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Aerospace Vehicle Design And System Integration 3 AENG30013 (AVDASI3)

2019-2020

XFLR5

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Content

- Summary of aerodynamic design stream
- Brief summary of aircraft design process
- Aerodynamic modelling methods
- XFLR5

AVDASI 3 – Aerodynamic Design

5	17	FW Aerodynamics: Intro Aerodynamic Design and Tools	Lecture 1	Dan Poole
		FW Aerodynamics: Constraint Diagram + intro to coursework	Lecture 2	Dan Poole
		Supervised Lab + Self Learning	Computer Lab	Dan Poole / Djamel Rezgui
6	18	Reading Week		
7	19	Aerodynamics Lecture	Lecture 1	Dan Poole
		Flight Mechanics	Lecture 2	Tom Richardson
		Supervised Lab + Self Learning	Computer Lab	Dan Poole / Djamel Rezgui
8	20	Aerodynamics: Q&A	Lecture 1	Dan Poole
		No lecture	Lecture 2	N/A
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		Submit coursework on BB	Assessment	5pm Friday 20 March

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NOTE: Lecture on Thursday 12pm, rather than Tuesday 9am

Aircraft Design Process

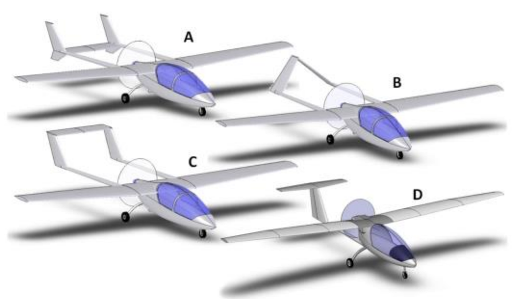
Requirement Phase

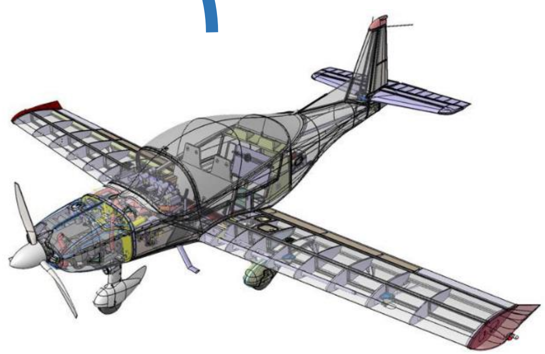
Conceptual Design Phase

Preliminary Design Phase

Detailed design Phase, and

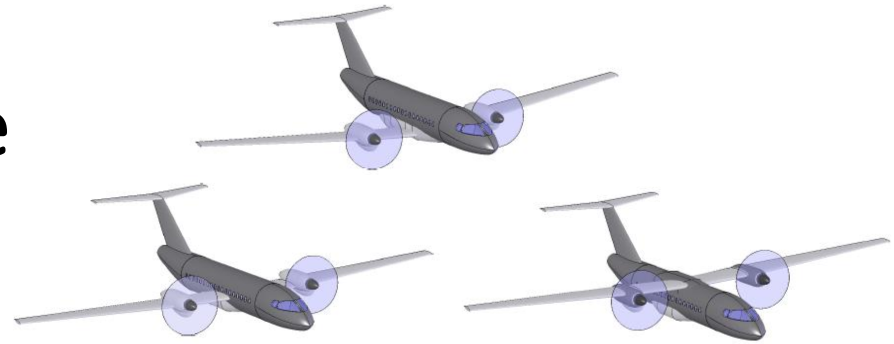
Proof-of-concept testing phase

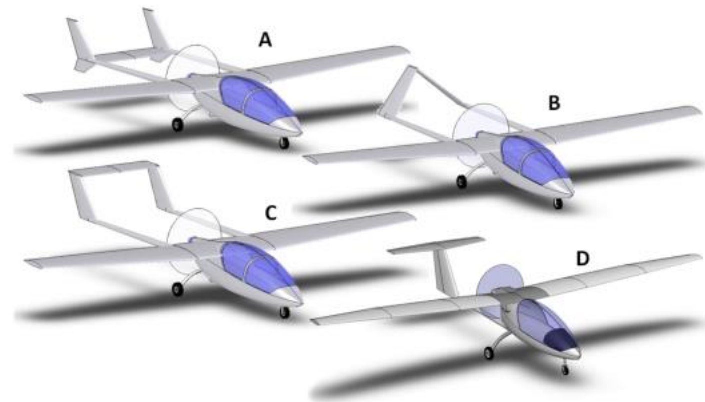


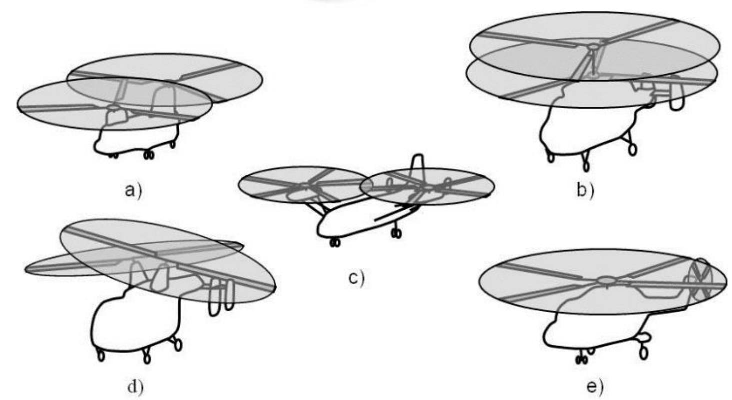


Conceptual Design Phase

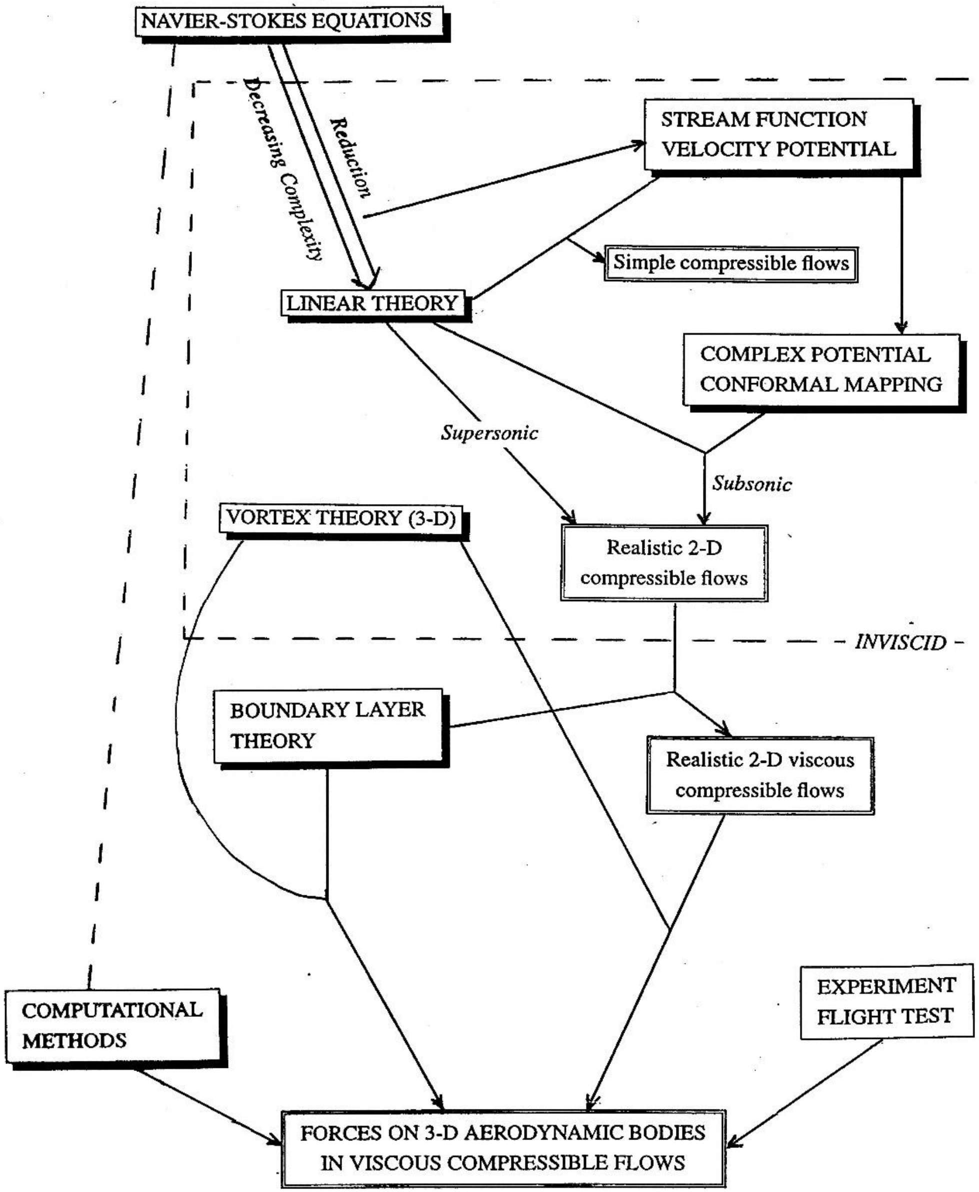
- Establishes the initial idea
- Low-order analysis methods
- Map out design space and identify constraints on the solution
- Several design changes are generally required



