

# HX5™

# DARE TO BUILD SMARTER.



## A WHITE PAPER FOR THE AEROSPACE INDUSTRY



HX5™ is a trademark of Alpine Advanced Materials, LLC.



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## INTRODUCTION

In 2007, Lockheed Martin's Skunk Works® set out to satisfy the most challenging structural, environmental, and physical requirements of next-generation air and spacecraft platforms. A strategic technology was derived and the most balanced, capable, and processable reinforced high-performance thermoplastic nanocomposite around, **HX5™**, was created.

In 2019, Alpine Advanced Materials, a leading expert in the design and manufacture of custom-engineered parts, acquired HX5 from Lockheed Martin and is now leveraging this technology to solve the world's most demanding performance challenges in the commercial aerospace and defense markets.

# 90%

*the strength of 6061-T6 aluminum*

# 50%

*the weight of 6061-T6 aluminum*

Engineered to replace machined aerospace-grade aluminum at half of the weight, HX5 represents more than a decade of testing and validation, with an R&D investment of **over \$50 million**. In test after test, HX5 has demonstrated the ability to withstand the most demanding aerospace, defense and space applications, and is **certified** for use in commercial airliners, jet fighters, high-speed helicopters, unmanned aerial vehicles, amphibious transport vehicles, rockets, and satellites.

**HX5 HAS BEEN TESTED AND  
PROVEN AGAINST THE HARSHTEST  
ENVIRONMENTS IN THE WORLD  
AND BEYOND.**

HX5 easily meets the demands of aerospace environments and is extremely resistant to corrosion, solvents and fuel. Highly adaptable without sacrificing strength or performance, HX5 can be metalized to meet EMI shielding requirements. And, its customization and unrivaled manufacturability combined with its high tolerance and dimensional stability make it an ideal alternative to the cost and production challenges associated with aluminum.

The aerospace industry requires a material that is radically lightweight, turnkey, and environmentally robust: **HX5 answers the call.**

## KEY ADVANTAGES OF HX5™

**1**

### **PERFORMANCE**

Performance is retained in the most extreme environments.

**2**

### **WEIGHT**

Half the weight of 6061-T6 aluminum components.

**3**

### **AFFORDABILITY**

Verified cost savings over machined aluminum components.

**4**

### **PRODUCTION**

High-rate manufacturability allowing the processing of thousands of parts per day.

**5**

### **DESIGN**

High tolerance and dimensional stability for complex shapes.

*HX5 is built for applications where weight savings, corrosion resistance and performance are paramount.*

