TECHNOLOGY WHITE PAPER

Optimizing Air Data Computers for Rotorcraft Applications

CURTISS-WRIGHT

DEFENSE SOLUTIONS

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Introduction

Aircraft use Air Data Computers (ADC) to acquire and process data from pitot and static pressure sensors, data buses, and analog inputs to obtain key air data parameters essential to flight. These parameters include altitude, airspeed, height deviation, and temperature.

There are some unique phenomena that influence the accuracy of pressure measurements for rotorcraft because of the downwash from the rotors. This is particularly evident during take-off, landing, and hovering. Additionally, rotorcraft fleets often consist of different aircraft, and this can create additional logistics overhead as air data units must be separately calibrated for each aircraft type. This white paper discusses how optimized ADCs can address some of the unique requirements for rotorcraft.

Challenges for Air Data Computers

Information from air data units is critical to the effective and safe operation of all aircraft. The raw data aircraft typically use to calculate base parameters is derived from pressure measurements. In the case of rotorcraft, the pressure measurements are compromised because the air around the sensors is disturbed by the effect of rotor downwash.

Rotor downwash occurs as the sensors are located on the airframe and, without forward velocity, they are caught in the air that is pushed down by the rotor blades. This creates pulses of pressure, also referred to as pneumatic noise, which must be corrected or will result in inaccurate readings. This rotor blade modulation will give approximately 4 Hz air pressure pulse/revolution. Downwash from rotor blades makes accurate measurement impossible at low airspeed (<30kt) as the downwash dominates the air pressure.

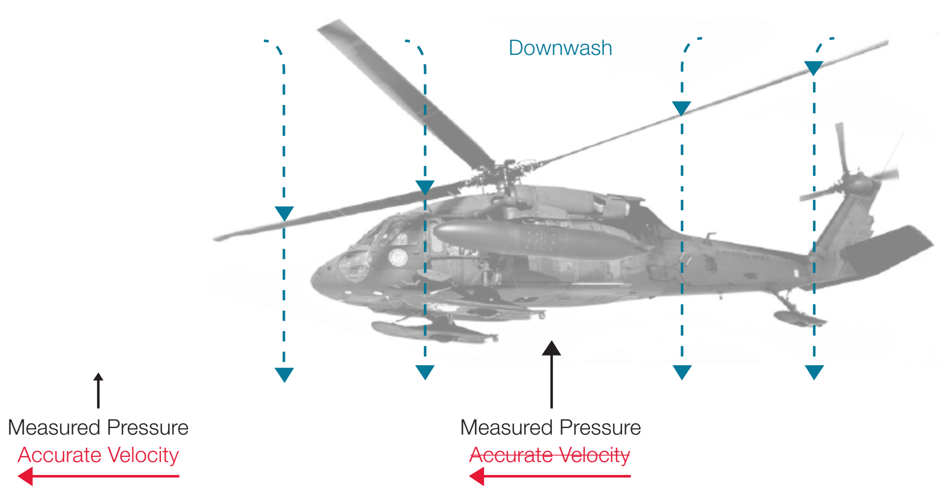

Figure 1. At low speeds, downwash interferes with accurate velocity readings

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A related effect is when a rotorcraft moves vertically in liftoff – a rush of air downwards further obscures the pressure sensors and can cause a negative speed reading on instruments.

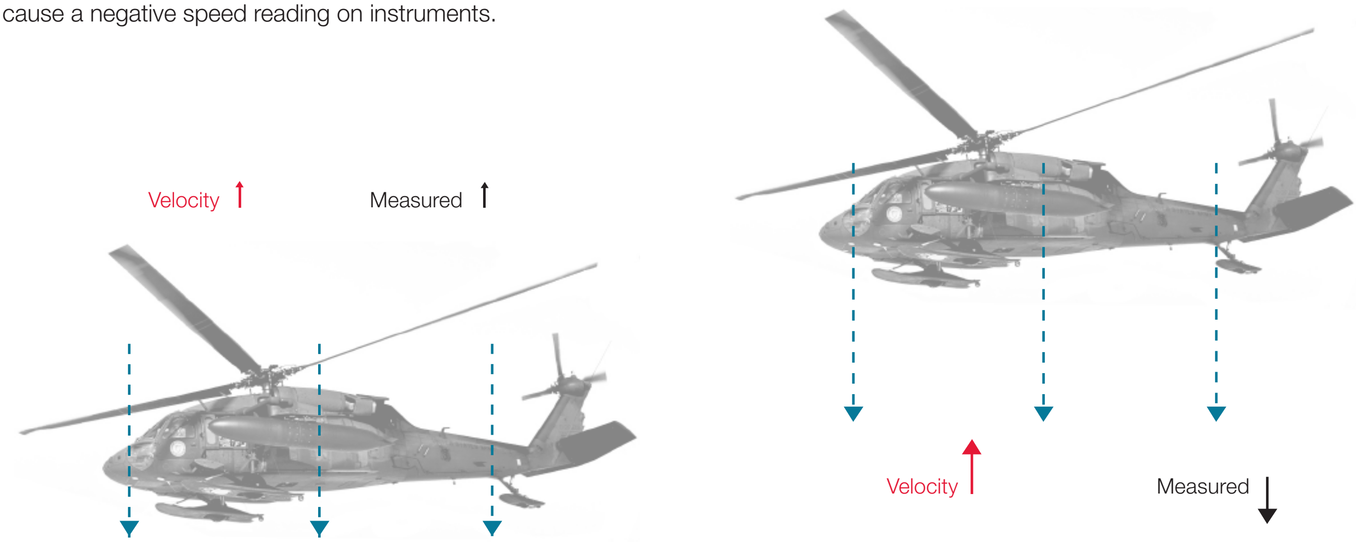

Figure 2. A rapid upward velocity caused a downwash to obscure the accurate measured velocity

