VOLTES FLY

Senior Design Fall 2011
University of Central Florida
College of Electrical Engineering &
Computer Science

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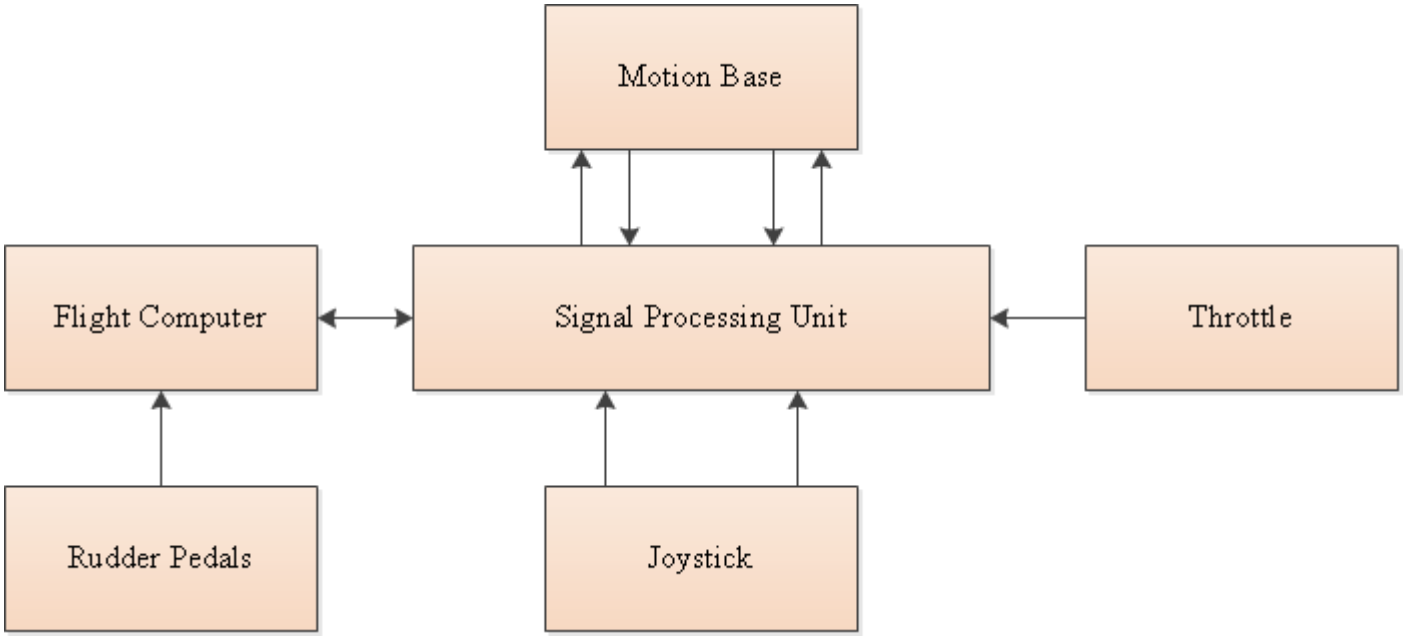
Motivation

- Homemade Flight simulator videos found online
- Relevant to industry in the Orlando Area
- Project will pay off with it’s entertainment value!