**SEAT COMPONENTS**

**GALLEY COMPONENTS**

**LAVATORY COMPONENTS**

**ELECTRICAL CONNECTOR HOUSINGS**

**AVIONIC RACKS**

**BRACKETS/CLIPS/FASTENERS**

**HARDWARE/HINGES**

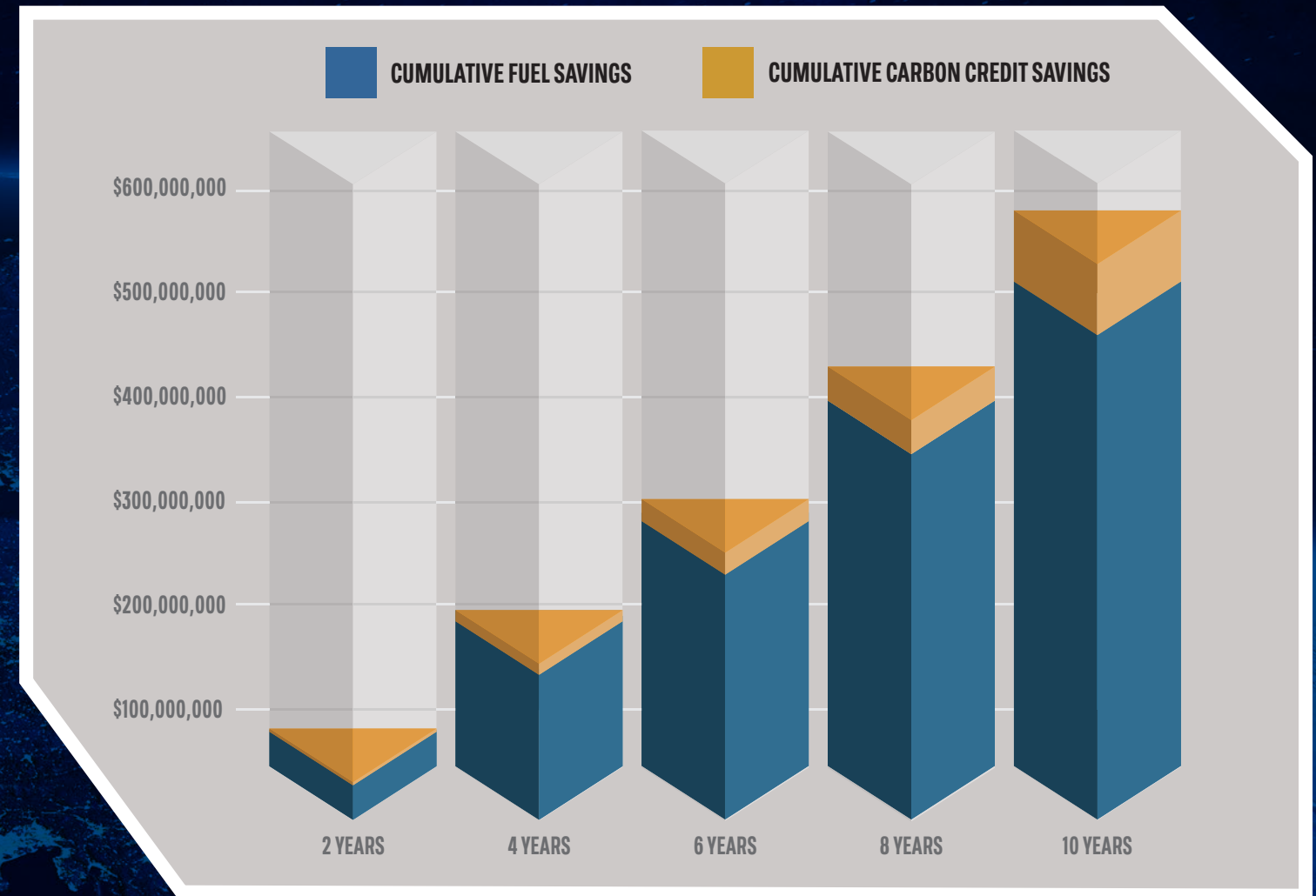


# WHY HX5™



## CUMULATIVE AIRLINE SAVINGS

(inflation adjusted)



	WIDE BODY	NARROW BODY
<i>Fleet Size</i>	150	700
<i>Weight Reduction/Aircraft (Kgs)</i>	1,000	750
<i>Conversion Rate/Yr (%)</i>	20%	20%

# HX5™ PROPERTIES

## MECHANICAL

### HX5 vs. Aluminum

HX5's extreme mechanical performance is characterized by a broad range of standard ASTM tests that are important to engineers seeking to replace aerospace-grade aluminum with a material of the same strength, but far less weight compared to aluminum.

MECHANICAL PROPERTIES	ASTM	HX5 (73°F)	6061-T6 (73°F)
Tensile Strength (ksi)	D638	38.2	40
Density (lbs/ft³)	D792	89	169
Specific Strength (lb/in²) / (lb/in³)		741,700	410,300

### HX5 vs. Thermoplastics

HX5 also enables robust composite structures with best-in-class properties compared to other industry standard thermoplastics with a shear strength of 14 ksi, compressive strength of 43 ksi, and specific modulus of  $7.97 \times 10^7$  (lb/in²)/(lb/in³).

## THERMAL

### HX5 vs. Aluminum

HX5 thermal properties are important for stable structural designs in elevated temperatures. HX5 boasts a high Heat Deflection Temp (HDT) that is five times less than typical aerospace-grade aluminum, and a low Thermal Conductivity. The combination of these properties is ideally suited to greatly reduce twisting, warping, and fatigue of molded structures in high thermal gradient environments.





THERMAL PROPERTIES	ASTM	HX5
Glass Transition Temperature (°F)	D3418	316
Heat Deflection Temperature (°F)	D648	500
Thermal Conductivity (Heating, BTU-in/hr-ft²-°F)	E1530	3.30 to 3.58
Coefficient of Thermal Expansion, (L/L/°F)	E831	$2.11 \times 10^{-6}$

# HX5™ PERFORMANCE

While HX5 has truly impressive mechanical and thermal performance, what really separates it from the pack are its environmental and processing characteristics.

