Program Goals and Objectives/Instructional Design

Title: Beyond Multi-Copters: Transitioning the New Drone Pilot to Fixed Wing Aircraft

Instructor: James M. Page, LeTourneau University and Seraphim Aerial

Program Goal: To provide the modern gyro-stabilized drone pilot who desires to expand into traditional, fixed-wing sUAS with the foundational knowledge required to properly assemble and set-up the aircraft and begin flight training at the local R/C club.

Program Objectives:

1. Explain selection and setup of an appropriate traditional, fixed-wing sUAS and its associated systems.
2. Review terminology and language common to traditional, fixed wing sUAS operators and relate that to language the modern gyro-stabilized drone pilot will understand.

Timeframe and Composition: 9.5 hours of total instruction divided into seven modules. Each module will be made up of 5-25 minute sections of online instruction utilizing video, quizzing, and animation.

Module 1: Selecting the First Aircraft (105 minutes)

Learning Objectives The participants will:	**Section Title**	**Key Points to Emphasize**	**Instructional Techniques**	**Estimated Time**
List the six sub-sections of the module.	Introduction	Review the six sections of the Module.	Lecture	10 minutes
1. List the basic visual characteristics of an appropriate trainer and explain why they are desirable. 2. Define the aerodynamic stall and state the appropriate recovery technique. 3. Define adverse yaw.	Aerodynamic Considerations	Point out that fixed-wing aircraft have significantly different aerodynamic characteristics than a typical gyro-stabilized drone. Describe the stall and how to recognize when the aircraft is approach it. Describe adverse yaw and how it is counteracted. Describe "self-righting" characteristics of a proper trainer and point out some visual characteristics denoting these characteristics.	Lecture with visual aids (to clarify the powerpoint): 1. Animated airfoil showing stall and video of stalling full-scale airplane. 2. Suitable trainer model.	25 minutes
List three advantages and disadvantages of both	Foam vs. Wood construction	Explain advantages and disadvantages of foam and wood construction.	Lecture with examples of foam and wood construction.	15 minutes

foam and wood airframe construction.				
Discuss and critique the ease of repair and maintenance for a given sUAS aircraft and why the discussed characteristics are important when selecting a first airplane.	Ease of repair and maintenance	Review examples of sUAS trainers and highlight characteristics affecting ease of repair and maintenance. Give a brief overview of basic construction techniques and power systems to segue into the next two sections.	Lecture with visual aids. Tutorial video on common minor repairs on different types of aircraft to emphasize *why* the suitable airplane will have the characteristics endorsed.	15 minutes
Explain the differences between electric and internal combustion power systems. Discuss one advantage and one disadvantage of each system.	Power system introduction	Discuss internal combustion power systems and relate them to the electrical systems the drone operator is familiar with. Explain advantages and disadvantages of each type of power system.	Lecture with visual aids. Tutorial video on tuning of gasoline-based internal combustion engines.	15 minutes
List two advantages and two disadvantages of gyro-stabilization on a fixed wing sUAS.	Gyro-stabilization of fixed wing sUAS	Describe gyro-stabilization systems as applied to fixed-wing sUAS. Discuss advantages and disadvantages of gyro-stabilization for a first sUAS.	Lecture	10 minutes
List the three basic forms of ARF aircraft and explain ease of assembly over kit aircraft.	Almost-Ready-to-Fly vs. Kit	Explain the differences between ARF and Kit aircraft. Highlight the ease of assembly of ARF aircraft.	Lecture with examples of ARF and kit trainer aircraft.	15 minutes

Module 2: Power System Setup and Tuning (120 minutes)

Learning Objectives The participants will:	**Section Title**	**Key Points to Emphasize**	**Instructional Techniques**	**Estimated Time**
List the two types of power systems.	Introduction	Review the two major power system choices. Review the material regarding advantages and disadvantages covered in Module 1.	Lecture	10 minutes
Explain the major difference between glow ignition and gasoline-	Internal Combustion Power	Glow engines usually require a specialized and expensive fuel, but are simpler. Gasoline-based	Lecture with examples of each type of engine.	15 minutes