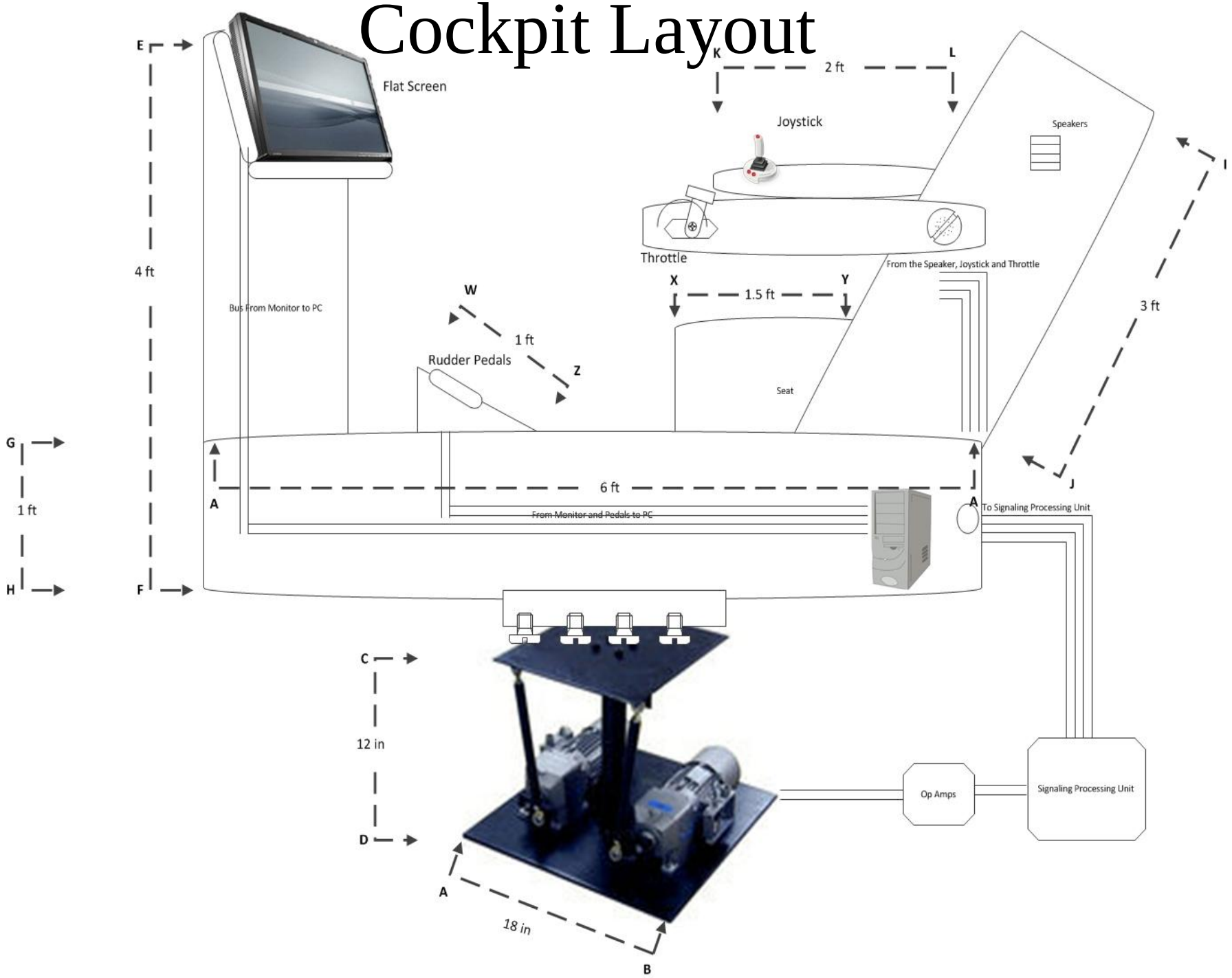
Goals

- Build a functional vestibular cueing flight simulator for a Cessna 172
- Implement a Throttle
- Implement a Joystick with haptic feedback
- Gain valuable experience in embedded and software design

System Overview



Cockpit Layout



Specifications

- Pilot can be a maximum of 250lbs and 6’5” in height
- Image Generator (X-Plane) runs at a minimum of 30 fps
- Instructor/Operator Station runs at a minimum of 50 Hz

Motion Base

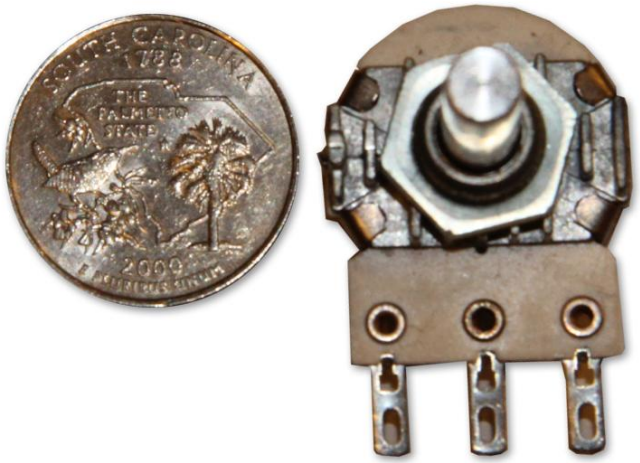
- COTS item loaned from Servos & Simulation Inc.
- 2 degrees of freedom achieved by 2 Servomotors, operational at 220V. (Transformer was provided)
- Max tilt of 20 degrees for pitch and roll

Motion Base Continued…

- Drive amplifiers allow each motor to maintain rotational position with a range of +/-7 VDC
- 2 Potentiometers provide position feedback for implementation of a closed loop system
- Includes a 5/15VDC power supply which will be used for the other components

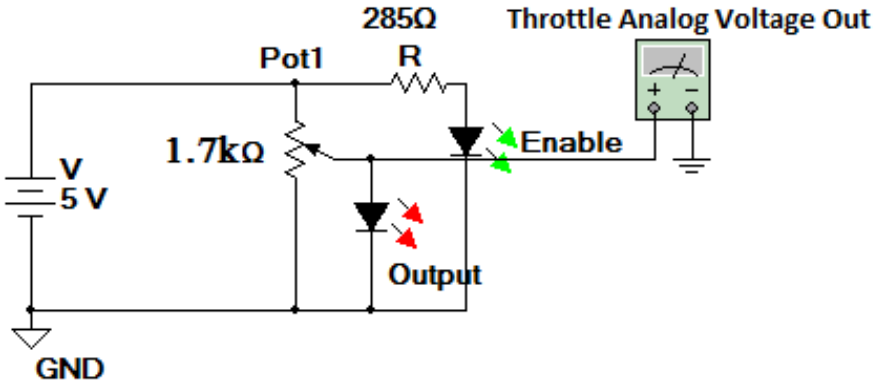
Potentiometers

- Will be used to provide positional feedback
- **Rotary** vs. Slide
- **Linear** vs. Logarithmic response
- Shaft rotates a maximum of **270°**



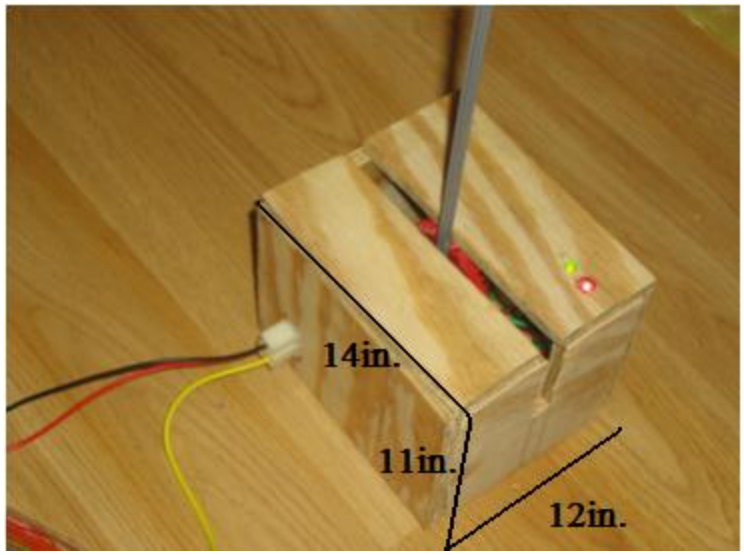
Throttle

- Potentiometer wiper outputs voltage ranging from 0 to Vin and max current of 2.4mA
- Ratio between 2 gears connecting shaft and lever allow for the complete use of 270°