## ENGINEERED TO SURVIVE.

### HX5 Environmental Stability

-  Meets flame, smoke, toxicity (FST) requirements for commercial aerospace and defence applications, meeting the most stringent requirements for the Horizontal Burn Rate with no measurable toxic gases being emitted. **(Figure 1)**
-  Extremely resistant to solvents, fuels, lubricants, and chemicals including, but not limited to: Skydrol®, Jet A fuel, insecticides, disinfectants—and even Coca-Cola®.
-  Corrosion resistant in numerous environments.
-  Maintains a high degree of mechanical performance under various fatigue and creep conditions. **(Figure 2 & 3)**

FLAME, SMOKE, TOXICITY (FST)	ASTM	HX5
Horizontal Burn Rate	D635	Meets Requirements
Optical Smoke Density Evaluation	E662	Meets Requirements
Toxicity	E800	Meets Requirements
FAR 25.853 Appendix F	Part I (a) (1) (i) Part I (a) (1) (ii) Part V AITM 3.0005	Meets Requirements

Figure 1

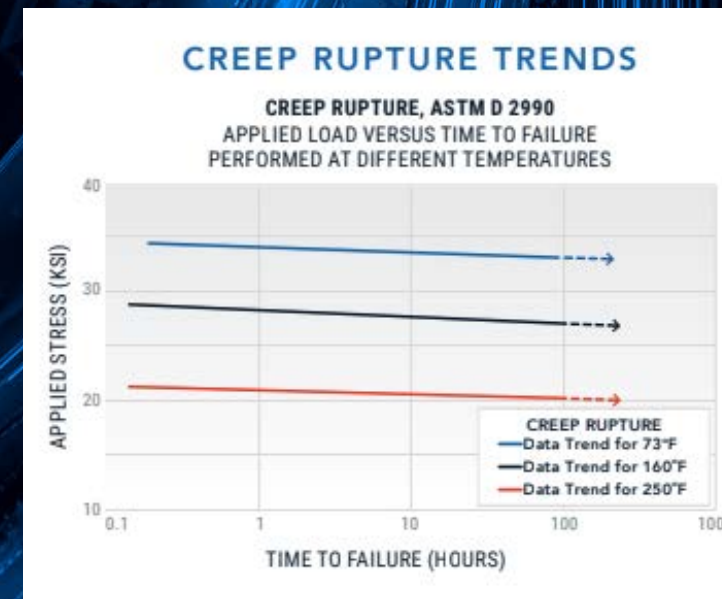


Figure 2

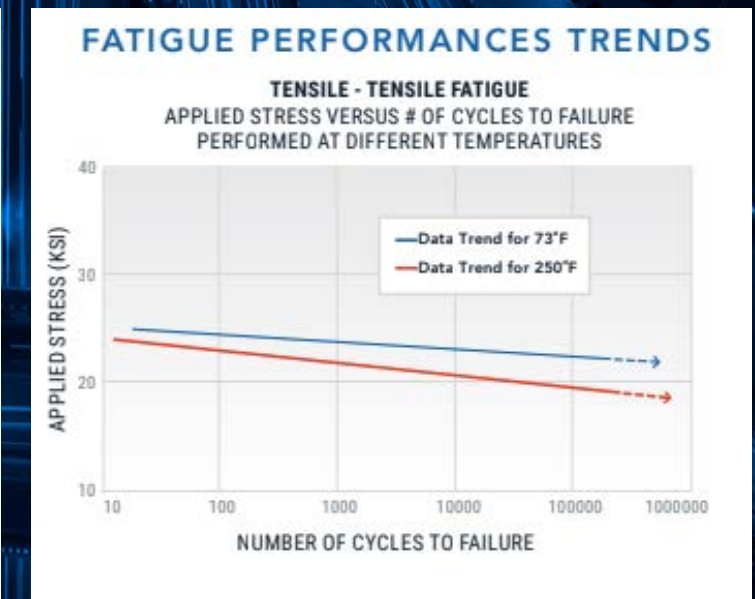


Figure 3

# PROCESSABILITY

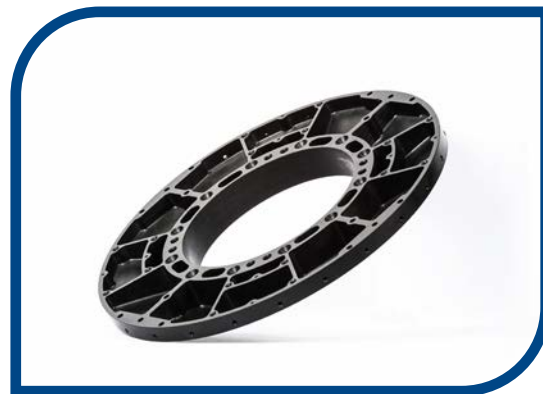
Alpine Advanced Materials has the unique capability to utilize these characteristics of HX5™ and mold extremely strategic parts. Through the use of state-of-the-art tools and technologies, HX5 helps to minimize shrink and optimize materials.

