
# Modernizing the Nation's Aerospace and Defense Test Infrastructure

## Unlocking ROI, Automation, and Readiness through Digital Test Transformation

Applied Dynamics International (ADI) | Whitepaper | 2025

## Executive Overview

Across the U.S. aerospace and defense industry, the backbone of engineering innovation, the nation's test infrastructure, is aging. Test rigs, control systems, and instrumentation platforms that once defined aerospace excellence are now old, brittle, and increasingly difficult to maintain.

These systems remain indispensable, supporting flight control development, propulsion testing, and system certification for aircraft, spacecraft, submarines, and mission systems. Yet decades of underinvestment have left them technologically obsolete, costly to sustain, and poorly integrated with today's digital engineering environments.

As the Department of War and industry leaders accelerate toward digital transformation, modernizing these test assets has become a strategic imperative, critical to maintaining readiness, safety, and technological leadership.

# The State of U.S. Aerospace & Defense Test Assets

## Aging and Obsolete Systems

Commercial and government organizations in the U.S. operate hundreds of test assets that are 15–30+ years old. Many rely on:

- Outdated real-time operating systems and legacy bus architectures.
- Custom electronics and proprietary software no longer supported by vendors.
- Limited data integration, restricting automation and insight.
- Weak or nonexistent cybersecurity protection against modern threats.

## Impact on Efficiency and Mission Readiness

Aging test systems result in:

- High sustainment costs and prolonged downtime.
- Dependence on tribal knowledge as experienced staff retire.
- Manual test execution and data reduction, slowing certification and delivery.

## The Opportunity for Digital Transformation

Modernization is no longer a cost center, it's an ROI-positive investment that drives speed, reliability, and mission assurance. By replacing legacy hardware and software with COTS computing platforms, modern software frameworks, and cyber-hardened architectures, organizations can:

- Achieve automated, real-time test execution and data processing.
- Cut test cycles and accelerate certification timelines.
- Integrate seamlessly with digital twin and simulation environments.
- Enhance cyber resilience and operational uptime.

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# Anatomy of an Aerospace Test Facility

Aerospace and defense test facilities are highly specialized environments, the physical heart of system validation, certification, and sustainment. They are the industrial-scale embodiment of engineering precision, combining mechanical structures, complex data networks, and real-time control systems into a unified test ecosystem.

## Structural and Physical Construction

Most aerospace test facilities are constructed using box steel frameworks designed for rigidity, vibration resistance, and structural flexibility. This allows for the mounting of heavy simulation hardware, control cabinets, and test equipment capable of withstanding dynamic loads during testing.
The floor and frame often incorporate shock-absorbing mounts, reinforced grounding, and environmental control systems to ensure stable electrical and thermal operation. Many labs operate under cleanroom or controlled conditions to maintain the integrity of electronic and hydraulic components.

## Computing and Instrumentation Infrastructure

At the core of each facility are industrial-grade computing cabinets housing the real-time control, simulation, and data acquisition systems.

- These racks often contain dozens of computers, instrumentation modules, and power distribution units connected through high-density backplanes.
- Modern systems commonly use PXI/PXIe, whereas legacy systems have used VME, or custom electronics that have reached end of life but are deeply embedded in test operations.
- Cabling and interface panels route data and power to every subsystem, from simulated flight controls to environmental sensors and telemetry links.

Modern facilities increasingly adopt COTS server-class hardware that integrates seamlessly with the ADEPT™ edge computing platform, delivering deterministic real-time performance and distributed computing across multiple racks and test zones.

## Connectivity and Integration

Aerospace test facilities interface with thousands of discrete signals and data channels:

- Industrial and military-standard connectors provide ruggedized connectivity for analog, digital, and power signals.
- Aerospace data buses including MIL-STD-1553, ARINC 429/664/825, SpaceWire, and others are used extensively for system communication.
- Extensive cabling harnesses route between computing cabinets, test articles, and instrumentation racks, often spanning tens or hundreds of meters across the lab.
- Facilities frequently host actual aircraft subsystems operating as hardware-in-the-loop within the test environment, e.g. avionics boxes, power systems, or flight control actuators.

