Development of Subsonic Single Aft Engine (SUSAN) Attritable Research Vehicle (SARV) Wing Structure

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Outline

- SARV Overview
- Objective
- Unique Considerations
- Wing Structure Evolution & Analysis
- Manufacturing Demonstration Vehicle
- Wing Skin Development
- Conclusions & Next Steps

Subsonic Single Aft Engine (SUSAN) Attritable Research Vehicle (SARV) Overview

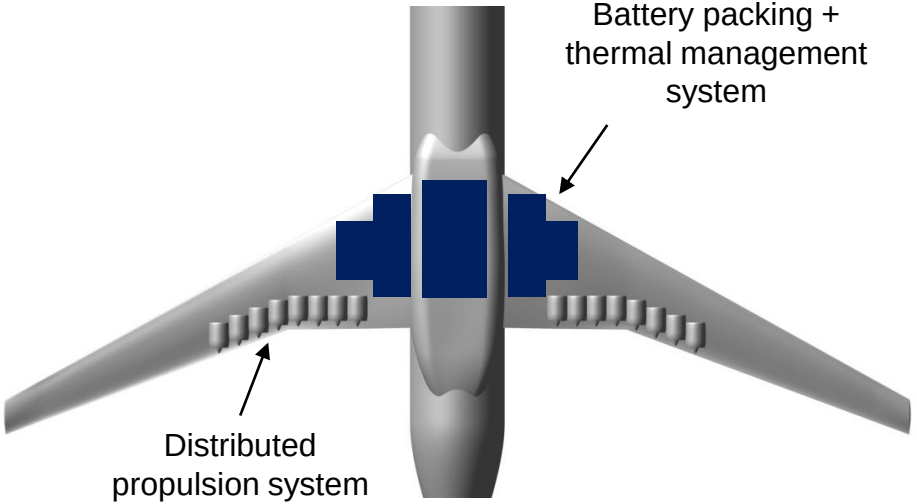
- **SUSAN:**
  - Regional jet transport aircraft concept
  - Utilizes aft mounted single turbofan engine and underwing electrified aircraft propulsion
- **SARV:**
  - 25% direct scale down of SUSAN full scale (180 passenger aircraft)
  - Serves as remotely piloted flying research testbed for:
    - Integrated flight
    - Propulsion
    - Controls architecture

Objective

- Development of SARV wing structure
  - Considerations for:
    - Wing skins
    - Internal structure
    - Battery box storage
- Vehicle must be low cost & quick to manufacture allowing for:
  - Incremental validation of novel design concepts
  - Reduced technical risk

Unique Wing Structure Considerations

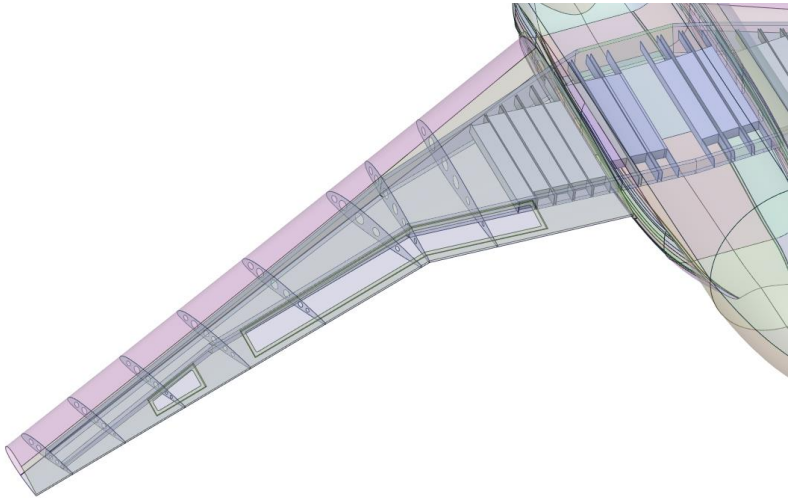
- Battery pack and fuel storage in wings
  - Landing weight closer to takeoff weight
- Wing mounted electric engines
  - Impact to control surfaces, loads more distributed across the wing
- Entire vehicle must be transportable via common shipping container
  - Wings attached to fuselage via a separable joint
  - Joint must be able to carry aerodynamic loads seen in flight