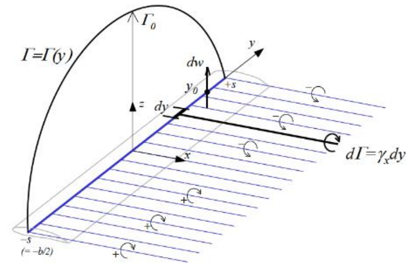




AERODYNAMICS APPROACHES

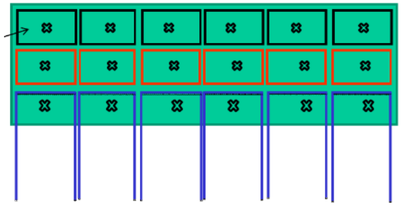


Computational Aerodynamic Analysis



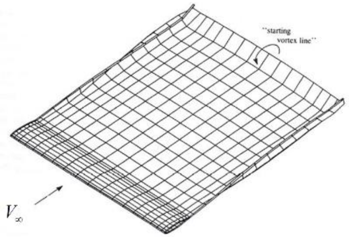
Empirical Methods – look-up tables, correlation to experiment

Lifting-line – use simple approximations to get approximate lift

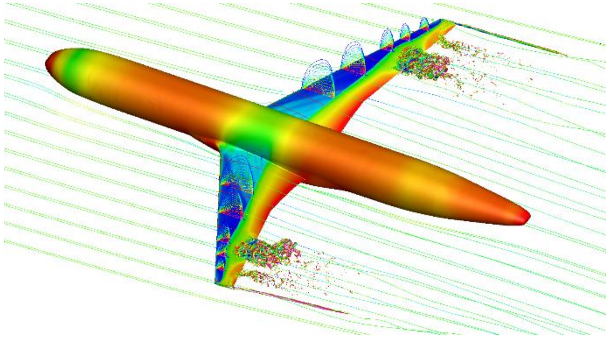


VLM – Extend L-L for better planform modelling

Panel – Use surface mesh and allow modelling of thickness



Viscous-coupled – link previous methods to boundary layer model



PDE-solutions – iteration methods for various DE equations

- Full potential
- Euler
- RANS
- LES/DNS

Computational Aerodynamic Analysis

Empirical Methods – look-up tables, correlation to experiment

Lifting-line – use simple approximations to get approximate lift

VLM – Extend L-L for better planform modelling

Panel – Use surface mesh and allow modelling of thickness

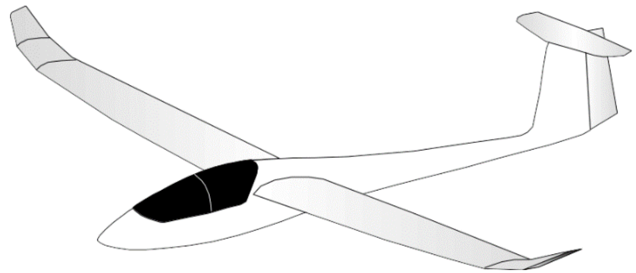
Viscous-coupled – link previous methods to boundary layer model

PDE-solutions – iteration methods for various DE equations

Later in design process

Better approximation, higher cost

xflr5



- 3-D inviscid wing modeller with viscous terms obtained via XFOIL
  - 3-D flow obtained by either L-L, VLM or Panel
  - Use XFOIL to obtain viscous 'corrections' but interpolation
  - Iterate this to get a converged answer

