

THUNDERBIRD: Advancing Aerospace Test Capability Through Portable Precision Pressure and Vacuum Control



The Challenge

A defense customer responsible for maintaining and validating mission-critical aerospace systems faced a growing challenge. Acceptance testing activities increasingly needed to be performed closer to the point of maintenance rather than within centralized laboratory environments. However, the pressure and vacuum test systems traditionally used to support these activities were often large, facility-based assets that were difficult to deploy where they were needed most.

This created logistical obstacles that could extend equipment downtime, increase transportation requirements, and limit testing flexibility across geographically dispersed maintenance operations. At the same time, the customer required laboratory-grade pressure and vacuum performance to support demanding aerospace test procedures and could not compromise measurement accuracy or reliability in exchange for portability.

Existing solutions typically prioritized either portability or performance, but rarely both. Systems capable of delivering the precision required for aerospace applications were often too large or complex for field deployment, while portable alternatives frequently lacked the accuracy, scalability, or integration flexibility needed to support operational test requirements.

The Solution

ADVINT designed and built a rugged pressure and vacuum control platform, THUNDERBIRD. A portable solution capable of delivering precise closed-loop performance in a compact, field-deployable package. To bring advanced aerospace test capability closer to the point of need, the following design features were implemented:

- **Capable:** Provide high-accuracy pressure and vacuum control across a broad operating range to support diverse test applications.
- **Compact:** Deliver advanced functionality in a portable, space-efficient form factor.
- **Compatible:** Integrate easily with existing test systems using standard interfaces and industry-proven technologies.
- **Rugged:** Ensure reliable operation in demanding field and laboratory environments.
- **Scalable:** Support growth and evolving test requirements without increasing system complexity.
- **Safe:** Incorporate multiple layers of protection for personnel, equipment, and UUTs.
- **User Oriented:** Reduce operator workload through intuitive software, automated functions, and simplified maintenance procedures.

THUNDERBIRD Solution Overview

THUNDERBIRD is a rugged 3U rackmount pressure and vacuum control assembly built using National Instruments (NI) hardware and LabVIEW® software. Designed to deliver precise closed-loop control across a range of zero (0) to seven hundred twenty-five (725) pounds per square inch absolute (PSIA) or zero (0) to fifty (50) bar, THUNDERBIRD combines laboratory-grade accuracy with a compact, field-deployable form factor.

While optimized for integration with ADVINT's Portable Universal Multi-Channel Asset (PUMA) platform, THUNDERBIRD can be deployed within any standard four-post, 19-inch rack. Its flexible architecture enables advanced pressure and vacuum testing capabilities to be deployed closer to the point of need while reducing reliance on centralized test infrastructure.



Capable

THUNDERBIRD incorporates three precision pressure transducers, delivering full scale (FS) measurement accuracy of up to 0.008% of reading (RDG), as shown in Table 1. Two of the transducers feature configurable measurement ranges, allowing the system to be tailored to application-specific requirements while maintaining high accuracy across a broad operating envelope.

Table 1: Transducer Reading Accuracy

Range	Accuracy
≥33% FS	0.008% of RDG
<33% FS	0.008% of FS/3

Using LabVIEW, THUNDERBIRD continuously monitors pressure feedback and automatically adjusts outputs to maintain precise setpoint control. In addition to pressure regulation, the system supports static vacuum leak testing for both internal self-test functions and external Unit Under Test (UUT) verification.

Compact

Conventional pressure and vacuum control systems require significant rack space and supporting infrastructure. THUNDERBIRD consolidates this functionality into a compact 3U chassis measuring only 28 inches deep.

This reduced footprint enables deployment alongside field test equipment without sacrificing performance, allowing advanced test capabilities to be integrated into environments where space and mobility are critical considerations.

Compatible

Designed for seamless integration into both existing and future test architectures, THUNDERBIRD utilizes an onboard NI USB-6423 mioDAQ device to manage analog and digital input/output (I/O) through a simple USB interface.

The system accommodates a wide range of pneumatic pressure and vacuum sources, utilizing industry-standard ¼-inch Joint Industrial Council (JIC) connections (SAE J514) for reliable operation and simplified integration. Three independently switched outputs distribute pressure setpoints only where needed, increasing flexibility and operational efficiency.

THUNDERBIRD accepts universal input power from eighty-five (85) to two hundred sixty-four (264) volts alternating current (VAC), enabling deployment across a variety of operating environments with minimal infrastructure requirements.

Rugged

THUNDERBIRD was engineered for aerospace and defense environments where equipment must withstand frequent transportation and operation in demanding conditions.

Solid stainless-steel process lines and pneumatic components provide durable, leak-resistant connections, while vibration-resistant hardware enhances reliability during transport and operational use. When integrated with ADVINT's PUMA platform, these features help support long-term operational readiness and system durability.

Scalable

As operational requirements evolve, test systems must be capable of adapting without introducing excessive complexity.

THUNDERBIRD minimizes infrastructure requirements by utilizing only alternating current (AC) power and USB communication. This architecture allows multiple THUNDERBIRD assemblies to be deployed within a single test system, expanding pressure and vacuum control capabilities without requiring extensive system modifications or additional resources.

