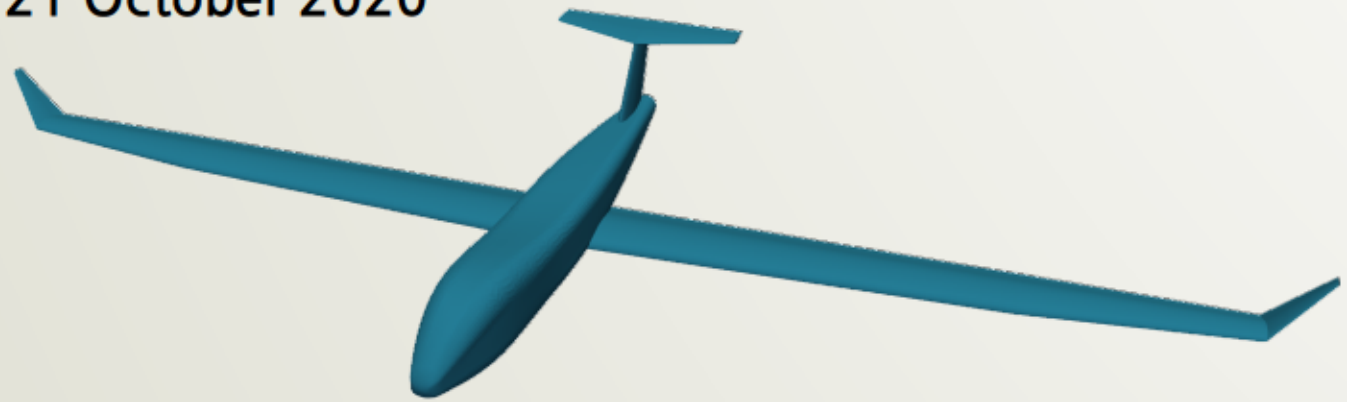
READ/EWADE 2020

CEASIOMpy
Conceptual Aircraft Design Environment

Using surrogate models to speed up the creation of aerodynamic databases in CEASIOMpy

21 October 2020



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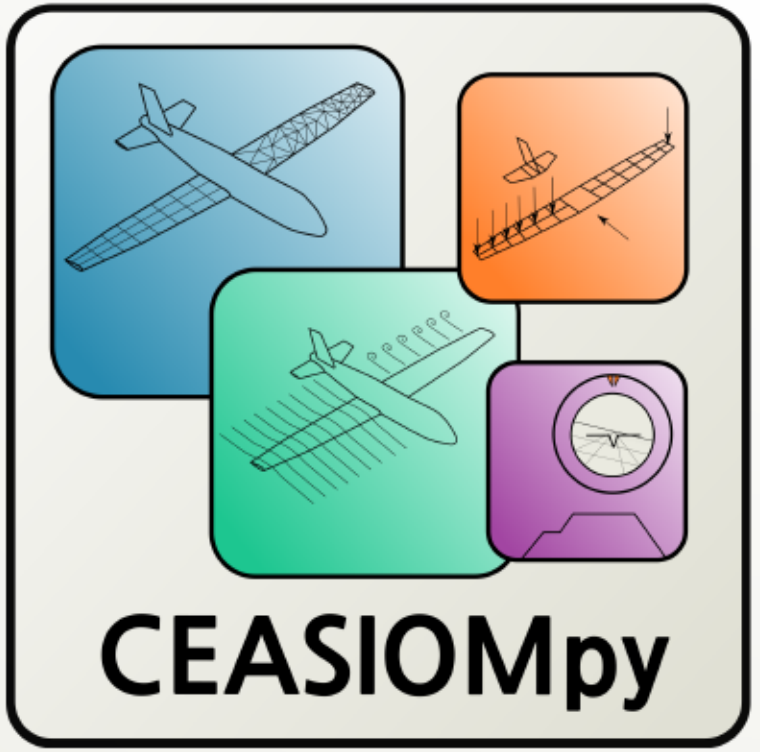
AGILE 4.0

Introduction

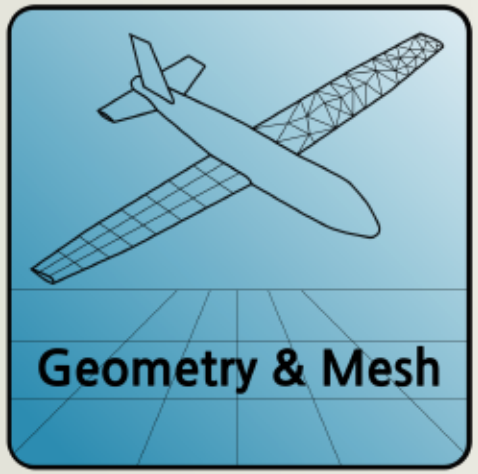
- Conceptual aircraft design environment
- Legacy from FP6 SimSAC (2006-2009)
- Based on Python 3.5 and CPACS 3.1
- Open-source:

  http://github.com/cfsengineering/CEASIOMpy

  http://ceasiompy.readthedocs.io



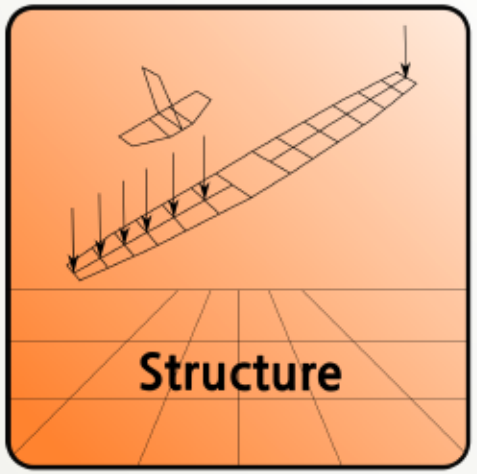
Introduction



- CPACSCreator
- SUMO

- CLCalculator
- PyTornado
- SU2
- SkinFriction

- Weights conventional
- Weights unconventional
- Balance conventional
- Balance unconventional



- AeroFrame
- FrameAT

- Range
- Static Stability

Introduction

- CPACS format
  - Common Parametric Aircraft Configuration Schema
  - Developed by the DLR (Germany)
  - XML based
  - Libraries TiXI/TiGL
  - Can be stored:
    - Geometry
    - Structure
    - Weights
    - Aerodynamics databases
    - …

