Analytical Drag Model

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Background and Goals

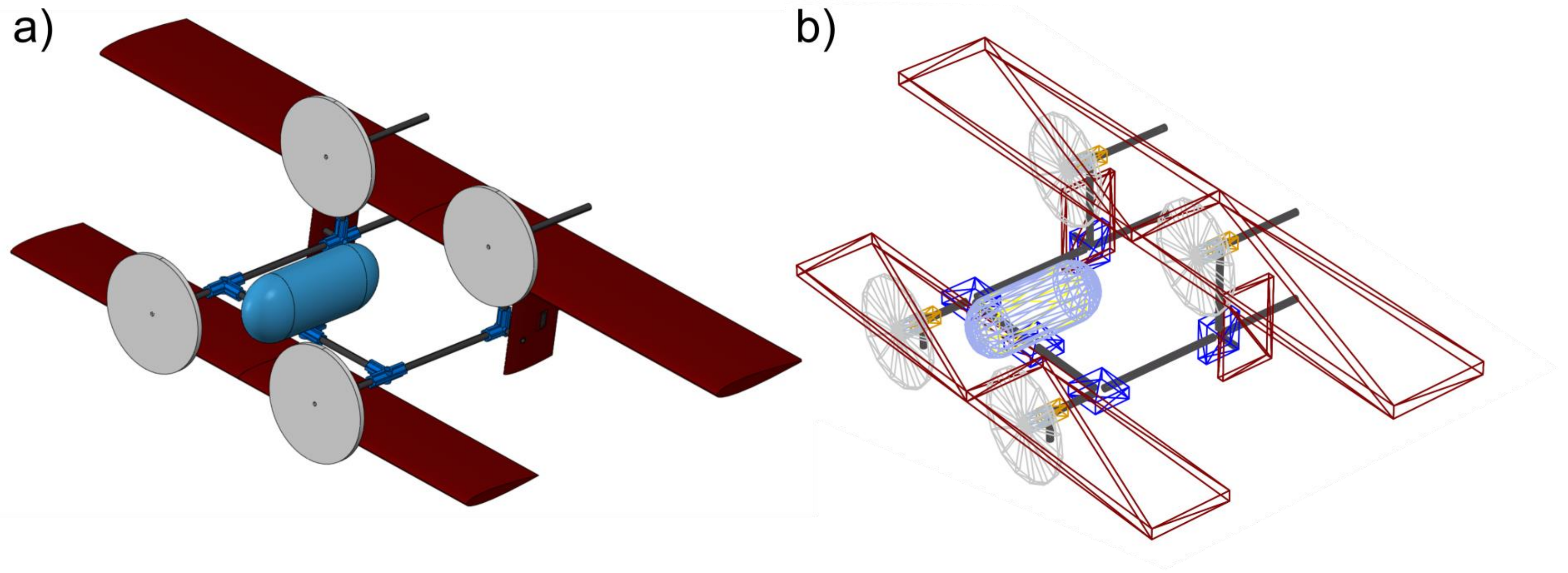
- The FDM currently (and in the past) has 6 inputs concerning the body drag of an aircraft (X_fuseuu, Y_fusevv, Z_fuseww, x_fuse, y_fuse, z_fuse)
  - The first 3 are orientation specific reference areas, which in-effect combine the coefficient of drag and the reference area, seen in the classic drag equation
  - The last 3 are body coordinates of where the drag force is spatially applied

$$Drag_j = C_D\left(\frac{1}{2}\right)\rho V_j^2 A_{p,j}$$

- Old projected area drag calculation has been replaced
  - Old method – calculated projected areas along X, Y, and Z axes and applied body drag force at the center of gravity
    - Could be reduced by minimizing frontal area and results in zero drag moment
- Goals of the new drag model
  - Fast computation – Analytical formulation (*Hoerner, S.F. (1965) Fluid-Dynamic Drag*)
  - Account for drag of different geometries, account for part-to-part interference drag