Its modular design provides flexibility for future enhancements and evolving program requirements.

Safe

Safety considerations were integrated throughout every aspect of the THUNDERBIRD design.

Configurable overpressure protection switches provide redundant safeguards to prevent outputs from exceeding UUT pressure limits. Integrated pressure relief devices and filtration systems protect both the platform and connected equipment from overpressure events and foreign object debris (FOD).

A low-noise exhaust system improves operator comfort while reducing hearing hazards, while a manual vent valve enables pressure to be safely released prior to disconnecting external sources.

Together, these features help support safe operation across laboratory and field environments.

User Oriented

THUNDERBIRD simplifies operation through a combination of intelligent software controls and thoughtful hardware design.

LED indicators provide clear visibility into system power and pneumatic output status, while a switched AC outlet automatically controls an external vacuum pump, reducing operator workload and simplifying test setup.

Software-controlled pressure setpoints automatically compensate for altitude and barometric pressure variations, eliminating the need for manual adjustment and supporting greater repeatability across operating environments.

ADVINT developed a LabVIEW instrument driver and customizable user interface that provides practical implementation of the system application programming interface (API). These tools simplify integration, accelerate deployment, and help users quickly understand system functionality.

Maintainability was a key design objective. Pressure transducers can be accessed and replaced without removing the assembly from the test system, helping to streamline service and calibration activities.

SWaP

THUNDERBIRD delivers high-performance pressure and vacuum control in a compact, lightweight package optimized for both laboratory and field deployment.

Table 2: Size (S), Weight (W), and Power (P)

	Size	Weight	Power
THUNDERBIRD	31.3" X 19.0" X 5.3" (795mm X 483mm X 133mm)	49 lbs. (22.2 kg)	210 Watts
Rack-Based System	31.0" X 23.0" X 50.0" (78.74cm X 58.42cm X 127cm)	400 lbs (181 kg)	750 Watts

Leveraging LabVIEW and NI Technology

NI hardware and LabVIEW software provided a proven measurement, control, and development foundation that enabled ADVINT engineers to rapidly develop THUNDERBIRD while focusing on application-specific functionality rather than underlying infrastructure.

The NI USB-6423 mioDAQ device simplified analog and digital I/O integration while providing the measurement performance needed for precision pressure and vacuum control. The USB-6423 mioDAQ was compact enough to fit within TUNDERBIRD’s condensed chassis eliminating the need for custom wiring between THUNDERBIRD and the rest of the test system, thereby reducing the electrical connection requirements to only power and USB. Moreover, it seamlessly integrated with the existing LabVIEW architecture, allowing a unified environment for data acquisition, automation, control system development, and user interface design.

This combination allowed ADVINT to rapidly develop and refine THUNDERBIRD's closed-loop control capabilities, operator interfaces, safety functions, and system integration features while maintaining the flexibility needed to support future enhancements.

By leveraging proven NI technologies, ADVINT was able to focus engineering resources on solving the unique challenges associated with portable aerospace pressure and vacuum testing.



Addressing the Need for Portable Aerospace Test Capability

Modern aerospace platforms rely on increasingly sophisticated test procedures to validate system performance and maintain operational readiness. Many of these procedures require precise pressure and vacuum control to verify mission-critical components and subsystems.

Historically, these tests have often been performed using centralized equipment located within dedicated maintenance facilities. While effective, this approach encounters transportation delays, increase equipment downtime, and limit testing flexibility when assets and personnel are distributed across multiple locations.

THUNDERBIRD provides a practical approach to extend advanced pressure and vacuum testing capabilities beyond traditional laboratory environments. Key design features – portability, compact, precision, scalability, rugged – enable organizations to deploy critical test capability where it is needed most while reducing logistical complexity.

By combining NI hardware, LabVIEW software, and ADVINT's expertise in automated test and measurement systems, THUNDERBIRD is a configurable commercial off-the-shelf (COTS) product capable of supporting aerospace, defense, and industrial applications closer to the point of need.

As aerospace and defense organizations continue to seek ways to improve operational readiness and reduce dependence on centralized test infrastructure, portable solutions that provide accurate measurement, automation, and simplified deployment, such as THUNDERBIRD, will be an increasingly important role in supporting maintenance and readiness objectives.

About ADVINT

Located in Columbus, Ohio, ADVINT is a veteran-owned small business and a recognized leader in the design and build of automatic test systems for military and commercial applications. As a full-service system integrator, we provide end-to-end hardware and software development, custom fabrication, and turnkey solutions tailored to the most demanding environments without compromising precision or performance. Our multifaceted platforms integrate advanced data acquisition, control, and analysis capabilities, empowering clients to solve complex challenges in any industry (clean energy, aerospace, defense, life sciences, manufacturing, etc.). Whether you're seeking real-time field diagnostics, intuitive user interfaces, or scalable automation, ADVINT, known for unsurpassed customer responsiveness, supports everything from early-stage consultation to full deployment.

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