- Useful for obtaining approximation of viscous effects in 3-D

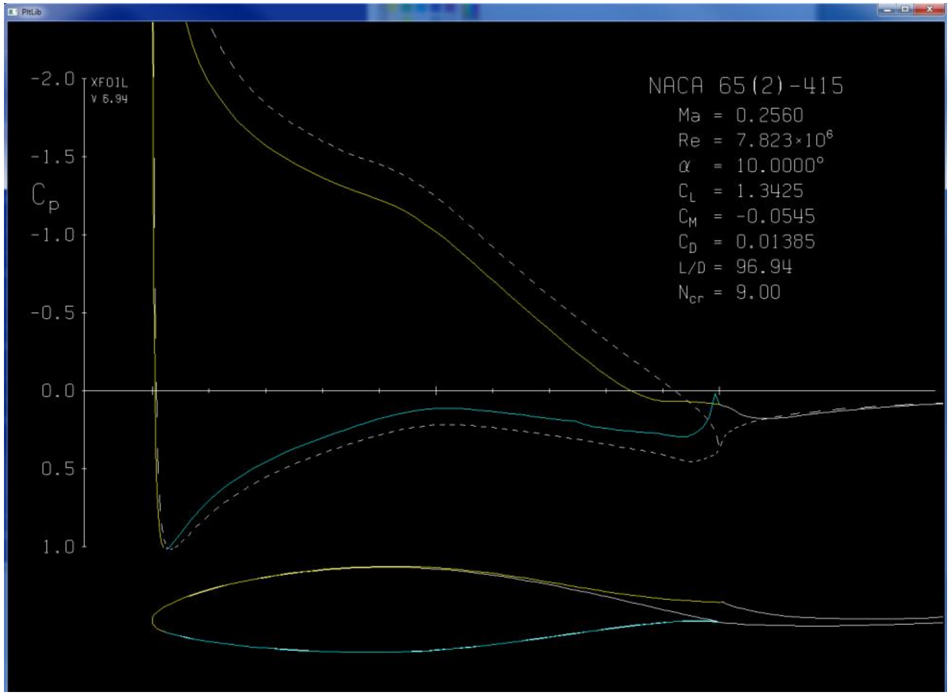
CAVEAT

- *"The code has been intended and written exclusively for the design of model sailplanes, for which it gives reasonable and consistent results."*

- *"The code's use for all other purposes, especially for the design of real size aircraft is strongly disapproved."*

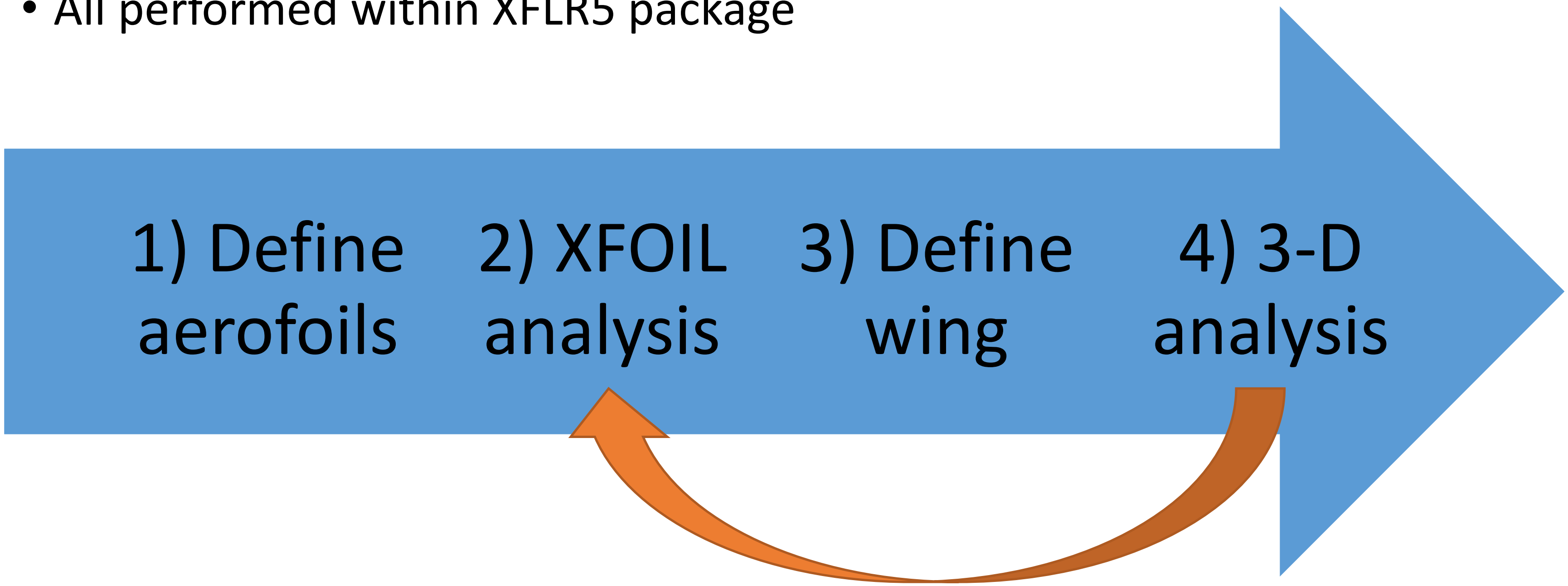
XFOIL

- 2-D viscous aerofoil design and analysis tool
  - ➢Developed by Mark Drela, MIT
- Panel method with coupled boundary layer model
- Can model viscous effects, including transition
- Incompressible – PG scaling