Throttle

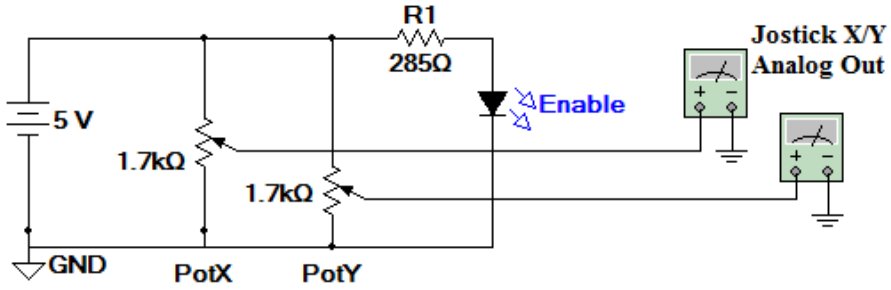
- Finished Prototype, gives pilot approximately 143° of lever rotation



Lever Angle	Wiper Voltage(V)
7°	.04
30°	.17
50°	1.07
70°	1.66
90°	1.73
110°	1.84
130°	2.15
150°	2.52

Joystick

- Same concept is extended to track 2 axis of movement



Haptic Feedback

- 2 Pittman Gear head DC Motors GM9236C460

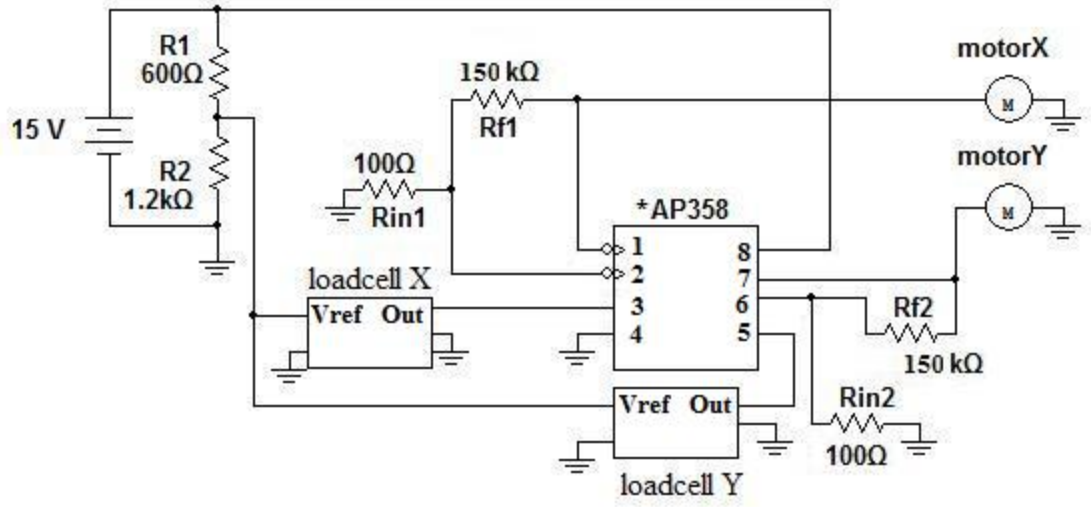
  -operate between 6-24V, max torque .0671Nm
- 2 LCC-ESP4 Low capacity load cells

