Mitigating Risk with Answer Engineering

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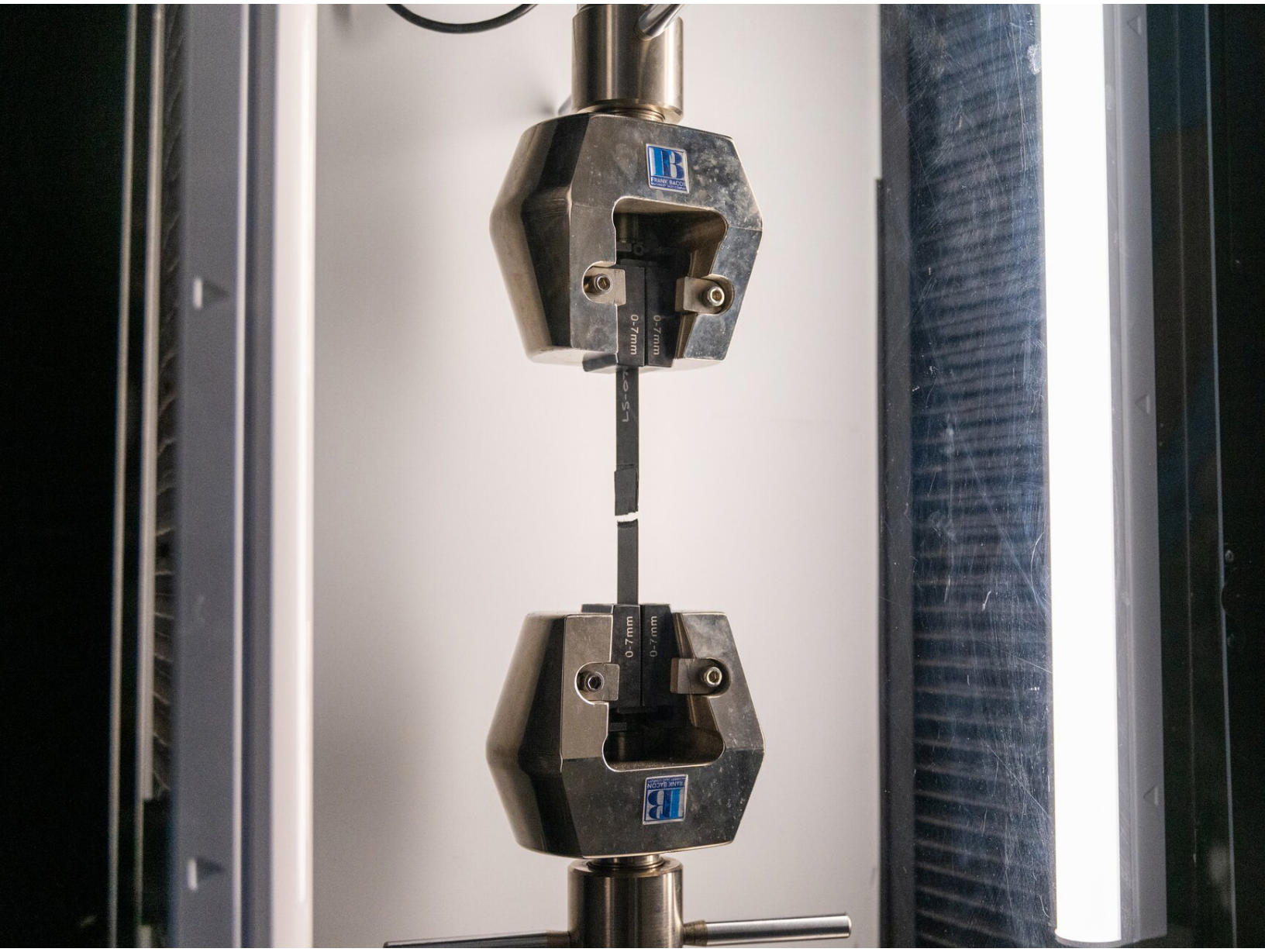


