A General Approach to Lifting-Line Theory, Applied to Wings with Sweep

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Lifting-Line Theory
Lifting-Line Theory
Aerodynamic Tools

1900
Wright Flyer
Sopwith Camel

1930
Supermarine Spitfire
Bell X-1

1960
SR-71 Blackbird
F-16
F-117

1990
B-2
Predator
Boeing 787

2020
Morphing Aircraft
Solar Impulse 2

Conformal Transformations
Lifting-Line
Weissinger
Mutterperl
Kuchemann

Low-Order/Analytic

Panel Methods

CFD
Grumfoil
CFL3D
STAR-CCM+

Program H
TRANAIR
OVERFLOW
SU2

VSAERO
PANAIR
PMARC
XFOIL

Weissinger
Munk
Mutterperl
Kuchemann

Wright Flyer
Sopwith Camel
Supermarine Spitfire
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Morphing Aircraft
Usefulness of Prandtl's Implementation

Prandtl's classical implementation was instrumental in the design of aircraft during WWII.

Küchemann (1956) modeled the locus of aerodynamic centers (LAC) for swept wings.
Influence of Vortices
Influence of Vortices

Influence is finite only if the bound vortex has **no curvature**.

Influence is finite only if the trailing vortices are **perpendicular** to locus of aerodynamic centers.
Jointed Trailing Vortices:

- Finite vortex segment perpendicular to LAC
- Semi-infinite vortex aligned with freestream
Influence of Vortices

Jointed Trailing Vortices:
- Finite vortex segment perpendicular to LAC
- Semi-infinite vortex aligned with freestream

Effective Loci of Aerodynamic Centers:
- No concavity at control point
- Blend between tangent line and original LAC
General Implementation Accuracy

Airfoil: NACA 0012
Sweep: 45°
Aspect Ratio: 5
Taper Ratio: 1
General Implementation Accuracy

Airfoil: NACA 0012
Sweep: 45°
Aspect Ratio: 5
Taper Ratio: 1

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- Experiment
- Phillips’ LL
- General LL
- PAN AIR
Thank You

For More Information: