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The Thick Of Composite Repair

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Bolt on your doublers and crank on the hot bonder, it's time to tool up next-gen aircraft repairs.

By Vicki P. McConnell

Something big is on the horizon: current orders stand at 1,624 for the next-generation, composites-intensive commercial aircraft, and that's just counting the obvious short list of Airbus A380, A350 XWB and Boeing 787 models. Monolithic structural components—which could reach an estimated 100 plies or up to 2 in. of thickness—will dominate on these aircraft, with total composites content by weight ranging from 25% (A380) and 50% (787) to 53% (A350). More bonded-in, rather than fastened original design, features also are expected, along with the integration of multiple small parts into larger, single-piece components with complex contours. A higher percentage of carbon fiber pressurized main fuselage also will debut.

So is it surprising that demand for carbon fiber to meet the needs of building new commercial aircraft is projected at 24 million lbs. by 2018?

Although composite repair is not new, these step changes in materials, design and manufacturing naturally lead MROs and airlines to wonder what it's going to take to tool up for repairing damage to these composite-technology aircraft.

Repairing thick composites will require new tools, technical training and design data.*Credit: HAECO*

Building On The Past

Opinions vary among MROs, airlines, original equipment manufacturers (OEMs), composites and training consultants, and the FAA regarding the composite repair challenges for next-generation aircraft. OEMs suggest the progress with new materials and composite component manufacturing in monolithic structures will build on four decades of established repair practices for fixing damage to sandwich-constructed parts (polymer resin skins reinforced with glass, aramid and carbon fiber in the 3-30-ply range, covering non-metallic core).

Ron Murray, chief 787 mechanic for Boeing, says, "Repairs to the 787 will be accomplished using composite repair equipment that is similar or the same as that used in industry today."

At Airbus, Dr. Roland Thevenin, senior expert in composite structure conformance, explains that "there is no change regarding the applicability of bolted (structural) repairs or bonded (cosmetic) repairs for A380 or A350 primary composite structures. For any bolted repairs, metallic (temporary) and carbon fiber reinforced composite (permanent) doublers can be used. For bonded repairs, harmonization of materials and repair techniques will be introduced in our documentation, and provide the airlines and MROs with a substantial improvement over what is typically undertaken today."

Even with these assurances, repair service providers have their own ideas about what they may encounter with composites on new aircraft. "There is no question that the new structures—by their material make-up, as well as the size of the sections—will drive a need for new tools, repair equipment and training," says Leonard Kazmerski, VP marketing and business development for Timco Aviation Services. "At least initially, the variability in types of required repairs and inspections could create some of the biggest planning challenges in the early years of flying by the new composite aircraft. How to stage the right materials where they are needed, how to insure that correctly trained talent is available when the maintenance requirement presents [itself]—these are the questions that might make some folks view this shift as daunting, at least until standardized approaches are adopted," says Kazmerski.

SR Technics supports some 800 aircraft through line stations at 19 international airports. Jürg Bislin, VP engineering and planning, offers his take on the coming composite repair tool-up. "One of the biggest challenges will be to develop approved in-house composite repair capabilities and ensure that we have the facilities to cope with the size, quality and volume of repairs. Old-fashioned shops won't be able to efficiently deliver the quality standards expected," he says. These high-tech repairs also will require clean room environments.

Carrying 71 million passengers a year on nearly 600 aircraft more than qualifies Air France KLM and its MRO arm to weigh in on maintenance realities for new aircraft. Michel Bruet, Air France Industries KLM Engineering & Maintenance's VP aerostructures, says, "Shop activities will need more adaptivity in logistics, asset management and global services offered to customers. Some costly equipment might have to be invested in among partners in order to share high cost and low utilization rate due to on-wing reliability, as it has been in the past for repairs on some specific engine parts."

When it comes to materials, he thinks "the issue is not in the storage facilities, but far more in securing sources at reasonable prices, in a market where MROs buy small quantities and manufacturers and OEMs buy a significant portion of composite materials volume." He suggests partners should consider common sourcing.

Ron Torres, United Airlines' managing director of component maintenance, says "From what we have seen so far, the 787 fuselage hot-bond prepreg repair process will be challenging to meet the requirements for porosity, compaction and other parameters. Boeing has added several steps to ensure strength and reliability, which may make the entire repair process longer than a bolted repair. Time will tell."

Torres says United has been working with Boeing for at least three years to prepare for its 787 aircraft, the first of which is slated for delivery in 2012. This includes buying NDT equipment and curing tools for its dedicated composites center in San Francisco.

Devil in the Details

To repair these new aircraft, where the devil comes out in different details is in the thickness of composite plies in monolithic structures. "There will be significant differences in the repair of primary structures made of composite laminates greater than 100 plies," says Leigh Sargent, president of Applied Composites Engineering. His company provides repairs services for regional airlines and primes, as well as design and manufacture of composite aircraft components.