based electronic ignition engines.	Systems: Glow vs. Gas	electronic ignition engines use a familiar and inexpensive fuel, but are more complex.		
Define a lean and rich mixture. List one way to ascertain a lean mixture and one way to ascertain a rich mixture.	Internal Combustion Power Systems: Tuning	Demonstrate successful tuning of both glow and gasoline with electronic ignition engines. Demonstrate techniques for assessing the mixture setting of the engine.	Tutorial video review of tuning of a glow based engine and a gasoline based electronic ignition engine.	20 minutes
List two methods for securing fasteners against vibration on aircraft equipped with Internal Combustion Power Systems. Interpret propeller designations and explain geometric pitch. Describe the primary way an engine indicates overheat.	Internal Combustion Power Systems: Other Factors	Demonstrate methods for securing fasteners against vibration. Emphasize how vibration can damage electronics and demonstrate a method for isolation of components. Explain propeller designations and geometric pitch. Explain how prop choice can affect performance of the engine, especially regarding heat build-up and mixture. Give an example of a functional baffle system and explain how it works to cool the engine.	Tutorial video for vibration mitigation portion. Lecture with examples for propellers and heat mitigation.	20 minutes
List the two major differences between brushed and brushless power systems. Explain one advantage of brushless over brushed power systems. Explain one advantage of brushed power systems over brushless power systems.	Electric Power Systems: Brushed vs. Brushless Motors	Describe the main differences between brushless and brushed power systems while reviewing the advantages and disadvantages of each.	Lecture with physical examples of components of each type of power system.	10 minutes
Describe the major adjustable parameters of a standard brushless controller and explain the typical default setup.	Brushless Electric Controllers	Review the complexity of a typical brushless controller and explain the programming process. Explain that a brushed controller is simpler and thus doesn't require much explanation.	Tutorial video of programming process for a typical brushless controller.	15 minutes

List the two major reasons for LiPo battery failure. Explain the effect of heat on the LiPo battery.	Electric Power Systems: Review of Lithium Polymer (LiPo) Batteries	Explain the advantages of LiPo over other chemistries and why the LiPo battery is so common. List the major reasons LiPo batteries fail and signs of imminent failure.	Tutorial video using a sophisticated LiPo charger during LiPo charge and discharge operations to highlight the main points.	15 minutes
Given two different propellers, both suitable for a given power system, explain the differences in power system performance for each propeller in terms of power output (in Watts), current draw, voltage drop, and heat build-up in both the motor and ESC. Describe a typical airframe thermal control scheme from air entry to air exit.	Electric Power Systems: Other Factors	Review propeller selection and how the propeller will affect the power system. Explain the importance of proper ventilation and thermal control with regard to the ESC and motor of an electric power system. Reinforce the importance of thermal control when using a LiPo battery.	Lecture with interspersed tutorial videos.	15 minutes

Module 3: Servos (50 minutes)

Learning Objectives The participants will:	Section Title	Key Points to Emphasize	Instructional Techniques	Estimated Time
State the definition of a servo, and recognize the servo's role in the onboard systems of a traditional sUAS.	What is a Servo?	Define the servo: A servo converts signals from radio system into mechanical motion. Servos can be linear or rotary.	Tutorial video with examples of different servos.	15 minutes
Interpret servo torque and speed requirements for a given sUAS aircraft and select an appropriate servo for the application.	Torque and Speed Rating	Point out that servo performance is rated based on torque and speed. A smaller servo that offers the same torque and speed can be a reasonable way to save weight.	Lecture	15 minutes
Describe a correct servo installation with relation to servo arm position and servo mounting.	Proper Mechanical Setup of a Servo.	Explain that servo arm should be installed to allow symmetric motion around center. Servo should be mounted with suitable security and geometry.	Tutorial video of an example servo installation.	10 minutes

Define servo stall and servo overload. List two ways to avoid servo stall and overload.	Servo Stalling and Overload	Stalled and overloaded servos build heat, do not function well, and can affect other systems on the aircraft.	Tutorial video showing examples of stalled and overloaded servos. Lecture on how to avoid these situations.	10 minutes

Module 4: Onboard Avionics System (65 minutes)

Learning Objectives The participants will:	Section Title	Key Points to Emphasize	Instructional Techniques	Estimated Time
List three differences between the avionics of a gyro-stabilized drone and a traditional fixed-wing sUAS.	Introduction	Explain the differences between the avionics power system of a typical drone and the avionics power system of a typical traditional sUAS.	Lecture	10 minutes
List the three major battery chemistries and one advantage and disadvantage of each. Describe the BEC and list its advantages and disadvantages.	Choosing an Onboard Power Source	Explain advantages and disadvantages of various battery chemistries used for onboard avionics power. Explain the BEC (Battery Eliminator Circuit) and its appropriate use as well as advantages and disadvantages.	Lecture with examples of each battery type and a BEC.	20 minutes
Explain the relationship of wire size/length to voltage drop. Recognize incorrect applications for a standard "JR" or "Futaba J" style connector.	Wiring	Explain the relationship of wire size/length to voltage drop. Explain the limitations of a standard "JR or Futaba J" connector. Give examples of connectors for higher current applications.	Tutorial video with examples of appropriate wiring installations	15 minutes
Define the mechanical switch and the electronic switch. Explain how a switch can affect overall system voltage.	Switches	Explain the differences between a standard mechanical switch and an electronic or "soft" switch. Explain the contribution of the switch to voltage drop and possible heat build-up.	Lecture	10 minutes
Describe the modern 2.4 Ghz receiver as a small computer. Explain the importance of stable system voltage to a 2.4 Ghz receiver. List three	2.4 Ghz Receivers	Explain that the program will only cover 2.4 Ghz receivers because the majority of systems in use are 2.4 Ghz. Explain the 2.4 Ghz receiver is	Lecture with short tutorial videos of receiver failure due to voltage drop and correct and incorrect receiver installations.	10 minutes