  -support tension and compression

  -rated output 1mV /V of excitation

  -output is amplified and used to power motor

Haptic Feedback

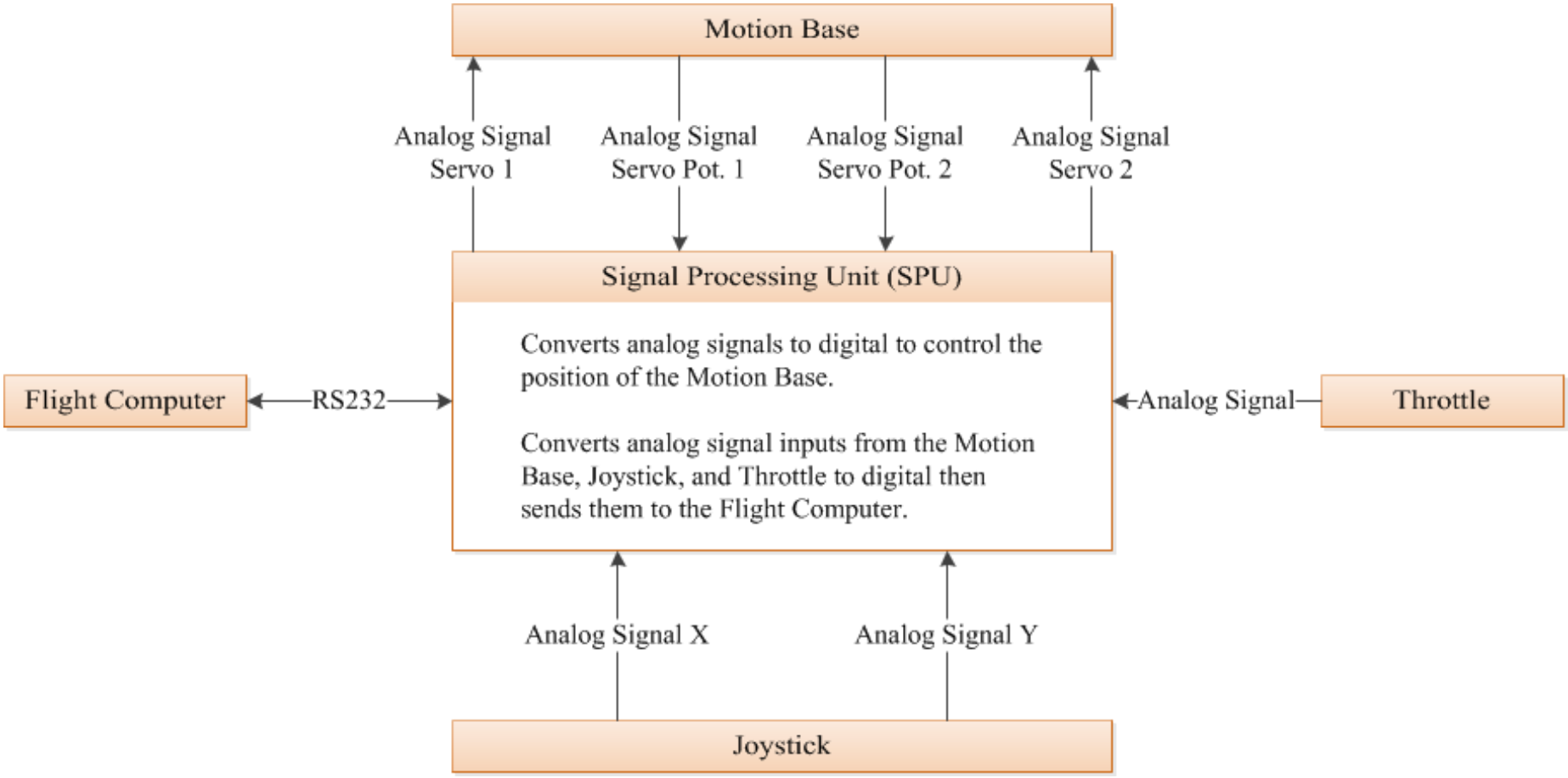


*pin1 Output1
pin2 Inv. In1
pin3 Non. In.1
pin4 Ground
pin5 Non. In.2
pin6 Inv. In.2
pin7 Output2
pin8 V+

Possible Issues

- The type of load cells needed to implement this design are valued at approximately $200 each; alternatives are being explored
- Joystick is expected to experience vibration at the origin because of the feedback nature of the system; a filter would have to be implemented

Signal Processing Unit (SPU)



SPU

- What is the purpose of the SPU?

- Provide a centralized interface for communication between each system

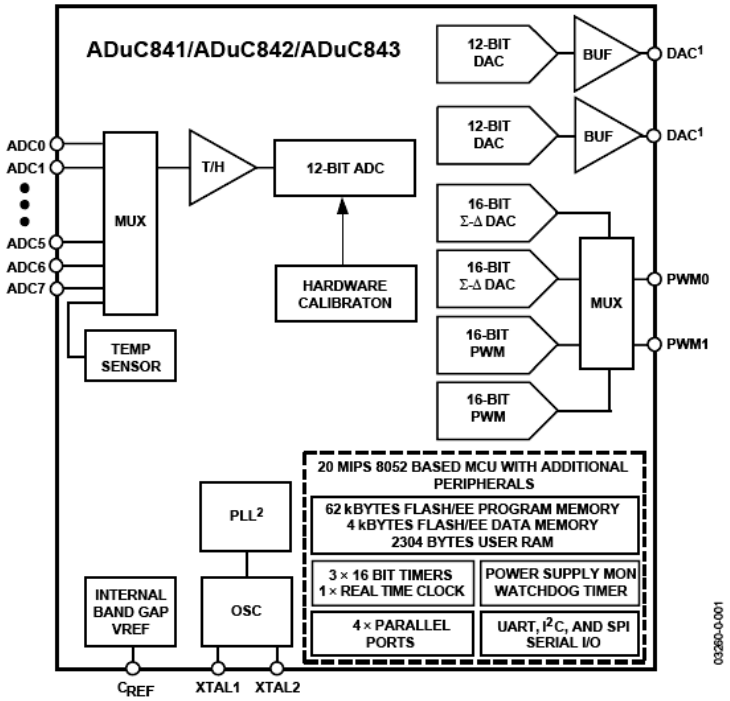
- Perform secondary error checking on input and output range values

- Perform signal conversions

- Low cost solution

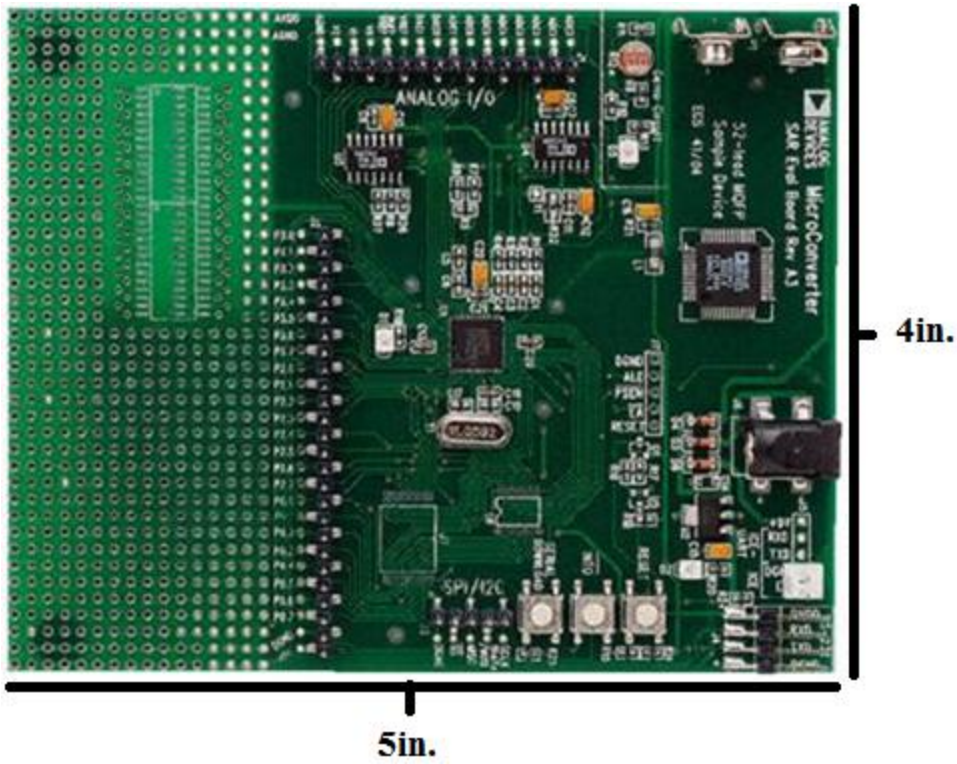
Analog Devices ADuC841 MicroConverter

- Specifications
  - 2304 Bytes of SRAM
  - 8 Channel, 400kSPS, Self-Calibrating, 12-Bit ADC
  - Two 12-Bit Rail-to-Rail Voltage-Output DACs
  - Precision Voltage Reference , Serial Interface ports
  - Embedded Download/Debug & Emulation



