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New Boron Longeron Makes Boeing B-1 Aircraft Flight Worthy Again

by

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B-1 aircraft 86-0125 (*Swift Justice*) is being delivered back to the Air Force at Ellsworth AFB at Rapid City, South Dakota thanks to the efforts of multiple sites and organizations within the Boeing Co after undergoing a major structural repair at Long Beach, CA. These organizations included the Boeing Recovery And Modification Services (RAMS) center, C-17 Tooling and B-1 Engineering all in Long Beach, the Seattle Composite Fabrication & Assembly Center (CFAC) and the Composites and Adhesives Group in Huntington Beach, CA, as well as material vendors.

This repair was required when an overtemp light came on during a routine training mission. The systems tunnel sensors indicated things were hotter than normal, and so *Justice* came home and landed uneventfully at Ellsworth AFB. Upon inspection, it was discovered that the engine bleed air duct system ruptured and blew the 500F+ engine exhaust up into the dorsal tunnels causing severe damage to the backbone of the jet. In order to make 86-0125 fully operational again, a replacement Upper Center Boron Longeron, a hybrid made up of a titanium base with a co-cure/co-bonded cap of boron/epoxy composite, was required - a part unique to each aircraft, with no spares. As a result of the damage, significant flight restrictions were put on the aircraft that effectively grounded it. Shortly thereafter Boeing was put on contract to repair the aircraft and thus began a year+ exercise in process archeology as this part had not been fabricated for on the order of 25 years and all the engineering, tooling and sundry items were scattered in Air Force depot stores. Through great efforts the past was uncovered in terms of tooling, drawings, process specifications, materials (including replacement of defunct items) and MRB.

The actual longeron fabrication could not be done until the original tooling was found, restored and deciphered - as the usage and assembly instructions were never found! The Bond Jig, with scores of mystery parts, was located in the Arizona desert at the 309th Aerospace Maintenance and Regeneration Group (AMARG) site; an empennage cradle was found in the excess yard at Tinker AFB, but the transportation dolly was never found.



**Bond Jig Sitting in the Desert (L) and Fuselage Cradles in the Yard (R)
(Customer and AMARG Employee)**

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Miscellaneous Parts and Pieces of Longeron Bond Jig in Arizona Desert

The tools were shipped from AMARG and Tinker AFB to Boeing C-17 Tooling group (Long Beach) for refurbishment in mid-2008. Both tools required extensive restoration work to repair damage and wear from years of outdoor exposure. The bond jig, originally bare steel since it stayed in a clean room during production days, was given a custom paint scheme approved by the USG customer. The transportation dolly that was never found was fabricated new from the original vellum drawings.



Restored Longeron Bond Jig (L) and New Transportation Dolly (R)

In July 2008, the crippled B-1 was ferry-flown from Ellsworth AFB to the Boeing Recovery And Modification Services (RAMS) Center in the Long Beach for its' backbone operation. The aircraft was jig-jacked to both unload the longeron as much as possible for removal and support it while the backbone was not in the jet. Removing the longeron took about two weeks between jacking and crawling inside the narrow fuselage to reach fasteners that were never intended to be reached. Removal operations were timed with the completion of the tooling so that the longeron would be out of the aircraft for a minimal amount of time.

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Swift Justice on Jacks (L) and Removal Operations (R)

(Pat Gandall, Will Fry (inside fuselage), Jimmie Lipsky)

The boron/epoxy backbone of the B-1 is an extremely aggressive composite design, even by today's standards. Michael Goodrich, from the Composites and Adhesives Group (Huntington Beach) was a crucial advisor to the B-1 program regarding some of the technical items recovered from the desert, as well as assisting in the fabrication of the replacement Longeron. Due to its complexity, uniqueness and 47.5-foot length; the CFAC, with their 90-foot autoclaves and composite development shop, was selected to do the layup. Lamar Dearth, an ME at the CFAC, wrote 357 pages of planning to get the part fabricated! The actual fabrication work of the longeron began after significant activity regarding reassembly of the bond jig by the CFAC Tooling group. The bond jig is assembled AROUND the titanium base plate in order to make a net part.



