Have a Safe Flight: Bon Voyage!

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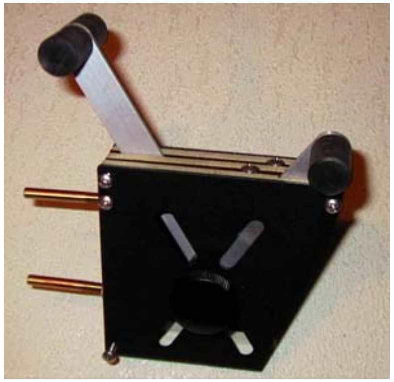
Making the “Smart Flight Vest”

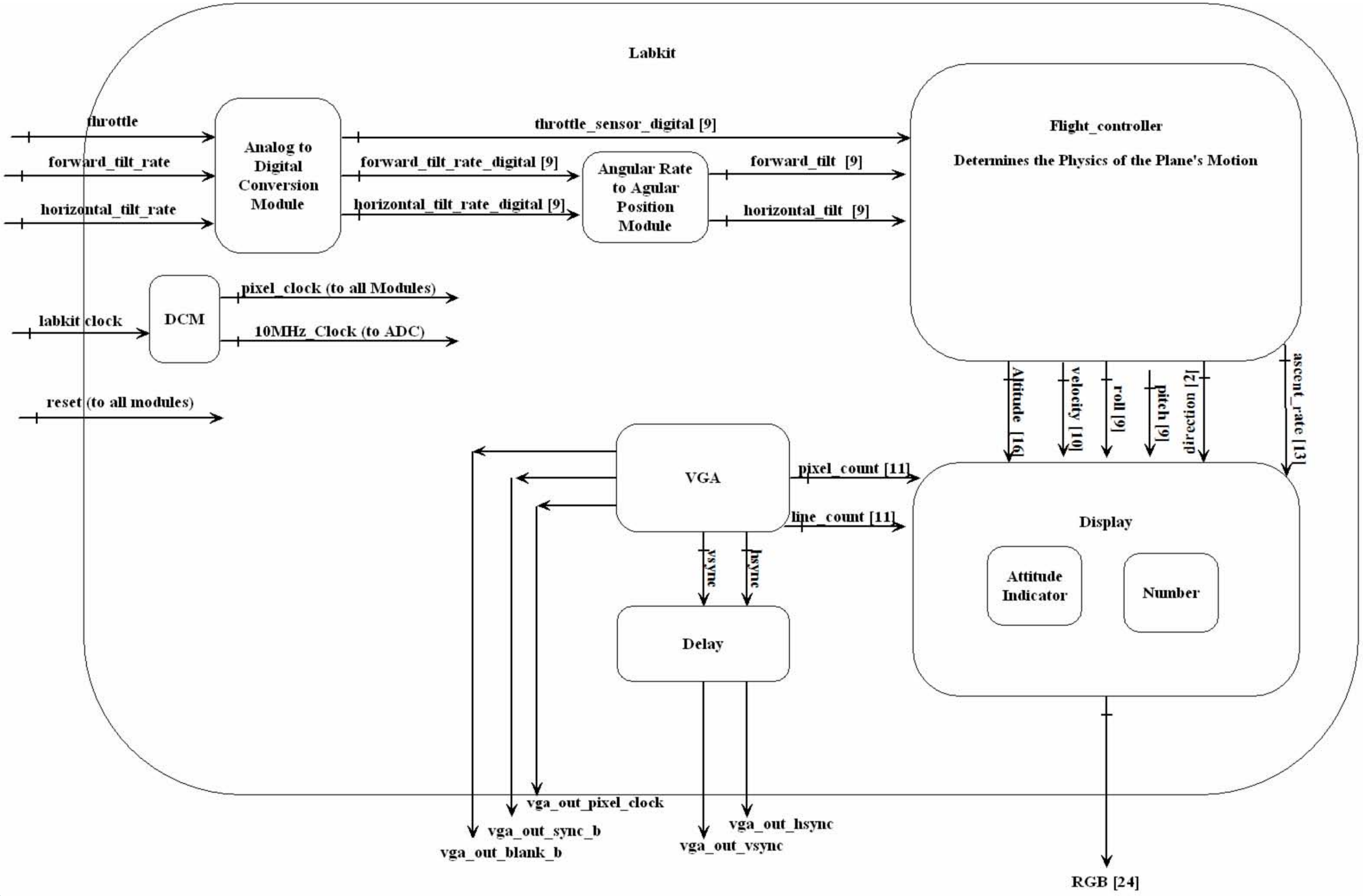
- Mount two angular rate sensors onto the upper body of the flight vest
- Separate device will measure throttle

