Comparison of the Pressure Transducer for airspeed measurement.

Background

A comparison of the performance of the air speed measurement data by the pressure transducer is done in a wind tunnel with the pressure transducer from:

1. Wind tunnel instrumented pressure transducer
2. Crossbow Mnav pressure transducer
3. Micropilot pressure transducer

Setup

The wind tunnel (open channel) is instrumented with a differential pressure transducer that should be relatively accurate for wind tunnel experimentation and hence, this will be used as a baseline for us to check the performance of the 2 other pressure transducers that have been integrated into the sensor suits in the FCS.

As the pressure transducer used in the sensor suit does not have a differential port for the air speed measurement (or they are using the static pressure measurement from the barometer as the differential port), I set the static pressure to be the ambient condition rather than the static pressure in the wind tunnel test section as this will eliminate some effort to put the FCS or IMU into the wind tunnel test section. Therefore, for the pressure transducer that is instrumented in the wind tunnel, I removed the static probe tubing connected to the test section and let it be expose to the ambient air condition so that the 3 pressure transducer will have the same reference point for the dynamic and static pressure measurement.

Due to the constraint that there is only one probe instrumented at the test section and Greg told me that the wind tunnel airflow is quite repeatable with the same motor (fan) setting, I did the run in a sequential way instead of having the 3 pressure transducer collecting the data concurrently.

Conduct of the experiment

The speed of the air flow in the wind tunnel is increased by increasing the percent of the duty cycle of the motor that is driving the fan of the wind tunnel. The duty cycle of the motor is increase from 0 to 50% duty cycle with an incremental of 5% at every 30 seconds interval so that the airflow in the wind tunnel can reach a steady state between each increment.
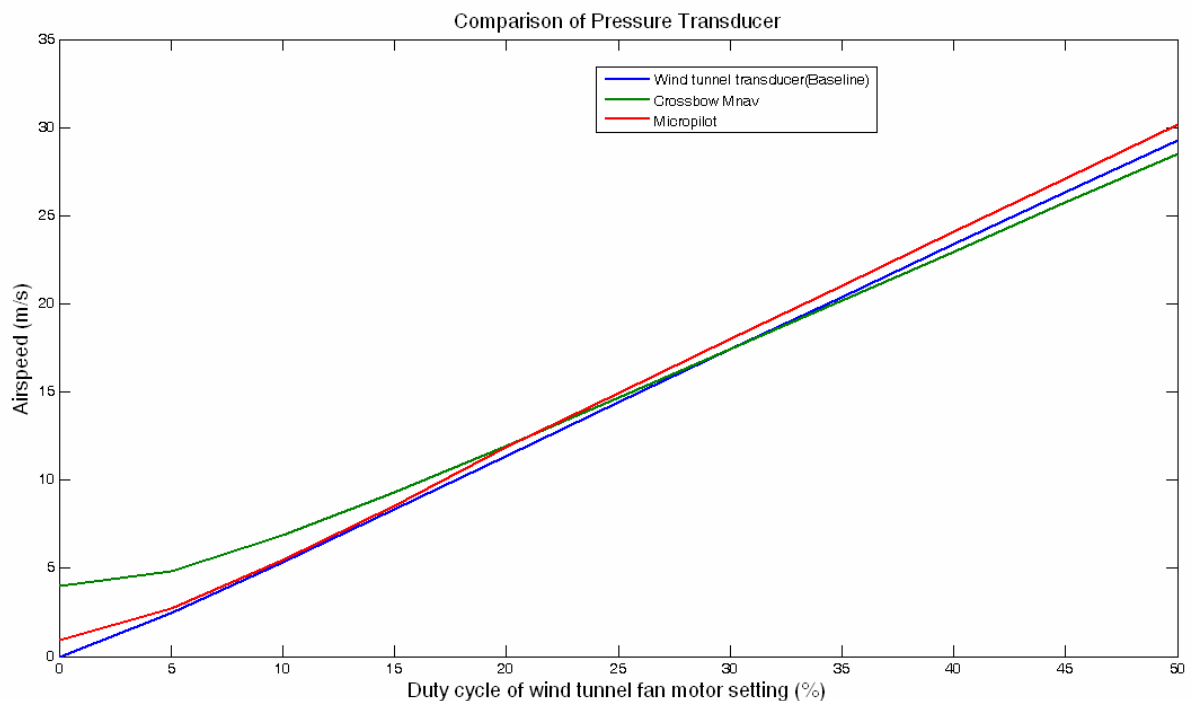
Result

Figure 1 Plot of the airspeed measured from the 3 pressure transducer

Figure 1 shows the plot of the comparison of the 3 pressure transducers. If we use the wind tunnel pressure transducer as the baseline (i.e. assume it to be accurate), it can be seen that the Micropilot FCS is much more accurate as compared to the Crossbow IMU. At the low speed, there is a huge bias in the airspeed measured by the Crossbow.