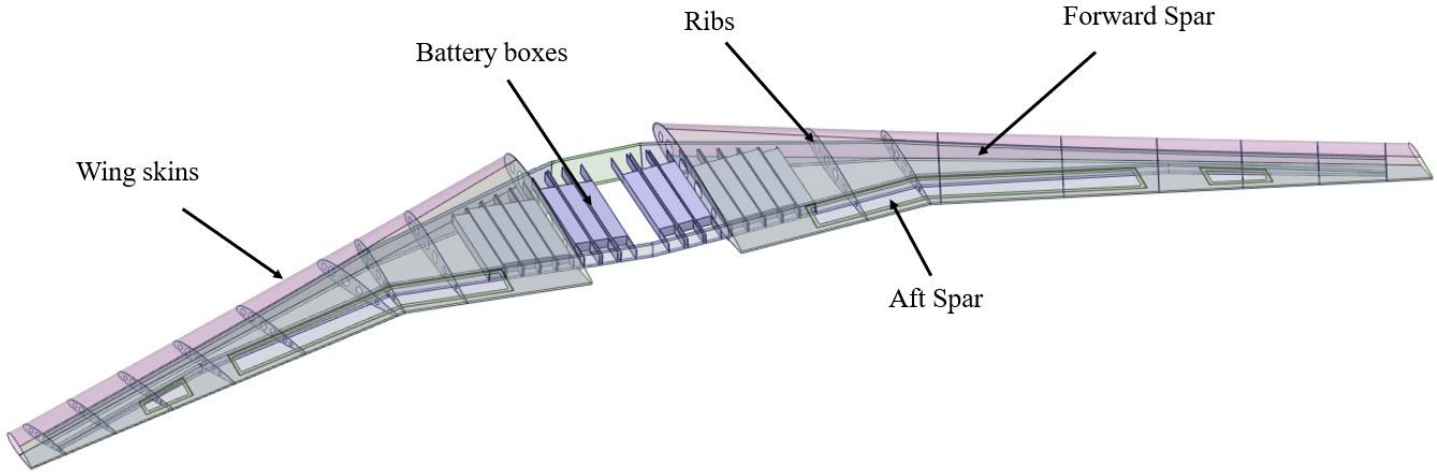
Wing Structure Evolution

- Design evolutions of wing structure focused around updating wing structure around battery box concept

Iteration 3: Structural rib-like battery box layout



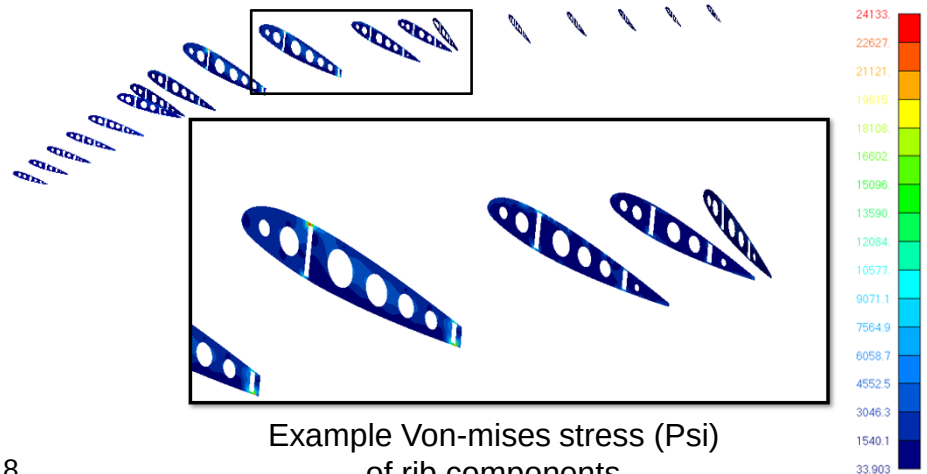
Wing Design Description



- Tapered c- channels at both the forward and aft spar locations
  - Forward spar @ ¼ cord location
  - Battery box storage in wings/wingbox
  - Composite wing skins attached @ ribs

