LIFTLINE Manual

Christopher C. Chinske

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1 Introduction

LIFTLINE is a collection of MATLAB scripts and functions that implement lifting-line theory. It solves the monoplane equation to estimate aerodynamic characteristics of a finite wing. It also provides capabilities to analyze shear force and bending moment along the wing spar.

1.1 Theory

LIFTLINE implements lifting-line theory as described in [1] and [2]. The program estimates the spanwise circulation of a finite wing. Following from this result, the program can compute the lift and vortex-induced drag coefficients. The program can also estimate structural characteristics, such as shear and bending moment along the wing.

Classical lifting-line theory assumes incompressible flow, no wing sweep, and linear airfoil section lift-curve slopes. Currently, LIFTLINE assumes:

1. Incompressible flow
2. No wing sweep (input required to properly draw planform)
3. Linear airfoil section lift-curve slopes
4. Symmetrical loading.

Future versions of LIFTLINE will implement a modified lifting-line theory and relax these assumptions.

1.2 Program Organization

The directory scripts_aircraft contains input scripts that define wing geometry and structural loads (e.g., fuel or stores). The directory scripts_cases contains input scripts that define case parameters. These parameters may be overridden for certain analyses.

1.3 Concept of Operations

When analyzing a wing of finite span, the primary goals are to determine: spanwise circulation, spanwise lift distribution, lift coefficient, and vortex-induced drag coefficient. Other goals might include finding shear and bending moment for a cantilever wing, determining rolling and yawing moments (for asymmetric loading), or determining the stalling angle of attack. The general procedure for carrying out this analysis using LIFTLINE is outlined below.

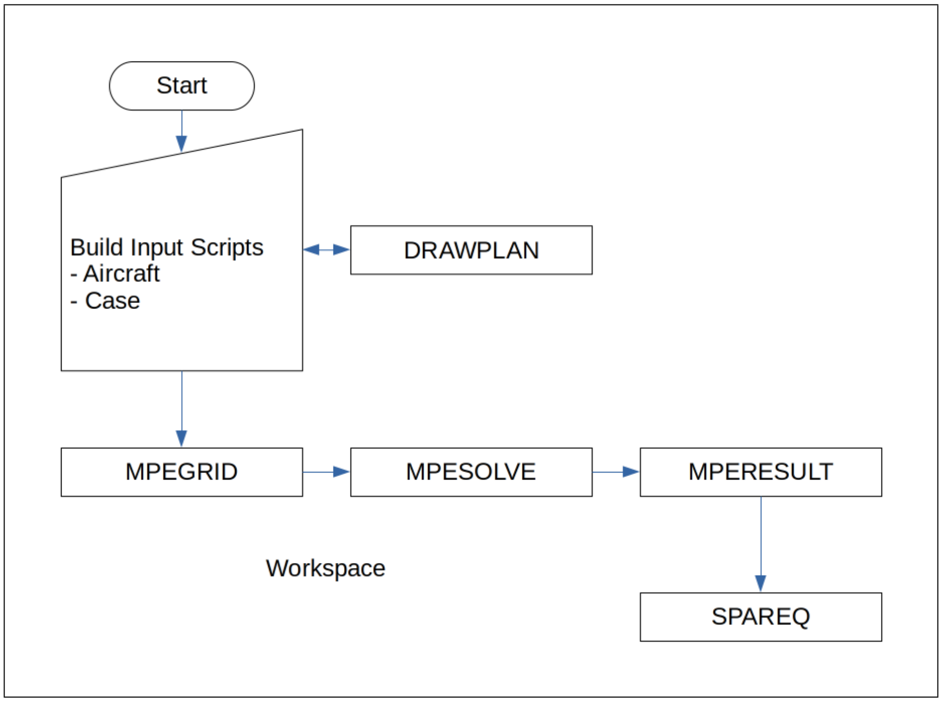
1. Build an input script (aircraft) that defines the wing geometry.
2. Plot and verify the planform geometry.

3. Build an input script (case) that defines case parameters.
4. Run a grid convergence analysis, and update the case script.
5. For level flight, find the angle of attack for L = W, and update the case script.
6. Run case for a particular angle of attack to get spanwise circulation, spanwise lift distribution, lift coefficient, and vortex-induced drag coefficient.

If desired, the lift and vortex-induced drag coefficients can be computed across a range of angles of attack. The spar shear and bending moment can also be computed.

The function LIFTLINEUI provides an interactive user interface, which aids the user in executing many of these tasks.

Advanced users can also call any of the program's library functions directly. In this way, users can build custom analysis routines. The figure below graphically depicts a typical workflow.



References

[1] John J. Bertin and Russell M. Cummings. *Aerodynamics for Engineers.* 5th ed. Upper Saddle River, NJ: Pearson Prentice-Hall, 2009.

[2] John D. Anderson. *Fundamentals of Aerodynamcs.* 5th ed. New York: McGraw-Hill, 2011.