CPACS.xml

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- <vehicles>
  - <aircraft>
    - <model uID="OptimaleBL3">
      - <reference>
          <area>55.209</area>
          <length>1.801</length>
        - <point uID="referencePoint1">
            <x>10.057</x>
            <y>0</y>
            <z>2.53</z>
          </point>
        </reference>
      - <fuselages>
        - <fuselage uID="Fuselage">
          - <transformation uID="Fuselage_transformation1">
            - <scaling uID="Fuselage_transformation1_scaling1">
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                <y>0.001</y>
                <z>0.001</z>
              </scaling>
            - <rotation uID="Fuselage_transformation1_rotation1">
                <x>0</x>
                <y>0</y>
                <z>0</z>
              </rotation>
            - <translation uID="Fuselage_transformation1_translation1" refType="absLocal">
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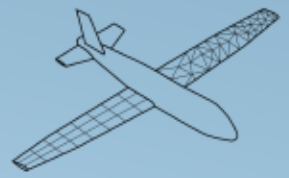
                <y>0</y>
                <z>3</z>
              </translation>
            </transformation>
          - <sections>
            - <section uID="OptimaleBL3_Fuselage_Sec1">
              - <transformation uID="OptimaleBL3_Fuselage_Sec1_transformation1">
                - <scaling uID="OptimaleBL3_Fuselage_Sec1_transformation1_scaling1">
                    <x>1</x>
                    <y>1</y>
```

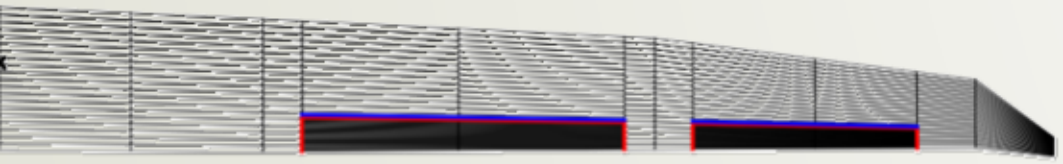


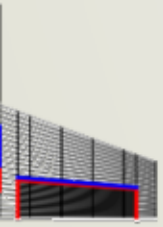
Geometry & Mesh

- OPTIMALE aircraft
  - UAV
  - Medium Altitude Long Endurance
  - German AeroStruct research project
  - H2020 - AGILE4.0

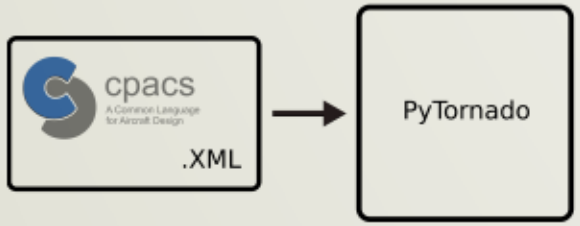
Semi-span	16,2 m
Ref. area	55 m^2
Cruise speed	150 m/s
Cruise altitude	15’500 m

Geometry & Mesh

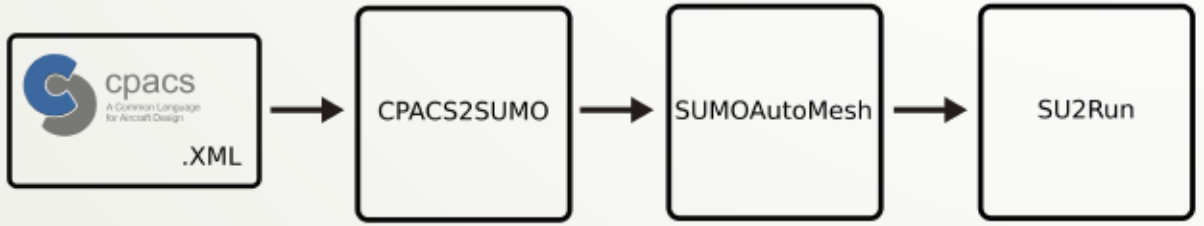


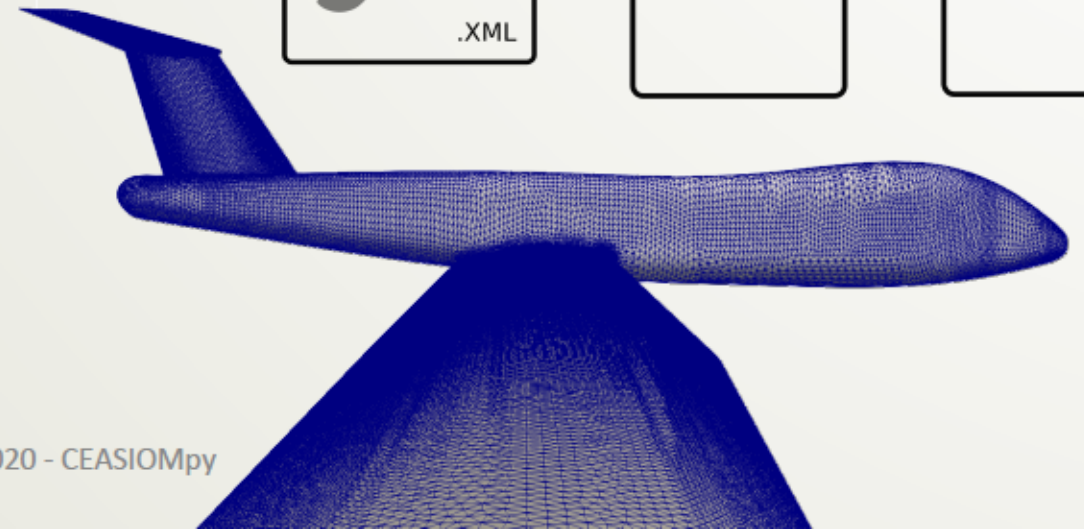


- VLM mesh
  - Automatic paneling
  - No fuselage



- Unstructured tetrahedron mesh
  - SUMO/Tetgen
  - Euler equation
  - Mesh convergence has been tested





Aerodynamic

PyTornado

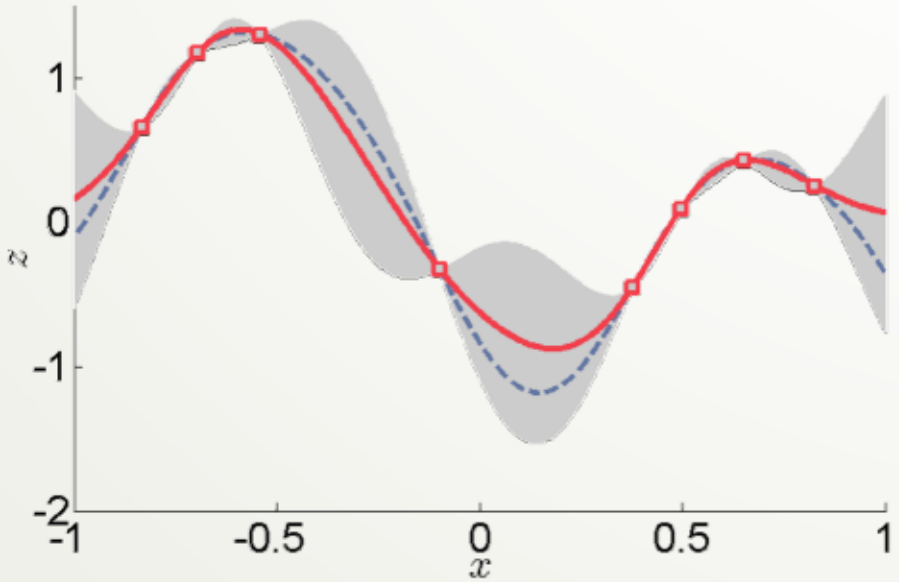
- Open-source
- Vortex Lattice Method (VLM)
- No fuselage
- Wing thickness not taken into account

SU2 code

- Open-source, developed by J.Alonso et al. at Stanford University