Wing Structure Analysis

Design Iteration	Component Location	Material	Section Thickness	Weight Per Wing*	Yield MoS	Ultimate MoS
1	Spars	AL 6061	0.375 in.	97 lb.	3.67	1.61
	Ribs	AL 6061	0.375 in.		2.68	1.15
2	Spars	AL 6061	0.25 in.	65 lb.	1.40	0.41
	Ribs	AL 6061	0.25 in.		1.76	0.51
3	Spars	AL 6061	0.19 in.	49.6 lb.	0.63	0.04
	Ribs	AL 6061	0.19 in.		1.38	0.24
4	Spars	AL 7075	0.125 in.	33.3 lb.	0.77	0.07
	Ribs	AL 7075	0.125 in.		1.86	0.59

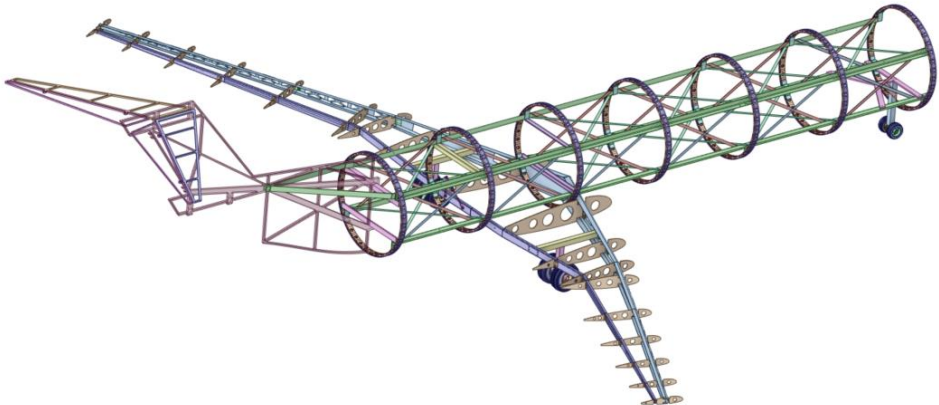


Example Von-mises stress (Psi) of rib components

- Shell elements modeled in FEMAP to iterate section thicknesses
- Analysis iterations cut wing weight by 64 lb. each side
- Symmetric pull-up maneuver analyzed:
  - 3.75g load factor
  - 11.05 deg angle of attack
  - Wing aerodynamic loads applied (provided by CFD)
  - Weight of batteries in wings included

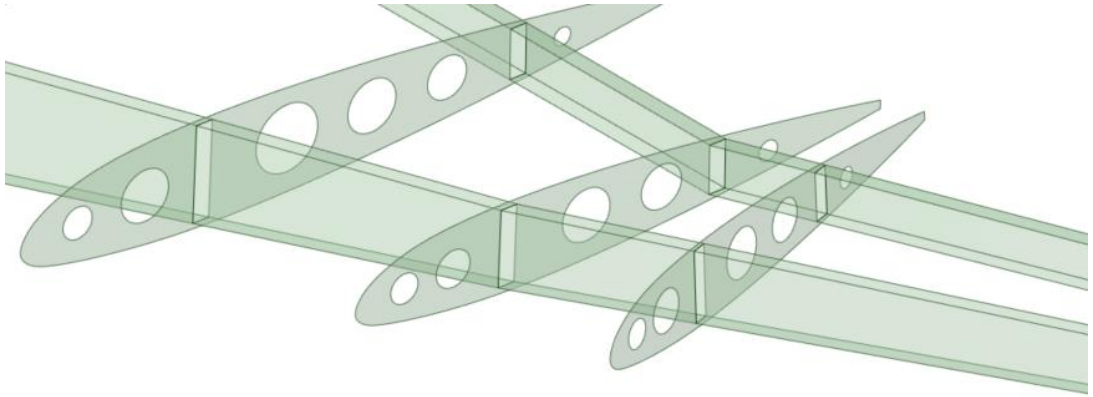
Manufacturing Demonstration Vehicle

- Took simplified flight wing design and incorporated manufacturing considerations
- In addition to the wings, vehicle featured:
  - Fuselage build
  - T-tail
  - Engine mount
  - Static landing gear