"At this thickness and class of structure, autoclave cure is mandated. The prepared area will be digitally scanned, reverse-engineered, and tooling [will be] designed and made specifically for the structural patch/parts and or additions where these are cured in an autoclave. Components that make up the engineered repair will be wet-bonded in place with the possible addition of fasteners and a post-cure of an adhesive with a broad temperature range to assure full cure," says Sargent. This will require technicians who hand-prepare the area to have high levels of reverse-engineering and tooling capability, and "sound engineering for the repair design will be the basis of major structural repairs."

Sargent's comment touches on a prevailing industry concern about the level of training that will be necessary to complete thick-section laminate repair and about the current dearth of well-trained technicians in general.

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Rusty Jones, FAA manager of the special projects branch, has coordinated development of FAA Advisory Circular 65-33, "Training and Qualification Programs for Composite Maintenance Technicians," to address these issues. He says, "Part 145 repair stations and Part 121 air carriers are required to have a training program. This AC provides guidance for the minimum content for training composite maintenance technicians." Collaboration on the recommended curriculum was provided by the Commercial Aircraft Composite Repair Committee and through public review.

OEMs offer maintenance training for their aircraft to ensure operators are ready to maintain the airplanes as they enter fleets. Boeing's Murray makes the point that "MROs should update their training to meet or exceed OEM training to assure the skills are there and the technicians are practiced." He notes that introduction of next-gen aircraft will be gradual, so "for the next few foreseeable years, composite-intensive aircraft will be the minority of the aircraft in service, and statistically, the damage incurred will be similarly small."

Reducing AOG

An aircraft on ground (AOG) is the bane of any airline's existence, so a tool that optimizes the time to complete a repair is welcome. Two resources come immediately to mind: the structural repair manual (or SRM), which provides recommended repair materials and methods, and design organization approvals for engineered repairs. Both originate at the OEM, but to be most effective, they require communication between all parties involved in conducting repairs. For next-gen aircraft, wielding this tool may mean a broader reach in both directions.

Sunny Mirchandani, VP engineering and international sales for Taikoo AeroSystems (JinJiang) Composite Co., comments on the importance of the OEM/service vendor exchange. "Repairs to thick laminates (50-100-plus plies) will certainly require more 'innovative' repair procedures and support from the OEM to evaluate the effects on the fatigue life of the structure. Further, specific repair prepregs may have different storage requirements and short shelf lives, adding costs for small repair shops."

Sargent emphasizes that availability of sufficient SRM information is necessary to understand a structure's original design before it needs repairs, as well as for repair time efficiency. "With this knowledge, the repair facility can design, tool and manufacture the area in question, and then post-bond the manufactured repair section into the original structure. The incorporation of inserts, stiffeners and other features can be accurately positioned, structurally matched and the joint designed to transfer loads," he says.

What Lies Beneath

Visual inspection remains the primary method for assessing damage to composites. Lou Dorworth, division manager of direct service at Abaris Training, explains that "thick-walled, integrally stiffened composite structures are more damage tolerant and inherently reliable than current aluminum-skinned, frame and stringer-stiffened airframes. Conversely, these same structures exhibit elastic behavior when impacted and tend to hide damage more readily than metallic structures."

He adds, "To determine damage that penetrates thicker laminate layups, airlines will have to invest in non-destructive inspection technologies, such as flash thermography, laser shearography, and interferometry."

There may be a way to add more inspectors who can keep protective eyes on these new assets—even if informally. Stephen Hoy, technical instructor for Lufthansa Resource Technical Training, suggests, "Structure familiarization for technicians, maintenance managers, engineers, refuelers, baggage handlers and others will help them understand composite material properties, the potential for damage under static and dynamic loads, how

composites are maintained and what is required to repair them. This knowledge could increase reporting of incidences where impacts may have occurred but leave no visible indication."

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Dialogue and Vigilance

The A380 has been in service for four years, flying 15 metric tons lighter than if built of all metal; the A350 is due for first flight next year, and at our presstime, Boeing was scheduled to deliver the first 787 to All Nippon Airways. So, MROs and operators are entering the thick of the maintenance reality that will involve a higher level of composite repair.

Timco's Kazmerski offers an overview of this challenge. "OEMs and material developers have conducted extensive testing to prove integrity and longevity as to the materials applicability for new aircraft. However, dialogue among OEMs, MROs and airlines flying the new aircraft has only begun to grapple with performance over fleet life and optimal repairs and their subsequent longevity."

When asked for advice from United's years of composites repair that would enhance the success of repairs on next-gen aircraft, Ron Torres says, "The best lesson is that every airplane requires continuous performance monitoring from day one. Vigilance, with an eye toward identifying new failure modes as the aircraft ages, will help provide important feedback to the OEMs, who can then develop corrective actions. I see the industry continuing to evolve in handling composites, just as it has evolved with aluminum aircraft over the last 60 years."