Discrete, Mesoscale Modeling Of Composite For Attritable Aircraft

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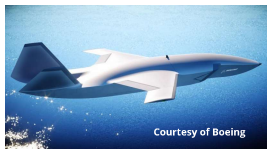
Why Moving Towards *Attritable* Aircraft ?

3rd Gen: F-111 (1960s) — 4th Gen: F-16 (1970s) — 5th Gen: F-35 (2015)

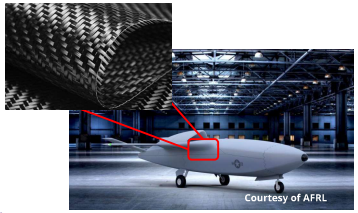
- Operation cost: ~$27,000 per hour of flight
- Estimated lifetime cost of F-35 (-2070) is $1.5 trillion according to Pentagon

- Solution: *Attritable aircraft* – UAS with low cost in procurement and maintenance; easily replaceable
- Low risk of losing them during a mission



Composites And Automated Manufacturing

- The capability profile of attritable aircraft is similar to that of manned aircraft (e.g. F-35)



Advantages of Composites:
- Low density (Light weight)
- High stiffness
- High strength

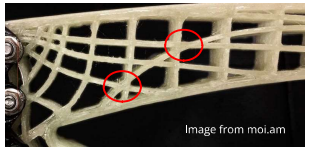
Benefits:
- Lower operation cost
- Advanced operation profile

Advantages of Automation:
- Reduce manufacturing cost
- Reduce waste material
- Increase consistency
- Increase accuracy of parts

MTorres: Automated Fiber Placement

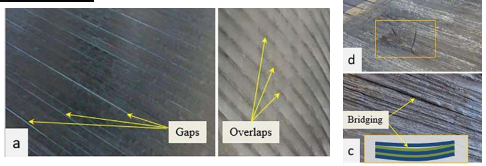
Continuous Composites: 3D printing continuous fibers

Challenges From Automated Manufacturing



1) Analysis of
- Complex joints
- Complex structural parts

2) Defects from manufacturing process
- Requires more testing for analyzing these structures

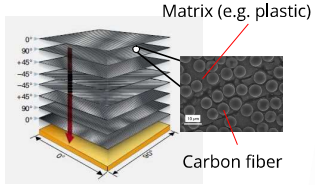


Oromiehie et al., Comp. Struc., 2019

Project Objective

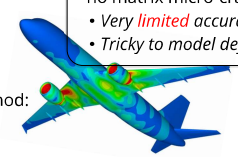
- *"Develop a model to predict the mechanical behavior (damage and failure) of composite materials on attritable aircraft to reduce design iterations and high-cost experiments."*

Discrete Approach for a Mesoscale Model

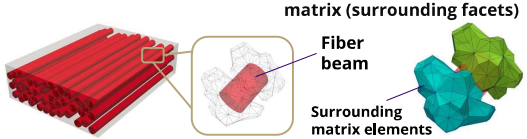


Popular & widely used method:
- *Homogenized* approach

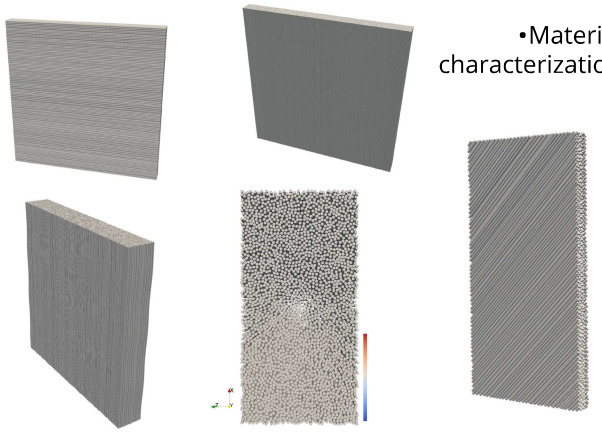
Problem of homogenized approaches
- The laminate/lamina is treated as *equivalent homogeneous medium*;
- *No progressive damage* (no delamination, no matrix micro-cracking etc);
- *Very limited accuracy*
- *Tricky to model defects, complex joints*



- **Our discrete approach: *explicitly* model fibers (beams) and matrix (surrounding facets)**

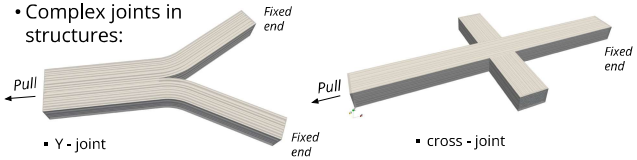


Simulation Results

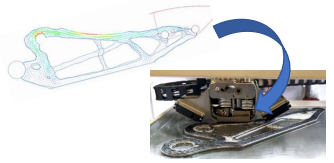


- Material characterization

- Complex joints in structures:



Future Work, and Acknowledgments



Fedulov et al., Comp. B., 2021

- Model manufacturing process
- Topology optimization

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