that wind variations are often larger than airdata calibration accuracy standards (typically 0.003 Mach). Ehernberger's data showed typical variations in wind of 0.075 Knots/mile and typical RMS values of 6 Knots over a 3.5 hour time period. His results agreed reasonably well with wind variability determined from larger data sets produced by the National Meteorological Center and the USAF Global Weather Center.

Chan[15] did a similar study of a vertical wind. For turbulent flight, it was possible to have large excursions in vertical wind data (+/- 6 knots peak-to-peak in two minutes) during a 20-min session, with the vertical wind returning to a mean value (2 knots) after the perturbation. Chan also concluded that, for most of the flight, the atmosphere was smooth, and the vertical winds generally averaged zero over a long period of time. In consideration of the above data, the SCADS technique employs a wind model which can vary linearly with time.

6.0 THE SCADS TECHNIQUE

The purpose of the flight test manoeuvre in the SCADS technique is to create an aircraft time history for which the errors in the airdata system are independent of wind speed and direction. The standard method of eliminating the correlation between wind speed and pitot-static errors is to fly the aircraft on reciprocal headings. This approach does not, however, adequately discern errors in the measurement of sideslip angle. In the SCADS technique, therefore, the aircraft is flown in a wind box pattern (see Figure 1). To further produce variation in angles of attack and sideslip and, therefore, to improve the information content of the time history, variations in airspeed and beta sweep manoeuvres have been incorporated in the various "legs" of the wind box.

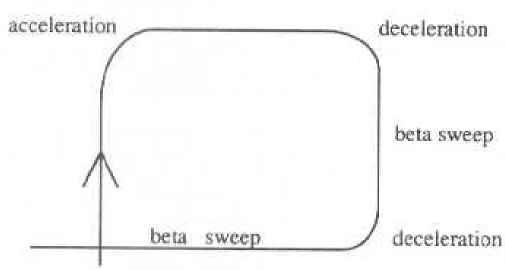

Figure 1 Typical Wind Box Pattern

According to the SCADS results from previous flight tests on the NRC Falcon 20[5], a wind box with an acceleration/deceleration manoeuvre in the first two legs of the wind box was better than a wind box flown at a single constant speed. In the present work, the requirement for a variation in airspeed over the SCADS manoeuvre was met by accelerating or decelerating the aircraft either on straight segments or during turns. For all wind boxes, a gradual sideslip change with constant track was executed in both directions (known as a beta sweep) on the third and last legs of the wind box. Each wind box covered the entire airspeed envelope of the helicopter. All wind boxes were performed within 25 km of the GPS reference station to maintain the optimum GPS measurement accuracy.

The general equations for SCADS were presented in Reference 5. Some of the equations specific to the SCADS application in helicopters will be listed below. The equations for the position error correction (ΔP), true dynamic pressure (P_d) and true static pressure (P_s) of the Bell 206B helicopter are approximated by:

$$\Delta P = C_{P0} + C_{P1} * P_{di} + C_{P2} * P_{di}^2$$
$$P_d = P_{di} + \Delta P$$
$$P_s = P_{si} - \Delta P$$

where

P_{di}, P_{si} are the indicated dynamic and static pressures.

The second order error term is uniquely used in this application on a Bell 206B. The helicopter up- and side-wash effects, as previously discussed in Section 4.0, 'Flow Angle Modelling', may be implicitly expressed in the vane calibration equations as:

$$\alpha = C_{A0} + C_{A1} * \alpha_m$$

$$\beta = C_{B0} + C_{B1} * \beta_{Fm}$$

where the terms C_{A0} and C_{B0} reflect the sum of biases from the misalignment of the noseboom plus the up- or side- wash effects. C_{A1} and C_{B1} are sensitivity factors, and α_m, β_{Fm} are the geometric or static angle of attack and flank angle of attack measures.

To summarize the SCADS technique, the following parameters were measured during the wind box manoeuvre:

- dynamic pressure, static pressure, 3 attitudes (θ, ϕ, ψ),
- total temperature, 2 noseboom vane deflections,
- 3 angular rates (P, Q, R), 3 GPS ground speeds (V_{GN}, V_{GE}, V_{GD}), and GPS altitude (Z_G).

The aircraft ground speed vector for the manoeuvre is calculated from the true airspeed vector and an assumed wind model. The Direct Search Complex Algorithm method[16,17] varies the coefficients of 1) the position error correction equations, 2) the airflow angle model and 3) the wind model in order to minimize the weighted sum of the errors between the GPS-measured ground speed vector and the calculated ground speed vector. The minimization also considers the difference between calculated pressure altitude and GPS-derived altitude.

7.0 AIRCRAFT DESCRIPTION

The validation of the SCADS technique was performed using the NRC Bell 206B JetRanger (see Figure 2). This aircraft is a single engine utility-type helicopter. The main rotor is a two-bladed, semi-rigid see-saw type. The main rotor blades are of all-metal construction of aluminum alloy monocoque type. The diameter of the main rotor is 33 ft 4.0 in and the length of the chord is 13 inches.

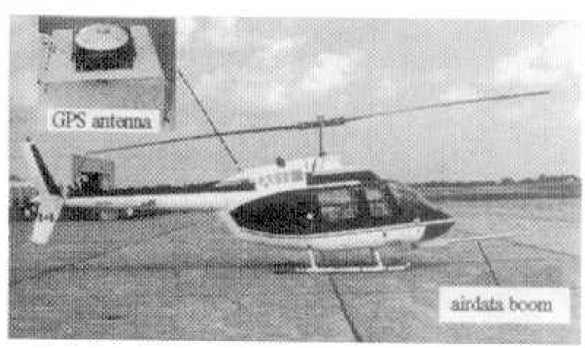

Figure 2 The NRC Bell 206 Helicopter