Controlling Throttle

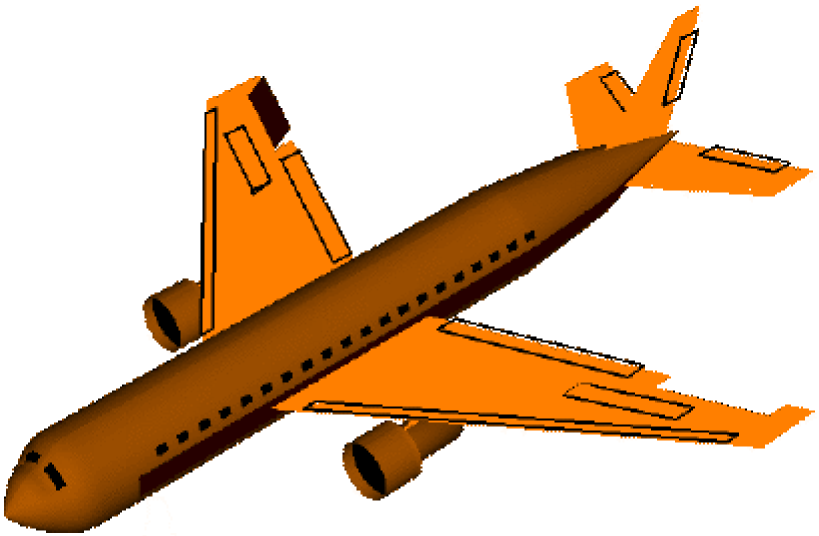
- Want functionality of being able to adjust and set throttle
- Will mount a handle onto resistor arm to imitate a throttle lever



Main Block Diagram

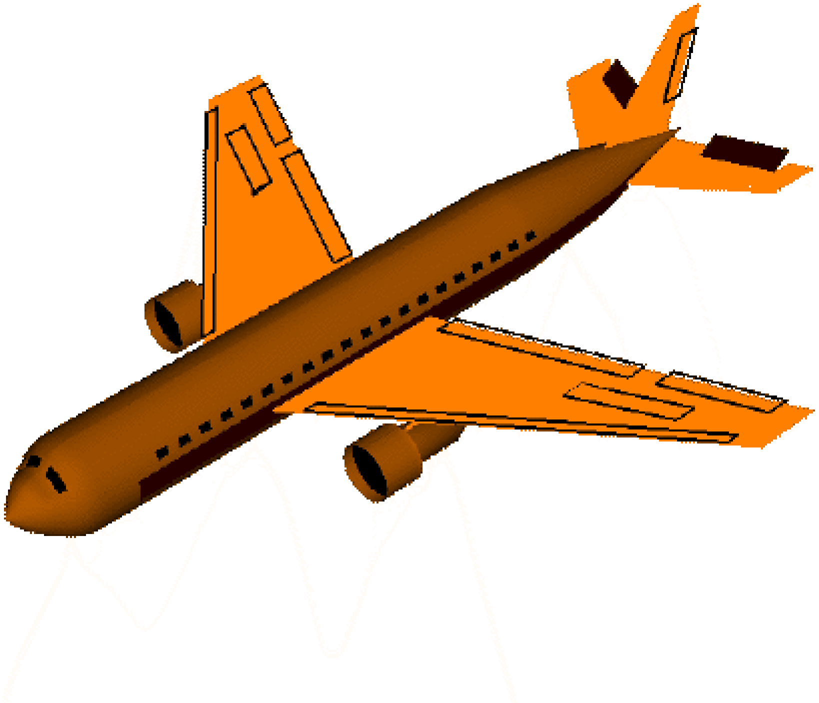


Measuring the Roll of the Plane



Please see http://www.grc.nasa.gov/WWW/K-12/airplane/roll.html

Measuring the Pitch of the Plane



Please see http://www.grc.nasa.gov/WWW/K-12/airplane/pitch.html

ADXRS300 - Angular Rate Sensor

- Contains an internal Gyroscope
- Output voltage proportional to the angular rate about the axis perpendicular to the surface of the chip
- Range of rate: +/- 300 ^{o}/sec
- Zero movement: outputs 2.5 V

Getting an Angle from Angular Rate

- AngleRate = K * (ADCVoltage-ZeroVoltage)
- K is some constant (Degs/sec/volt)
- Angle = Angle + AngleRate*deltaT
- May need calibration for ZeroVoltage

