Structures

Goals:
- Calculate tip deflection due to aerodynamic loads
- Compute load factor for range of flight conditions
- Provide initial design layout and structural model of wings and other structural elements

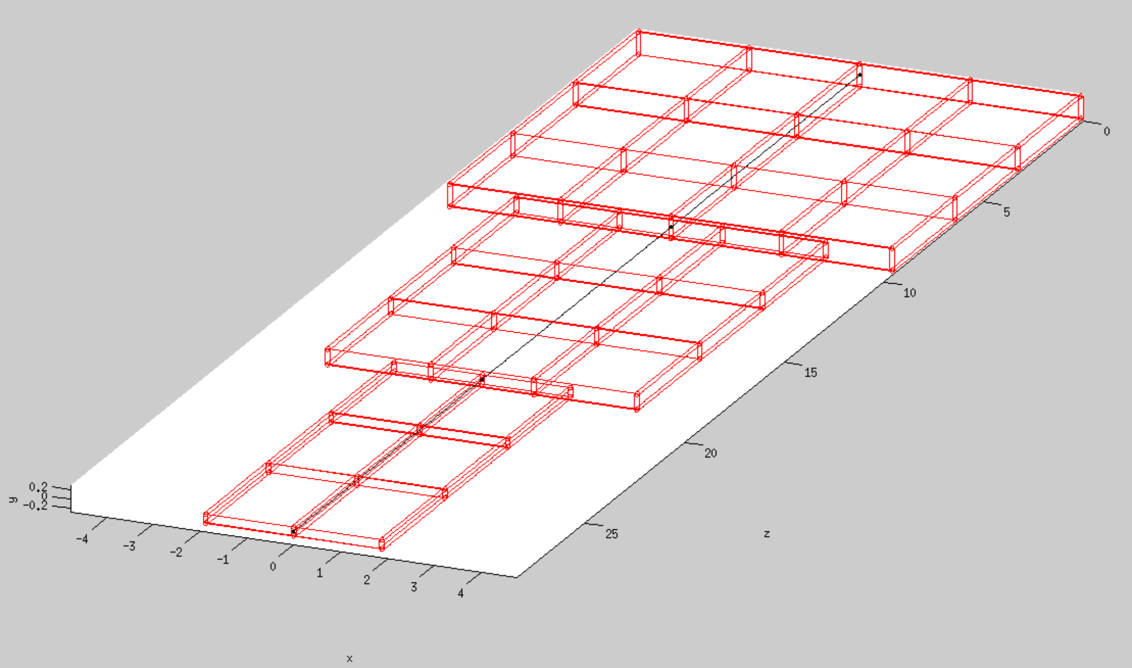
Input Parameters:
- Multi-cell beam dimensions
- Aerodynamic loads

Constraints:
- Airfoil t/c
- Wing geometry
- Maximum tip deflection

Structures

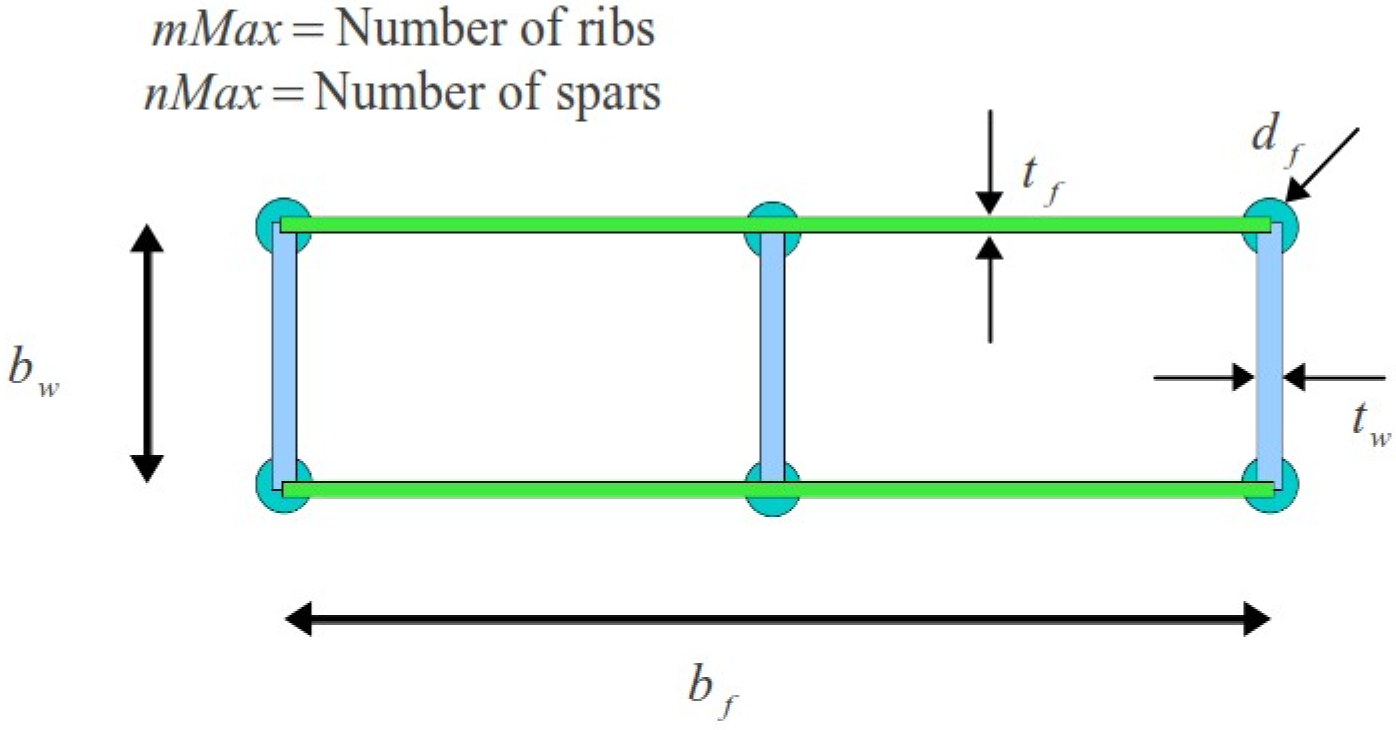
Approach:

- Multi-cell beam sections joined by ribs
- Piecewise-defined deflection curve
- Technical beam theory used for bending analysis
- Matrix-based approach allows for arbitrary rib and spar positioning



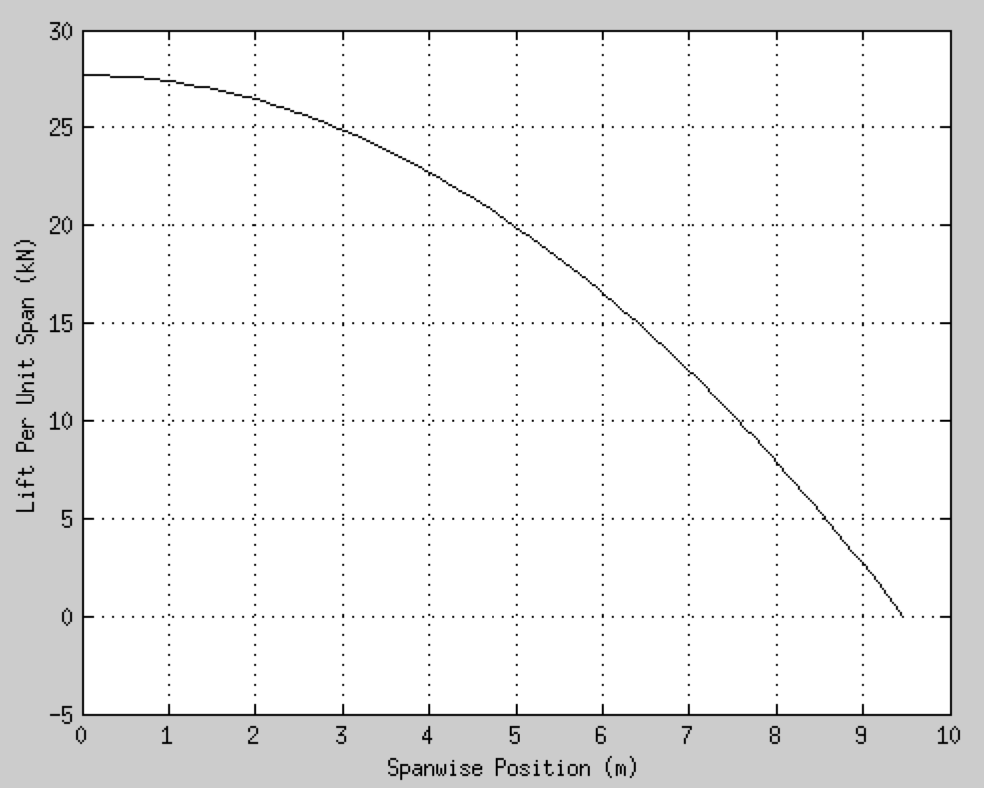
Structures

Multi-cell stringer-stiffened box beam geometric specification:



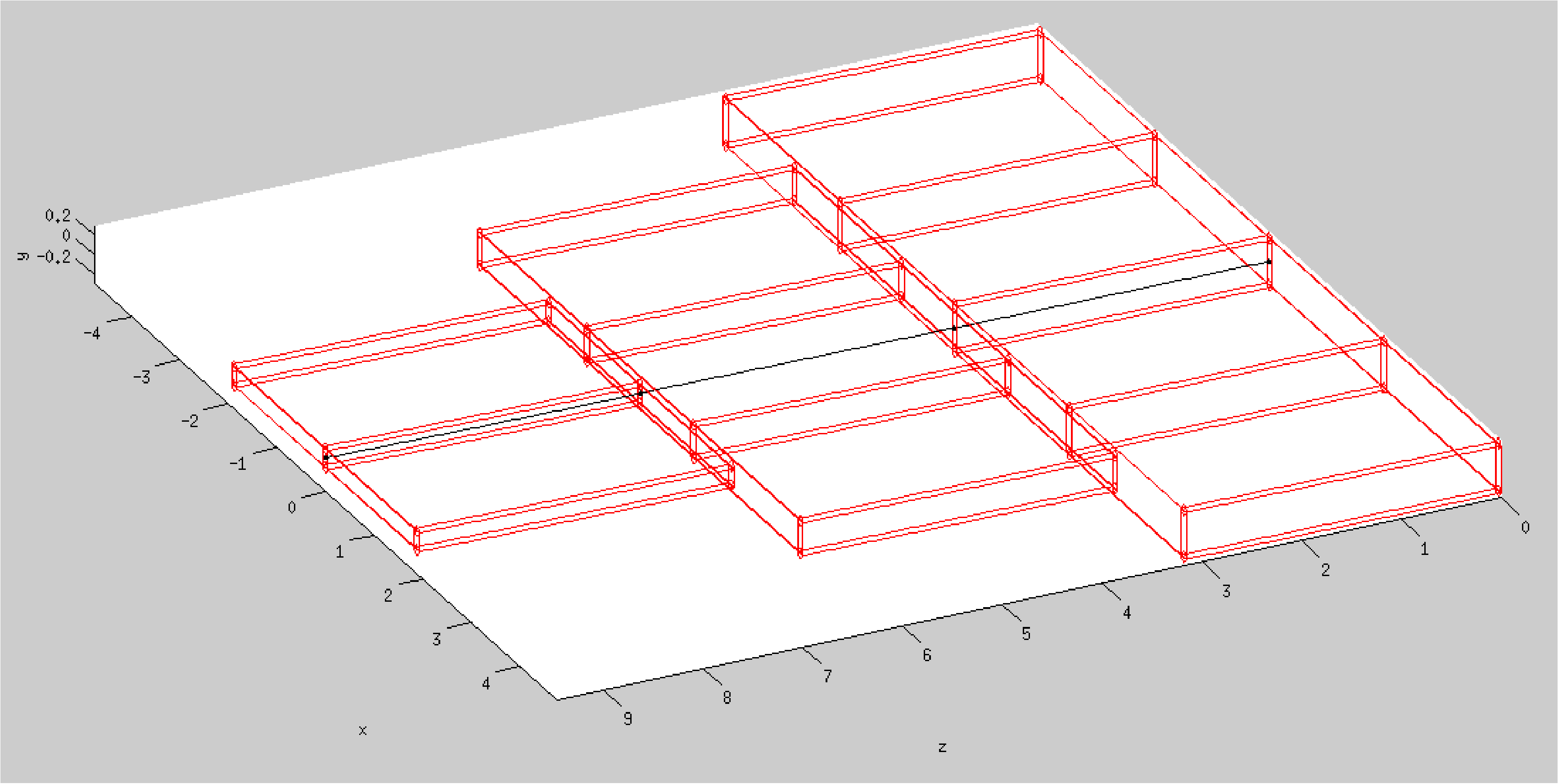
Structures

Loads (Quadratic Lift Loading):



Structures

Visualization:



Structures

Future Goals:

- Optimize number, size, and spatial distribution of spars
- Incorporate wing sweep, twist, and more complex planform area (especially strakes)
- Analyze tail surfaces and fuselage
- Compute realistic lift distribution
- Include loads from fuel and control systems

Appendix: Structures

Structures

Technical Beam Theory – Bending:

$$\boxed{\frac{d^2}{dz^2}[EI\frac{d^2w(z)}{dz^2}]=q(z)}$$

$$\boxed{\frac{d}{dz}[EI\frac{d^2w(z)}{dz^2}]=\int q(z)+C_0}$$

$$\boxed{EI\frac{d^2w(z)}{dz^2}=\int\int q(z)+C_0z+C_1}$$

$$\boxed{EI\frac{d\,w(z)}{dz}=\int\int\int q(z)+\frac{1}{2}C_0z^2+C_1z+C_2}$$

$$\boxed{EI\,w(z)=\int\int\int\int q(z)+\frac{1}{6}C_0z^3+\frac{1}{2}C_1z^2+C_2z+C_3}$$