Evaluation Board EVAL-ADuC841QSPZ

- Specifications
  - 4 pin UART header to connect RS232 Interface Cable
  - Reset/External Interrupt 0 Push Buttons
  - Access to all ADC inputs from external header.
  - DAC output channel buffered to external header
  - All device Ports and Strobes are brought out to external header pins
  - Surface Mount and Through Hole General Purpose Prototype Area



Packet Structure
Flight Computer to SPU

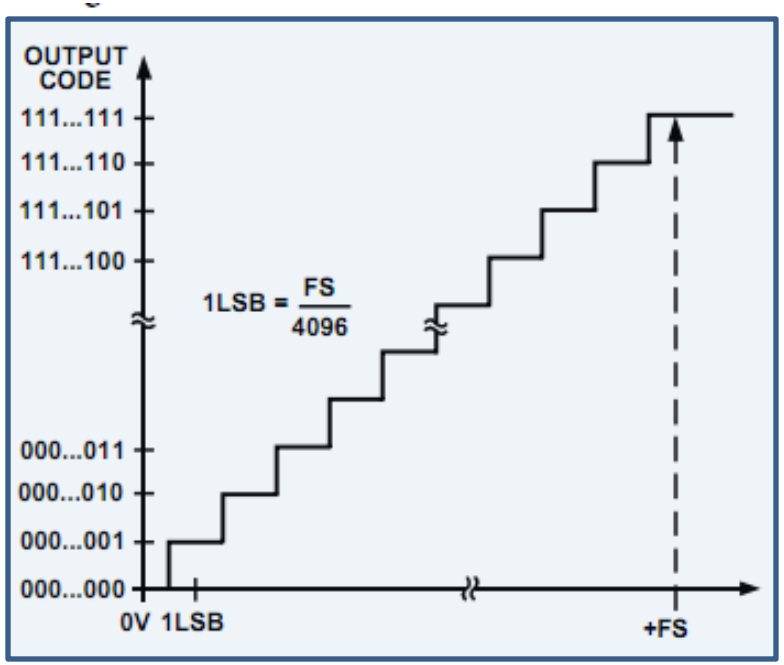
- Represents the data payload of the packet
- Voltage values represent the angular position of the servo motors
- Header and Tail bits have not yet been defined

Packet Structure
SPU to Flight Computer

- **Heartbeat:** Continuously transmits for verification that the software is cycling and making hardware connections
- **Joystick Status:** Notifies Flight Computer if the Joystick is connected to the SPU (1 if connected, 0 otherwise)
- **Throttle Status:** Notifies Flight Computer if the Throttle is connected to the SPU (1 if connected, 0 otherwise)
- **Throttle Position:** Value of the Throttle output
- **Joystick X Position:** Joystick position along the X-Axis
- **Joystick Y Position:** Joystick position along the Y-Axis
- **Servo 1 Potentiometer Position:** Absolute position of Servo 1
- **Servo 2 Potentiometer Position:** Absolute position of Servo 2

Data Conversion

Why is data conversion needed ?