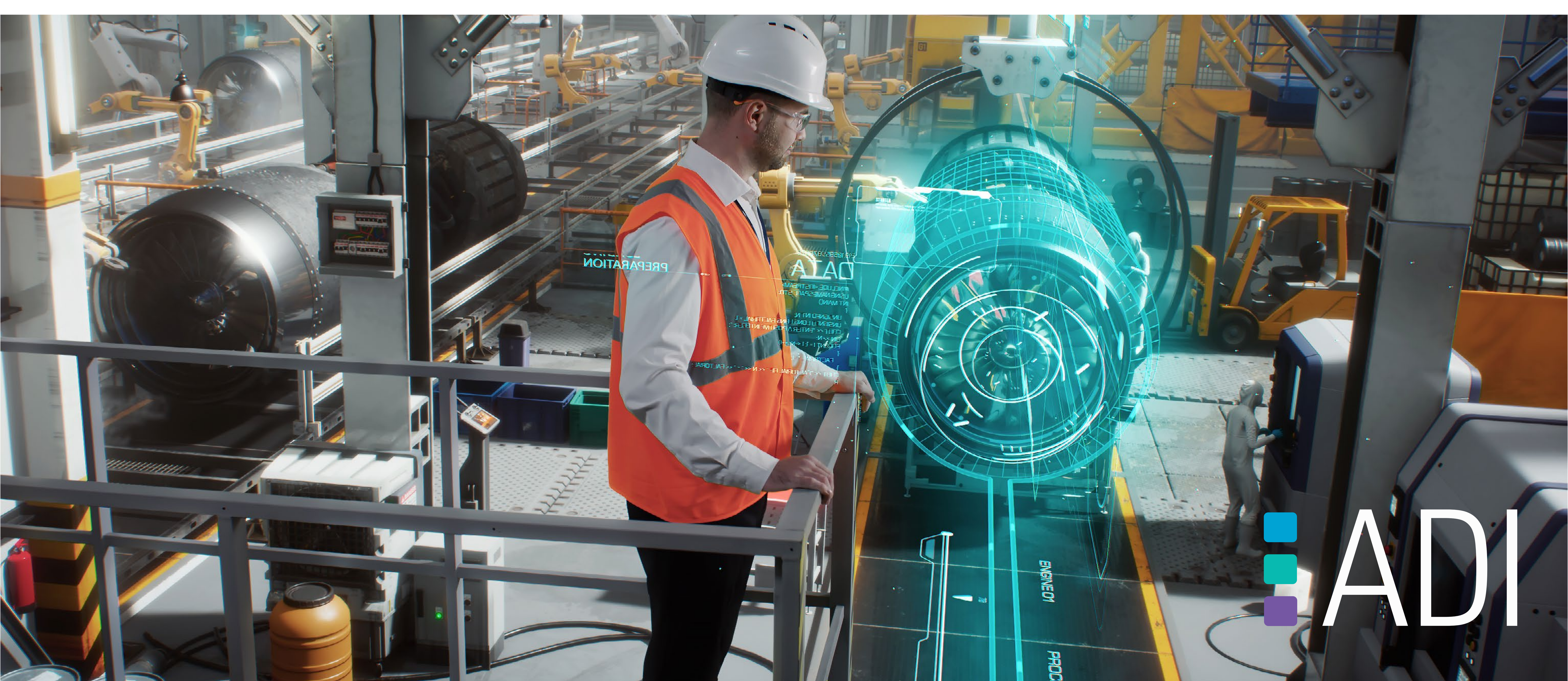
## Modernization Implications

The scale and complexity of these facilities mean that modernization is far more than a software upgrade, it is a complete systems engineering challenge.

Key modernization requirements include:

- Comprehensive I/O mapping to ensure compatibility with existing cabling, connectors, and hardware interfaces.
- Ruggedized computing equipment that fits existing cabinet and rack configurations.
- Careful change management and phased upgrades to avoid interrupting test operations.
- Enhanced cybersecurity integration, as many of these systems were never designed to operate in connected digital environments.

Modernization with ADI's ADEPT edge computing platform allows these facilities to preserve their physical infrastructure while replacing obsolete computing and control components with modern, automated, cyber-hardened systems, maximizing the return on decades of capital investment.



# The Value of Modern Real-Time Computing, Control, and Instrumentation

Modern test infrastructures built on ADI's ADEPT edge computing platform deliver the real-time performance and digital integration required for the next generation of aerospace and defense innovation.

