

U A V O P E R A T I O N T R A I N I N G

Building UAV Operators for the Future



TRAINING CURRICULUM

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UAV Operation Training Program

Introduction

This curriculum is designed to be used as a guide to facilitate learning, not as a “canned curriculum” and be relegated to a shelf somewhere, unused. Users need to treat this as a living framework for instruction. Uninhabited Aerial Systems are a rapidly changing field and training methods need to be allowed to evolve to accommodate changes. Likewise, students are multitasked and should not be confined to following rank and file through a standard operating procedure where “seat time” is regarded above demonstrated ability. This curriculum essentially is a proficiency based model where, if a student demonstrates and documents competency, then they continue to move along the curriculum. This model allows the instructor to facilitate learning while guiding the students through training without hindering the educational process.

Course Scope and Sequence

This course guides instructors through the training of High School age UAV Operators from safety, the primary concern for all UAS use, to application of skills and knowledge producing viable results. This document by itself will not produce finished Operators. That is the work of the instructors, the trainers, and most of all, the potential Operators taking part in their own instruction. Instruction in this course can be as deep and thorough or as cursory as the candidates make it. Students must be responsible for their own education, meaning that the outset of this training process is very self directed and needs to be facilitated, but not directly given, by the instructor. This produces a two-fold outcome; students take on the responsibility for their understanding with various learning processes and they participate in scientific inquiry that results in relevant, updated, and engaging education.

This course should start with rigorous, but accessible demands. Instructors need to establish a precedent from the outset that the goal of this course is to produce students with both an understanding of the theory behind UAV flight and operation, but also the ability to apply that knowledge. This necessitates demonstrable understanding from students in both academic assessment and practical application.

This entire course should be driven by application. From the outset the instructor should overlay the class with a project base. This means that students will be required to work in teams to accomplish an actual mission goal. It is the instructor’s prerogative as to how they will manage the project teams, however, application is imperative to maintaining the rigor and relevance of the curriculum. Completing a project serves to regulate course content for both the students and instructors by ensuring that all necessary topics and nuances of content are covered. Under no circumstances should the project based nature of this course be supplanted by classroom instruction.

The 18 weeks of instruction described in this document are designed to fit into a semester schedule, but can be modified to fit trimesters, year-long classes, and proficiency based instruction. What needs to be kept in mind by the instructor is that progress must be made by students in order to move forward and that competency should be rewarded with encouragement and rapid, but meticulous progression. The ultimate goal of this curriculum is to train highly competent, capable and creative UAV Operators who can work effectively in this rapidly changing and evolving field.

UAV Initial Training Requirements

UAV Operation Training Syllabus

Semester Length Course

This syllabus is designed as a guide for the semester. It is subject to change by the instructor at any time.

Course Description:

This course is designed for certification of Uninhabited Aerial Vehicle Operator training and includes the essential topics of safety/liability considerations, operational risk management, GPS and navigational topics, preflight operations, manual and automatic flight, and emergency procedures and equipment malfunctions. Each of these topics include first-hand investigation via extensive equipment use, research, and inquiry. **All students in this class are expected to participate in all class activities.** No class text is used for this class, but external reading, handouts, and research will be expected. Grade evaluation is based on participation, demonstration of skills, a portfolio including multiple reports with a complete log of flight and simulator time, a midterm, and a comprehensive final. The grading scheme is based on a standard A-F scale where 100% is earned in three different categories. Written projects make up 20%, Tests 30%, and Participation 50%, of the total grade.

Description of a Weekly Write-Up:

For each weekly topic, students will research the topics outside of class, take notes from instruction, and write a one page summary, or Précis, detailing the essential aspects included. These documents make up the bulk of the portfolio and will be used to judge the fitness of Operators for certification.

Description of Tests and Mid-Terms:

Tests consist of several open-ended questions allowing students to demonstrate their knowledge of the subject matter and demonstration of introduced skills. Full credit on essay questions is only earned for answers that are completely, clearly, and accurately stated in a concise and succinct manner. Full credit for demonstration is only earned when the Operator competently performs the required skill in a timely fashion. Demonstrations must be in the presence of an instructor and clearly indicate an understanding and ability.

Participation:

Participation is earned as a combination of weekly write-up scores, labs, and daily participation scores. All Operators must demonstrate proficiency in all areas of UAV training to be considered for certification. Neglecting any area of knowledge or skill can have extremely negative results. Therefore, all participants must maintain a log chronicling all simulator time and flight time. The flight log must include date, time, mission type, encountered safety issues, weather conditions, aircraft type, and any significant notes. All log entries are to be made at flight time. Operators must also develop and maintain a portfolio including all write-ups, logs, activities, tests, and any other written or graphic materials that demonstrate training and competence.

Certification as a UAV Operator depends upon a student's completion of these course materials and a clear demonstration of capabilities. The aim is to generate individuals who can apply their skills in actual practice and join the workforce. Practical application is the intent of this course and should drive its implementation.