"best practices" for receiver installation.		actually a small computer and as such has voltage requirements to stay operational. Describe receiver installation "best practices".		

Module 5: Radio Control Transmitter Setup (90 minutes)

Learning Objectives The participants will:	Section Title	Key Points to Emphasize	Instructional Techniques	Estimated Time
List the three reasons why proper transmitter setup is important	Introduction	Proper transmitter setup is a major contributor to the safety, efficiency, and reliability of a traditional sUAS.	Lecture	10 minutes
List seven major features of a transmitter in order of importance	Selecting a Transmitter	Review, and rank in order of importance, the major characteristics of a typical sUAS transmitter.	Lecture with examples	15 minutes
For a given transmitter, create a new model in memory for a typical traditional sUAS trainer	Model Memory	Explain the use of model memory on a given transmitter	Tutorial video	5 minutes
Define and apply sub-trim, end-point limits, and travel volume.	Introduction to Servo Travel Adjustments	Explain sub-trim, end point limits and travel volume adjustment. Emphasize the importance of correct servo installation and that electronic setup cannot make up for improper installation.	Tutorial video of servo programming on a typical R/C transmitter	15 minutes
Apply a mix to two appropriate channels (a master and slave) of a typical fixed wing sUAS.	Mixing Functions Overview	Introduce two channel mixing functions on a typical R/C transmitter.	Tutorial video of setting up a mix for aileron to rudder and rudder to nose wheel steering on an example fixed wing sUAS.	10 minutes
Configure a multi-rate setup with exponential on a modern R/C transmitter.	Control Surface Throw "Rate" Setup	Explain multi-rate setup on a modern transmitter. Explain exponential rate and setup.	Tutorial video	10 minutes
Setup the trainer system on a modern R/C transmitter.	Trainer System Overview	Introduce a typical trainer system.	Tutorial video	10 minutes
Describe fail-safe and its use in a typical fixed-wing sUAS.	Fail-Safe	Describe fail-safe: Purpose, setup, and checking.	Tutorial video	5 minutes

List at least two applications of telemetry on a modern fixed wing sUAS.	Telemetry Setup and Application	Introduce Telemetry on a typical R/C transmitter. Explain aircraft-side components and setup on the transmitter.	Tutorial video	10 minutes

Module 6: Aircraft Setup (85 minutes)

Learning Objectives The participants will:	Section Title	Key Points to Emphasize	Instructional Techniques	Estimated Time
Explain the goal of aircraft setup is to increase reliability, controllability, and efficiency.	Overview and Introduction of Aircraft Setup	Give a brief overview of the tasks to be performed during aircraft setup and explain the importance regarding reliability, controllability, and efficiency.	Lecture	10 minutes
Identify correct and incorrect control surface hinge installations.	Control Surface Hinging and Throw	Explain how to properly align and set hinges for a given control surface.	Tutorial video	5 minutes
List the four factors of correct control surface linkage setup.	Control Surface Linkages and Geometry	Explain correct setup of servo-to-control-surface linkages. Describe the four factors of control surface setup: control horn location, servo arm location, alignment of control rod, and location of servo-side and control-surface-side clevises.	Tutorial video	10 minutes
Correctly apply electronic servo travel adjustment to control surface setup	Electronic Travel Adjustment	Review the concepts covered during the discussion on R/C transmitters. Emphasize incorrect and correct usage of sub-trim and travel limit adjustments.	Tutorial video	10 minutes
Recognize correct and incorrect throttle linkage setup on a typical fixed-wing sUAS with an I/C engine.	Throttle Setup (I/C power systems) or ESC Calibration (EL power systems)	Describe correct setup process for throttle on an I/C engine.	Tutorial video	5 minutes
Recognize the need to apply thrust-line corrections and state one	Engine or Motor Thrust-Line Setup	Define down-thrust and up-thrust, and left-thrust and right-thrust. Explain how to apply these	Lecture with examples	10 minutes