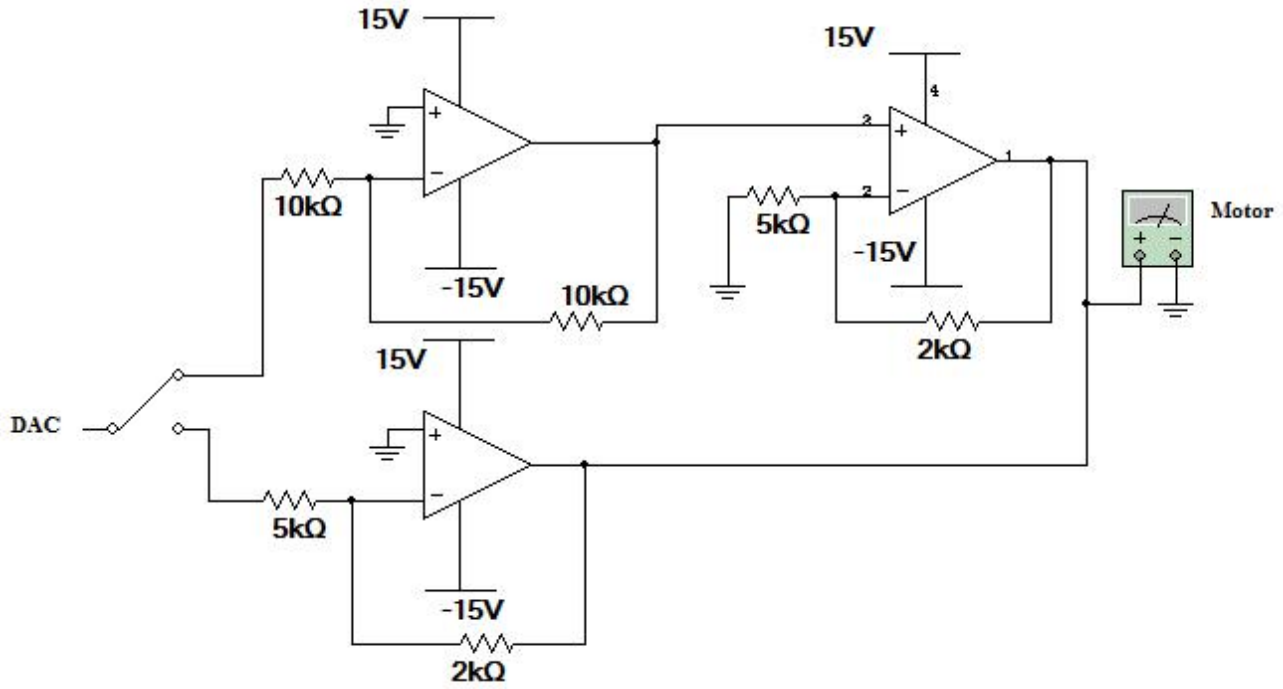


- 12-bit ADCs. Capable of representing 4096 steps
- Example: Vref = 5V

  5 ÷ 4096 = 1.22 mV

  step → 1.22 mV → 1LSB

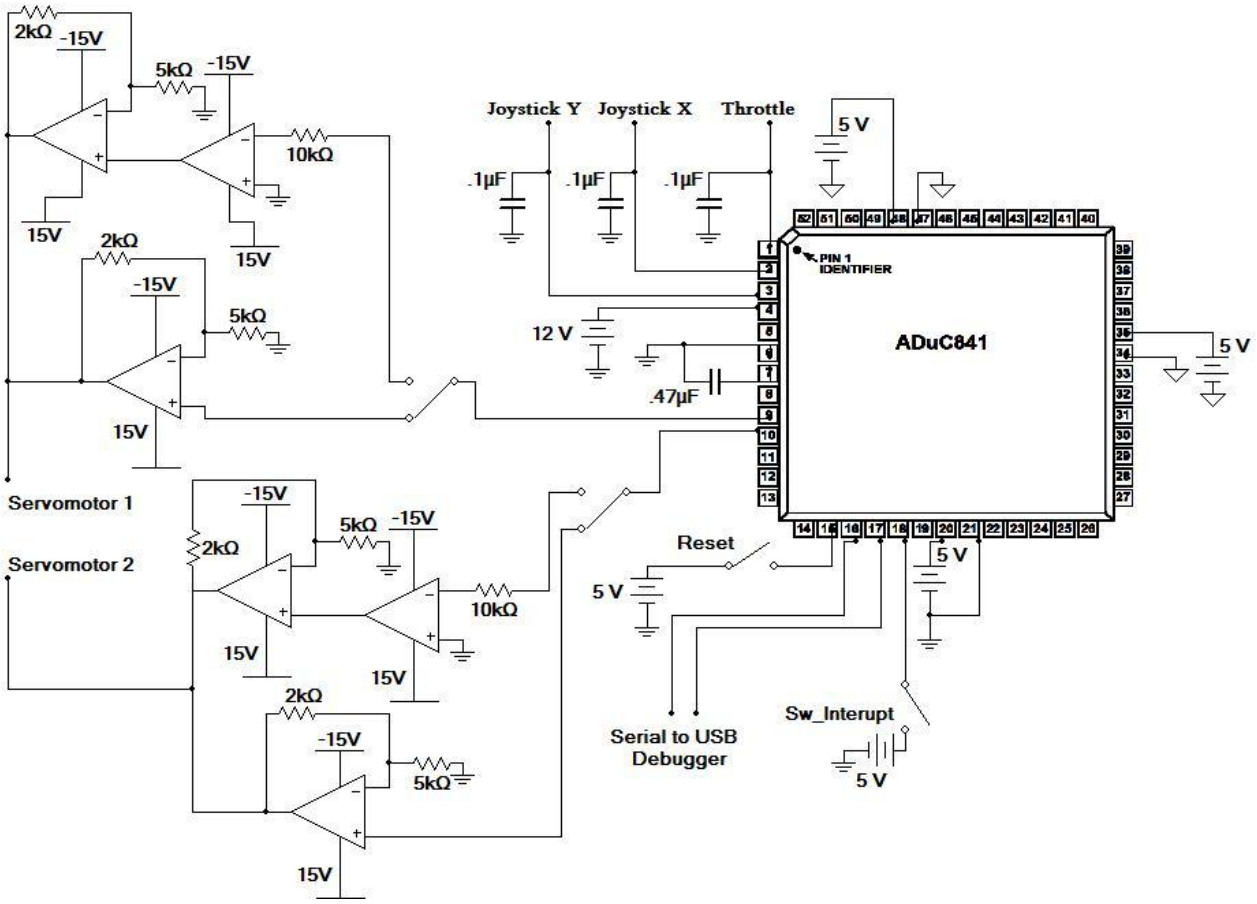
Data Amplification



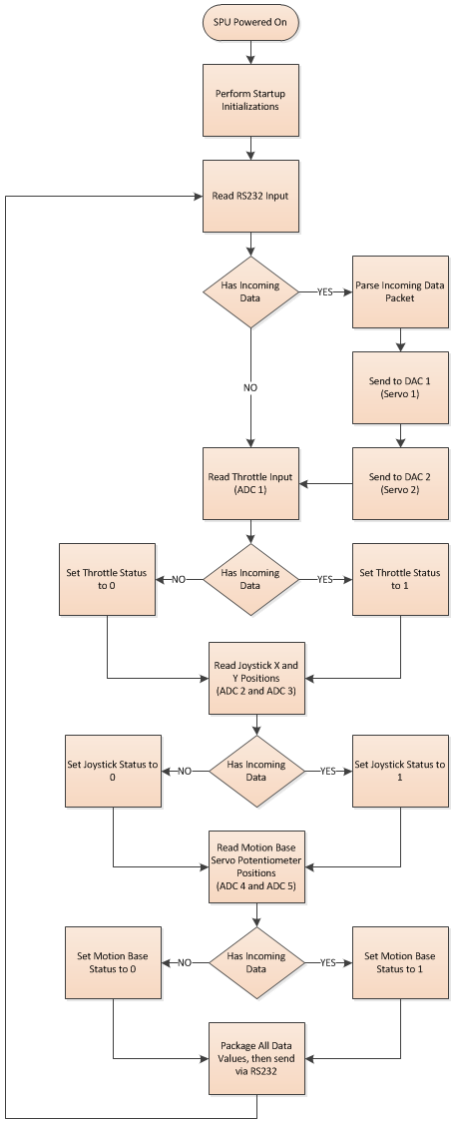
Why is Data Amplification needed ?