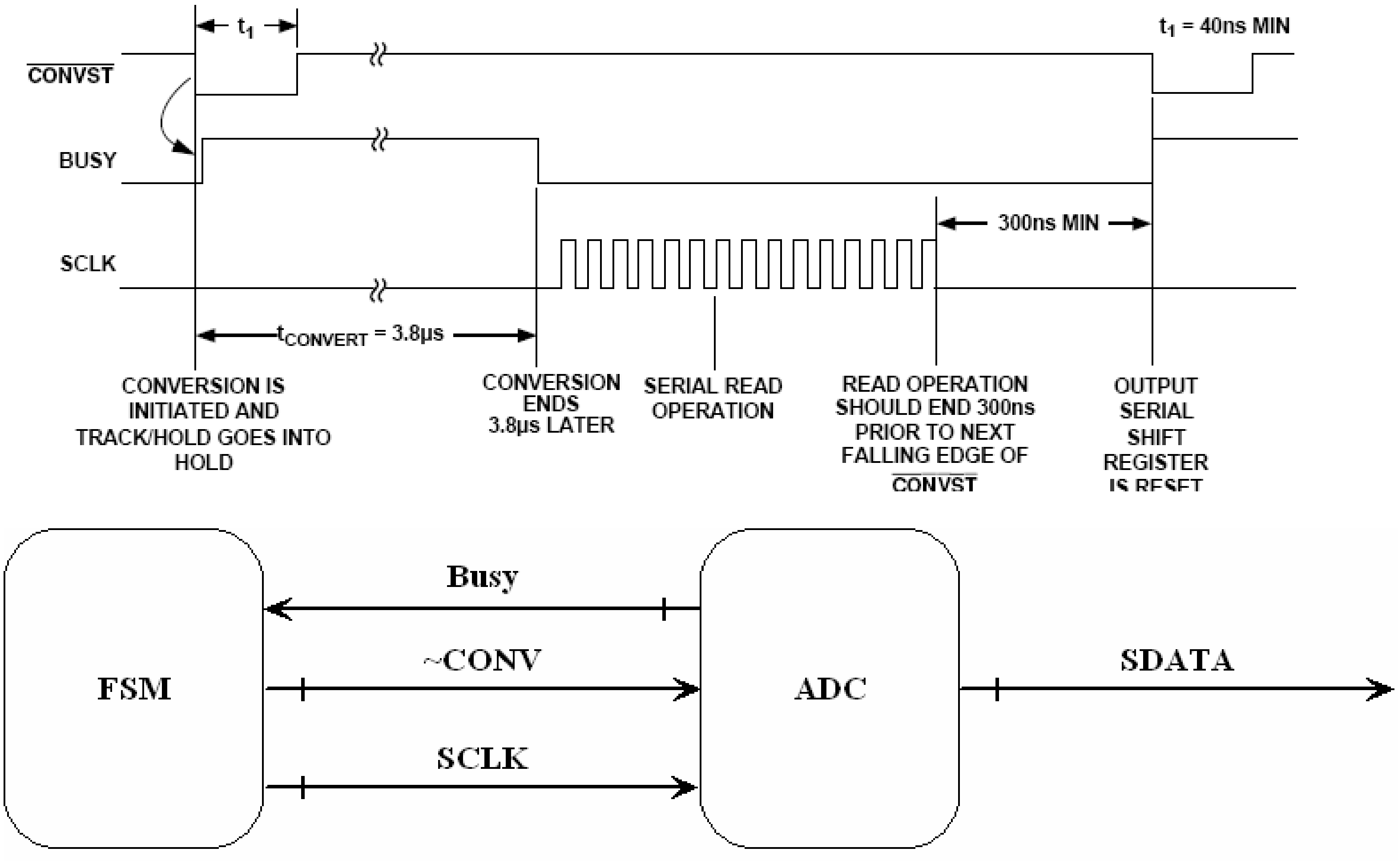
Interfacing the ADXRS300

- Will use an analog to digital converter AD7895AN-2
- Output of the AD7895 is 12 bits
- Uses a reference potential of 2.5 volts
- Serial Output