- Euler/Navier-Stokes equations

Surrogate models

- What is a surrogate model?
  - Model an unknown function
  - Train from known datapoints (DoE)
  - Create a response surface
  - Predict any new point in the training range

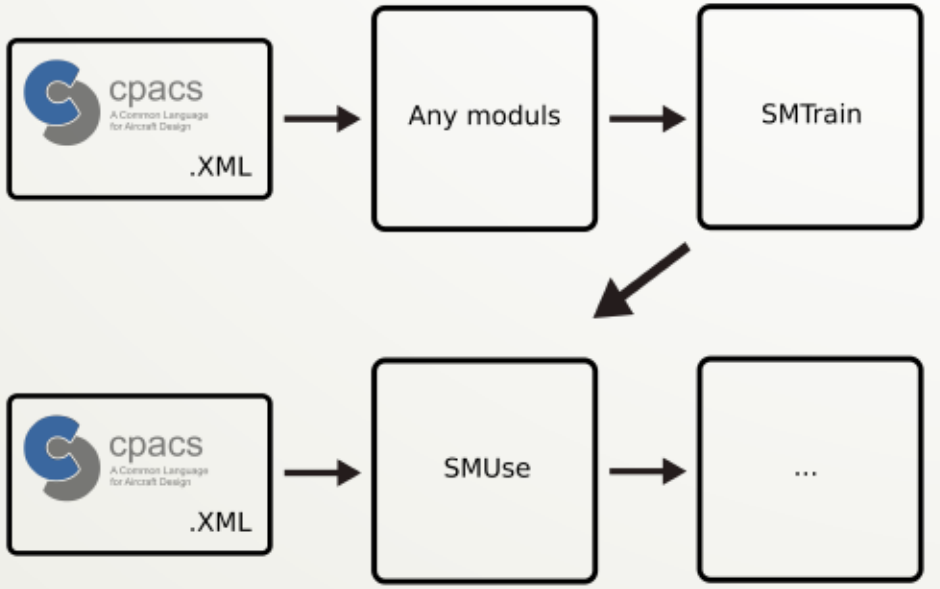


Surrogate models

- Surrogate modeling Toolbox (SMT)
  - Open-source Python package
  - Developed by M. A. Bouhlel et al.
  - Several models implemented
    - Kriging
    - Least square
    - KPLS
    - KPLSK

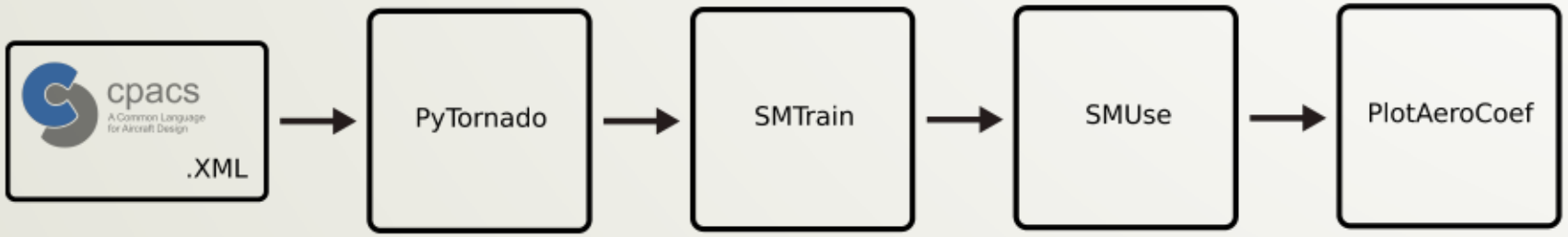
Surrogate models

- Integration into CEASIOMpy
  - **SMTrain** to train the Surrogate model
  - **SMUse** to predict values using the surrogate model
  - Compatible with all other modules



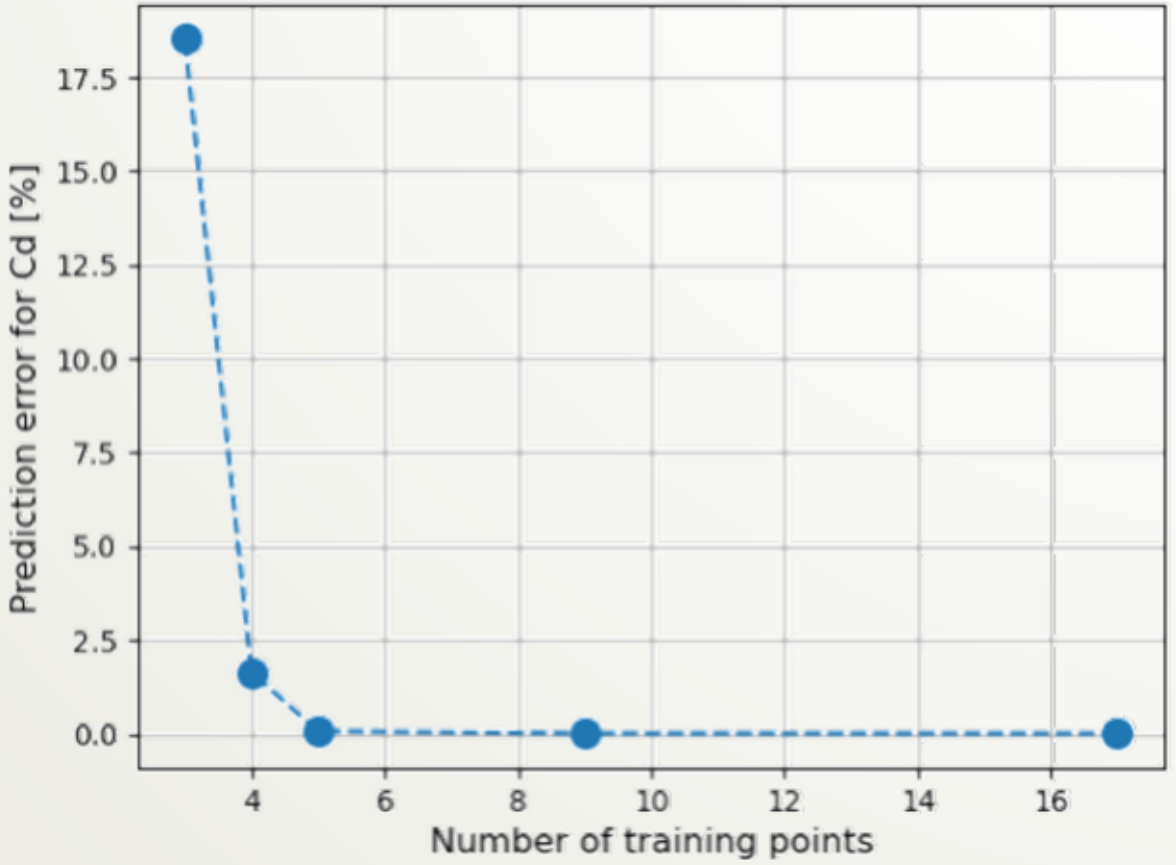
Applications

- Predict aerodynamic coefficients