- DACs just amplify up to Vref
- DACs do not output negative voltage values
- 3 Op amps needed per DAC

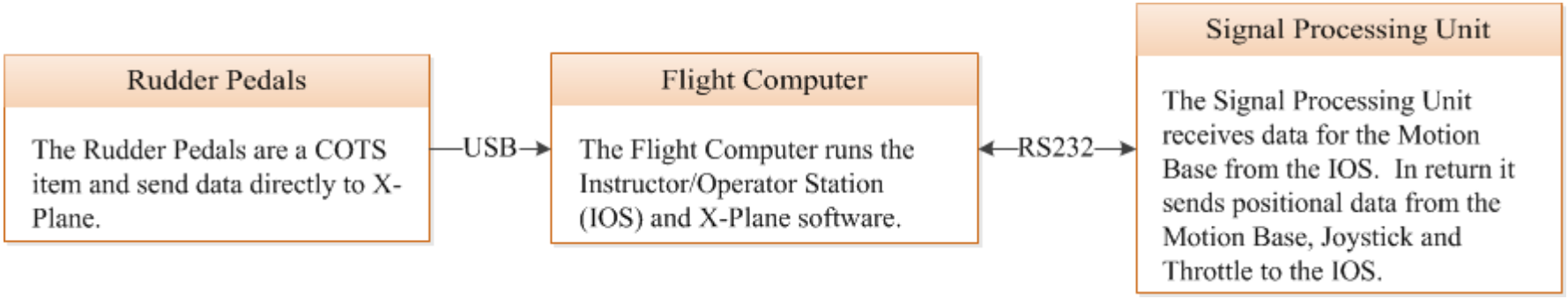
SPU Schematic



Embedded Software Flow



Flight Computer



- Specifications
  - AMD Athlon x64 dual core 2.5GHz
  - 2 GB RAM
  - Asus EN6800GT 256Mb Graphics Card

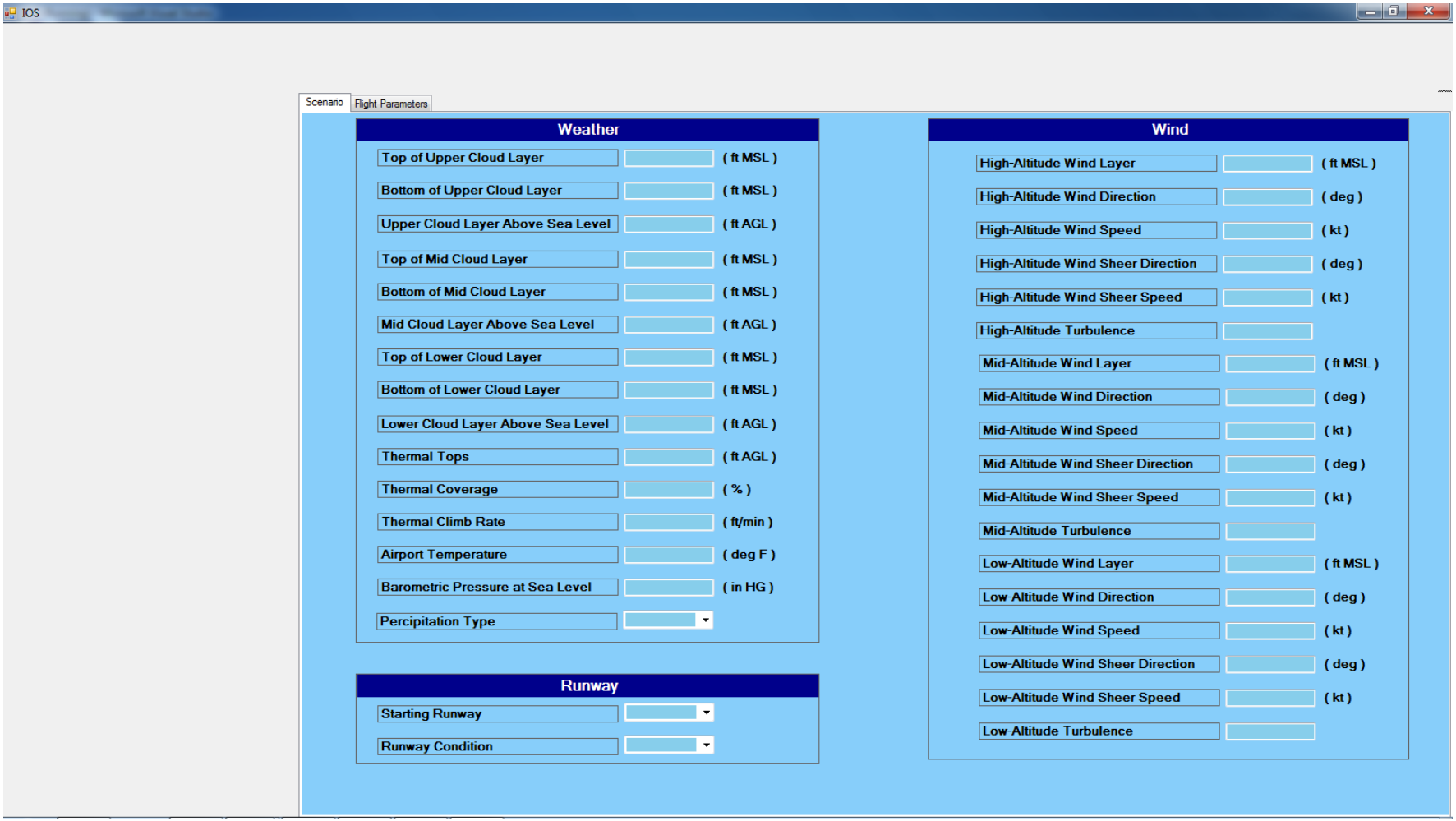
Instructor/Operator Station (IOS)

- Allows an instructor to set/monitor flight parameters for a simulation session
- Handles communication between X-Plane and the Signal Processing Unit
- 2 part design
  - GUI front end (called the IOS User Interface)
  - Simulation data processing backend (called the Simulator)

IOS User Interface

- Scenario Page
  - Allows instructor to choose weather conditions, starting runway, etc…
- Flight Parameter Page
  - Displays flight parameters from the IOS.Config file
    - Defines which values will be displayed, the variable in memory they update from and their update rate
  - Allows instructor to control which values will be displayed without having to re-code
- Health Page
  - Displays the Health Status for each system