These effects are most apparent at low airspeeds which can create safety and flight management issues; knowing the aircraft's speeds at take-off and landing is particularly important. It becomes even more problematic in conditions with poor visibility where a pilot cannot effectively use instruments to maneuver.

Another issue encountered frequently with rotorcraft fleets is the diversity of aircraft types. As different rotorcrafts suit different tasks (passenger transport, search and rescue and various military applications for example), and fleets grow over the years, it is not uncommon that operators will have more than one type of aircraft using the same type of ADC.

Each air data unit must be calibrated to the aerodynamics of each platform type, so it follows that different spare air data computers units are required for each platform. This adds to the logistics burden and increases the capital invested in spare parts.

Approaches to Overcoming Air Data Challenges for Rotorcraft

Current approaches to resolving these challenges are mixed. One tactic is to use a separate low speed probe. These can be used to provide a separate stream of information for periods of low speed operation and provide data for vertical acceleration. When forward velocity increases, data can be transitioned to the traditional ADC. This overcomes the limitations of a traditional ADC, but it requires the purchase, installation, and maintenance of another piece of hardware. Additionally, the primary ADC, or another unit, must be capable of providing the cockpit instrumentation with a single seamless stream of data from multiple sensors.

Another option is to use mechanical dampening which attempts to filter the pneumatic noise in air pressure to offset these effects. While this approach is proven, it adds weight, takes space, and increases the maintenance burden on the operator. It also doesn't address pressure issues during periods of vertical acceleration. An example of an implementation would be to insert an airflow restrictor in the pipe between a pitot tube and an ADC while connecting one liter of air volume into the pipework using a T-connector. This is analogous to placing a resistor in series and a capacitor in parallel to create a filter. This also implies that an electronic solution is possible – instead of correcting the signal into the pressure transducer, the resulting electrical signal can be filtered. This removes the need for voluminous and heavy mechanical solutions.

Reducing Logistics Overhead

A possible solution for easing logistic overheads for managing the required number of separate spares is to reduce the number of different types of air data units needed. Since each part number is typically managed separately, the objective is to have an ADC that can hold multiple configuration settings so that a single ADC can be installed on different platform types and easily set to apply

Figure 3. A bank of configurations stored within one ADC model eliminates the need to carry spares for all platform types

the correct calibration settings for that aircraft. This method is somewhat analogous to having several user profile settings on a single laptop.

Curtiss-Wright has over 50 years' experience developing air data systems and has evolved its line of air data computers to include features that address the unique requirements for rotorcraft operations. Its current ESCADU products implement these features to provide the market with compact products, ideal for rotorcraft.

To reduce the pneumatic noise associated with the rotor blades, the input pressures are subjected to one of four electronic low pass filters. The filter selected is a configurable item (no filter is an option). All applicable outputs are selectable (via Source Error Correction Enable input) for correction of pneumatic source errors. The digital interface pressure transducer uses software filters to employ a strategy that addresses the pneumatic noise and lowers cost of ownership by reducing weight and removing maintenance issues for the operators versus a mechanical solution.

The instantaneous downwash increase when the pilot applies the control that results in a negative Vertical Speed Indication when the helicopter is in fact climbing, is addressed through an interface to an accelerometer. The acceleration can be derived from an attached accelerometer giving a linear voltage output transform. The acceleration parameter input range is configurable by defining the "g" and associated input voltage range, for example +3.955V dc/g and at +1g over 0 to +2g. The measurement accuracy is better than ±1% full scale with resolution >1 mV, with a minimum accelerometer sensitivity of 0.5V/g.

Reducing logistic overheads is achieved by using four isolated discrete inputs on the ADC to select up to 15 different configuration table settings. Each configuration allows a unit to be customized for a specific aircraft platform. Selection is achieved by linking discrete input pins to a configuration common pin in the loom of the mating connector. Thus, it is simple to replace an ADC on up to 15 different aircraft platforms using a single part number.

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Conclusion

Accurate low airspeed measurement is critical in rotary applications and is problematic due to the effects of the flow of air from the rotor impinging on the pressure sensing system. This rotor downwash can particularly affect speed readings at take-off, landing and in the hover. Such can be addressed in a number of different ways including mechanical dampening systems and the installation of additional sensors. Curtiss-Wright has developed technologies within its ADC to mitigate these effects without requiring additional mass and space. Additionally, the needs of many rotorcraft operators to manage spares for diverse fleets is simplified with a single unit being usable on up to 15 different platforms through a simple pin-out selection.

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Interview with Stephen Willis: Air Data Computer