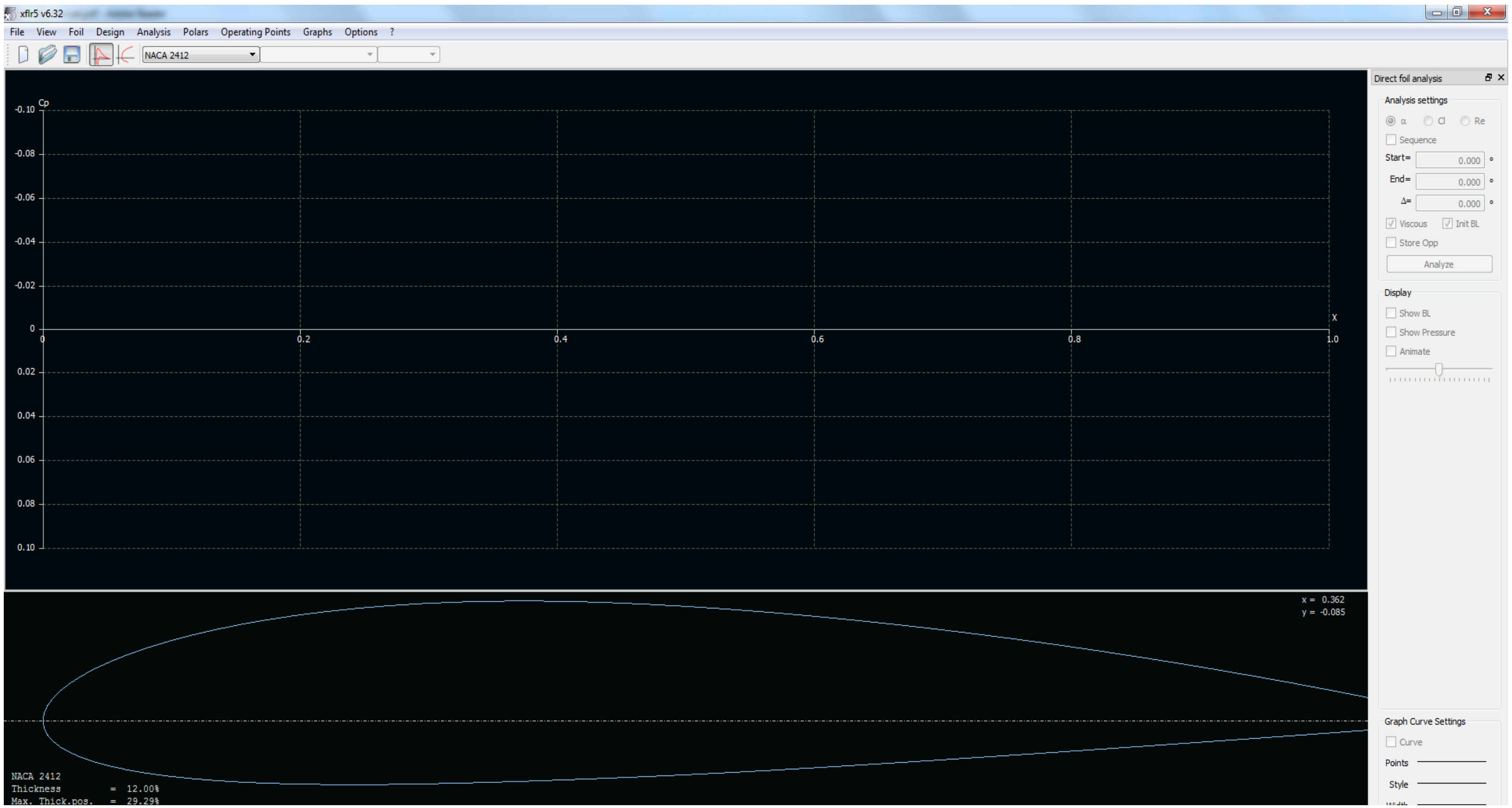
Work-Flow

- All performed within XFLR5 package



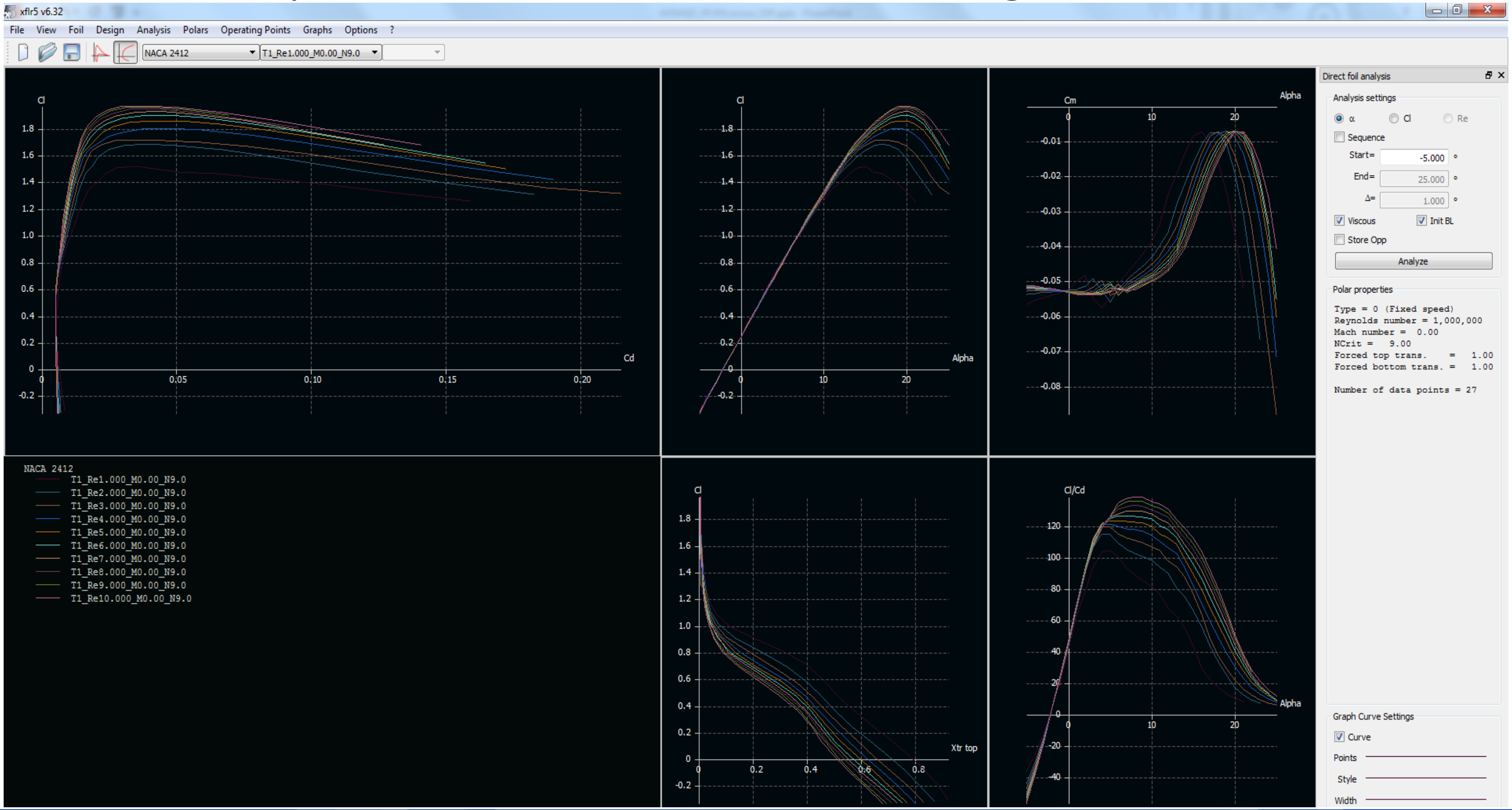
Define Aerofoils

- Can define 4 or 5 digit NACA series or import own



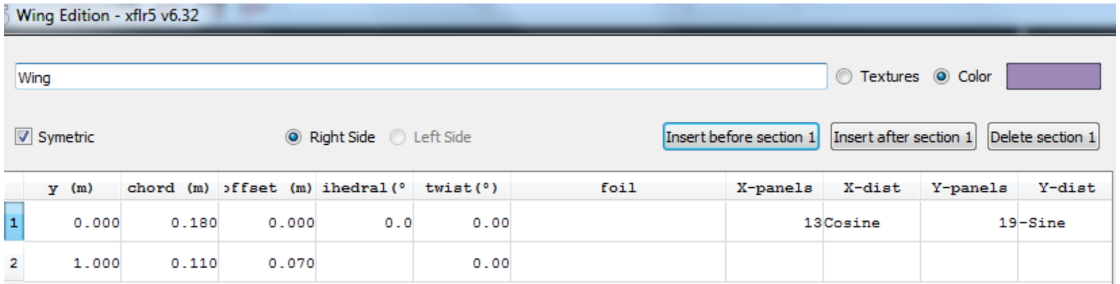
XFOIL Analysis

- For all aerofoils, need to obtain polars at different design conditions
- Used to interpolate viscous correction onto wing