One point to note that the crossbow sensor data measured make use of the original calibration data that has been done since we have the unit last year and I have not

recalibrate it prior to this wind tunnel testing. For the Micropilot FCS, every time when the FCS boot up and initializes, it recalibrate its airspeed sensor and this may explain why the crossbow sensor performance is worst off than the Micropilot. Hence, if this sensor unit is used in our FCS development, it might be a good practice to do a auto recalibration of the air speed sensor whenever we boot up to use the system.

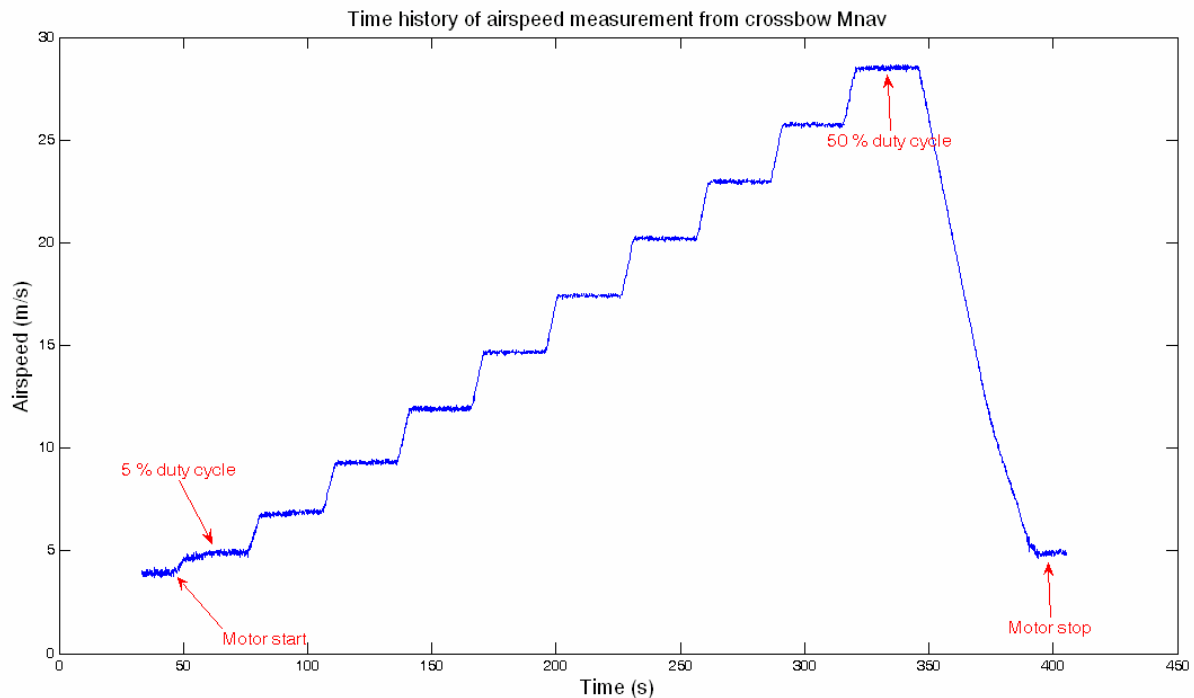## Time history of airspeed measurement from crossbow IMU

Figure 2 Plot of time history of air speed from crossbow Mnav

Figure 2 shows the time history of the plot of the air speed measured by the Mnav during the wind tunnel run which the duty cycle of the motor has been increased by 5 % in every time interval of 30 seconds. The sampling rate of the sensor is at 10 Hz (I used a low sampling rate as there is some problem of data logging using my laptop USB port with the serial converter)

