Automation Technology for Large Composite Structures Manufacturing

Steve Summitt

ATK Aerospace Structures
Iuka, MS
ATK Composite Products

COMMERCIAL
- Engine Cases
- Nacelle Structures
- Airframe Structures

A350
- Stringers
- Frames

MILITARY STRUCTURES
- Advanced Structures
- Wing Skins
- Nacelles

MILITARY SYSTEMS
- Apertures
- Survivable Structures
- Performance Verification
- Sensor Technology

LAUNCH
- Launch Structures
- Rocket Motor Cases
## A History of Innovation

### 1940’s
- ABL Manufacturers
- First Filament-Wound Rocket Motor

### 1971
- ATK Introduces S-Glass/Epoxy and Kevlar/Epoxy Materials

### 1978
- Introduced Carbon/Epoxy

### 1982
- Invented the Fiber Placement Process

### 2002
- Developed World’s Fastest Fiber Placement Machine

### 2005
- Manufactured Largest One-piece Fiber Placed Part on Any Military Aircraft

### 2007-2011
- Invented and Patented the Automated Stiffener Forming Machine (6 Patents in Total)

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**ATK – Innovator of Automation Technology**
Automation for Large Structures

KEY FEATURES
Located in Iuka, Mississippi
• Floor space: 320,000 sq ft
• 85,590 sq ft Clean Room
• Fiber Placement And Filament Winding Machines
  • Autoclaves
    - 17.5 Ft. Diameter X 50 ft Length
    - 20 Ft. Diameter X 83 ft Length
• 23m Belotti Machining Center
• 5-axis CNC Water Jet, 3-axis Machining Center
• 5-axis CNC Router
• Automated Ultrasonic Inspection (AUIS)
  - Horizontal And Vertical
  - 13 Degrees of Freedom
  - Modular, Accommodates Wet, Dry And Radiographic NDI
• Dockable Gantry ATL And Fiber Placement System

MANUFACTURING AREA

New Dockable Gantry ATL / Fiber Placement System Production Ready by 12/2013

Production Ready 23m Belotti Machining Center
SIGNIFICANT ATK HERITAGE OF LAUNCH STRUCTURES

Payload Attatch Fitting / Diaphragm (Not Seen) (ATK)
Debris Shield (Not Seen) (ATK)
Boattail (ATK)
Centaur Interstage Adapter (ATK)
Heat Shield (Not Seen) (ATK)

Payload Fairing (ATK)
Heavy Interstage (ATK)
Nose Cones (ATK)
LOX Skirts (ATK)
Center bodies (ATK)
Thermal Shields (Not Seen) (ATK)

Rocket Motor Stages 1, 2, 3 (ATK)
Payload Fairing (ATK)
Interstage (ATK)
Fairing (ATK)

Significant ATK Heritage of Launch Structures

- Over 350 Delta IV Structures Manufactured
- Over 60 Atlas V Structures Manufactured
- 7 Ariane V ISS Structures Manufactured
- Over 40 Pegasus Missions
- Orion Ogive Fairings
ATK Builds Stringers For These Sections

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ATK Builds Frames For These Sections

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ATK’s Automated Stiffener Forming Process (ASFM) Developed To Manufacture 25 miles/40 km Per Month At Rate
Fuselage and Wing Structures

Agusta Westland 609 Cockpit and Fuselage Skins

Passenger Jet Fuselage Structures

Passenger Jet Composite Demonstration Wing
ATK has assembled a capable and experienced design and analysis team.

- 30+ design and analysis engineers
- In-depth product knowledge in key areas
  - Aircraft primary and secondary structure
  - Launch vehicle structures
  - Pressure vessels, including tanks and rocket motor casings
  - Antennas and radomes
  - Graphite tooling
  - Composite rotor tubes

ATK specializes in the design and analysis of structures fabricated from advanced composite material systems.
ATK pioneered the fiber placement process in the early 1980's
ATK designs and fabricates its own machines
ATK operates 12 fiber placement machines
ATK fabricates structures up to 16 ft in diameter and 50 ft in length
• A technology built for next-generation aircraft, ATK’s patented Automated Stiffener Forming (ASF) technology provides lower cost, higher quality stringers and frames

• ASF offers superior compaction and repeatability compared to those produced using hand layup processes

• ASF achieves production rates of nearly 10 times that of the traditional layup process, minimizing touch labor by 90%
Technology — Hot Drape Forming

- Commonly used for manufacturing spars. Straight, flat parts with minimal taper, joggles and curvature and parts with a larger radius. Honeycomb sandwich panels and out of autoclave cure
- Materials can be either unidirectional (UD) tape or fabric – typically UD
- Benefits of Hot Drape Forming:
  - Lower Implementation Costs
  - Lower Cycle Times and Labor
  - Simpler Equipment
  - Good Cosmetic Finish
  - Capable of “Zonal” Heating and Pressure
  - Potentially Eliminate Autoclave Cure
  - Reduce Between Ply Compactions

The flat prepreg form is placed over a forming tool and under a membrane so that vacuum pressure can be exerted. Heating is provided by an overhead solarium. Under appropriate heat and vacuum, the component is rapidly formed to the desired shape. Hot Drape Forming machines allow multiple ply lay-ups to be formed into shape quickly and easily. They are designed to form the carbon fiber by allowing the individual plies to slip against each other and produce parts free from any stress wrinkling (Marcelling). The infra red lamps heat the carbon fiber quickly and evenly resulting in reduced production times and is zoned to give uniform heat distribution.
• Successfully fabricated out-of-autoclave part containing integral skin and stringers
• Successfully fabricated self-heating tool by dispersing nanno tube “K-factor” into resin
• Developed In-situ Out-of-Autoclave (OOA) process scalable to very large structures
• Combined ultrasonic tape lamination (UTL™) compaction with automated fiber placement
• Allows material to be placed and compacted to near net thickness as the laminate is created, allowing vacuum bag/oven cure
• Out-of-autoclave composite void volume compares favorably with conventional autoclave methods, having less than 1% void volume
ATK-developed, high-speed automated Non-Destructive Inspection (NDI) technology increases throughput, detection fidelity and data evaluation. All ATK composite products undergo complete inspection.

ATK developed NDI technology:
- Uses multiple independently operated detection heads, coupled with advanced signal processing software to greatly reduce scanning and data evaluation time
- Moves ultrasonic probes over the surface of the part at high speeds to create ultrasound images of defects and the internal structure of a part
- Evaluates results using advanced image processing algorithms
- Requires minimal operator involvement
ATK developed a Composite Health Monitoring System that knows when and where an impact occurred.

ATK’s Composite Health Monitoring System / Impact Damage Detection technology:
- Uses a physics-based approach
- Reduces footprint, using novel phased array techniques to dramatically reduce sensors and cabling
- Developed on full-scale components in real-world environments

Composite Crew Module (CCM) Liberty capsule pressure vessel built by ATK was instrumented with health monitoring and lightly impacted in pre-determined locations to test Health Monitoring system.
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