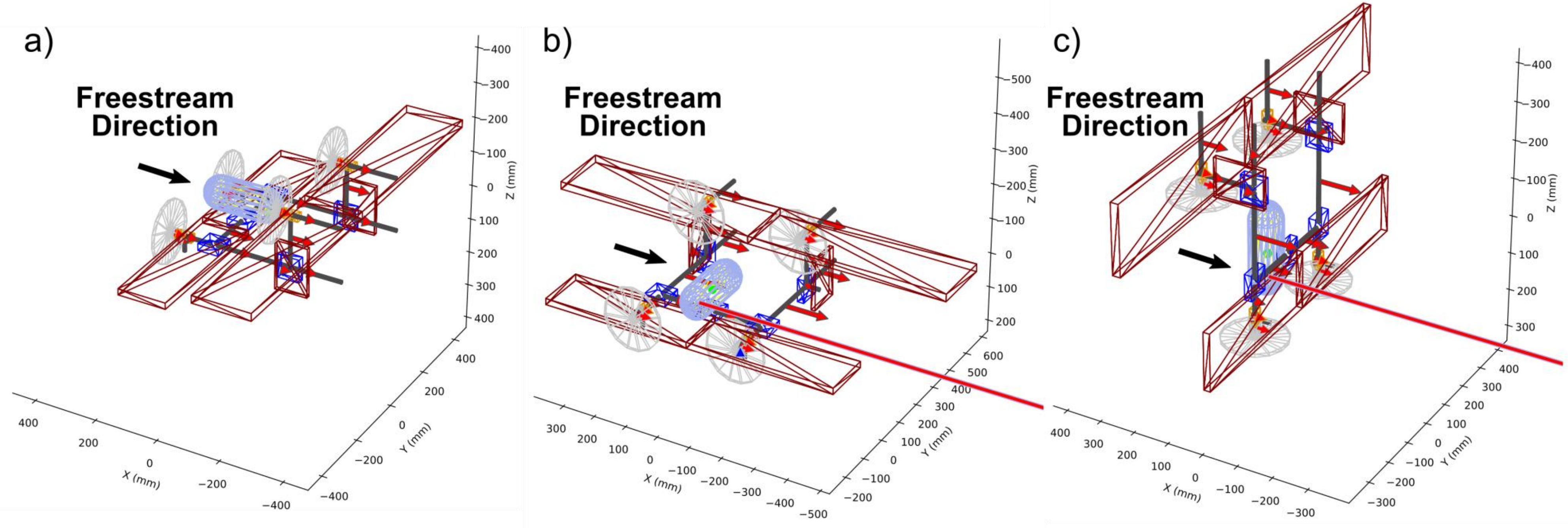
Aircraft Conversion

- First every part is assigned a primitive shape (cylinder, box, elliptical capsule), each with a distinct drag calculation function
- The primitive is given appropriate dimensions and then transformed into the body coordinate system to rebuild the aircraft
- The surrogate geometry is then analyzed for drag, part by part.
- The drag of wings is calculated in the FDM. Therefore, they have no drag in the drag model, but they DO affect the interreference drag of other parts
- Some notes: Connectors and propellers do not have any influence on drag, even though are shown



