



Development and Certification of Composite Rotor Blades

Presentation for FAA
Composite Modifications Workshop
July 19-20, 2016

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Company Description

- Located in Tempe, Arizona
- Founded in 2001, now more than 25 employees
- Business Model
 - Design, test, certificate, and manufacture composite main and tail rotor blades
 - Focus on legacy helicopters (developed 1960s-1970s) that still use metal rotor blades
 - VHA composite blades offer improved performance and increased service life versus metal OEM blades





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Models Supported (Current/Future)



Bell 206B/L



Bell 505



Bell UH-1



MD 500 Series



Bell 412/212



Rotor Blade Design Approach

- Use 2X Estimated Ultimate Load
- Avoid secondary bonds
 - Root end metallic components are fastened
 - Exception: bushings are pressed
- Co-cure Composite Assembly
 - Uses structural foam as layup mandrel (Fly away tooling)
 - Upper surface layup mold
 - Shell concept with no internal structure (NDI not required!)
 - Tolerate lower surface imperfections



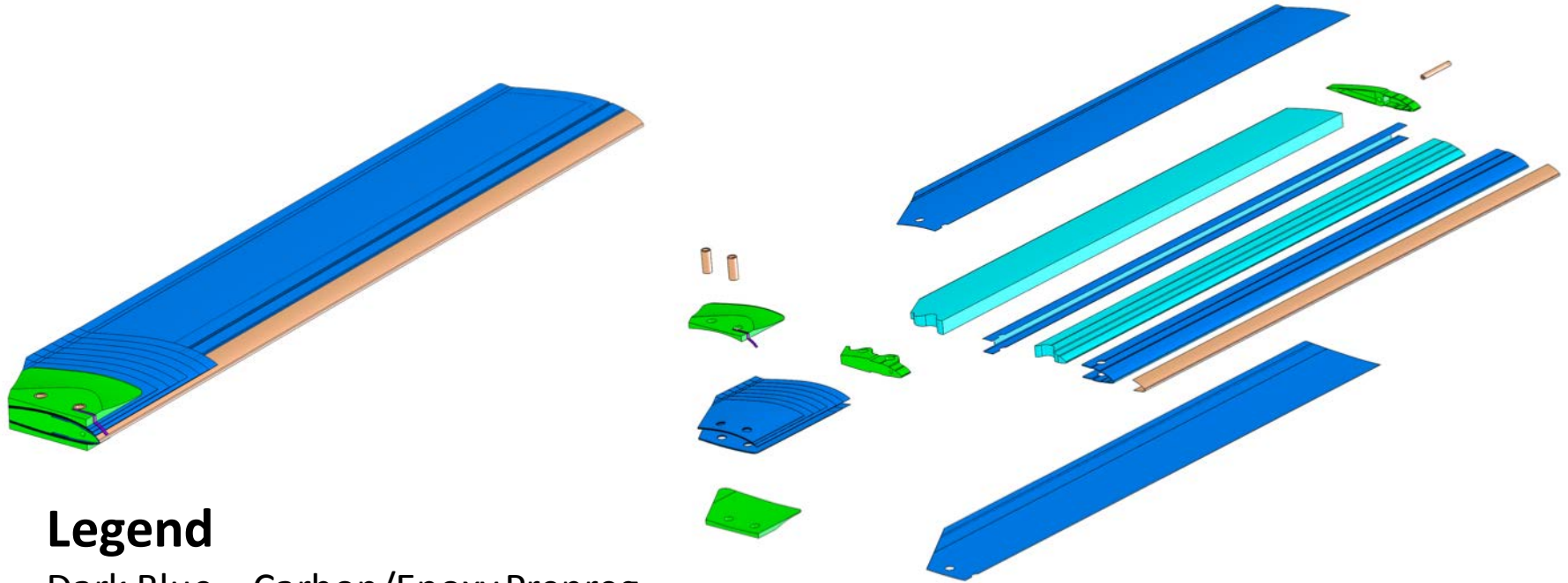
Rotor Blade Design Approach

- Root Doublers Stacked Internally
 - Avoids any highly loaded ply drop-offs
- Sacrifice Design Elegance for Manufacturability
 - Simple airfoil/twist contours
 - Surface preparations to reduce sanding/paint prep
- Not Focused on Weight Savings
 - Direct replacement blades need to be approximately same weight as OEM
 - More plies of carbon than needed for minimum strength



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UH-1 Tail Rotor Blade



Legend

Dark Blue = Carbon/Epoxy Prepreg

Light Blue = Structural Foam Core

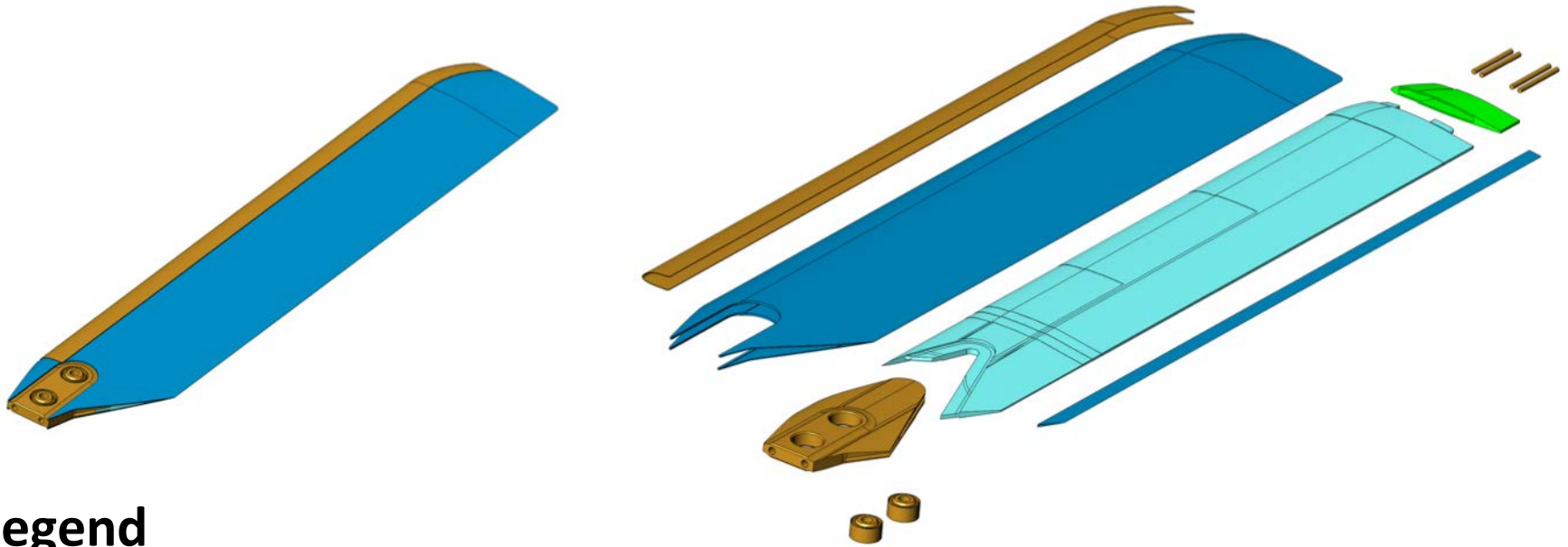
Green = Fiberglass/Epoxy Machined From Pre-cured Sheet

Other = Metallic



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Bell 206B/L/OH-58 Tail Rotor Blade



Legend

Dark Blue = Carbon/Epoxy Prepreg

Light Blue = Structural Foam Core

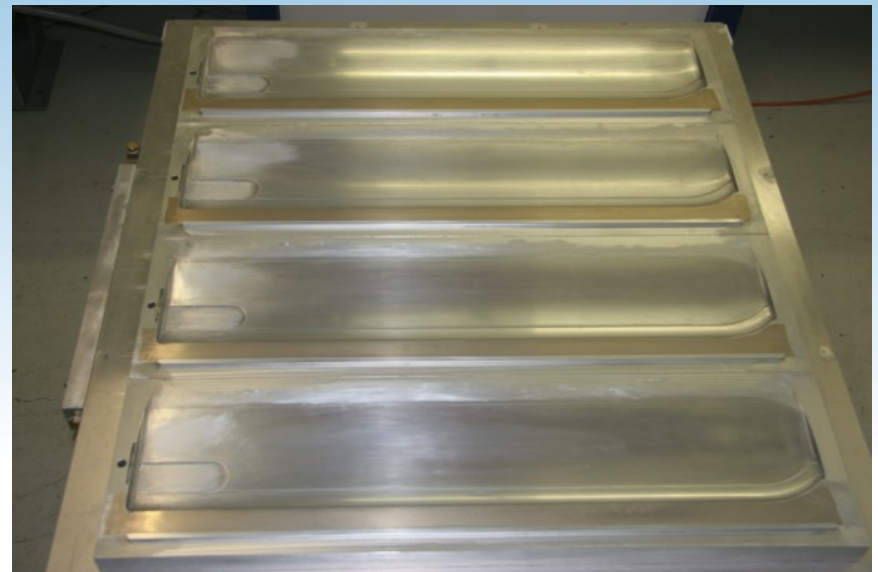
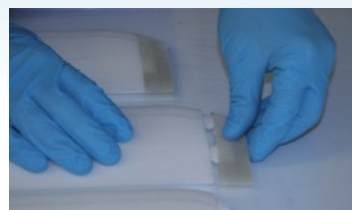
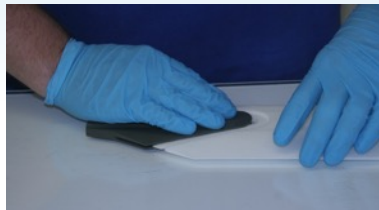
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206 Tail Rotor Blade Manufacturing





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Bell 412/212 Tail Rotor Blade



Legend

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Light Blue = Structural Foam Core

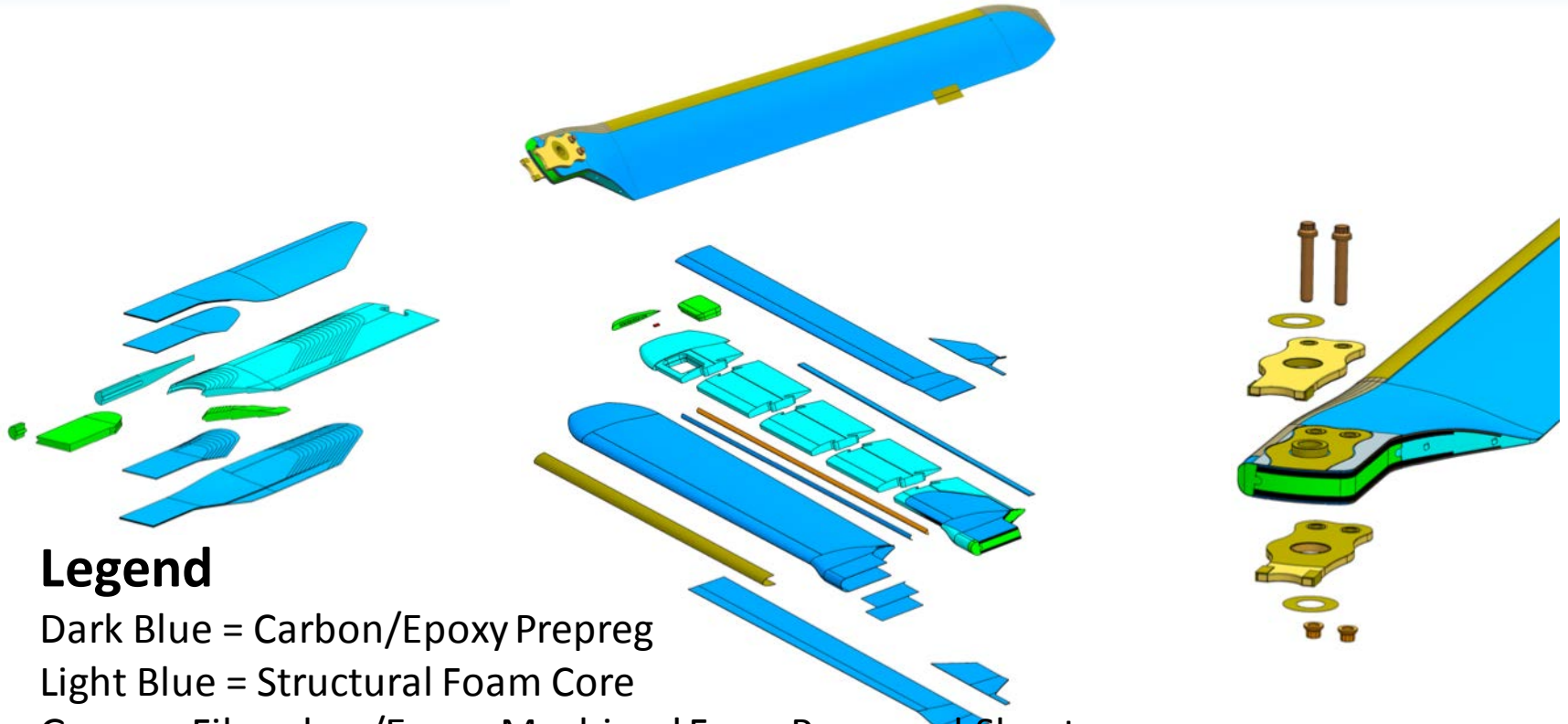
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Bell 206B Main Rotor Blade



Legend

Dark Blue = Carbon/Epoxy Prepreg

Light Blue = Structural Foam Core

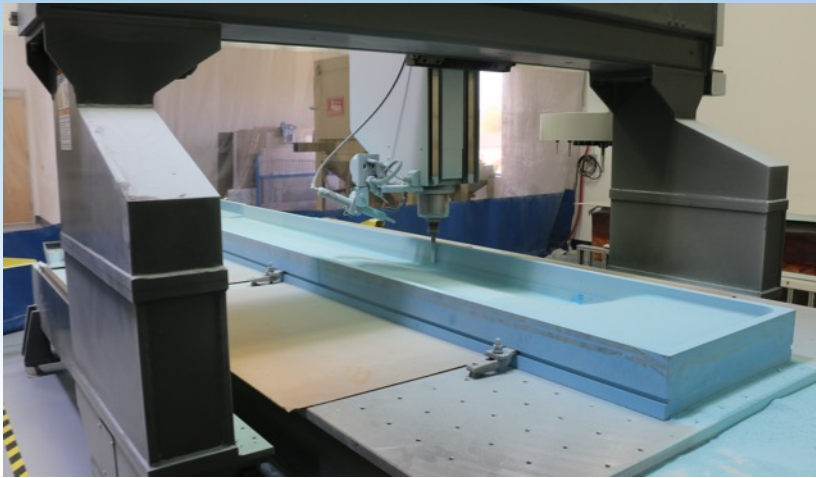
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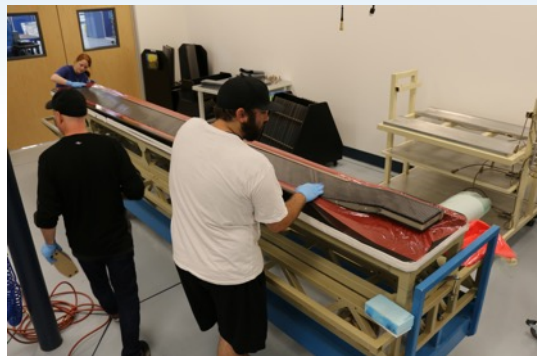
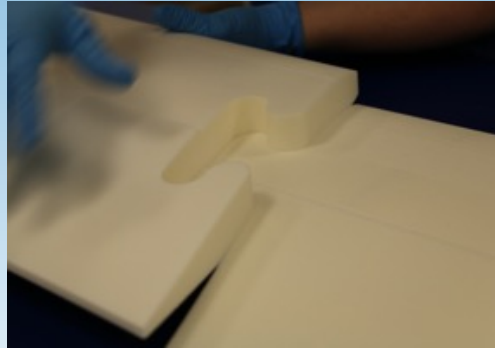
206B Main Rotor Blade Tooling