Interfacing the ADXRS300

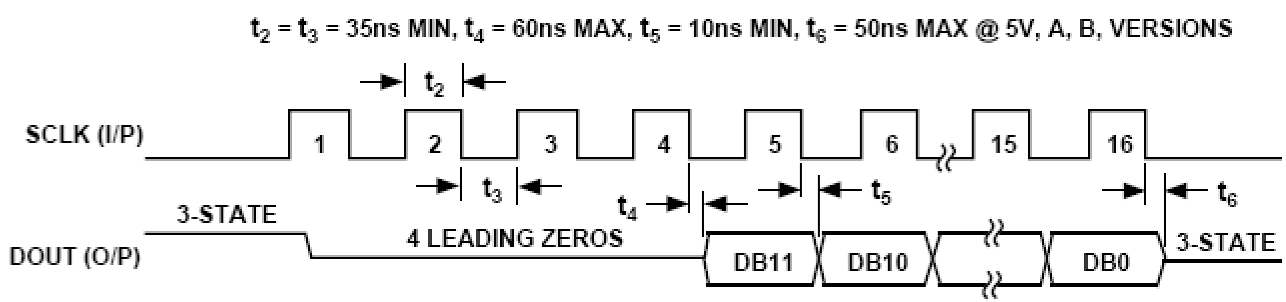
- Bandwidth of the ADXRS300: 400Hz
- Minimum sampling rate for ADC is 800Hz
- We’ll use 10 KHz sampling rate

Timing Operation Diagram



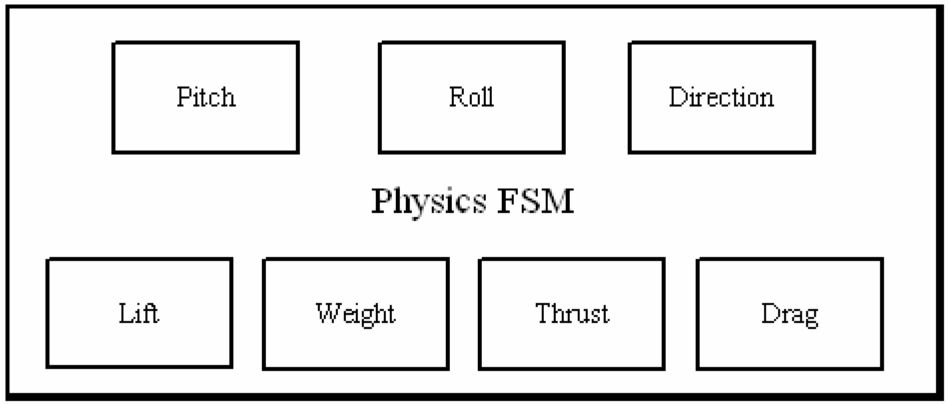
Data Read Operation

- AD7895 uses 16 clock cycles to output the digital data bits resulting from the conversion
- It outputs 4 leading zeros, then the 12 bits of actual data, starting with the MSB(DB 11)