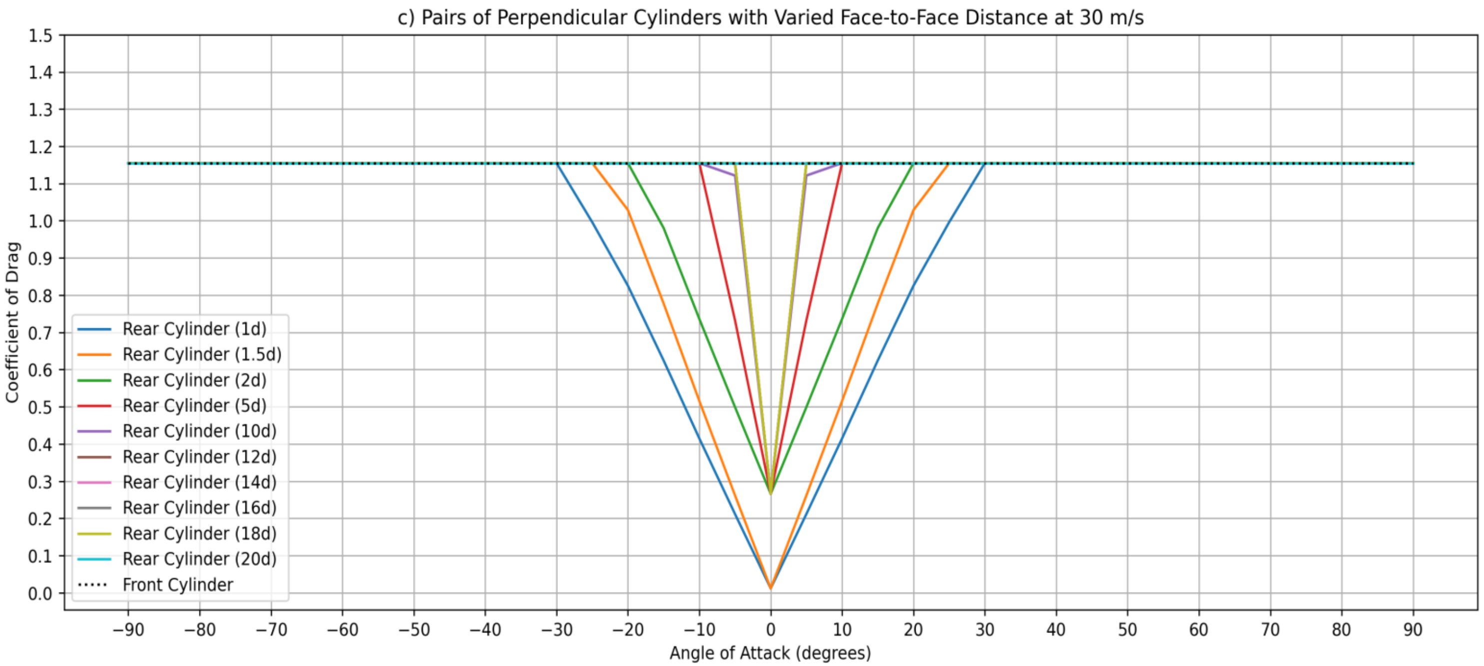
Aircraft Analysis

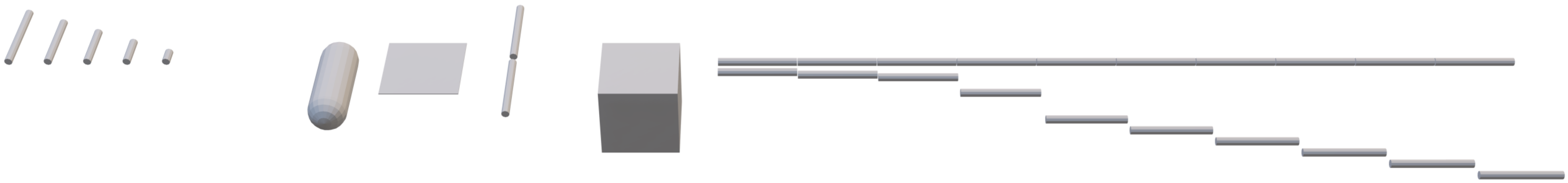
- The freestream drag coefficient is determined for each part
- Then based on the aspect ratio of the leading part, distance between parts, and the proportion of overlapped projected area, the coefficients get modified for interference
- The three parameters X_fuseuu, Y_fusevv, Z_fuseww are calculated independent of each other with a loop, where only the surrogate geometry is reoriented, like a virtual wind tunnel.
- The x_fuse, y_fuse, z_fuse parameters are then deduced from the total resultant moment in the 3 directions
- Computational time for all 3 orientations below is around 1 second, but will depend on the number of parts.



Interference Mechanisms

- Drag of each part depends on the shape and relative dimensions of each part
- It also depends on what is interfering with it
- There are two interference functions for low and high aspect ratio parts.
- To the right is an example for tubes
  - Note that only the zero AoA is currently given to the FDM, but is a good demonstration





Comparison to CFD

- For a soon coming publication, the analytical drag model has been compared to fast-running CFD computations for the primitive shapes and one full aircraft
- Each CFD run takes about 10 minutes of computational time with an additional 5 to 20 minutes of setup time
- Future improvements will be made to improve fidelity as well as to compute interactions, such as propeller-to-wing and wing-to-wing interferences