Project Definition Document

Aerospace Senior Projects (ASEN 4018 & 4028)
Fall 2003 and Spring 2004

1.0 Information

1.1 Project Title

UAV Stability Augmentation System (USAS) Digital automatic pitch control augmentation system for a remotely piloted unmanned aerial vehicle (UAV)

1.2 Project Customers

Team USAS

2.0 Background and Context

2.1 Purpose

Small, unmanned aircraft suffer from inherent instabilities in the pitch axis due to their size and the lack of pilot feedback. We propose to develop an electronic pitch stability augmentation system whose primary function consists of artificial stabilization of a small aircraft. Other attempts by CU students at developing digital electronic control systems have had limited success. Previous attempts at similar systems have failed primarily due to excess complexity and insufficient time. By reducing the scope of the system to a modular single-axis system, our team will create an essential subsystem within the normal senior design period of two semesters. In order to successfully complete this project, our team will construct a test-bed aircraft with the USAS control system, and a simulation package for software testing. We will build the airplane and control system with typical model airplane components and common electronics that are both inexpensive and readily available. The benefits of such a system justify the cost and effort required to develop it. The UAV Stability Augmentation System (USAS) is a vital component of fully automated control systems needed for projects such as Tornado Chaser and Fire UAV. As a stand-alone system, USAS will enhance the reliability of small aircraft, which are plagued by pilot error mishaps due to pitch instabilities.

2.2 Methodology

Modern integrated circuit technology has introduced electronic control systems into miniature aircraft that had previously been employed only in the most sophisticated full size aircraft. Inexpensive, commercially available microprocessors are well suited for use as miniature flight control computers. The USAS stability augmentation system will consist of a microprocessor which reads inputs from a pitch rate gyro, linear accelerometers, or other sensors as required, and whose primary output is a pitch command signal. This signal will be mixed with the pilot commanded pitch signal from a radio control system, and sent to the pitch control servo. The microprocessor will also facilitate data acquisition using either onboard storage, down linked telemetry, or both. The system will have command override capability that allows disabling of the processor functions in-flight. In command override mode, the pitch control commands are sent directly to the elevator servo, bypassing the USAS software module. A block diagram of the system is shown in Figure 1.

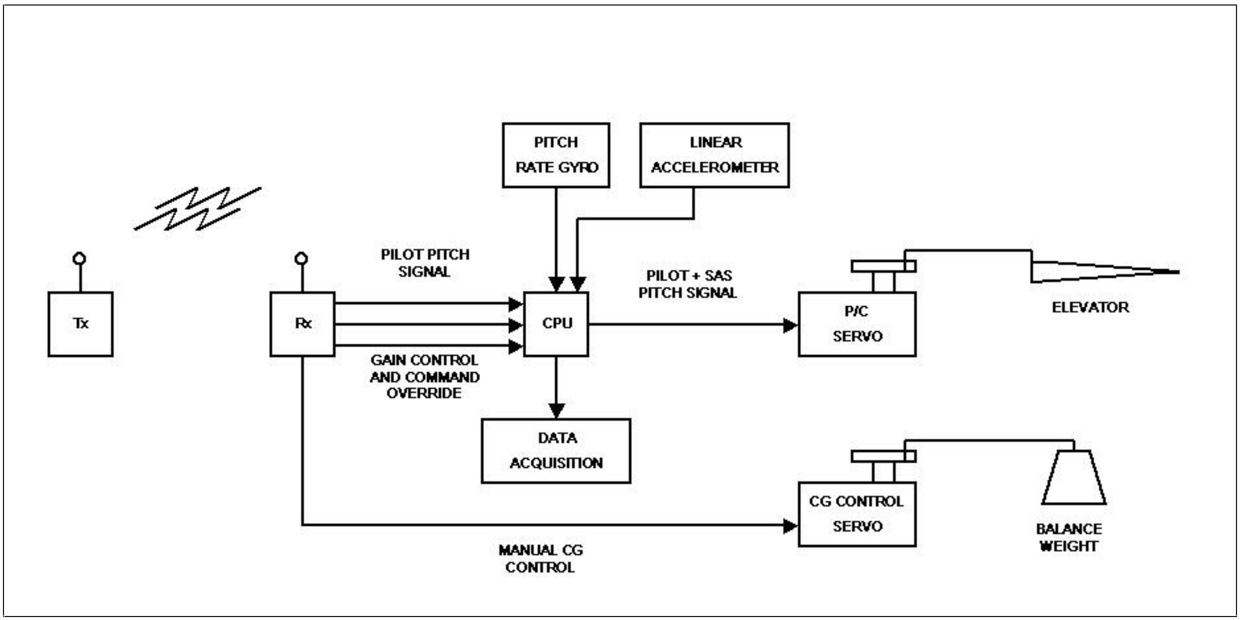

Figure 1 – Block diagram of proposed system (conceptual)

3.0 Objectives

3.1 Primary Objective

The overall objective of the proposed project is to conceive, design, fabricate, integrate and test a stability augmentation system that provides pitch rate damping of a radio controlled UAV.