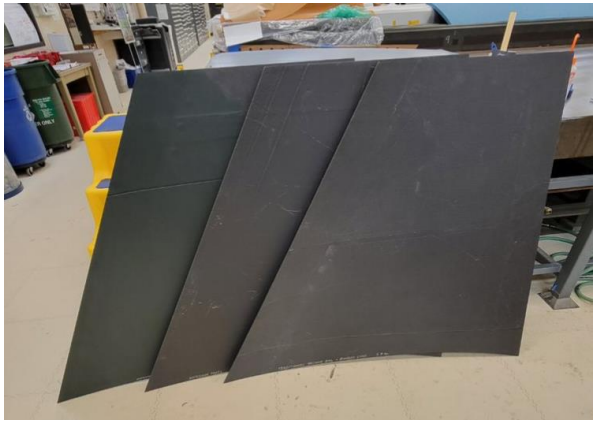
Manufacturing Demonstration Vehicle

- Manufacturing & tooling limitations drove following changes to wing design:
  - Original: single piece ribs with slots for spars to feed through
  - Manufacturing update: ribs broken into three parts & bolted to leading and trailing edge



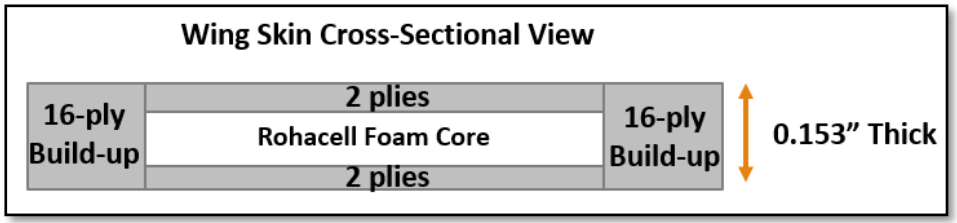
Wing Skin Development

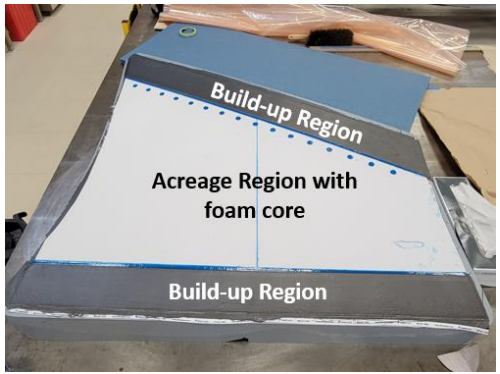
- Composite wing skins designed and manufactured to demonstrate the manufacturing process
- Composite testing carried out for material characterization



Wing Skin Design

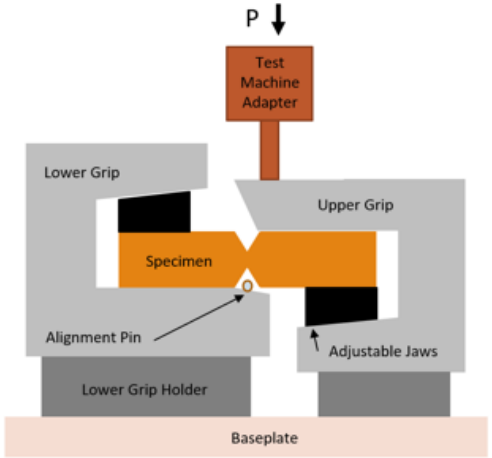
- Mix of two material systems & foam core used in composite configuration:
  - Fibreglast 2363 – Plain weave carbon fiber (0.005” thick)
  - Fibreglast 530 – Plain weave carbon fiber (0.009” thick)
  - Rohacell IG31 Foam (0.125” thick)





Wing Skin Characterization

- Composite coupon testing completed to characterize wing skin laminate properties
  - Fed into structural analysis and margin of safety calculations
  - Tensile and shear testing to determine in-plane properties



Conclusions & Next Steps

- Introduced the high-level overview of the design and development of the SARV wing structure
- Manufacturing mock-up → workable flight concept that is:
  - Serviceable
  - Low cost & quick manufacturing
  - Maintains adequate stress and stiffness
  - Integrates all design concepts
- Next steps in wing development:
  - Integrate distributed electric propulsion
  - Landing gear packaging
  - Updates to battery box packaging
  - Define control surfaces
  - Iterate on separable wing joint design

Acknowledgements

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