## MOLDING



HX5 was designed with an eye for melt rheology and flow behavior. As a result, **the material flows exceptionally**, allowing it to fill **fine detail features** without distortion, resulting in **dimensionally stable precision components** better than other materials in its category.

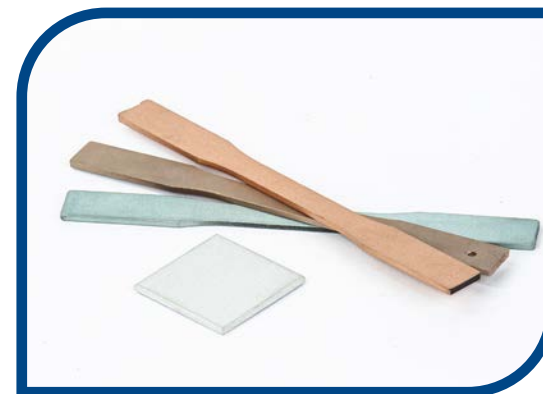
## MACHINING



Additionally, because it 'machines like aluminum' **without chipping, cracking or galling**, HX5 readily handles cutting and machining operations. This includes drilling and tapping parts, which ultimately extends the range of complex manufacturing possibilities.



## COATING



The versatility of HX5 components allows for an extended range of finishing operations for product manufacturing not available with other engineering-grade thermoplastic resins. HX5's coating and adhesive bonding characteristics are **unique for this class of material**, considering its excellent solvent resistance. Resistance to solvents

traditionally means that painting, powder coating, plating, abrasion resistance, decorative metallization and adhesive bonding suffer, but the carefully tailored formulation of HX5 **provides excellent performance across the board**.

Additionally, HX5 can be easily metalized for EMI shielding applications.



## CASE STUDIES



# DARE TO PERFORM.

## PERFORMANCE

The performance superiority of HX5™ over aluminum extends well beyond its mechanical properties. For example, this missile bracket replaced a machined aluminum version after **outperforming it by 15%** in a critical load condition. The bracket has a threaded insert and raised ID markings molded in place. Not only was the HX5 bracket **30% less weight**, but 200 ready-to-install units were also produced in a **single work shift**. By contrast, the replaced aluminum bracket had a 28-day lead time requiring multiple fixturing operations and post-process finishing.

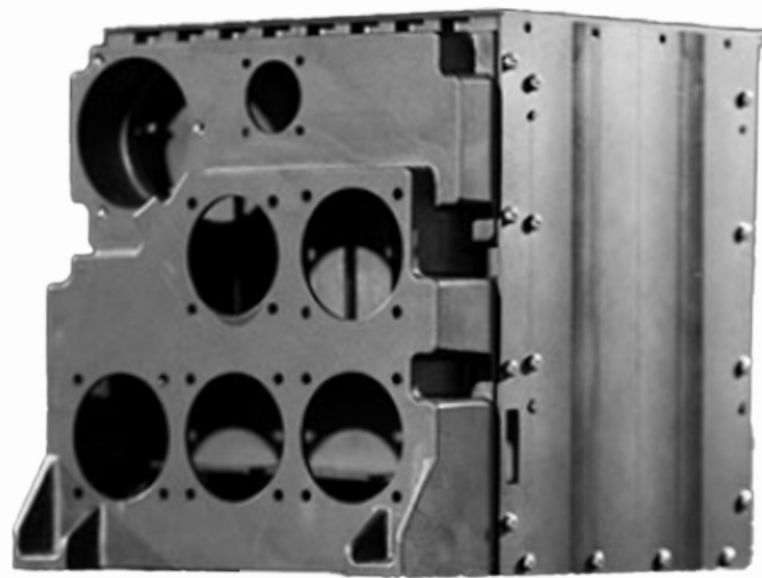
**THE HX5 BRACKET REDUCED WEIGHT BY 30% AND ALLOWED FOR 200 READY-TO-INSTALL UNITS TO BE PRODUCED IN A SINGLE WORK SHIFT.**



## WEIGHT

Weight savings is another key advantage HX5™ has over aluminum components. For example, this electronics enclosure has been both **flight proven** and **accepted** on the Sikorsky S-97 RAIDER®, Sikorsky UH60W and Bell V-280 Valor helicopter programs among other platforms. This is due, in part to its **45% weight savings** over the traditional metal enclosure, as well as its design advantages that improve convective cooling of the internal electronics over the legacy metal enclosure.