3.2 Secondary Goals

Time permitting, the capabilities of the system will be expanded to include any of the following functionalities:

1. Load factor limiting
2. Stall prevention or recovery
3. Artificial stabilization of a statically neutral or unstable configuration
4. Control augmentation of pilot input (defined as amplification of control deflections as a function of control deflection rate-of-change)
5. Ability to expand system to additional axis of freedom

4.0 Requirements

4.1 Central Processing Unit (CPU)

4.1.1 Objective

The microcontroller subsystem will provide the core from which the control system software is run and the basic interface to the control system's peripherals.

4.1.2 Discussion

The CPU will consist of a commercially available microcontroller, such as the Microchip PIC series, which interfaces with the sensor suite and the control actuators. The system may either share the power supply used by the radio receiver, or contain its own power source.

4.2 Data Acquisition Subsystem

4.2.1 Objective

The data acquisition subsystem will interface the CPU with the sensor outputs and flight control inputs in order to log data.

4.2.2 Discussion

The data acquisition system will facilitate test and analysis by recording pertinent data in-flight. The system will either store data using onboard memory or transmit the data to a ground station via telemetry.

4.3 Modularity and Scalability

4.3.1 Objective

The device will have a modular structure such that it may be interfaced with other identical units. In addition, the device will have a standardized digital interface through which it can communicate with external systems.

4.3.2 Discussion

This allows the control system to be used as a modular subsystem of more complex systems that are currently available or will be developed later.

4.4 Simulation Package

4.4.1 Objective

A simulation package consisting of a software simulation or other approprate apparatus will be required to evaluate the system's performance prior to the flight tests.

4.4.2 Discussion

In order to verify the behavior of the control algorithms and associated hardware, they must be tested on the ground using a simulation. This will ensure that the system will function as expected prior to flight testing.

4.5 Test Bed Aircraft

4.5.1 Objective

The test bed aircraft will provide a demonstration and test platform from which to evaluate the control system's effectiveness. The aircraft must have sufficient lifting capability and internal volume to carry aloft the control system and its associated hardware, but be relatively small to minimize cost. It must be a modular design, which can be reconfigured to facilitate different test parameters, which may include but not be limited to a moveable center of gravity and adjustable tail volume.

4.5.2 Discussion

A simple design will be emphasized. The aircraft will be a custom built electric-powered (reduced vibrations), radio controlled craft, with a minimum payload capacity of 2.5 pounds and minimum useable payload volume of 4x4x8 inches. The aircraft size will not exceed "0.60" size, defined as the required engine displacement in cubic inches. The wing loading will be between 20 and 40 ounces per square foot at maximum takeoff gross weight (TOGW), with a maximum TOGW of 15 pounds. The aircraft will consist of a modular design in order to allow for reconfiguration if needed. In addition the aircraft will be equipped with a remotely controlled moveable center of gravity (described below).

4.6 Flight Control Subsystem

4.6.1 Objective

The FCS will facilitate remote piloting of the vehicle and control of auxiliary systems.

4.6.2 Discussion

The FCS will consist of a commercially available radio control model airplane control system, which will interface with the microcontroller subsystem.

4.7 CG Control Subsystem

4.7.1 Objective

The device will vary the location of the aircraft center of gravity for test and evaluation purposes.

4.7.2 Discussion

This is required to evaluate the control system's ability or inability to stabilize an unstable or marginally stable aircraft configuration. The adjustable CG allows the aircraft to be flown to a safe altitude prior to initiating the tests.

5.0 Anticipated Engineering Expertise

Technical Expertise	**How Applied**
Mechanical Design	Develop conceptual and detailed solid 3D models of the system components
Electromechanical Actuators	Actuator subsystem for variable center of gravity
Sensors	Angular velocity, acceleration, pressure, or other required sensor inputs to the control system
Digital Electronics	Central processing unit of control system
Data Acquisition Systems	Real-time measurement subsystem
Control Software	Real-time control subsystem
Mechanical Fabrication	Component machining and assembly
Electronic Fabrication	Digital electronic subsystems
Mechanical and Dynamic Test	Test and verification of system performance
Structural Fabrication	Aircraft construction and flight control rigging
Radio Control Flight	Piloting of test bed aircraft
Flight Mechanics	Aerodynamic design of test bed aircraft and simulation software

6.0 Resources

6.1 Facilities

The project will require access to the Senior Design Laboratory and the UAV Workshop.

6.2 Additional Advisors

Remaining ASEN Faculty

6.3 Cost and Funding

The projected cost is approximately $4000, which will be provided by AES.