  - 1 parameter
    - Angle of attack, from -8 to 8 degrees
  - Surrogate model trained with different number of points (17, 9, 5, 4, 3)



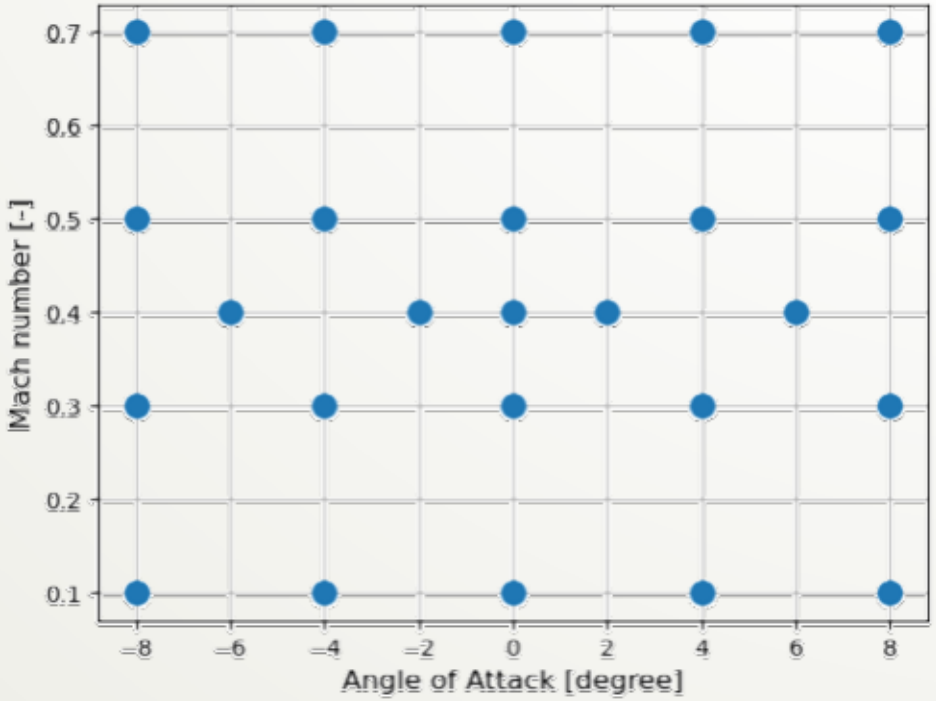
Applications

- Results
  - Error between predicted and calculated Drag coefficient
  - For simple cases 5 points are sufficient

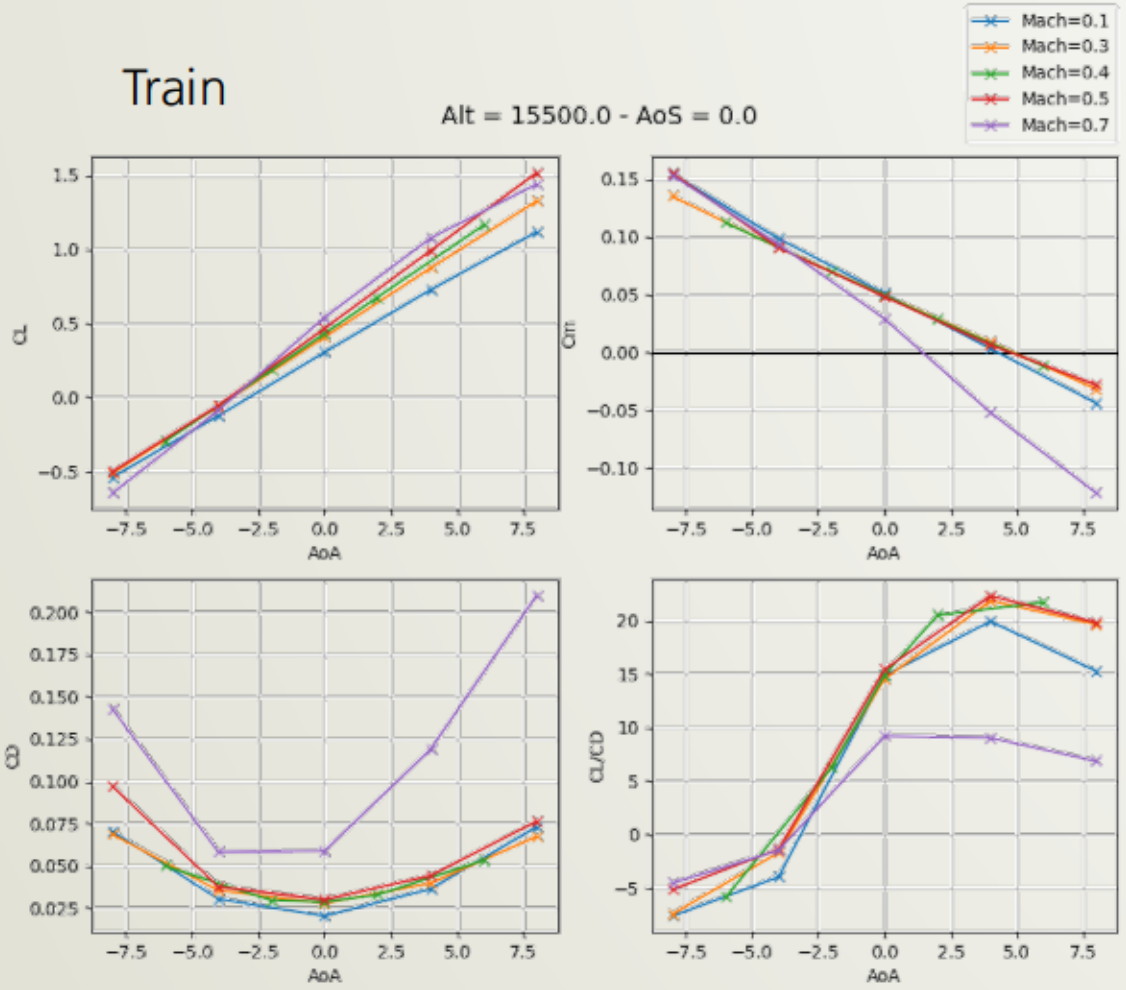


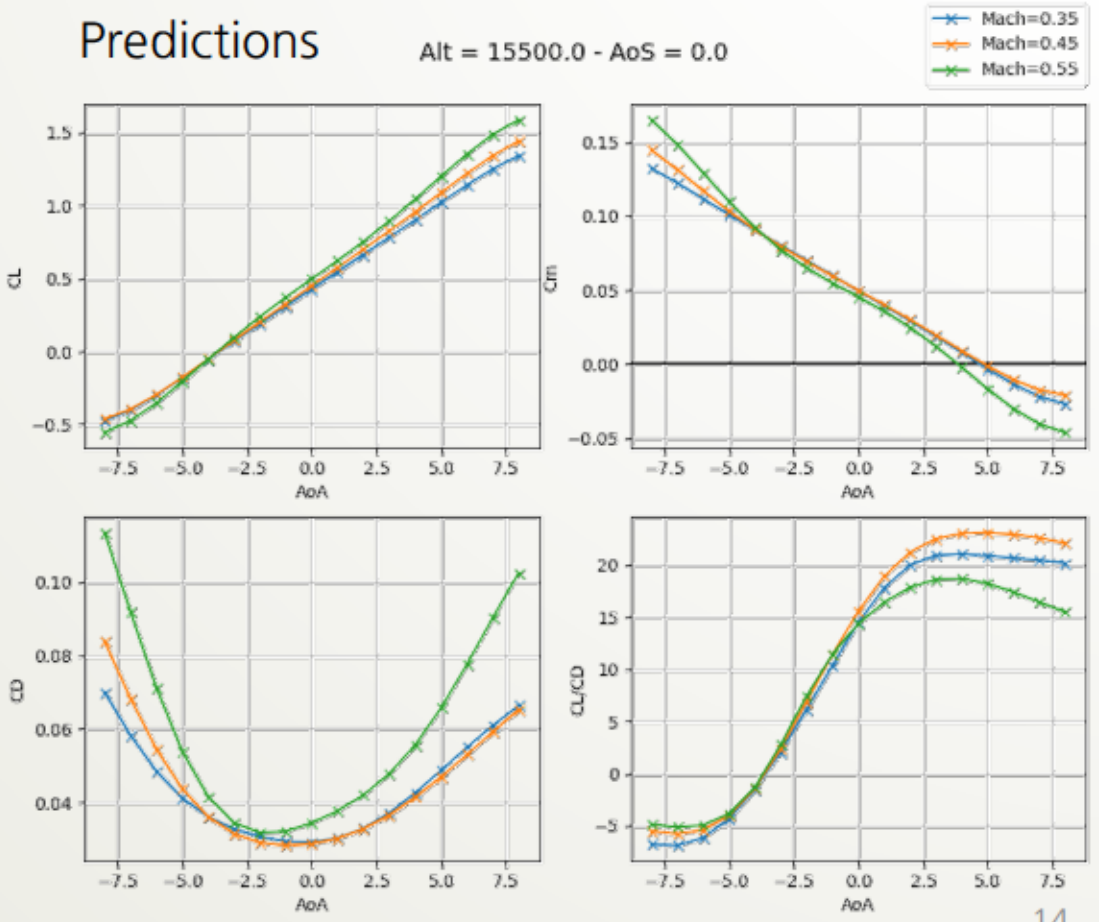
Applications

- Predict aerodynamic coefficients
  - 2 parameters
    - Angle of attack
    - Mach number
  - Training point calculated with:
    - SU2 (Euler) + skin friction
  - Closer to real application



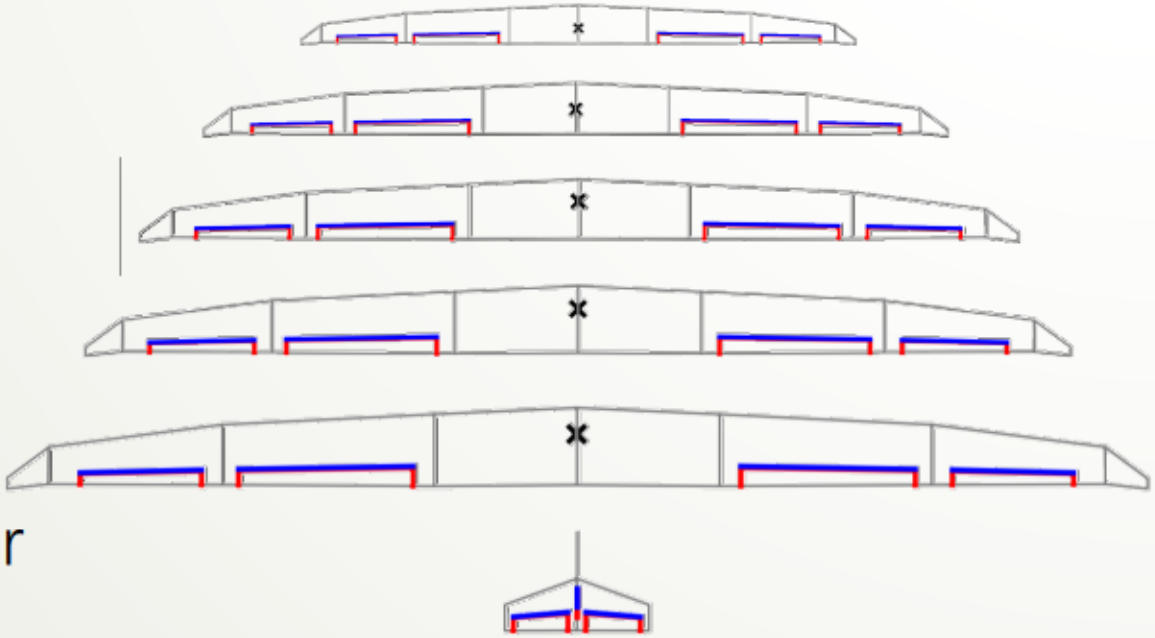
Applications





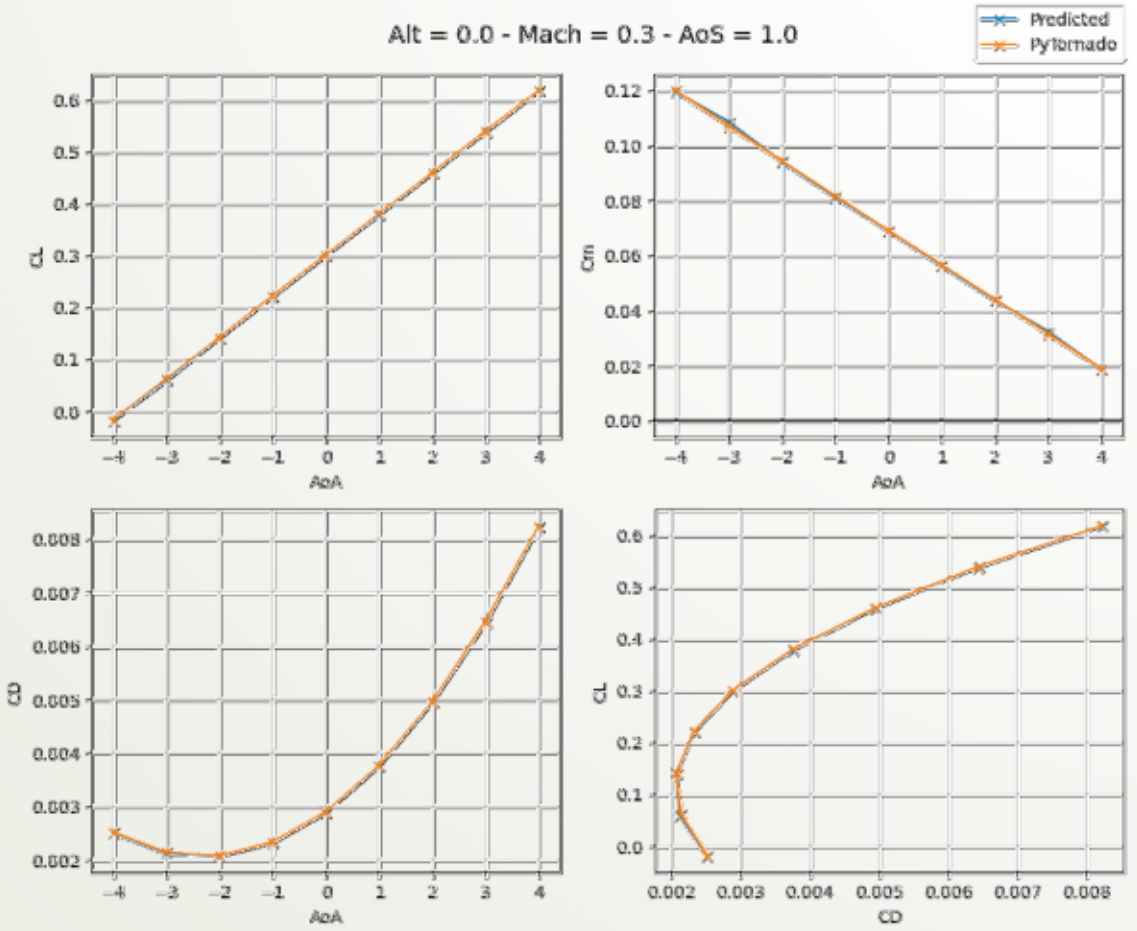
Applications

- Predict aerodynamic coefficients
  - 3 parameters
    - Angle of attack, -4 to 4 degrees
    - Angle of sideslip, -5 to 5 degrees
    - Wing span from, 10 to 20 m
  - Full factorial, 5 values per parameter
  - 125 training points
  - Calculated with PyTornado



Applications

- Results
  - For an uncalculated:
    - Wing span: 14m
    - Angle of sideslip: 1 degree
  - Almost perfect match
  - More points give better results



Conclusion

- Successful integration of SMT into CEASIOMpy
- Many possible applications for
  - Conceptual aircraft design
  - Multi-Disciplinary Optimization
- Room for possible improvement in the integrations
- More tests to find out the best parameters

CEASIOMpy

Conceptual Aircraft Design Environment

HORIZON 2020

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