RE:BUILD MANUFACTURING | ANSWER ENGINEERING

SUMMARY

Program failures in aerospace development are expensive and can derail schedules, inflate costs, and damage reputations. Re:Build Answer Engineering mitigates these risks through proven engineering expertise and disciplined program management that catches problems early. Our integrated capabilities span early design and analysis through testing with comprehensive certification expertise. This combination delivers predictable outcomes, protected margins, and accelerated paths to certification. Partnering with Re:Build Answer Engineering means fewer program surprises, lower technical risk, and greater confidence in meeting critical milestones and market commitments.

RISK MITIGATION IN AEROSPACE

The aerospace industry operates under uniquely unforgiving conditions where technical failures carry catastrophic consequences, not only to program budgets and schedules, but to human safety and brand reputation. Unlike other manufacturing sectors, aerospace development faces the convergence of extreme performance requirements, stringent regulatory oversight, and minimal tolerance for error. A structural miscalculation discovered late in development can trigger cascading delays worth tens of millions of dollars, while certification setbacks can close market windows permanently. This high-stakes environment demands a fundamentally different approach to risk management, one that identifies and resolves technical, programmatic, and regulatory challenges early in the development cycle when corrections remain economically viable.

MANUFACTURING CONSTRAINED DESIGN

Manufacturing Constrained Design™ (MCD) is a concept that Re:Build Manufacturing developed to improve upon the more commonly referenced Design for Manufacturing (DFM) that industry typically utilizes to inform manufacturing efforts. Instead of bringing manufacturing resources into a design effort to provide manufacturability inputs on a given design, we challenge manufacturing to provide rigid design constraints that engineering must work within. By starting with the most constrained design space possible and establishing audacious goals for cost and throughput, MCD leads to high creativity and breakthroughs in product design, cost, and manufacturability.

Organizations that embrace MCD make a subtle but profound shift: they stop optimizing for time-to-prototype and start optimizing for time-to-stable-production. MCD enables teams to move decisively, compressing total development time by ensuring that each step forward is built on solid manufacturing foundations rather than optimistic assumptions.

Download our Manufacturing Constrained Design White Paper for more information.

STRUCTURAL INTEGRITY

The ability of a structure to safely withstand operational loads throughout its service life depends on a comprehensive understanding of material behavior, rigorous analysis methods, and validated design criteria. Structural integrity encompasses the full lifecycle assessment of components and assemblies, from initial material selection through design, fabrication, and operational use. This requires a systematic approach that integrates material science, engineering analysis, and regulatory compliance to demonstrate that structures will perform as intended under all anticipated conditions, including normal operations, limit loads, and ultimate load scenarios.

MATERIAL PROPERTIES AND MATERIAL ALLOWABLES

A critical aspect of composite structure design involves establishing realistic and appropriate material allowables. A common pitfall in composite design is the misapplication of material property data, particularly from MIL-HDBK-17.

Design Allowables vs. Material Properties

It is important to note that MIL-HDBK-17 design stress allowables should not be directly used as design stress allowables for structural analysis. While MIL-HDBK-17 provides valuable baseline material characterization data, these values represent idealized coupon-level performance that often cannot be achieved in full-scale structures.

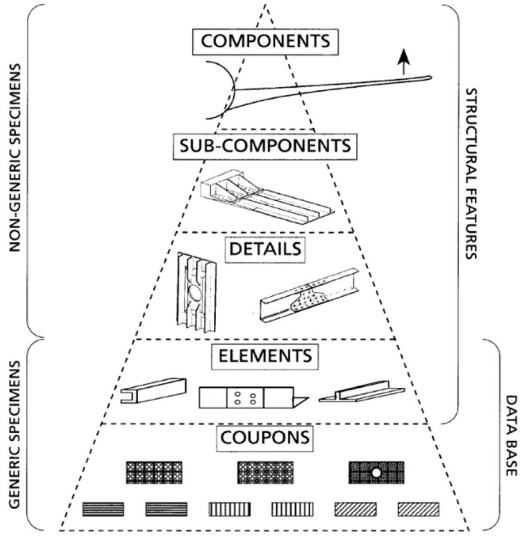


Figure 1. MIL-HDBK-17 Composite Test Pyramid

The Composite Test Pyramid Approach

To establish realistic design allowables, programs should implement a composite test pyramid methodology. This approach involves testing progressively larger and more complex specimens:

- Coupons: Basic material characterization
- Elements: Structural features and details
- Sub-components: Integrated structural assemblies
- Components: Full-scale validation

Design allowables should be built from element and sub-component testing, where realistic structural constraints, load introduction methods, and manufacturing effects are represented.

Realistic Strain Allowables

Bonded Structures

Pristine compression allowables from coupon testing often show failure strains in the 10,000-12,000 microstrain range. However, this level of performance is unrealistic for full-scale bonded structures due to factors such as:

- Manufacturing imperfections
- Load distribution effects
- Scale effects
- Environmental conditioning

Element and sub-component testing typically demonstrate compression failure in the 5,000-8,000 microstrain range for bonded structures. These values provide a more appropriate basis for design allowables.

Bolted Structures

For mechanically fastened (bolted) structures, the open-hole and filled-hole tension and compression allowables published in MIL-HDBK-17 are appropriate for use as design allowables. These values account for the stress concentrations inherent in bolted joints and typically show failure in the 3,000-4,500 microstrain range.

The lower allowables for bolted structures reflect the stress concentration effects of fastener holes and bearing loads, which are well-characterized at the coupon level and translate more directly to full-scale structure behavior.

STRUCTURAL ANALYSIS APPROACH

Effective structural analysis typically employs two complementary methodologies that work in tandem to deliver robust, cost-effective designs: hand calculations and Finite Element Analysis (FEA).

Hand analysis serves as a first line of engineering evaluation. This method is fast and cost-effective, focusing on fundamental engineering principles to generate quick approximate answers. The efficiency of hand calculations enables rapid exploration of design alternatives and trade studies without significant time or resource investment. This speed is particularly valuable during early design phases when multiple configurations need evaluation.

FEA analysis provides the refined precision required for final design validation. While more time-intensive and expensive than hand calculations, FEA delivers the detailed stress distributions, displacement predictions, and failure mode identification necessary for high-confidence structural verification. FEA is strategically deployed after hand analysis has narrowed the design space, maximizing the value of this more resource-intensive tool.

These two methods are not competing approaches but rather complementary tools in an analysis toolkit. Hand calculations provide engineering intuition and rapid iteration capability, while FEA supplies precision and detailed insights for final validation.

Common structural analysis applications include:

- Sandwich panel design methodologies
- Buckling calculation approaches
- Vibration mode shape prediction
- Vibration response characterization

Critically, both analysis methodologies depend on high-quality material design allowables. Accurate material properties, failure criteria, and safety factors form the foundation upon which both hand calculations and FEA models are built. Maintaining robust, validated design allowables ensures that both analysis approaches deliver reliable results.

TESTING

Testing serves as the critical validation point where analytical predictions meet physical reality. At Re:Build Answer Engineering, our testing philosophy bridges the gap between design confidence and certification evidence, transforming theoretical analysis into demonstrable compliance. Strategic testing programs catch discrepancies between predicted and actual behavior early, when design adjustments remain economically viable rather than program threatening.

Our testing approach spans the full development spectrum, from early-stage prototype validation through formal certification testing. This integrated capability enables programs to progressively build confidence through a systematic test pyramid that parallels our composite material characterization methodology, beginning with component-level validation and advancing through sub-assembly integration to full-scale article testing.

Testing Capabilities

Our in-house facilities support rapid iteration during development phases while maintaining the rigor required for certification testing. This dual capability eliminates the schedule delays and communication gaps that plague programs forced to separate development testing from certification activities across multiple vendors.