technique for applying them.		concepts to motor or engine mounting.		
Describe proper longitudinal and lateral balance for a typical traditional sUAS	Center of Gravity: Longitudinal and Lateral	Explain the importance of longitudinal Center-of-Gravity regarding aircraft stability and lateral CG regarding aircraft in-flight trim. Describe techniques for adjusting Center-of-Gravity.	Tutorial video	20 minutes
Recognize correct and incorrect wire routing and securing schemes.	Wire Routing and Security	Discuss wire routing and security best-practices and give examples of products and techniques to accomplish these practices.	Lecture with visual examples of correct and incorrect wire routing and securing	5 minutes
Identify flaps and retractable landing gear.	Secondary Controls and Functions	Introduce secondary controls. Emphasize that an aircraft with these features is beyond the recommended aircraft type for this program.	Lecture	10 minutes

Module 7: Support Equipment (55 minutes)

Learning Objectives The participants will:	Section Title	Key Points to Emphasize	Instructional Techniques	Estimated Time
Describe three pieces of important support equipment for a given fixed-wing sUAS.	Introduction to Support Equipment	Traditional fixed-wing sUAS require support equipment beyond what may be required for a typical gyro-stabilized drone.	Lecture	10 minutes
Recognize appropriate storage containers and fueling systems for tradition sUAS powered by Internal Combustion engines.	Fueling Systems for I/C Engines	Safe fuel storage requires an appropriate container. Describe appropriate means for pumping fuel from the storage container to the aircraft.	Tutorial video	10 minutes
Given a battery with correct labeling, identify and apply correct charge settings to the charger.	Charging Systems for Electric Power Systems	Safe charging of batteries requires a suitable charger and understanding of charger setup and battery chemistry. Emphasize the importance of reading the charger manual.	Tutorial video with a suitable charger and various battery chemistries.	15 minutes

Given a set of hand-held starters, select the appropriate starter for a given engine.	Hand-Held Starters for I/C Engines	Give examples of various hand-held starters and illustrate appropriate use of a hand-held starter.	Tutorial video	5 minutes
Use a tachometer to measure engine RPM. Use a watt meter to measure power output of an electric power system.	Tachometer and Watt (Power) Meters	Describe tachometer and watt meter use in various applications for traditional fixed-wing sUAS.	Tutorial video	5 minutes
Identify the tools that make up an appropriate basic tool set for a traditional fixed-wing sUAS.	Basic Tools	List the appropriate tools in a basic set for an I/C powered and an electric powered traditional fixed-wing sUAS.	Lecture	10 minutes

Assessment Plan:

Each lesson will include a short quiz utilizing multiple choice, fill-in-the-blank, hot-spot (click the appropriate depiction), and simulation to assess accomplishment of the learning objective(s) for that lesson. Each module will have a comprehensive quiz covering the entire module utilizing the same kinds of questions.

A final open-ended program evaluation will be offered after completion of all modules. This assessment will be the primary means of gain feedback on the program.

Assessments will be optional as the program itself is being built for the benefit of the community. Participants will be encouraged to accomplish the assessments with incentives offered only to those who complete the course (including assessments). Incentives could include:

1. "Shares" on Social Media: Participants will be able to share the "medals" they receive from the in-line and module assessments on Facebook.
2. Each assessment will offer an entry into a drawing for hobby related prizes donated by (hopefully) sponsors of the program.
3. If a partnership can be arranged with a vendor like Horizon Hobby, it is hoped that gift cards will be available. These will be offered to those who complete the course, including assessments. Gift cards are not anticipated to be large denomination (~$10 - $15) but the planner is hopeful that this incentive will be possible if the program yields a decent rate of traffic. This traffic could be leveraged to bring sponsors onboard and add more incentive for participants to accomplish the full program, including assessments.

Hopefully, as the program gains steam, assessment participation will increase and this will give better data to tweak the program going forward.

Instructional Resources:

For Instructor	For Participants
PowerPoint presentation for each session	Computer with at least 1024 x 768 screen, mouse, and keyboard
Example engines	Audio speakers or headphones connected to computer
Example motors	Internet connection with at least 1 Mbps download and 1 Mbps upload
Example avionics	Email account
Various example aircraft	Suitable chair and desk
Example wiring, electronics, switches	
Camera for recording lecture	
Camera for close-up recording of examples	
Camtasia 9.0 for lecture and tutorial recording	
iSpring Suite 8.x for integration of PowerPoint, lecture video, and creation of simulations for the online course	
Suitable web hosting service to host the program	
Microphone for recording audio	
Ipad with Doceri app for real time annotation and PowerPoint control during lecture	