AeroBox™ ULD
Advanced Composite Structures (ACS)

ADVANCED COMPOSITE STRUCTURES

With the Boeing 787 maiden flight, composites in commercial aircraft have moved from a bit player into a starring role. Composites have likewise become important in the air cargo segment. They provide significant advantages in performance, and operating costs. This segment has been slower to adopt new-materials, but higher fuel prices and a more competitive cost environment are prodding the change. Air cargo containers, commonly referred to as Unit Load Devices (ULDs), are the first to start this transition.

"Composite" purely means a combination of discrete materials which work together to create superior properties. Typically, these materials are layers of reinforcing cloth, coated with a resin and laminated into a solid. Traditional composites use epoxy as the matrix or "glue holding everything together".

Newer composites use tougher, more environmentally friendly thermoplastics as the matrix. Structural aircraft applications typically use a "sandwich" structure with a honeycomb core between two layers of composite material. This construction provides a much higher strength to weight ratio than composite sheet alone. Below shows the construction that makes AeroBox™ containers so effective in

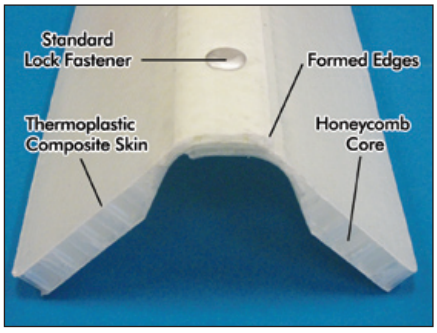

Figure 1: AeroBox™ Sandwich Panel

Figure 2: Both loaded units were impacted at same height and angle by a fork-truck

distributing dynamic and impact loads through the entire structure.

The thermoplastic composite panels used to manufacture AeroBox™ ULDs have a remarkably high stiffness/toughness at a very low weight. Using a weight guideline of (2.3 kg/m^3) this panel is 420 times stiffer than aluminum, 480 times stiffer than thin sheet composites, and an incredible 3180 times stiffer than steel. It is this type of performance that will drive the growth of composites in air cargo.

Why composites when aluminum is much cheaper?

At the 2008 World Cargo Symposium, Alex Popovitch, Global Head of Cargo for IATA, euphemistically suggested "Capital punishment for ULD damage". This expression reflects industry concern that an estimated USD$150 million is spent annually on maintaining, repairing or replacing the fleet of over 1,000,000 predominately aluminum containers and pallets. Inability to control this situation has created a push for more damage tolerant units without adding weight. Composites alone provide the technological key to solve this mutually exclusive challenge of high durability at a lower weight and reasonable cost.

Composite ULD Containers

There are two types of commercially available composite ULD containers. Both contain aluminum in locations where strength or impact damage tolerance is beyond the capability of composite material alone. Until handling procedures are improved, a 100% composite unit represents a dream which may never be completely realized.

1. Most manufacturers currently supply a ULD consisting of thin composite skins riveted to an aluminum frame and connected to an aluminum base. These are essentially the same design as older units, with the aluminum sheet replaced by a composite sheet to save weight. The frame carries the majority load and creates the overall shape. Unfortunately, the aluminum frame is the target of most severe operational damage. The thin composite panels contain the cargo but can bulge significantly beyond the envelope of the container. Advertised minimum weights vary from 55kg to 67kg, but with added stiffeners, can easily fall into the 68kg to 72kg range.
2. ACS produces the AeroBox™, utilizing patented frameless composite sandwich panels coupled with an aluminum base. The unique design

combines advantages of composite materials with assembly techniques that follow industry norms. The rigid nature of the panels eliminates the need for an exterior frame, not deforming when cargo shifts. The structure of the AeroBox™ ULD requires no additional stiffeners and is sold at a published weight of 64kg.

Figure 2 shows the effect of an identical fork-truck impact on the corner of each of the two types of composite containers. The AeroBox™ unit survived with only minor cosmetic damage and is still airworthy.

Overall Cost of Operation of Unit Load Devices

Figure 3 shows a graphical comparison of annual cost for aluminum and AeroBox™ composite LD3 ULD Containers. Although there are many contributors to operational cost, the major factors are listed below:

- **Delivered Purchase Price** – Often considered most important. Amazingly, this is the smallest factor in overall cost. A USD$1000 aluminum container can cost over USD$40,000 in fuel and maintenance over its lifetime.

