleet of Intelligent Mobile Plants for Unknown Territory Exploration

Advisor: Prof. Qingze Zou

Email: qzzou@rutgers.edu

Project Abstract: In this project, we are creating a fleet of mobile plants combining both ground robots and drones working cooperatively together to seek resources and maximize the plants survivability in an unknown and potentially hazardous territory. The idea is to equip the plants with mobility, environment sensing (e.g., light, temperature, and vision) and communication capability (wireless communication), and allow and help the plants to communicate and share information with each other about the environment, to seek resources (e.g., water, light) and/or avoid dangers (e.g., harsh temperature and/or harmful insects), thereby, turning the group of plants into a group of social "animal-like" subjects. This project is built upon the success of IndaPlant senior design projects and plant-centered mobile robot network in the last a few years. The task of your team is to further enhance the function and capability of three mobile robots, develop autonomously-flying drones, and make the robots and drones working together in real-time for territory exploration.

Project Goals: Creating a fleet of mobile plants combining both ground robots and drones working cooperatively together to seek resources and maximize the plants survivability in an unknown and potentially hazardous territory.

Project Envisioned Outcomes: Enhance the function and capability of the robot network, develop autonomously-flying drones, and make the robots and drones working together in real-time for territory exploration.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design		☑			
Analysis	☑				
Hand tools		☑			
Traditional Machining	☑				
CNC machining	☑				
3D printing	☑				
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)			☑		
Bonding		☑			
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol	☑				
Python	☑				
Ansys	☑				
SolidWorks	☑				
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program			☑		

Additional Requirements and Information:

Programming experience with Arduino and Raspberry Pi