Fabrication Integration

Our integrated machine shop and composite layup station enable rapid design-build-test cycles. When testing reveals design improvements, we can implement changes and return to test within days rather than weeks. This fabrication-testing integration is particularly valuable for structures, propulsion systems, mechanical subsystems, and complete flight assemblies where iterative refinement drives optimal designs.

Test Article Scale and Complexity

Our facilities accommodate test articles ranging from hand-sized components through full-scale Light Sport aircraft structures, including wing spans up to ~35 feet. This scalability supports both early-stage coupon and element testing as well as component and sub-component validation required for building realistic design allowables.

Testing Services Scope

- Development Testing: R&D validation, design iteration support, and performance benchmarking
- Certification Testing: Formal compliance demonstration supporting FAA and regulatory approval
- Custom Test Protocols: Tailored testing programs designed to address program-specific technical risks
- Precision Instrumentation: Comprehensive data acquisition capturing critical parameters for analysis correlation and model validation

Landing Gear Testing

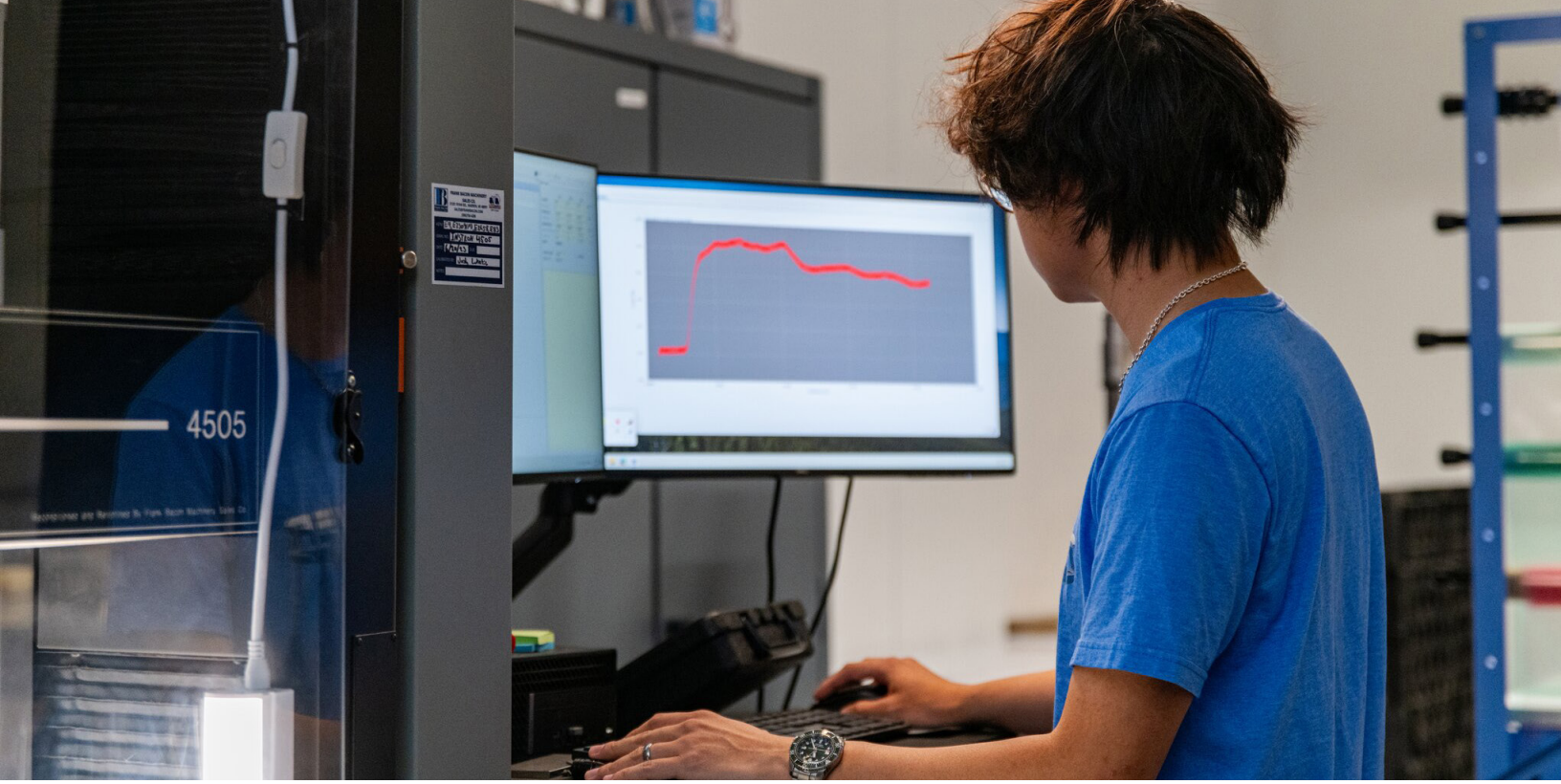
In addition to our landing gear design expertise, Re:Build Answer Engineering offers custom aircraft landing gear testing services through FAA certification for landing weights up to 10,000 pounds. Testing services include swing arm style drop rigs, easily modifiable impact energy, wheel spin-up to 145 knots, data acquisition, test report generation, nose gear shimmy testing to 90 knots, and nose gear steering force measurements.