Figure 3.1 and 3.2 shows the zoom in plot for figure 2 to the operating range that we had on the Micropilot for the indoor flight that we conduct previously.
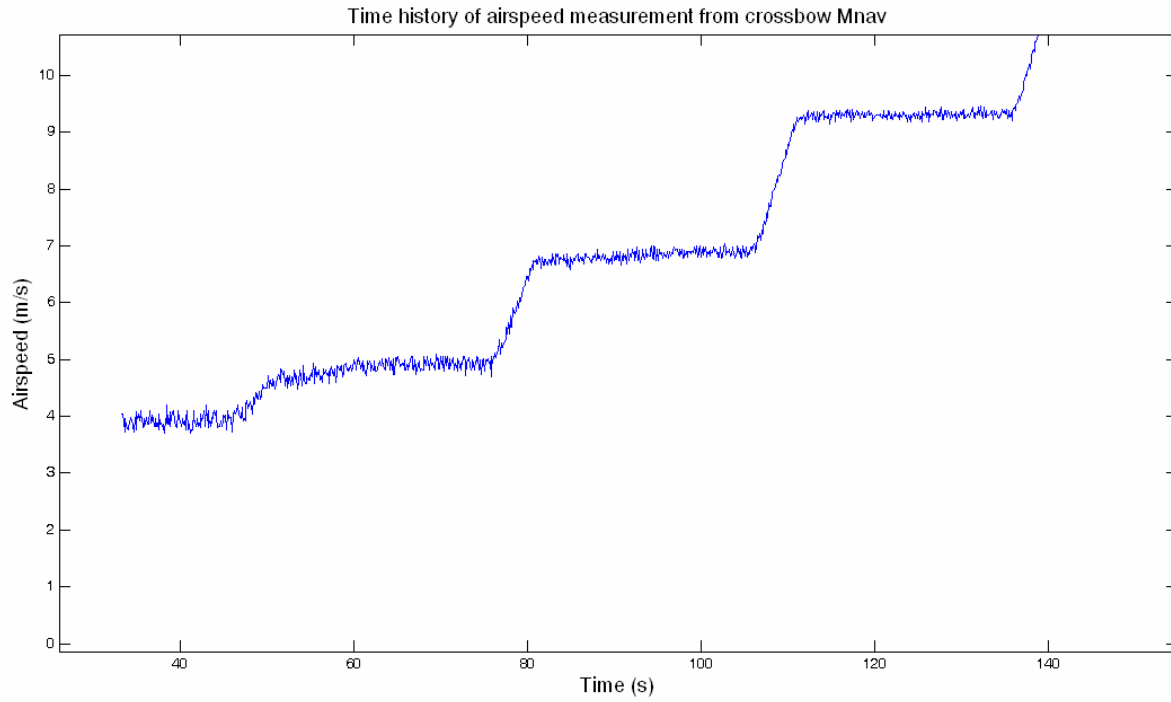
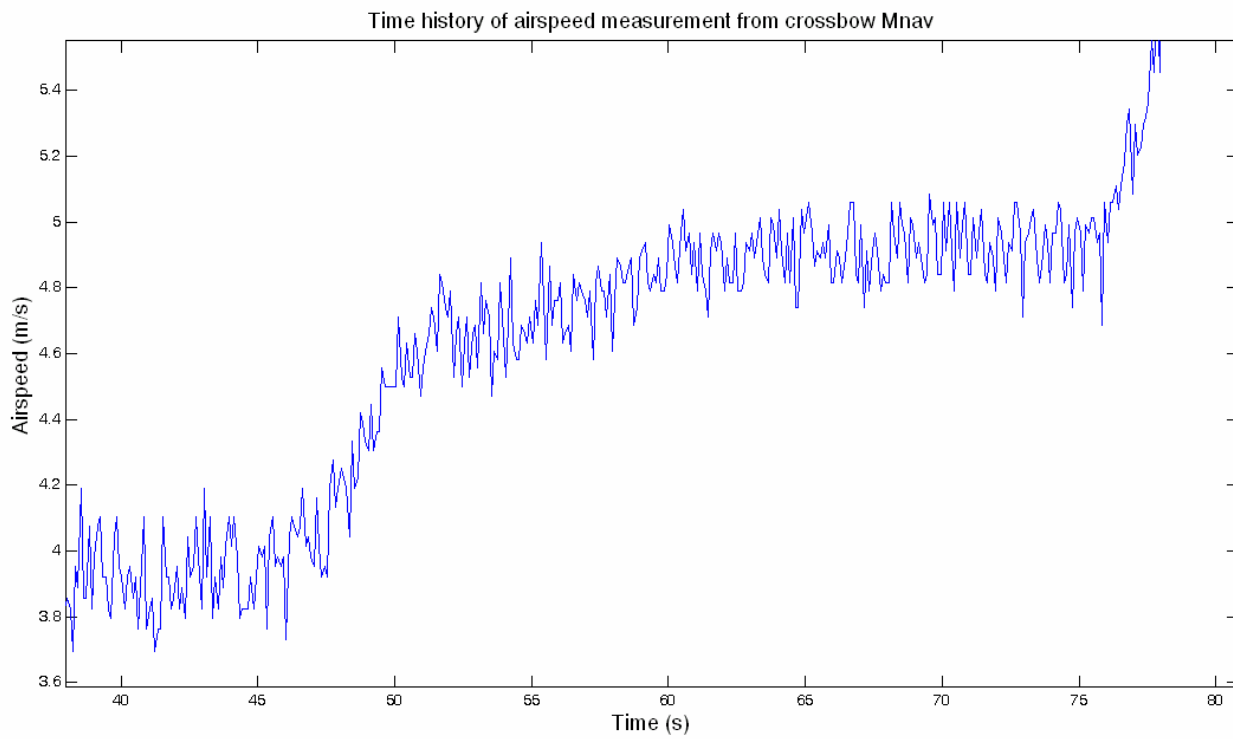Figure 3.1 Airspeed measurement from Mnav