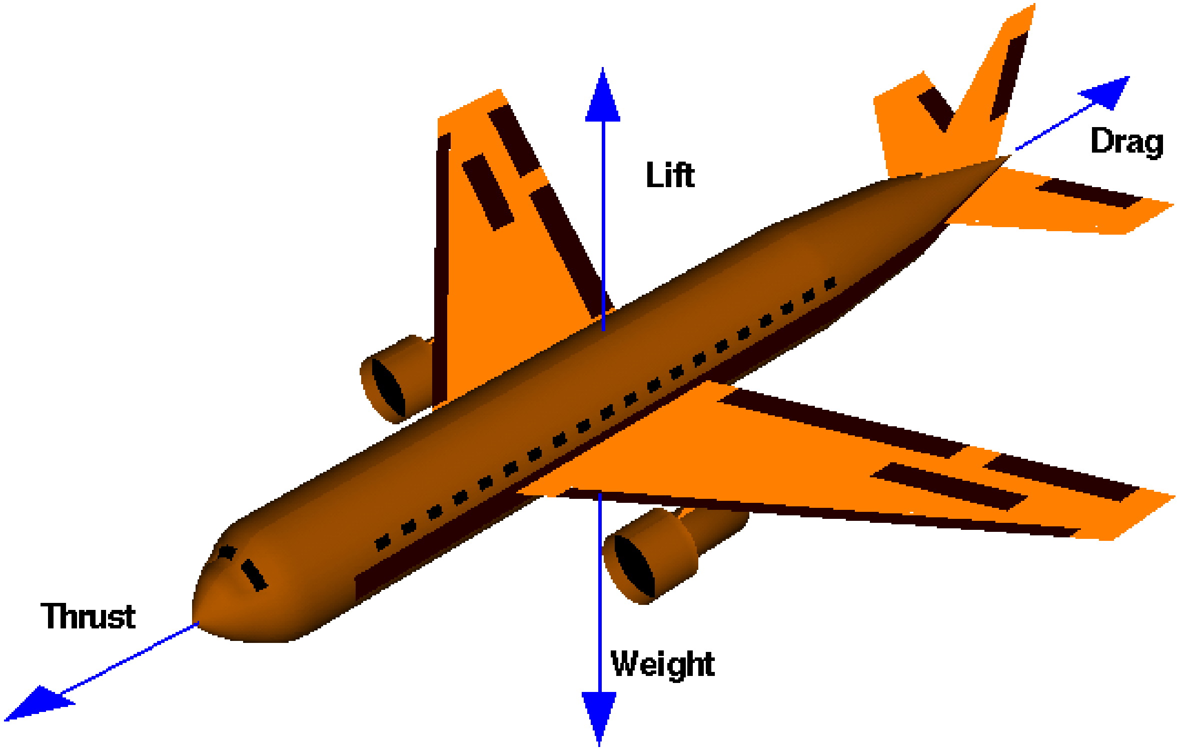
Forces Determined in Physics Module

- Forces and Anglular Velocities determined in Minor FSM
- Positions and Angles calculated in Physics FSM



Forces on an Airplane

Please see http://www.grc.nasa.gov/WWW/K-12/airplane/forces.html

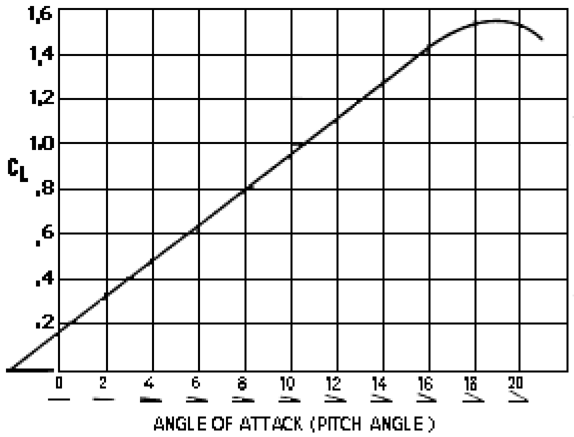


Force equations

- Thrust: F = ma
- Weight: F = mg

$$\text{lift} = C_L \times \left(\tfrac{1}{2}\rho V^2\right) \times S$$

$$\text{drag} = C_D \times \left(\tfrac{1}{2}\rho V^2\right) \times A$$



Please see:

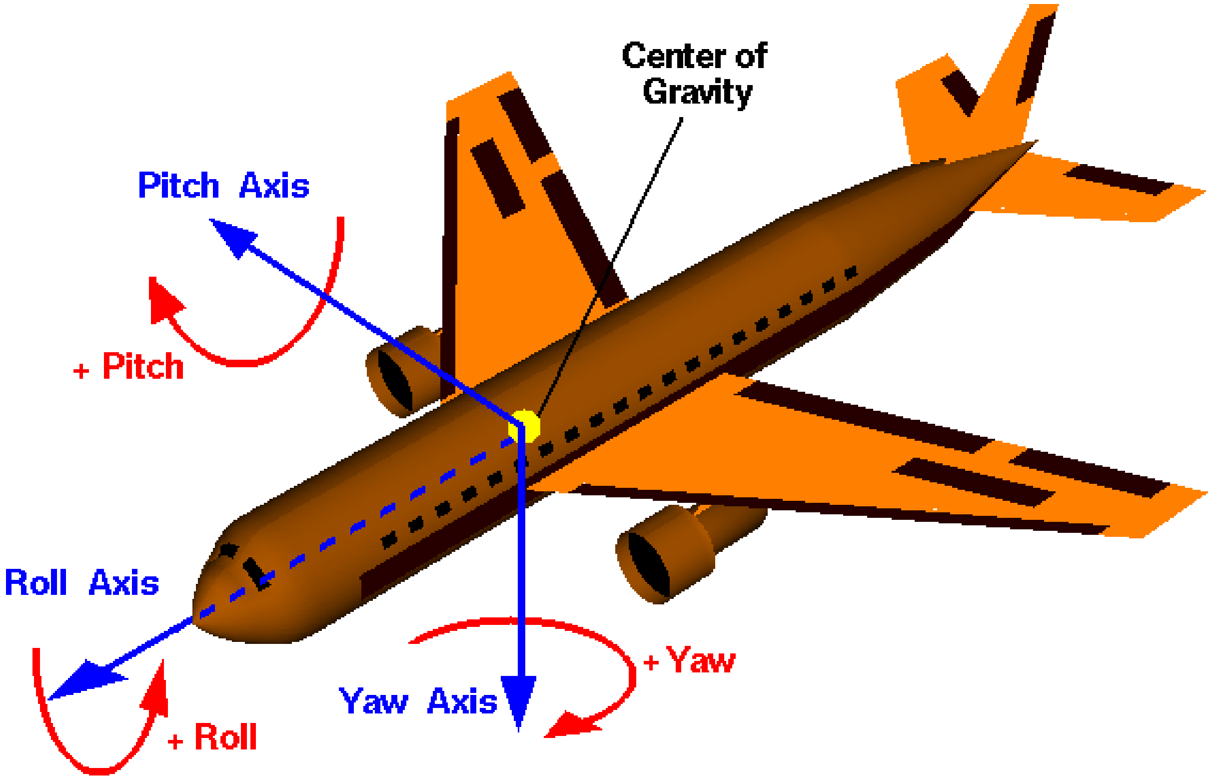
http://www.grc.nasa.gov/WWW/K-12/WindTunnel/Activities/lift_formula1.GIF