Introduction

Syllabus, expectations, and Safety should be introduced as the reoccurring theme that guides all operations for this course. **Never neglect safety considerations.**

Week 1

First Uses of Unmanned Aircraft

- Where it all began
 - Balloons
- What motivated the industry
 - Military

The Unmanned Aircraft types and designations

- Designations
 - MCAV
 - UCAV
- Types
 - VTOL
 - Fixed Wing
 - Lighter than Air
- Sizes
 - Micro
 - Hand launched / Belly landing
 - Medium
 - Catapult / Net and runway landing
 - Large
 - Paved Runway

Week 2

UAV design Considerations

- The purpose decides the design
 - Optical only = Lighter designs

- Payload haulers = Heavier Designs
- End user's ability and funding
 - Mobile and small unit deployment
 - Fixed location and personnel
 - Costs of upkeep and deployment

Characteristics and Design Parameters

- Wing Types and tendencies
 - High Wing
 - Shoulder Wing
 - Low Wing
 - Delta / Swept
- Fuselage Design
 - Pusher Prop
 - Tractor Prop
- Power Plant
 - Piston Driven
 - Nitro
 - Gas
 - Turbine
 - Electric
 - Brushless Motors and Batteries

Intro to Hexacopter (All Students)

- Components
 - Schematics and Subsystems
- Limitations
 - Flight limits and Capabilities
- Intended Use
 - Quick Hop Short Duration

Intro to HAWK and Observer (All Students)

- Components
 - Schematics and Subsystems
- Limitations
 - Flight Limits and Capabilities
- Intended Use

- Longer Loiter / High Altitude

Week3

Payload Options

- Optics
- Sensors
- Other

Common Equipment and Personnel (What we will use)

- Control of Flight
 - Pilot / 2.4GHZ Radio, Video Goggles (FPV)
- Camera and Telemetry Equipment
 - Mission Commander / Laptop and Monitor
- Auxiliary and Support
 - Technician / Antenna Arrays, Setup and Support

Week 4

Four Forces of Flight

- Lift
 - Effect of Wing design and Type
- Weight
 - Time in Air
- Thrust
 - Stability and Safety
- Drag
 - Parasite Drag

Flight Simulation Intro (All Students)

- Basic Maneuvers
- Experience
- Aviation

Week 5

UAV design LAB

- Students begin design and planning of a small Fixed Wing UAV
- Research and estimate cost to build
- Develop a Plan of Action, assign tasks to students depending on interest and skill
- Contents of class ideas stored in class project binder
 - Divided into Categories

- Sketches
- Estimates
- Research / Testing Discoveries
- Task Team Assignments

Week 6

Operational Risk Management (ORM) considerations

- Weather
 - Advanced Planning based on Forecast
- Routes
 - Pre-Map Planning / Story Board if Relevant
 - Pre-Walk of Flight area / Safety checks
- Operator training proficiency (Simulator use for intended Aircraft)
- Operator health/fitness for duty

Regulation Governing UAV

- Current FAA Regulations
- Proposed UAV Airspace assignments
- LAB Time (UAV BUILD)

Week 7

Technician Procedure

- Task Assignment
 - Mechanical Upkeep and Setup / Inspection
- Duties Pre-Flight
 - Sets up Equipment
- Duties During Flight
 - Maintains Antenna Orientation
 - Acts as Spotter for Pilot
- Duties Post Flight
 - Take Down and Disassembly of equipment
 - Inventories and Stows Equipment

Mission Manager Procedure

- Task Assignment
 - Operates Laptop and systems for Telemetry
 - Monitors Video Link
 - Provides Pilot with Data details

- Duties Pre-Flight
 - Activates All Telemetry and Video Links
 - Validates Pilots Direction and Activity
- Duties During Flight
 - Monitors all Satellite, Aircraft and Mapping via Laptop
 - Echo Status given by Pilot, Advises Pilot of Issues
- Duties Post Flight
 - Mission de-Brief and documentation (Flight Log)

Pilot Procedure

- Task Assignment
 - Insure Aircraft is Airworthy
 - Validate Safe flying Environment
 - Oversee the flight process
 - Pilot the UAV
- Duties Pre-Flight
 - Validate flight plan
 - Inspect and Validate flying area and Conditions
- Duties During Flight
 - Operate the UAV in a safe manner
 - Complete the mission as specified
- Duties Post Flight
 - Post Flight Inspection
 - De-Brief crew of flight issues noted
 - Insure all documentation is completed

Week 8

Team Tryouts and Assignments

- Teams create a team Binder for Mission planning etc
- Team A (VTOL)
 - 3 person Minimum
- Team B (FIXED WING)
 - 2 Person Minimum

Week 9

Mid Term

- Test Day 1 (Report, Instructor gives topic)

- Test Day 2 (Demonstrated Hands on)
- Student produces cover sheet stating their specific duty Interest

Week 10

Pilot Flight Training (VTOL and Fixed Wing)

