Using LAMS to Determine PCors

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BACKGROUND

Make the same assumptions that underlie the present PCors:

1. The total pressure at the tip of a pitot tube, p_t, is the correct static-plus-dynamic pressure and is measured correctly.
2. Errors in measurement of static pressure or dynamic pressure (respective true values $\{p_a, q_a\}$ and measured values $\{p_m, q_m\}$) both arise from an error in the pressure at the static buttons, Δp, so:

$$p_a = p_m + \Delta p$$

$$q_a = q_m - \Delta p$$

Note that $p_t = p_a + q_a = p_m + q_m$.

CURRENT USAGE

C-130:

$$\Delta p = c_0 + c_1 \frac{ADIFR}{QCR}$$

GV:

$$\Delta p = c_o + c_1 ADIFR + c_2 p_m + c_3 p_m^2$$

This is determined either from comparison to the avionics pressure or the trailing-cone pressure. There are significant differences, and it is not clear why.

CHOICES NOW MADE

- Initially, it was thought that the trailing-cone results should be more reliable, so those were used in early calculations.
- In HEFT-08, a set of reverse-heading maneuvers made the results based on the avionics pressure appear more reliable, so a change was made to those coefficients.
- However, it appears to me that the maneuvers were not done well for this purpose. They extend over a long time, during which speed was continuously increased, so there is no reverse-heading comparison for legs at the same speed and the same location.

EQUATIONS

Dynamic Pressure

$$q_a = \rho_a \frac{v^2}{2} = \frac{p_a}{R_a T_a} \frac{v^2}{2} \qquad (1)$$

$$q_a = q_m - \Delta p \qquad (2)$$

$$\Delta p = q_m - \frac{p_a}{R_a T_a} \frac{v^2}{2} \qquad (3)$$

Using LAMS To Determine Δp

- LAMS provides an independent measurement of v.
- Used with (3), errors in measurements of p_a and T_m have only minor effects on the resulting determination of Δp because they are small fractional errors.

ERROR ANALYSIS

$$q_a = \frac{p_a}{R_a T_a} \frac{v^2}{2}$$

Standard error propagation for independent error contributions:

$$\left(\frac{\delta q_a}{q_a}\right)^2 = \left(\frac{\delta p_a}{p_a}\right)^2 + \left(\frac{\delta T_a}{T_a}\right)^2 + 4\left(\frac{\delta v}{v}\right)^2$$

- If $\{p_a, T_a\}$ are each determined to $<$1% accuracy and v to 0.1% accuracy, q_a is determined to about 1.4% accuracy or, for values in the range 20-70 mb, an uncertainty of 0.3-1.0 mb.
- Measurements are probably better than this.
- For determining how Δp depends on various flight characteristics, the absolute accuracy is still less important.

PROPOSED NEW APPROACH

Use LAMS To Determine Δp:

1. Obtain a data file with LAMS processed for angle corrections, edited for QC, and inserted into a normal data file.
2. Use the preceding equations to determine the correction needed to pressure and the dependence of that correction on q_a, angle of attack, p_a, Mach number, etc.

Added Benefit: Calibration of Temperature

- Vertical integration of the hydrostatic equation requires accurate measurements of pressure and temperature.
- Once pressure is improved, integration between two pressure levels, compared to the geometric height difference between those two levels as given by GPS, will give a mean temperature for the layer. Uncertainty estimation: Accuracy of a few tenths degree C.