- **Fuel Burn** – Clearly the largest contributor to cost of ownership. Estimates from aircraft manufacturers and airlines vary greatly based on length of flight and type of aircraft, but put operating cost around USD$42 per kg per year. Using this number, annual fuel savings created by using a 64kg AeroBox™ ULD is over USD$800 compared to an 82kg aluminum ULD.

- **Repair and Maintenance Costs** – are usually the result of container damage. Spares pricing and availability also impact cost and uptime. The use of damage tolerant composites has allowed the AeroBox™ ULD to average 0.4 repairs per container per year over 10,000 units. Aluminum containers have historically averaged 2.3 repairs per year – a factor of over 5X.

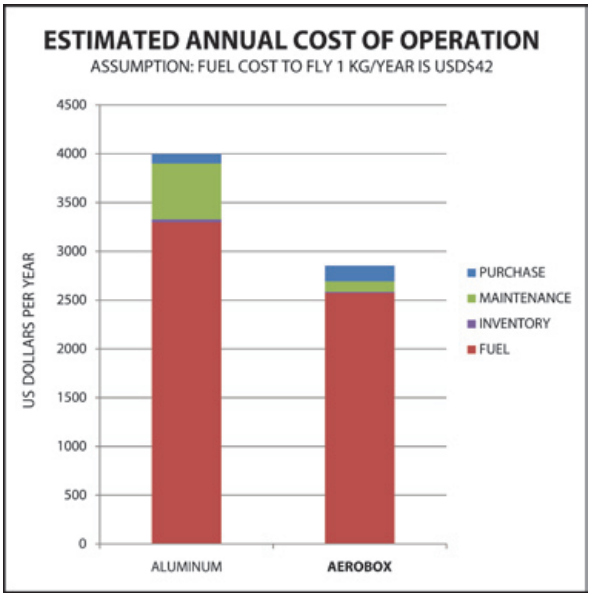

Figure 3: Estimated Overall Cost of Operation on Annual Basis

- **Downtime/Inventory** – Costs are directly related to repair rate and parts availability. A higher repair rate necessitates the purchase of more units to maintain a constant airworthy inventory.

- **Life Span** – All containers can be theoretically repaired and kept in service forever. At some point however, the container reaches its BER (Beyond Economical Repair) limit at which time, is less expensive to replace than continuing repairs. A study on 1000 containers done by JMI, a worldwide repair company, concluded that this point occurs about 5 years into the life of an average aluminum container.[2]

- **Repositioning Cost** – Maintaining inventory at remote cargo terminals to compensate for damaged containers increases inventory costs. Often, damaged containers are flown home empty at a cost of 80kg of freight and 4.8m3 of valuable cargo space.

- **Appearance Cost** – While not a true financial cost, dented and damaged containers portray a poor corporate image to the flying public and somehow seem to be a target for even more damage by ground handling crews.

Environmental Impact

Although fuel burn calculations vary between airlines and are highly dependent on aircraft type and length of flight, a conservative estimate for annual fuel burn is approximately 40 liters/kg cargo. Based on this figure, 18kg saved by using an AeroBox™ ULD compared to an aluminum ULD saves approximately 720 liters of fuel per year. According to the United States Energy Information Adminstration[1], each liter of jet fuel produces 2.5kg of CO_2 emissions. This calculates to a savings of 1800kg of CO_2 emissions per year for a 64kg AeroBox™ – quite significant when added to the financial savings.

The AeroBox™ is made from recyclable materials. The 7000 series aluminum can be recycled. The fiberglass/polypropylene composite including core can be mixed with polypropylene to make an injection molding compound.

Summary

Tough economic conditions and high fuel prices have put a spotlight on overall cost of operation for air cargo containers. This focus has created an opportunity for durable composite materials to showcase their versatility in this market. Proven composite technologies, similar to those used in new aircraft, can provide significant cost savings when compared to metals. ■

[1] United States Energy Information Administration http://www.eia.doe.gov/oiaf/1605/coefficients.html

[2] Presentation at IATA World Cargo Symposium 2009, Bangkok, Thailand. James Everett, JMI Aerospace. Used with permission.