http://www.grc.nasa.gov/WWW/K-12/airplane/lifteq.html

http://www.grc.nasa.gov/WWW/K-12/airplane/drageq.html

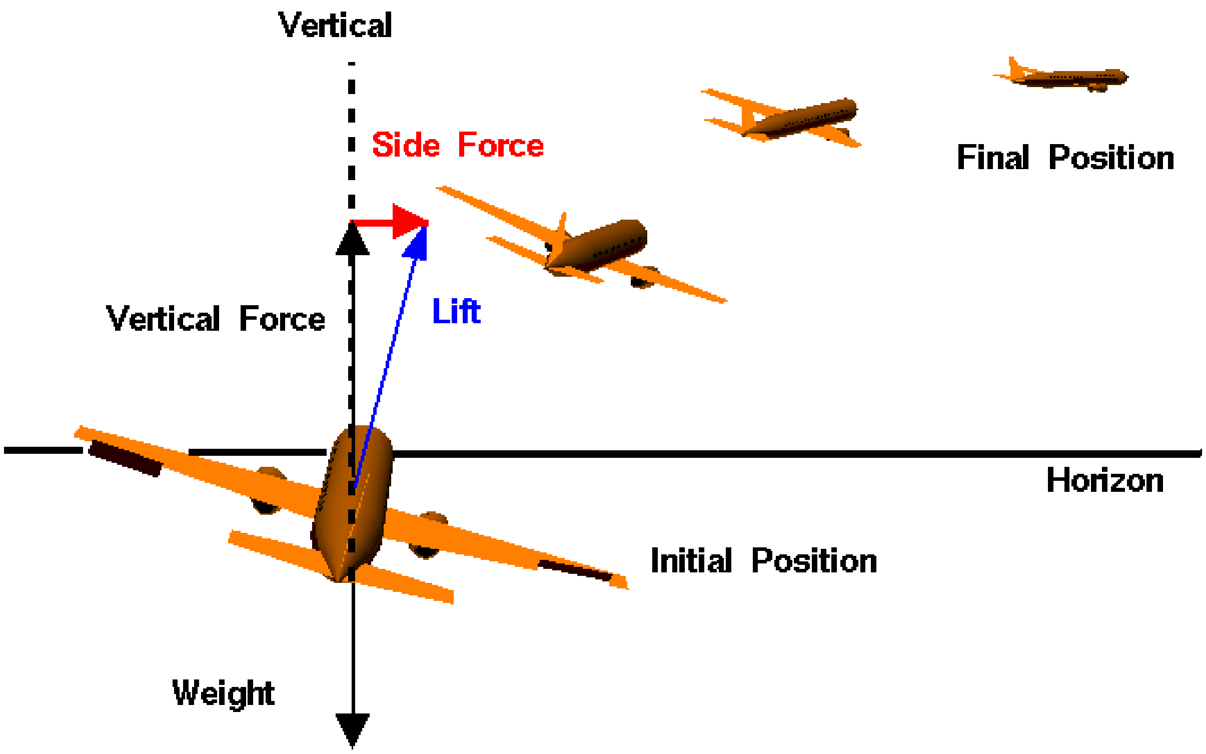
Aircraft Rotations

Please see http://www.grc.nasa.gov/WWW/K-12/airplane/rotations.html



Rotation produces Vectors

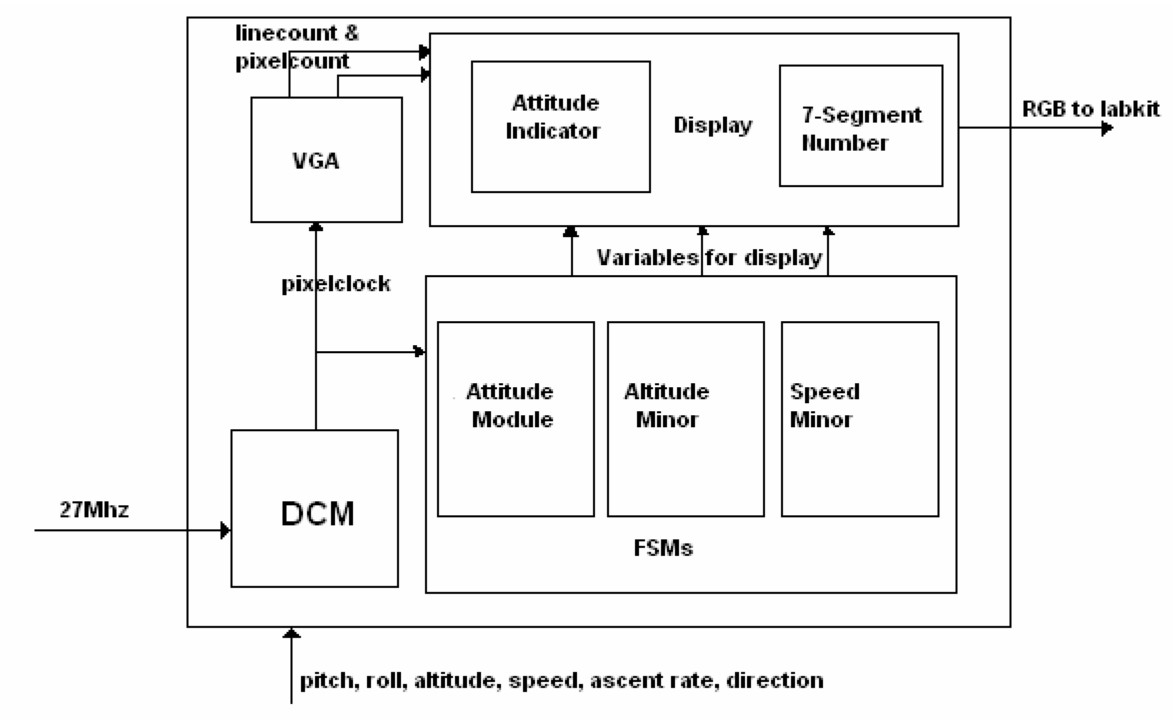
Please see http://www.grc.nasa.gov/WWW/K-12/airplane/turns.html