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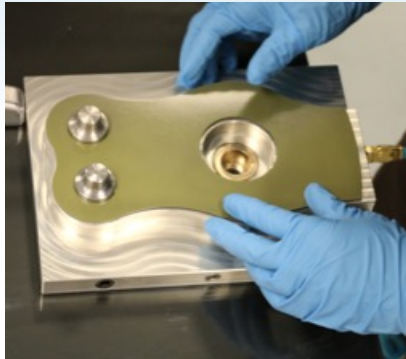
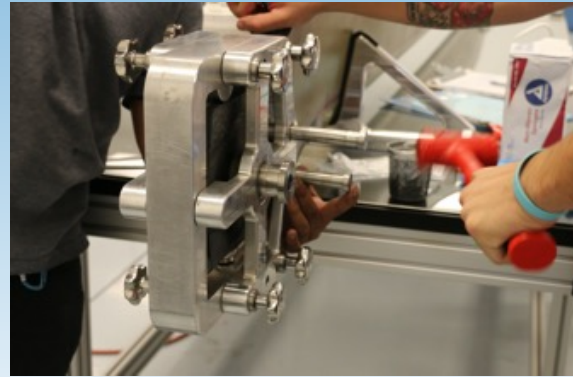
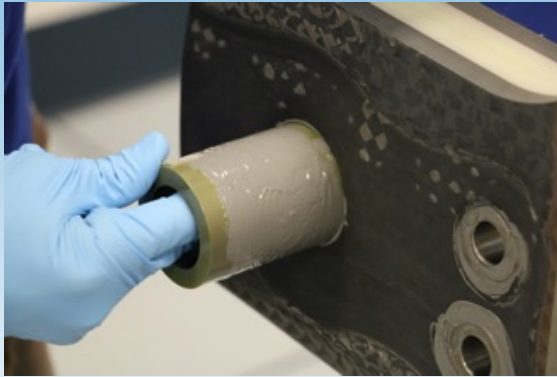
206B Main Blade Sub-Assembly





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206B Main Blade Root Bonding





Test Methodologies

- DOT/FAA/AR-10/6 Report Used as Basis for Structuring Lab Test Program
- Coupon Testing
 - Actual layups used
 - Establish Weibull shape factors
- Flight Testing
 - Flight strain survey to measure flight loads to be used in structural tests and analyses



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206B Main Blade Flight Strain Survey





