THE ARA SECOND-GENERATION ESP SYSTEM

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1 Introduction

The Aircraft Research Association (ARA) has been using electronically scanned pressure (ESP) sensors in its Transonic Wind Tunnel (TWT) for the last decade. These scanners have now largely replaced mechanically scanned pressure transducers (Scanivalve™) in tests at ARA, with acquisition times measured in milliseconds rather than seconds. This has made a significant contribution to wind tunnel productivity allowing continuous model motion during pressure measuring tests.

The first-generation ESP data acquisition system implemented at ARA has served the company well for many years. It however suffered from a number of operational deficiencies. ARA has now used its considerable experience with ESP sensors to design and manufacture its second-generation ESP data acquisition system.

2 First-Generation ARA ESP Data Acquisition System

The first-generation ARA ESP system comprised a Pressure Systems Incorporated (PSI) 8400 data acquisition system controlled by a Radstone VME computer. This computer also provided the interface between PSI 8400 and the main tunnel data acquisition and reduction systems. Although the system has occasionally been used with Scanivalve™ ZOC ESP scanners the majority of tests have been made with PSI™ 48 and 64 port SL and HD scanners. This initial implementation suffered from two main deficiencies:

- The only user interface available for checkout was a small two-line display and multi-function keypad. This made for inefficient model checkout and fault finding

- The length of time taken by the PSI 8400 to perform a calibration. PSI ESP modules have significant signal output drifts with temperature and this resulted in the need for frequent tunnel-on re-calibrations. The PSI 8400 system sequentially generated calibration pressures and, due to tubing lengths, this process took about one and a half minutes to perform. This was expensive in terms of wind on tunnel time and a frustrating delay for tunnel test teams.

3 ARA Second-Generation ESP System Requirements.

Both the system deficiencies and the age of some of the components in the first-generation ARA ESP system led to a requirement being issued for a replacement ESP data acquisition system. Included in the specification for this system were:

- The provision of a user friendly interface for checkout and fault finding.
- A reduction in the calibration time to that which could be hidden in the “fly back” time between polars.
- Full integration into the ARA data acquisition and reduction environment.
- Integrated quality assurance monitoring.
- Scaleable and modular design that would allow systems to be produced that match the requirements of a particular ARA facility.

- Reasonable production cost to allow for the provision of full pre-test checkout facilities in the model rigging bays.
- Minimization of model wiring.
- Robust and reliable design which is efficient to use and maintain in a commercial wind tunnel environment.
- The ability to use both PSI™ and Scanivalve™ scanners.

4 Available Options.

The options available to ARA were to purchase off-the-shelf ESP data acquisition systems from one of four commercial suppliers or develop an in-house system to ARA's specification. In particular the latest offering from PSI using its Digital Temperature Compensation (DTC) ESP modules was seriously considered. These modules incorporate a temperature compensation system that, the manufacturers claim, significantly reduces the requirement for wind-on re-calibrations. However no trade in for ARA's existing stock of twenty PSI ESP modules was available and the cost of purchasing a complete new set was prohibitively expensive. Also ARA tests models for many customers throughout the world, some of whom bring their own, uncompensated, ESP modules. It was considered that the system must be able to cater for these without any degradation in performance. In addition significant software development would be required to fully integrate any of the commercial systems into ARA's wind tunnel environment. In the final analysis it was felt that it would be more advantageous to put the software effort into the development of an in house ESP system, tailored to ARA's needs.

5 ARA ESP System.

The ARA ESP system was designed to meet all the criteria in section 3 above and comprises:

- Scanner interface system providing true differential input amplification and digital data buffering for up to 32 ESP modules.
- An efficient model wiring system eliminates the duplication of address and power supply wires.
- Up to four PC based 16 bit ADC cards with on board Digital Signal Processors (DSP) providing the real-time control, data acquisition and processing for up to 32 ESP modules simultaneously, providing high scanning rates even with a large number of scanners.
- A PC containing the ADC cards and acting as system controller with it's code written in Microsoft C and an Ethernet link to the ARA data reduction system providing for a high data throughput.
- A PC providing the user interface coded using National Instruments Lab View and connected to the System controller by an Ethernet link. An auto scanner and tube detect facility allows hands free leak checking of complete models. The simple network link permits the user display to be easily installed in the tunnel working section if required.
- A calibration system catering for ESP scanners with up to five different pressure ranges and containing precision calibration and quality assurance monitoring transducers. By presenting pre-generated calibration pressures to the ESP modules calibrations are performed in twenty seconds, providing a significant saving in calibration time.

6 Dynamic Data Acquisition

Advantage has been taken of the ADC cards on board DSPs to simultaneously calculate a measure (variance) of the dynamic content of the pressure on each port of the ESP scanner. It is intended that this will allow the detection of regions of separated flow and the tracking of vortical flows. Initial wind tunnel trials have yielded very encouraging results in this respect.