Placing the Titanium Cap on Bond Jig (L) and Building Jig Around Cap (R)

(FOREGROUND: Lamar Dearth, Randy Chinn, Ken Turrell, Kathy Grant)

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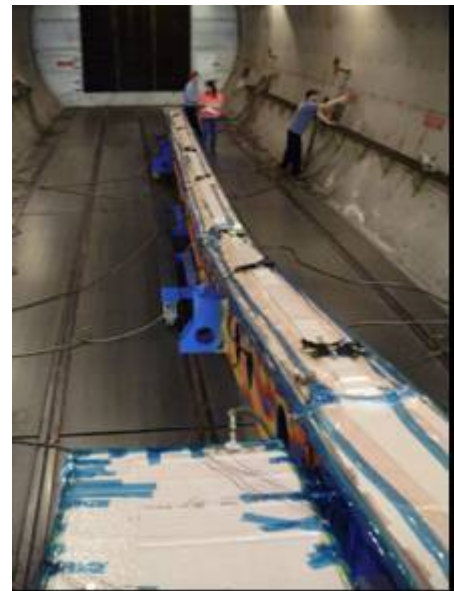
Contours of the tool/part make it extremely difficult to use current practice layup and inspection verification techniques; consequently, it was necessary to go back to the "old ways" in terms of accepting the tool and inspecting the layup (think mylars and rulers).



24/7 Layup Operations for Boron/Epoxy Longeron

(Clarita Dela Cruz, Chanty Ung, Ian Lorenz, Lehong Tram, Shane Collins, Loni Townsend, Ryan Swenson, Scott Fannin, Kathy Grant, Betty Jahner, Namhyo Na, Helen Ung, Maureen Vistante)

The original boron/epoxy material supplier (Specialty Materials, Inc.) supplied the 14,000 feet of 4-in wide unidirectional tape that was necessary to fabricate the longeron. The amount of 5.6-mil diameter boron filament used to make this part can encircle the earth over 1.5 times!!! The material out-time required that the 330-ply longeron, built to NET dimensions of 4.00-in (+0.005/-0.000), be completed in no more than 360 hours (15 days). The CFAC layup crews worked continuously 24/7 for eleven (11) days to meet that deadline and 330 plies later; the new Longeron was ready for the 90-foot autoclave!



Final Bag (L) and Setting Up in 90-ft Autoclave (R)

(FOREGROUND: Lamar Dearth, Mike Goodrich, xxxxxxxx)

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The 22-hour cure cycle did help create a perfect part but not without at least one notable harrowing event ... During a hold right after a resin exotherm spike, all vacuum was lost (blown bag) and it was too far into the cure cycle to stop the autoclave and assess potential damage to the half-million dollar material. The final twelve hours were pins and needles. When all was done, an ultrasonic inspection showed a flawless Longeron for delivery to the RAMS Center, where 86-0125 was waiting.



Reinstalling New Longeron (R) at RAMS Center

(Pat Gandall, James Anderson, Ramon Bernardo, Louis Vera)

The return to flight of 86-0125 required a lot of coordination and teamwork between Engineering, Materials & Processes, Tooling, Planning, Procurement, aircraft mechanics and the Customer. Fifteen months after being grounded for a catastrophically damaged backbone, B-1 aircraft #86-0125 'Swift Justice' is ready for a return to flight checkout!

Many thanks to those who helped this happen: R. Alvidrez, J. Anderson, R. Bernardo, L. Borden, R. Chinn, S. Collins, F. Compean, R. Cottom, J. Creager, L. Dearth, M. DeBry, M. Conca, C. Dela Cruz, B. Emens, S. Fannin, K. Farah, G. Freed, W. Fry, P. Gandall, M. Gatica, M. Goodrich, L. Guerrero, K. Grant, B. Jahner, J. Kennedy, J. Lipsky, I. Lorenz, J. Lorenz, N. Na, R. Oen, J. Orr, A. Pantoja, M. Peterson, A. Ridley, J. Ritter, Y. Simonetti, R. Swenson, C. Tice, L. Townsend, L. Tram, B. Turrell, O. Udani, C. Ung, H. Ung, L. Vera, M. Vistante, O. Vickers, M. Voorheis and R. Woodworth.