- Fixed Wing (HAWK and Observer)
 - Preflight Inspections
 - Checklist development based on students design
 - Flight (Simulator)
 - Chase View (Orientation Training)
 - Stationary (LOS)
 - FPV (Technical Flights)
 - Flight (Actual Aircraft)
 - Preflight Checklist
 - Hand Launch / Runway Take off
 - Straight and Level Flight / Controlled Turns
 - Figure '8's' / Box and Altitude maneuvers
 - Emergency Procedures
 - Lost Line of Sight
 - Lost Radio Link
 - Lost Video Link (If FPV)
 - Landing
 - Tail Wind / Into wind / Cross Wind / Dead Stick
- VTOL (Hexacopter)
 - Flight Simulator
 - Helicopter Platform in Chase view (Orientation Training)
 - Heli Platform in Stationary (LOS)
 - Heli Platform in (FPV)
- VTOL (Student Quad) Actual Aircraft
 - Pre-Flight Checklist
 - Takeoffs, Maneuvers, Landings

Week 11

Team Missions (Created by Team)

- Create their own Mission (Testing Ideas)
- Plan it Thoroughly

- Carry it out
- Evaluate the Results / Correct issues

Team Mission (Assigned, Created by Instructor)

- LOS
- FPV
- TELEMETRY (As Applies)

Week 12

UAV Build Lab week

- Pre-Build set up
 - Shop Space / Tools needed etc.
- Building the Aircraft
 - Overview of Plans / Delegate duties
- Electronics Specified, Ordered and Installed

Week 13

LAB Week

- Finalize the build
- Begin the flight testing and system integrations

Week 14

LAB Week

- Finalize the build
- Begin the flight testing and system integrations

Week 15

Software Instruction

- ArcGIS
- Google Earth
- Photomodeler 3D
- Tour Weaver / PanoWeaver / Gigapano
- Palienter (For Hex)
- MK Tools (For Hex)

Week 16

Systems Operations (Each Team)

- Hexacopter (Team A)
 - Map Integration Via Palientere
 - MK Tool use and system programming

- Still Capture ArcGIS input (Utilize Nat. Resource students)
- Fixed Wing (Team B)
 - Still Capture ArcGIS input (Utilize Nat. Resource students)

Week 17

LAB Week

- Finalize the build
- Begin the flight testing and system integrations

Week 18

Final

- Student groups assigned a topic they delegate a speaker
- FAA test (Multiple Choice)
- LAB Time (UAV BUILD)

Standards

Grade level: High School

Subject area: Science

Standard:

Structure and Function: A system's characteristics, form, and function are attributed to the quantity, type, and nature of its components.

Application:

Learning the design and how it relates to the function of a UAV provides clear ties between the Laws of Physics and their application in the real world. This also provides a context where different facts are interrelated and brought together into a framework which increases both understanding as well as memory retention.

Development and implementation of working teams helps students to also understand the inner workings and dynamics of groups with their multiple parts, particular functions, and contribution to the finished product. Students also gain an appreciation for how small changes can bring about radically new results and that those results can be detrimental or beneficial towards stated goals.

Grade level: High School

Subject area: Science

Standard:

Interaction and Change: The components in a system can interact in dynamic ways that may result in change. In systems, changes occur with a flow of energy and/or transfer of matter.

Application:

The application of knowledge while creativity is allowed enables students to think through and experience results that are not pre-determined. Finding new missions with various potential outcomes, flying new and dynamic UAV designs, working with various teams, and attempting to accomplish goals in the real world allows students to see how their actions and decisions affect the outcome of a project. They get to experience, first hand, the cause and effect of actions.

They develop both a working and theoretical understanding of how systems change and respond.

Through adding the component of a physical robotic unit, students receive immediate and obvious feedback from their decisions. This is the ultimate means to learn interaction and change.

Grade level: High School

Subject area: Science

Standard:

Scientific Inquiry: Scientific inquiry is the investigation of the natural world by a systematic process that includes proposing a testable question or hypothesis and developing procedures for questioning, collecting, analyzing, and interpreting multiple forms of accurate and relevant data to produce justifiable evidence-based explanations and new explorations.

Application:

This course, with the integrated opportunity to plan, implement, and design projects that are applied to the real world is the direct application of Inquiry. Students are taught rigorous understanding of the components of UAV operation, then required to apply that understanding in an unstructured, new direction. This requires students to learn, process, test, and evaluate actions and results then attempt to solve a problem. They need to take in information in various forms, both academic and kinesthetic, filter through that data to determine what is relevant and integrate that new understanding into their plan.

Grade level: High School

Subject area: Science

Standard:

Engineering Design: Engineering design is a process of formulating problem statements, identifying criteria and constraints, proposing and testing possible solutions, incorporating modifications based on test data, and communicating the recommendations.

Application:

The final project presentation allows students to integrate their understanding into real life and generate relevant outcomes while developing the ability to communicate those results. The entire process contributes to the engineering design process. As new information is gathered, it must be integrated and the plan must adapt accordingly. This makes the process of problem solving and incorporating modifications an almost daily occurrence. These opportunities help students to develop resilience and creativity while maintaining rigor.