Download our landing gear whitepaper for full details on our landing gear services.

When testing reveals unexpected results, our integrated capabilities enable rapid response. During recent certification testing of a landing gear component, structural testing identified an unanticipated failure mode. We immediately assembled a cross-functional team to conduct a root cause analysis, maintained transparent communication with our customer throughout the investigation, and leveraged our in-house design and fabrication capabilities to implement corrective actions. This integrated approach enabled us to move quickly from problem identification to validated solution, maintaining program momentum while ensuring structural integrity. This experience exemplifies our commitment to turning test discoveries into program improvements rather than program delays, and reinforces our continuous improvement philosophy that makes future programs stronger.

PROGRAM METRICS

Effective program metrics are essential to proactive risk mitigation in aerospace development, serving as early warning indicators that prevent costly late-stage discoveries. Weight tracking and center of gravity (CG) management must be implemented from day one, with rigorous tracking of each component's actual versus allocated weight and moment arm. Establishing a robust weight control system with regular audits ensures that programs don't discover too late that



an aircraft is overweight or has an aft CG condition, problems that can cascade into expensive redesigns, performance penalties, or schedule delays. Real-time dashboards that track weight margins, CG position, and growth trends enable engineering teams to make informed trade decisions before issues become critical.

Cost tracking metrics work in tandem with technical performance measures to provide program leadership with complete visibility into both fiscal and engineering health. By monitoring earned value metrics, burn rates, and cost-per-pound alongside weight and performance data, programs can identify adverse trends early, whether scope creep is driving up costs or design iterations are consuming weight margin. For Re:Build Answer Engineering customers, we have the expertise to implement integrated program metrics that correlate cost, schedule, weight, and technical performance to create a comprehensive risk management framework that enables data-driven decision-making and keeps programs on track to meet their commitments.

PARTNER WITH RE:BUILD ANSWER ENGINEERING

Effective aerospace risk mitigation requires integrated capabilities across multiple disciplines. Companies that master an integrated approach don't simply reduce technical risk; they create competitive advantage through faster certification timelines, protected margins, and predictable program execution.

The complexities of aerospace risk mitigation demand more than technical expertise, they require a partner with proven, integrated capabilities and a track record of successful execution. Re:Build Manufacturing brings together engineering excellence, manufacturing prowess, and program management discipline to help you navigate certification challenges, protect your margins, and deliver on schedule.

Whether you're developing next-generation aircraft systems, advanced propulsion technologies, or critical flight hardware, our team is ready to be your strategic partner in transforming risk into competitive advantage.

Let's discuss how Re:Build Answer can support your program's success.

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