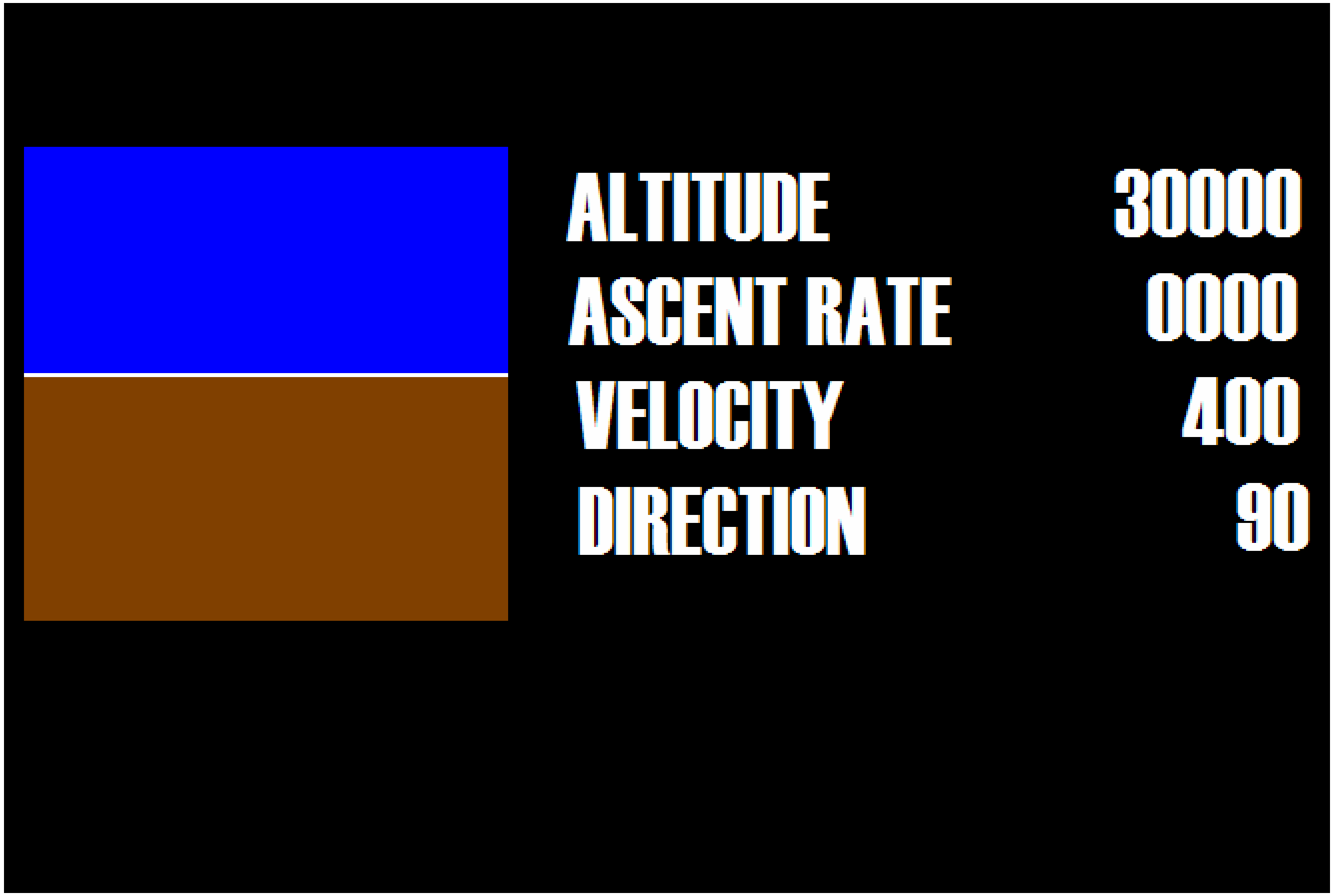
Displaying the State of the Flight

- The pilot flying the plane stands in front of a monitor that displays the main features of an airplane console, including an attitude indicator and a display for altitude, ascent rate, and velocity.

Video Display Block Diagram



Screenshot

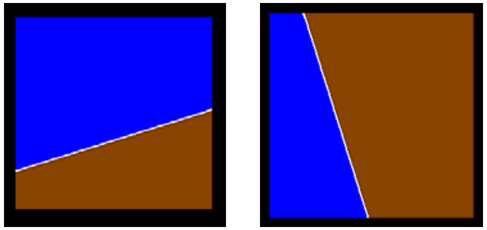


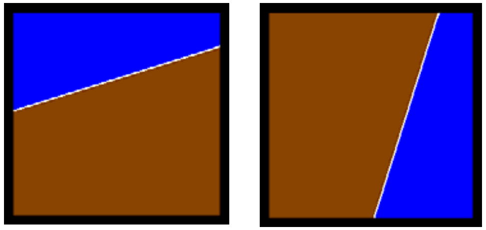
Displaying numbers

- Approach 1- Instantiate rectangles to form numbers (similar to how MIT logo was made in the Pong game)
- Approach 2- Create and store table of ASCII characters in memory and render characters when they are needed

Attitude Indicator

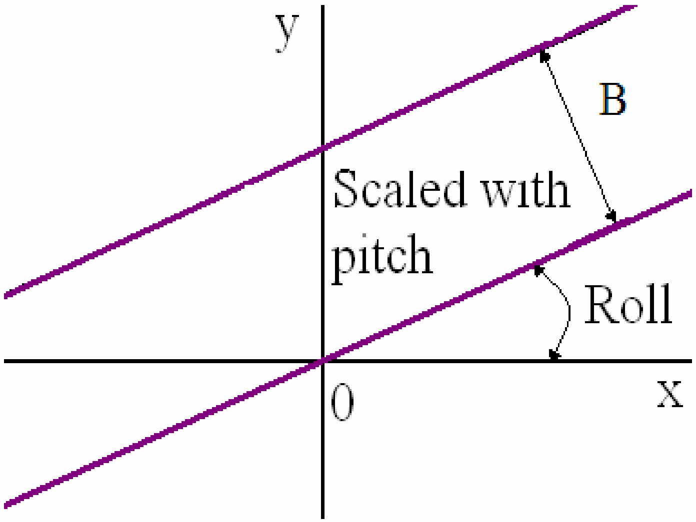
- The Attitude Indicator Module takes in two angles (pitch and roll).
- The roll of the airplane determines the slope of the white line (horizon) .
- The area above is colored blue (sky).
- The area below is colored brown (earth).
- The pitch determines the position of the horizon.





Attitude Indicator – Algorithm

- The goal is to make the horizon shift and rotate in response to pitch and roll.
- When airplane is flying “sideways,” a different equation is used to draw the line representing the horizon.



When Roll is not $\pi/2$ or $-\pi/2$

$y = (x + B * \sin(\text{Roll})) * \tan(\text{Roll}) + B * \cos(\text{Roll})$

When Roll is $\pi/2$ or $-\pi/2$

$x = -B * \sin(\text{Roll})$