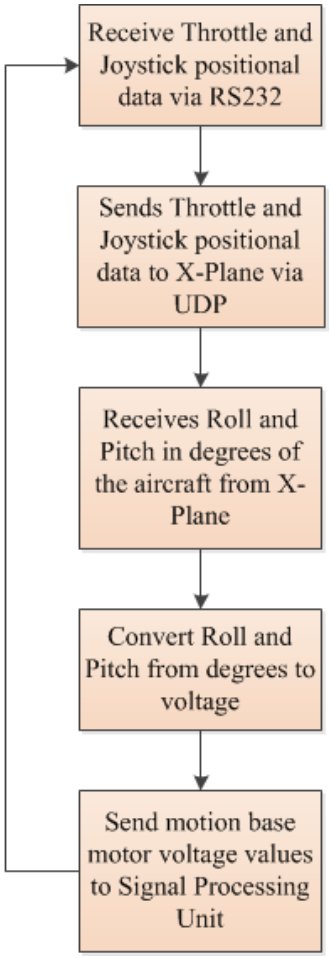
IOS User Interface Continued…



Simulator (backend)

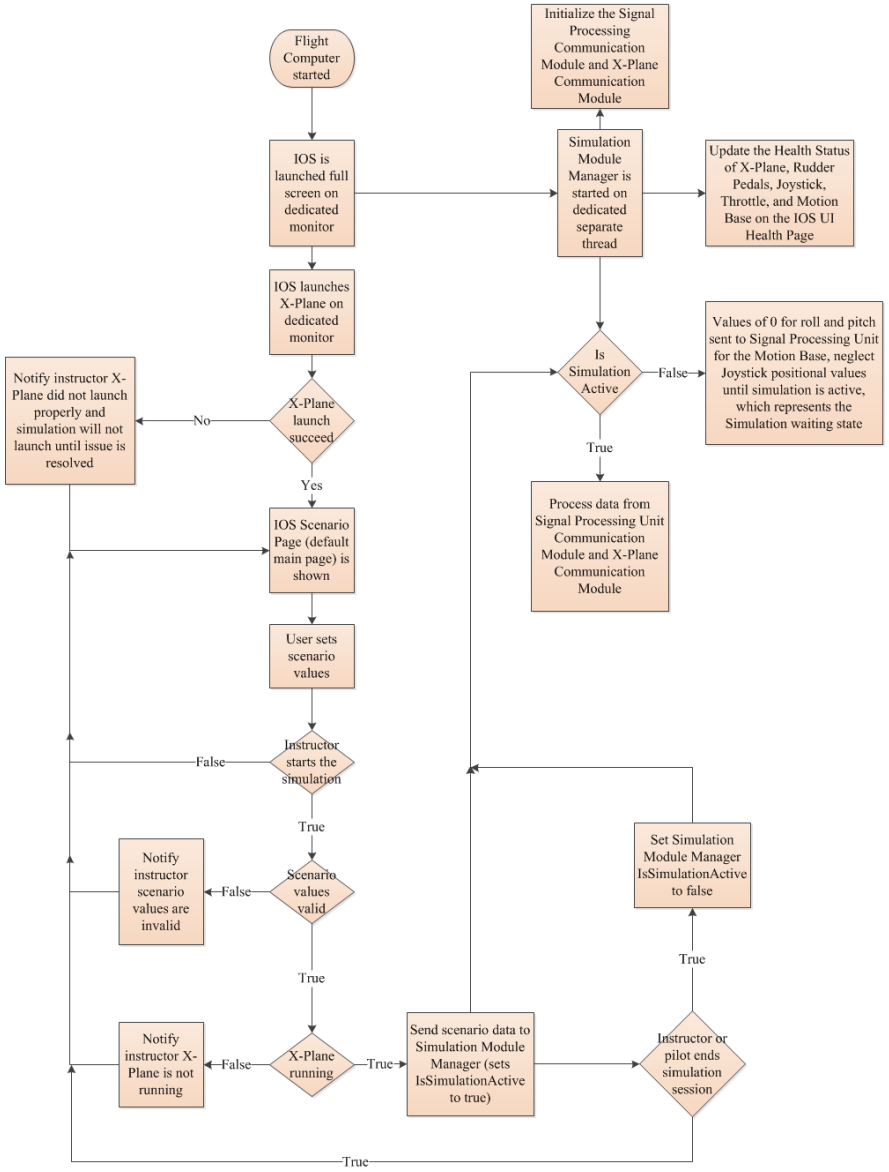
- Receives Joystick, Throttle, and Motion Base positional data from the Signal Processing Unit via RS232
- Receives aircraft attitude (Roll and Pitch) data from X-Plane via UDP
- Converts Roll and Pitch from degrees to the voltage required for each motion base motor
- Processes data at a rate between 50-100Hz
- Follows a more functional programming design

Simulator (backend) continued…



- Runs on separate thread from IOS User Interface

IOS Application Flow



Possible Issues

- Flight Computer cannot run both X-Plane and the IOS due to the high demand by X-Plane on the system resources
- Due to the high demand of the Simulator backend of the IOS, the application could fail

Current Costs

Parts	Costs ($)
Cockpit construction	40.00
Throttle	16.79
Tools	20.00
Motion Base Platform	0
ADuC8041 Micro converter Dev. board	170.10
Flight Computer	0
X-plane flight simulator software	29
Asus EN6800GT	0

- Self sponsored. Current spending totals up to $275.89

Division of work

Parts	Member Responsible
Peripherals and Interfacing	Manuel Arredondo
Signal Processing Unit	Hector Bermudez
Instructor/Operator Station	Joe Paolini

Progress

Subsystem	Percentage of completion
Throttle	100%
Joystick	15%
Signal Processing Unit	15%
IOS	55%

- Total project progress is **46.25%**

The Plan

- Obtainable weekly goals
- Work in parallel
- Test and Integrate approach
- Source Control
  - Fogcreek
- Microsoft SharePoint
  - Collaboration workspace environment

Questions?