## High-Performance Real-Time Control

ADEPT leverages the latest CPU and GPU architectures to provide:

- Deterministic, low-latency control for hardware-in-the-loop testing.
- Real-time data access and synchronization across distributed systems.
- Seamless integration between design, simulation, and physical test domains.

## Automation and Intelligence

Automation unlocks tremendous value in test execution and data management:

- Automated test scheduling and execution significantly reduce manual labor.
- Real-time analytics provide immediate insight into performance and anomalies.
- Automated reporting and certification traceability accelerate compliance.

Modern ADEPT-based facilities routinely deliver ROI multiples exceeding 5–10×, achieved through test time reduction, lower sustainment cost, and improved throughput.

## Cyber Resilience

Modernization enables implementation of zero-trust architectures and alignment with NIST 800-171, CMMC, and DoD cyber readiness standards, ensuring protection of critical assets and test data.

# A Structured 6-Step Approach to Test Asset Modernization

Successful modernization requires a disciplined, systems-engineered process. ADI recommends a six-step framework that integrates risk and requirements assessment into a single unified phase, ensuring a reliable and certifiable modernization outcome.

## Step 1: Establish the Modernization Business Case

- Define mission objectives and performance goals.
- Quantify test downtime, sustainment cost, and security risk.
- Build the ROI justification around automation, reliability, and lifecycle savings.

## Step 2: Define System Requirements and Assess Legacy Constraints

This phase integrates requirements development and legacy risk assessment into a single process.

- Capture performance, interoperability, and cybersecurity requirements.
- Assess existing hardware, software, and facility constraints.
- Identify obsolescence risks and interface dependencies.
- Define migration and compatibility strategies that preserve valuable test assets while eliminating high-risk components.

## Step 3: Architect the Modernized Solution

Develop the target system design leveraging:

- COTS hardware for scalability and maintainability.
- ADEPT edge computing software for deterministic real-time control.
- Open standards such as Ethernet, OPC UA, and DDS for seamless integration.
- Modular I/O and control subsystems for future flexibility.

## Step 4: Execute the Modernization Project

Implement the design through a structured integration plan:

- Conduct incremental upgrades to minimize operational disruption.
- Maintain full configuration and version control for certification traceability.
- Document test configurations and acceptance criteria at each stage.

### Step 5: Test and Validate the Modernized Asset

Confirm that the system is fit for purpose through rigorous validation:

- Verify performance, latency, and control loop determinism.
- Execute functional and safety testing across all modes of operation.
- Conduct cybersecurity verification and penetration testing.
- Validate data quality and correlation with legacy baselines.

### Step 6: Commission and Sustain

- Transition the system to full operational use.
- Establish a proactive sustainment plan for updates, patches, and lifecycle management.
- Track performance and ROI metrics over time to guide continuous improvement.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# Quantifiable Value and ROI

## Delivering Measurable Returns:

- 40–60% reduction in manual test time through automation.
- Up to 75% improvement in test data quality and traceability.
- ~50% reduction in sustainment costs through standardized COTS architectures.
- Dramatic improvement in system uptime, reliability, and cyber posture.

These measurable gains directly enhance engineering productivity and shorten technology readiness timelines, delivering tangible mission and financial returns.

## The Path Forward

The U.S. aerospace and defense ecosystem cannot rely on aging test infrastructure to meet the demands of future systems. The transition to digitally engineered, cyber-secure test environments is essential to maintaining global competitiveness and national defense capability.

Through the ADEPT edge computing platform, ADI delivers the open, data-centric, real-time foundation that enables this transformation, modernizing legacy test systems into fully integrated, automated, and cyber-resilient digital test environments.

At ADI, we're helping the world's leading innovators engineer faster, smarter, and with greater confidence at the edge.

## About Applied Dynamics International (ADI)

Applied Dynamics International (ADI) is a Michigan-based aerospace and defense technology innovator enabling digital engineering at the edge. ADI's ADEPT edge computing software delivers data-centric computing services optimized for real-time performance on modern CPU and GPU processors. With open architecture, automation, and cybersecurity at its core, ADEPT powers digital test, digital twin, and AI-connected factory applications across the world's leading aerospace and defense programs.

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