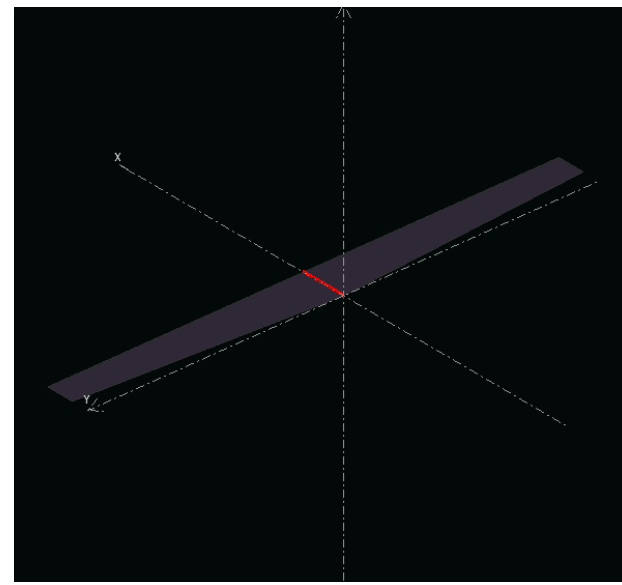


Define Wing

- Define planform (can include tail) and aerofoil sections

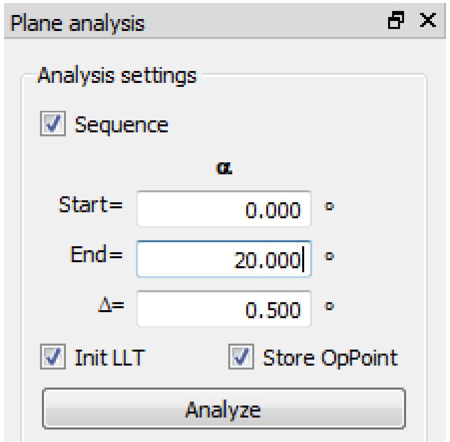


	y (m)	chord (m)	offset (m)	ihedral(°	twist(°)	foil	X-panels	X-dist	Y-panels	Y-dist
1	0.000	0.180	0.000	0.0	0.00		13	Cosine	19	-Sine
2	1.000	0.110	0.070		0.00					

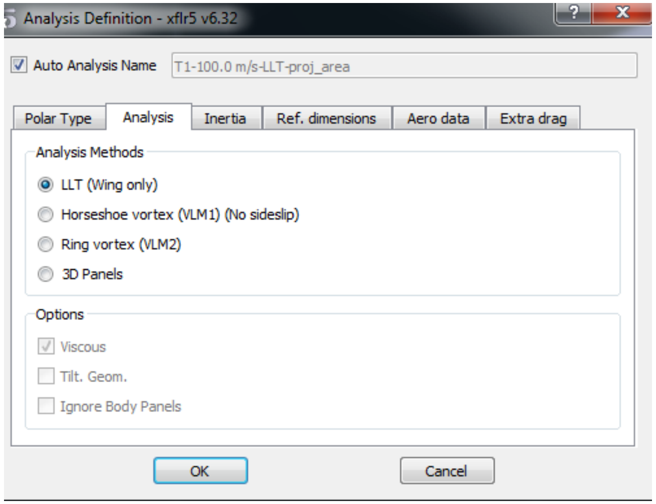


3-D Analysis

- Define conditions for 3-D analysis



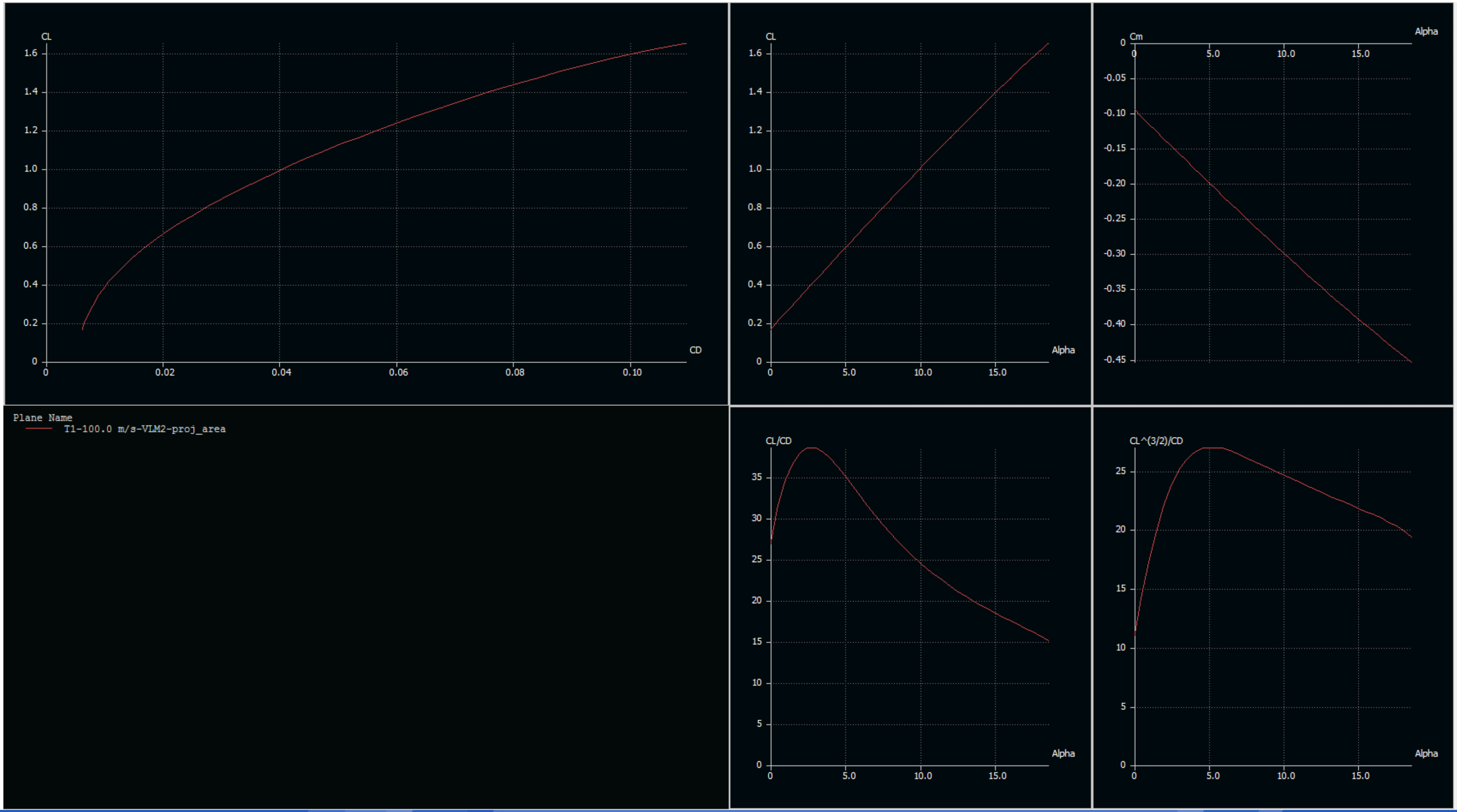
- Define method:



1. Non-linear lifting-line
   - Suitable for long, thin, slender wings
   - Interpolation is most robust
2. Vortex lattice method
   - Probably most widely applicable
3. 3-D panel
   - Generally best to avoid due to lack of maturity in the code
   - Can be used if Cp distributions of interest

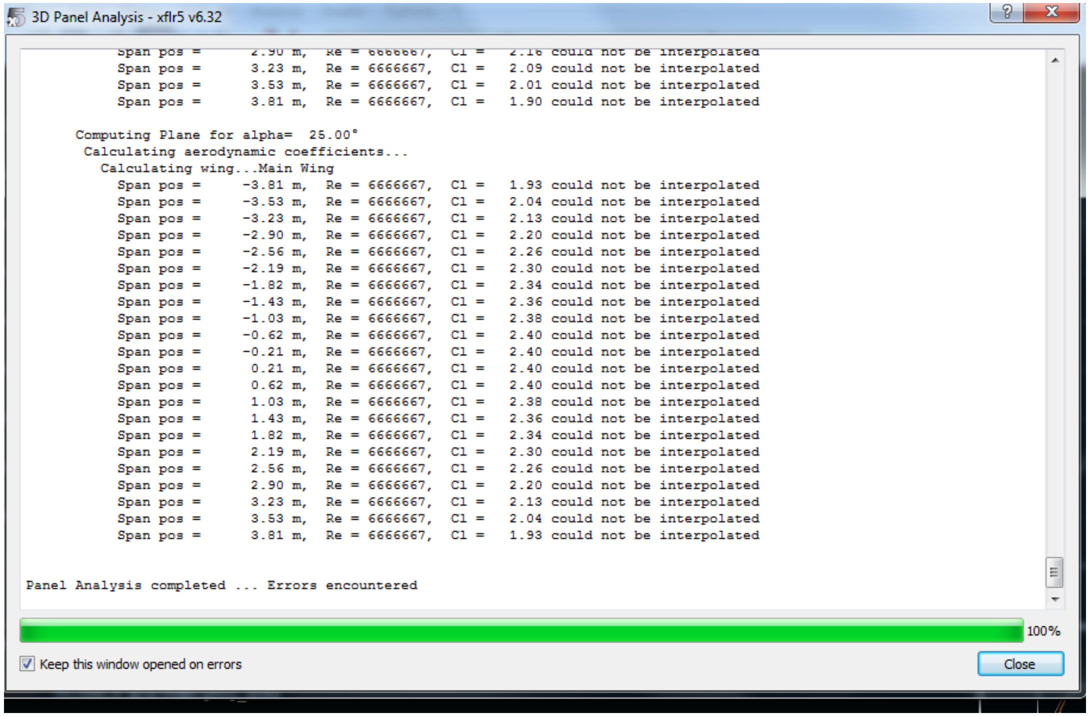
3-D Analysis

- Can obtain polar of data



3-D Analysis

- Sometimes, interpolation fails
- May have to go back and perform more XFOIL runs to obtain wider spread of data
- Generally less of an issue if using LLT – less accurate?



Limitations

- Selection of 3-D analysis methods limited by their own specific issues

- All limited by XFOIL applicability
  - Compressibility
  - Separation
  - Blunt trailing edge

- Less applicable further away from 2-D

- 3-D transition not modelled

Getting Started with XFLR5

- Download XFLR5 from Blackboard
- Go through Quick Start-up Guide (Blackboard)
- See video tutorials (link to Youtube) and Docs at

  http://www.xflr5.com/xflr5.htm
- Attend lab on Tuesday for second design exercise