LabVIEW Data Acquisition System for Aircraft RVSM Certification

by

Marcela Maldonado
Consultant, Measurement and Automation
Data Science Automation
USA

And

Rex Pawlak
Senior Electrical Engineer
Raytheon Aircraft Company
USA

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The Challenge
Facilitate the required testing to maintain Beechcraft Premier I Reduced Vertical Separation Minimum (RVSM) group certification without impacting delivery schedule.

The Solution
Assemble a portable data acquisition system, designed for quick installation and removal from test aircraft to record air data from instrumentation transducers and airplane avionics equipment during certification flights.

Introduction
Air traffic movements have been dramatically increasing during the past few years and forecasts indicate continued growth throughout the world. Major changes in the air traffic management systems are necessary to handle the increase. The industry is relying on the Reduced Vertical Separation Minimum (RVSM) method for a very cost effective short-term solution for meeting this need by providing additional flight levels (altitudes) where aircraft can fly safely.

Originally, during the 1950's, the vertical separation for aircraft was 1000 feet. However, the accuracy of mechanical pressure sensing altimeters at that time decreased significantly at higher altitudes. In 1960, the Vertical Separation Minimum at higher altitudes was increased from 1000 feet to 2000 feet.

Multiple international studies conducted during the 1980s demonstrated that reducing the vertical separation minimum was a safe, feasible and cost-effective method to allow increased air traffic. The first plans for implementing RVSM began in 1990 in Europe.

The U.S. domestic RVSM program is a key element of the FAA's National Airspace System Operational Evolution Plan. Its objective is implementing RVSM in the airspace of the 48 contiguous states of the United States, Alaska, and the Gulf of Mexico. There are seven flight levels (FL) over FL 290. The implementation of RVSM will create six additional flight levels. The benefits include additional airspace capacity, fuel savings through the use use of optimum altitude profiles, environmental benefits from reduced fuel burn, and other lesser benefits.

The System

Raytheon Aircraft Company (RAC) is a leading general aviation airplane manufacturer who produces the Beechcraft Premier I light business jet. The aircraft has to comply with the Minimum Aircraft Systems Performance Specification, which ensures altitude accuracy using at least two independent altimeters on board the aircraft to meet the RVSM regulatory requirement.

RVSM testing on other RAC business jets requires only static pressure from a trailing static cone. The Premier I aircraft also requires independent mea-surements of both pilot and copilot static pressures on the airplane under test. Additionally, analysts require data from the airplane's air data computers (ADC's) including airspeed, altitude, and static pressures.

The initial RVSM certifi-cation was conducted on the same airplane used in the type certification program. FAA regulations require testing every 20th airplane to verify that the 'group' continues to meet requirements. Raytheon Aircraft desired a portable data acquisition system to facilitate continuing testing without impacting deliveries of the Premier I jet. They turned to Data Science Automation (DSA), a National Instruments Select Integrator Partner with extensive experience in Measurement and Automation technologies for implementation of the RVSM data acquisition system.

When the need for the data acquisition system was identified, all test airplanes were scheduled for delivery to customers; therefore the system needed to be operational in a very short amount of time. The system had to be small and provide the facility to be installed and removed quickly from the airplanes. Raytheon Aircraft assembled a data acquisition system consisting of a laptop computer for the base of the system along with high precision instrumentation absolute pressure transducers (Rosemount 2014 Micro Air Data Transducer), the two air data computers (ADC) aboard the airplane, and a PCMCIA to ARINC 429 data conversion card (Condor Engineering CEI-710-84) used to acquire the data through the ARINC 429 protocol. In addition the test airplane or a pace airplane trailed a static cone to record the 'truth' altitude.

Data Science Automation implemented a computer-based system using LabVIEW. It acquires data from the two instrumentation transducers and the test airplane air data computers via the ARINC protocol, using a LabVIEW Instrument Driver obtained from the PCMCIA card manufacturer. The ARINC card supports eight receive channels

that can be used to communicate with four different ARINC data busses (the two pressure transducers and two ADCs in this case). The transducers and ship's ADCs support multiple *labels* (different measurements that can returned via the ARINC bus). The LabVIEW Virtual Instrument (VI) designed by DSA acquires data from 12 different labels among the four instruments at a rate of 10 scans per second. The data obtained from ARINC is returned in binary format. Different instruments return data in different formats so DSA implemented code that converts the binary data to the corresponding engineering units for each label read on each channel. The application then proceeds to record the measurements to the laptop's hard drive along with a timestamp and other critical information.

The user interface was designed taking into account the environment of where the application is executed - aboard the aircraft during a test flight. The user enters the aircraft serial number as well as the flight number. The system displays selected altitude and pressure data on the VI's control panel and provides the user with the ability to begin logging data to the file at any point. Data is recorded only when the airplane is at a specific weight, altitude and airspeed pre-defined test point to prevent recording superfluous data. Each time recording is initiated; a run number (which is recorded to the log file) is incremented. This allows easier post flight data analysis by comparing run numbers to the flight crew's test card. The user may also key an event by the clicking a front panel button or using a shortcut key. Events are used within a run to identify precisely when the desired condition was achieved, or to identify anomalies observed by the crew for later detail investigation.

Conclusion

In previous certifications, the ship values were hand recorded. To improve accuracy and obtain more data, Raytheon decided to record these values electronically. This provides analysts with the data needed to ensure continuing RVSM certification for the Beechcraft Premier I business jet. The portability of the system allows Raytheon Aircraft to conduct testing without impacting the airplane delivery schedule.

The application was developed in Pittsburgh, PA without access to the hardware in RAC's Kansas facility. NI LabVIEW provided the means to develop quick application prototypes that were mailed electronically to Raytheon to obtain feedback from engineers and users about the system's functionality and user interface. Incorporating modifications to accommodate fixes, new requirements, and additional features proved to be very simple and fast, which is extremely important when the delivery deadlines or test flights schedules are very tight. We were able to interact with third party boards and instruments seamlessly and efficiently. The fast development allowed by LabVIEW, as well as its communication, file I/O, and user interface tools, permitted us to concentrate on implementing the features required by the system without spending any time on implementing the interface and functions that are already an inherent part of LabVIEW.