Propeller

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Design Tab

- Mode
- General Design
- Propeller Metrics
Blades, Both, Disk Mode

Mode also determines representation for export an analysis (DegenGeom, VSPAERO, etc.).

Much Faster Update
$\beta_{3/4} = \text{Twist}_{3/4} + \text{Feather}$

$X_{3/4}$ : Value at $r/R = 0.75$
Pre-cone

Pre-cone = 0.0

10°
Construct X/C

Construct X/C = 1.0

Construct X/C = 0.5

Construct X/C = 0.0

Straight line about which planform is developed
Feather Axis & Offset

Location of feather axis on the blade (Axis) and relative to rotation axis (Offset).
## Propeller Metrics

- **Propeller**
  - Activity Factor
  - Integrated Design Lift Coefficient

- **Rotor**
  - Chord / R
    - Average
    - Thrust Weighted
    - Power Weighted
  - Solidity
    - Average
    - Thrust Weighted
    - Power Weighted

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### Propeller: PropGeom

<table>
<thead>
<tr>
<th>Design</th>
<th>Tare</th>
<th>Diameter</th>
<th>Num Blades</th>
<th>Rev</th>
<th>Rotate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30.00000</td>
<td>3</td>
<td>0.00000</td>
<td>20.00000</td>
</tr>
</tbody>
</table>

### Prop / Rotor Metrics

<table>
<thead>
<tr>
<th>Activity Factor</th>
<th>C/R</th>
<th>C_T/R</th>
<th>C_P/R</th>
<th>σ</th>
<th>σ_T</th>
<th>σ_P</th>
</tr>
</thead>
<tbody>
<tr>
<td>151.54</td>
<td>0.1777</td>
<td>0.1923</td>
<td>0.1943</td>
<td>0.1696</td>
<td>0.1837</td>
<td>0.1855</td>
</tr>
</tbody>
</table>
Curve Control

Planform, twist, and airfoil controlled via smooth continuous curves.

c_l,i control only between like airfoil types.

Recommend using as few Xsec types as possible (1 or 2).
Blade Curve Control

- Curve Selector
- Type Control
- Interactive Curve Editor
- Split Curve
- Delete Control Points
- Control Point Editor
- Enforce Continuity

Propeller: PropGeom

Curve Editor

- Curve: Chord
- Type: Cubic Bezier
- Convert to: Cubic Bezier

Chord/R

r/R

Control Points

- r_0, r_1, r_2, r_3, r_4, r_5, r_6, r_7, r_8, r_9
- crd_1, crd_2, crd_3, crd_4, crd_5, crd_6, crd_7, crd_8, crd_9
Planform Curves

Avoid using redundant controls. I.e. use Axial or Rake, not both.

Section view, root to tip
Planform Curves

Skew & Tangential change true diameter.
Rake & Axial change blade length.

Rear view, looking forward
Type Control

- **Linear**
  - Extremely simple
  - Great for linear taper / linear twist
- **Spline (PCHIP)**
  - Piecewise cubic Hermite interpolating polynomial
  - Default type for BEM import
  - Control not super-intuitive
- **Cubic Bezier**
  - Best for intuitive control of smooth curves
- **Approximate Cubic Bezier**
  - Converts to Cubic Bezier, but with fewer control points.
  - Great to use after BEM import
Curve Editing

- Drag-n-drop curve editing
  - Model does not update until release
  - Cubic Bezier tangents move with control points

- Split curve
  - Specified r/R
  - Click to pick

- Delete control points
  - By index selector (yellow highlight)
  - Click to pick

- Control point editor
  - Adjustable range slider inputs for control points
  - Enforce G1 continuity
  - UnavailableParms greyed out
XSec

- Almost identical to Wing Airfoil control
- Radius (\(r/R\))
  - 0\(^{th}\) XSec control’s hub \(r/R\)
  - Controls location where XSec type specified
- Use as few XSec’s as possible
  - Two to four sufficient almost all circumstances
  - Two – blades with single section type
  - Three – blades with circular / elliptical cuff
  - Four – blades with two foil types and transition
- Exceptions
  - File airfoils
  - CST airfoils
  - Both are clunky and awkward with propeller
  - Strongly recommend analytical types
Modify

- Identical to Wing Modify control

- Should be smart (DWIM)
  - Blunted airfoils with Abs thickness should maintain dimensional thickness even as chord varies.
More

- **Folding**
  - Control of folding axis (position & direction)
  - Control of fold angle
More

- **Tip Treatment**
  - Identical to similar Wing controls
- **Tessellation Control**
  - Num_U & Num_W on Gen tab
  - Clustering and tessellation controlled for entire prop
BEM Export

- Access through File…
...BEM Propeller...
Num_Sections: 66
Num_Blade: 3
Diameter: 30.00000000
Beta 3/4 (deg): 20.00000000
Feather (deg): 0.00000000
Pre_Cone (deg): 0.00000000
Center: 0.00000000, 0.00000000, 0.00000000
Normal: -1.00000000, 0.00000000, 0.00000000

Radius/R, Chord/R, Twist (deg), Rake/R, Skew/R, Sweep, t/c, CLi, Axial, Tangential

0.20000000, 0.08000000, 46.75000000, 0.00000000, 0.00000000, 0.12000000, 0.70000000, 0.00000000, 0.00000000
0.21230769, 0.08640386, 45.98069069, 0.00000000, 0.00000000, 0.12000000, 0.70000000, 0.00000000, 0.00000000
...
0.98769231, 0.17001209, 13.26915223, 0.00000000, 0.00000000, 0.03229378, 0.24474829, 0.00000000, 0.00000000
1.00000000, 0.13000000, 13.00000000, 0.00000000, 0.00000000, 0.03000000, 0.20000000, 0.00000000, 0.00000000

Section 0 X, Y
1.00000000, 0.00000000
0.99322572, -0.00017159
...
0.00408190, -0.00534301
0.00000000, 0.00000000
-0.00130232, 0.00689865
...
0.99313741, 0.00175775
1.00000000, 0.00000000

Section 1 X, Y
1.00000000, 0.00000000
BEM Import

- Imports BEM file & creates propeller
  - Ignores airfoil ordinates
  - Curves set to PCHIP w/ point at each station
  - Recommend ‘Approximate Cubic Bezier’
  - Likely very over-defined
  - Will be slow until cleanup
  - May still be slow after cleanup
Questions?

Practice