Minor: Engineering, Design and Operation of Uncrewed Aerial Systems

The minor will consist of both courses from the below Group A and two courses selected from the list in Group B for a total of at least 12 credit hours. Up to six credit hours in the minor may simultaneously be used to satisfy concurrent requirements of the major.

Group A (6 credits)

• Either ENGN 485 (3 cr) – Introduction to Uncrewed Aerial Systems
  [Prerequisite PHYS 112N] or GEOG 409 (3 cr) – *Drone Applications Proseminar [Prerequisite GEOG 402 or permission of instructor]*

• ENGN 486 (3 cr) – Multirotor UAS Design and Construction (3 Credit Hours)
  [Prerequisite PHYS 112N]

Group B (Select two of the following, 6 credits)

• ENGN 487 (3 cr) – Fixed Wing and VTOL UAS Design and Construction (3 Credit Hours) *[Prerequisite ENGN 486]*

• ENGN 488 (3 cr) – Autonomous Mission Platforms Systems Integration (3 credit hours)
  [Prerequisite ENGN 486]

• MAE 406/506 (3 cr) – Flight Vehicle Aerodynamics
  [Prerequisites: A grade of C or better in MAE 303; MAE 312 and MAE 340]

• MAE 403/503 (3 cr) – Flight Mechanics
  [Prerequisites: MAE 303 with a grade of C or better and MAE 340; Pre- or corequisite: MAE 436]

• MAE 417/517 (3 cr) – Propulsion Systems
  [Prerequisites: MAE 312 or MAE 414]

• ECE 408/508 (3 cr) – Fundamentals of Electric Vehicles
  [Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287]

• ECE 445/545 (3 cr) – Introduction to Computer Vision
  [Prerequisites: A grade of C or better in ENGN 150 or CS 150; Pre- or corequisite: ECE 350]

• *ECE 463/563* (3 cr) – *Design and Modeling of Autonomous Robotic Systems*

  [Prerequisites: CS 150 or ENGN 122 or ENGN 150]

• ECE 346 (3 cr) – Microcontrollers
  [Prerequisites: a grade of C or better in ECE 241]

• MAE 438/538 (3 cr) – Applied Analog and Digital Controls
  [Prerequisites: a grade of C or better in MAE 436]

• GEOG 402 (3 cr) – Geographic Information Systems
  [Prerequisites: Junior standing, GEOG 102T, or permission of instructor]

Total Credit Requirements: 12 credits

For completion of a minor, a student must have a minimum overall cumulative grade point average of 2.00 in all courses required for the minor exclusive of prerequisite courses. A minimum of six hours in upper-level courses in the minor must be completed through courses offered by Old Dominion University.

Course Descriptions:

I) **ENGN 485 Introduction to Uncrewed Aerial Systems** (3 Credit Hours)
This course introduces Small Uncrewed Aircraft Systems (sUAS) types and platforms (such as multirotor, fixed wing, hybrids) and explores mission planning, applications, payloads, flight authorization processes, and crew resource management. Additionally, this course introduces operation of autonomous vehicles in the National Airspace System including Universal Traffic Management, radio frequency allocations, and airport usage, including knowledge of government and industry compliance standards. Attention will be paid to topics of system integration for operations efficiency, risk management, safety, and human factors and human / machine interface in autonomous systems. Includes case studies.

II) **ENGN 486** Multirotor **UAS Design and Construction** (3 Credit Hours)
A look at engineering multi-rotor Uncrewed Aerial System (UAS) design. Course topics will include Stability and control of UAS, Electric propulsion and battery technology. Overview of sensors (lidar, sonar, vision etc.); autopilot design and automatic control; airframe structural design of UAS; Flight dynamics and simulation for UAS. Accompanying laboratory topics include motor/prop testing, building small quadcopters, understanding system elements, PID tuning, programming UAS, and autonomous drone operations. Students will learn to specify all components including motors, propellers, power system, autopilot, GPS, power monitor, frame, etc. Accompanying laboratory topics include autopilot setup, firmware configuration, telemetry configuration, ground station setup and sensor specifications and integration (lidar, sonar, radar, optical flow). Mission planning, and test flights will complete the course. (Prerequisite: Physics 112N).

III) **ENGN 487 Fixed Wing and VTOL UAS Design and Construction** (3 Credit Hours)
Fixed wing aerodynamics and aircraft performance, propeller performance; basic stability and automatic control of aircraft. Introduction to vertical takeoff and landing hybrid UAS design including tail sitting and lift-to-cruise. Electric propulsion: motor selection, prop matching and system integration. Airframe structural design methods. Instrumentation for autonomous flight. Accompanying laboratory topics include building small, fixed wing/vtol aircraft; autopilot configuration; flight test, planning and operations. (Pre-requisite: ENGN 486)

IV) **ENGN 488 Autonomous Mission Platforms Systems Integration** (3 credit hours)
This interdisciplinary class is a mission based, collaborative course with majors across the college working alongside industry partners and or mentors. Students will work in teams to research, design, build (or rebuild existing) Unmanned Vehicles and apply them toward ecologically, humanitarian or "customer based" focused projects. (Prerequisite: ENGN 486)