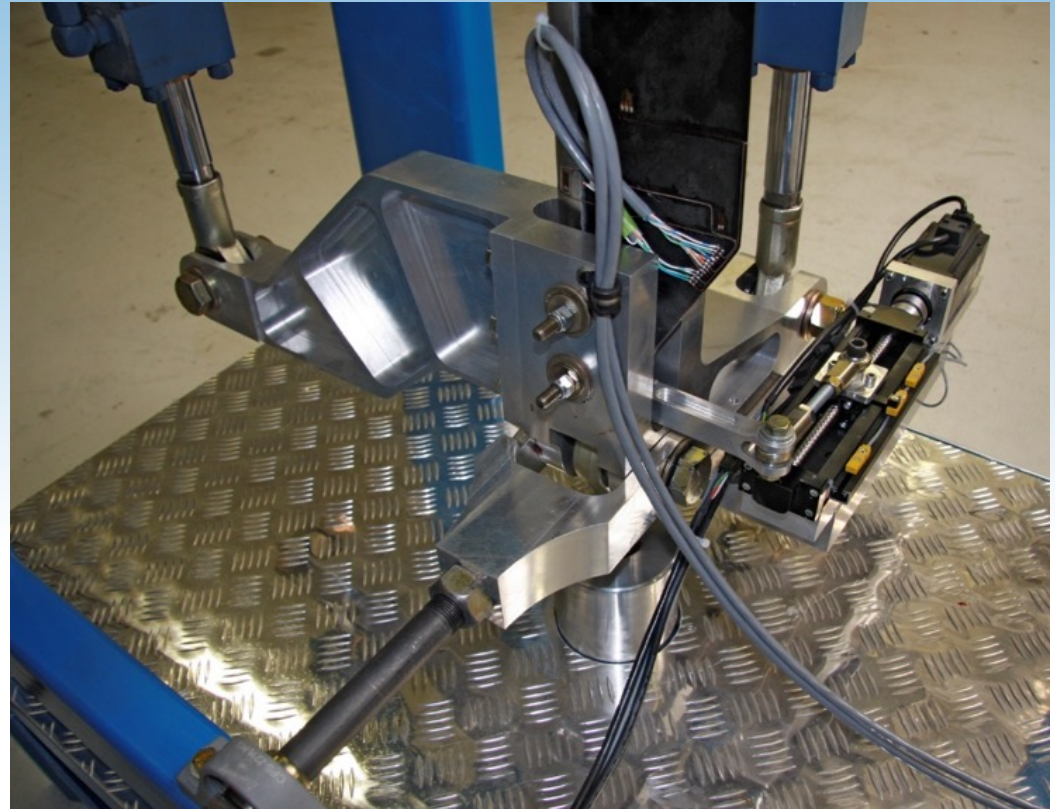
Test Methodologies

- Service Life/Fatigue Testing
 - Spectrum loading used
 - Analyses used to determine failure modes for three environmental factors:
 - RTD – Room Temperature Dry (ambient)
 - CTD – Cold Temperature Dry
 - ETW – Elevated Temperature Wet
 - Loads obtained from flight strain survey
 - Maintain fidelity between flight test loads and fatigue test loads
 - Include affected components



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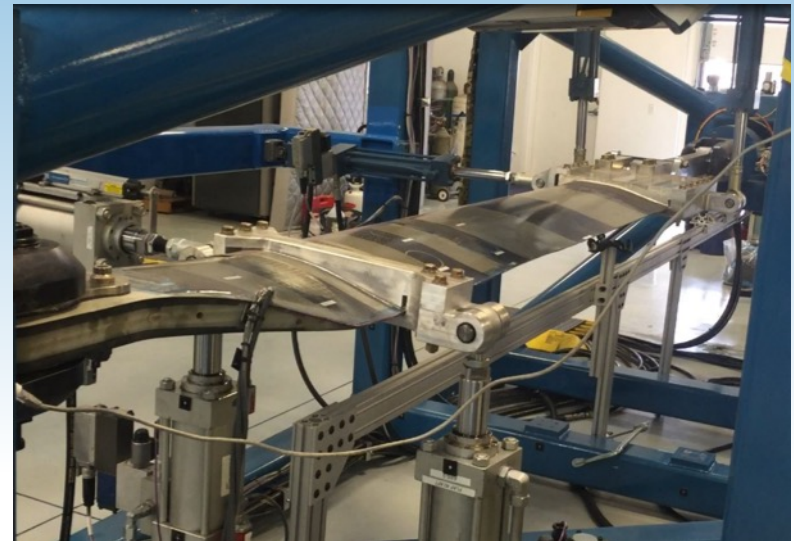
206B/L Tail Rotor Blade Fatigue Test





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206B Main Rotor Blade Fatigue Test





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206B Affected Component Fatigue Tests



Main Rotor Grip

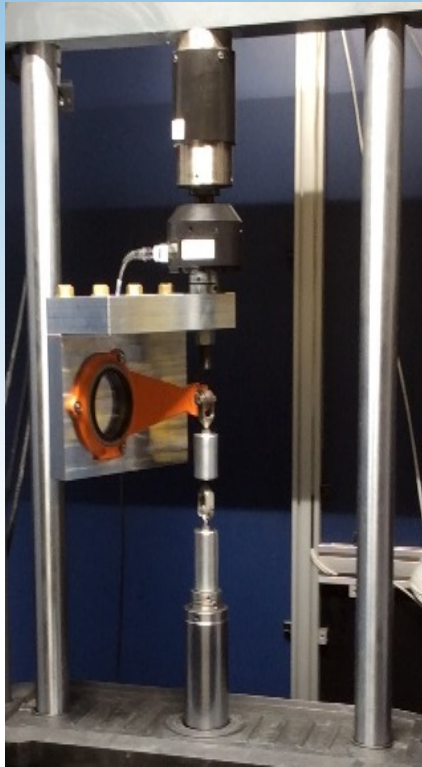


Main Rotor Yoke



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206B Affected Component Fatigue Tests



Main Rotor Pitch Horn



Main Rotor Control System



Future Development Work

- What is the actual rate and level of long term moisture absorption for composite rotor blades utilizing several layers of protection (primers and topcoats)?
- What is the rate of cooling through the cross section of main and tail rotor blades from stopped to operating rpm?
- Fretting protection for composite and metallic mechanically fastened components



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Future Development Work

- Embedded real time rotor blade load measurements
- Thermoplastic vs thermoset rotor blade construction

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Thank you for your attention!

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