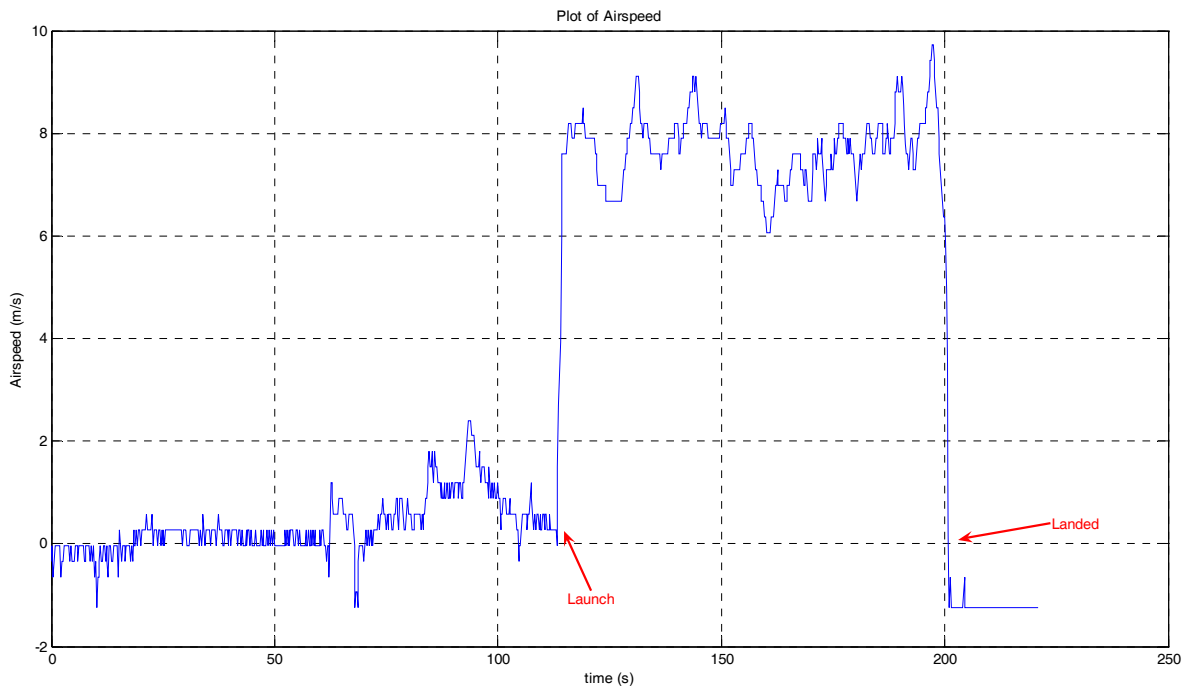Figure 3.2 Airspeed measurement from Mnav

Figure 4 Previous indoor flight test data using Micropilot

Figure 4 shows the previous flight test result using Micropilot. (I used this as I did not collect a time history data for the wind tunnel run using Micropilot) If we compared figure 3.1 and 4 for the effect of quantization in these 2 different systems, it is rather hard to tell which one has a larger quantization effect. However, the sampling rate of Micropilot (5 Hz) is lower as compared to Mnav (10 Hz), which makes the data from Micropilot looks like it has a large quantization error.