**FLIGHT PROVEN AND ACCEPTED,  
THE HX5 ELECTRONIC ENCLOSURE'S  
45% WEIGHT SAVINGS AND DESIGN  
ADVANTAGES HELPED IMPROVE  
CONVECTIVE COOLING.**



## PRODUCTION

HX5's high-rate production methods, such as injection molding, dramatically accelerate product schedules compared to machined aluminum or thermoset composite parts. For example, these satellite clips provide a mechanical joint between structural panels and were produced in a batch of **300 units in a matter of hours**. Additionally, the satellite clips delivered a **cost reduction** and a **5-20% weight reduction** over the machined aluminum predecessor. Reconfigurable tooling was also used to allow variations in size to accommodate different structural panel thicknesses.

**THE HX5 SATELLITE CLIP HELPED REDUCE  
COST, WEIGHT, AND PRODUCTION—  
WITH 300 UNITS BEING MADE IN A  
MATTER OF HOURS.**





## DESIGN

The design advantages available for molded thermoplastic nanocomposites enables efficient contoured geometries following critical load paths and allows for the integration of many assembly piece parts into **a single complete product**. Large-scale parts, such as this gunner chair, illustrate this design advantage of part count reduction. The original gunner chair was steel-based, contained more than **140 individual pieces**, and **weighed over 110 lbs**. By contrast, the HX5™ gunner chair now has just **15 total pieces** leading to a 90% part count and **75% weight reduction**. Additionally, the HX5 gunner chair passed in-depth shock and vibration testing to simulate a ballistic event.

**THE HX5 GUNNER CHAIR NOW HAS  
JUST 15 TOTAL PIECES LEADING TO  
A 90% PART COUNT AND 75%  
WEIGHT REDUCTION.**

**The strategic development of HX5 for aerospace accounted for all the mechanical, thermal, environmental, programmatic, financial and manufactural production considerations, resulting in a material with a magnified benefit. As illustrated in the previous examples, HX5 is the premier choice for high-value aerospace products.**

## CONCLUSION

### HX5™, THE ONLY CHOICE FOR HIGH-PERFORMANCE, NEXT-GENERATION AEROSPACE.

Best-in-class and ultra-lightweight, HX5 is one of the only structural thermoplastic nanocomposites that delivers excellent mechanical properties, thermal stability, environmental performance, and superior processability. Selecting HX5 over aluminum **will improve system performance and reduce manufacturing lead times.**

## WHY HX5

*Use the Best. Be the Best.*

### *Production*

- ✓ From weeks for machined components down to minutes with injection molded HX5, enabling the processing of thousands of parts per day and accommodating many versatile post-processing operations.

### *Aerospace Performance*

- ✓ Passed testing for impact performance, solvent resistance, flame smoke toxicity, and advanced coatings adhesion.

### *Weight*

- ✓ Half the weight of 6061-T6 aluminum components.

### *Design*

- ✓ High tolerance, fine detail processability and dimensional stability for complex shapes.

### *Environmental Impact*

- ✓ Weight reduction with HX5 components reduces fuel consumption and carbon emissions and therefore reduces overall carbon footprint.

# ABOUT ALPINE ADVANCED MATERIALS

Alpine Advanced Materials is headquartered in Dallas, Texas and is the perpetual and exclusive global license holder of the HX5™ thermoplastic nanocomposite technology.

Alpine Advanced Materials is a leading expert in the design and manufacture of purpose-built parts for the world's most demanding aerospace, defense, energy, space, and outdoor applications. Alpine designs parts using Moldflow which allows Alpine to more accurately monitor strength, deflection, and other mechanical properties so customers using HX5 can have optimized parts from design to delivery in an even shorter timeline. With B-basis engineering design databases, processing databases, and full-scale component testing, Alpine uses HX5 to design and manufacture high-performance, lightweight, purpose-built components that can be coated, painted, adhesively bonded, and metalized.

## FOR MORE INFO, CONTACT:

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