# airconics Documentation

***Release***

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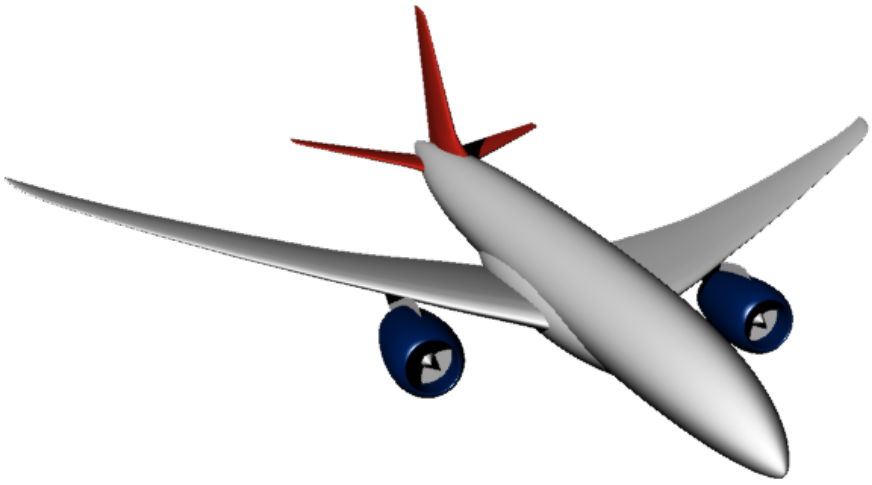
Contents



*occ_airconics* implements a scripted aircraft geometry package for Python, powered by Open CASCADE and PythonOCC.

While the majority of detailed aircraft design is performed by expert users of high-level Computer Aided Drawing (CAD) software, the bottom-up construction philosophy *'aircraft geometry as computer code'* has recently amassed interest in vehicle concept design and multidisciplinary optimisation. Primary aims of *occ_airconics* are to provide one such implementation through generic aircraft primitives, such as the `Airfoil`, `LiftingSurface`, `Engine` and `Fuselage` classes, with a view that they will be used in configuration-level geometry parametrisation and optimisation. An example of this functionality lies in the built-in transonic airliner model, capable of producing a range of conventional geometries (see above) and a box-wing style aircraft.

One of the key advantages of *occ_airconics* is that it benefits from being built on the open-source full CAD kernel Open CASCADE available through PythonOCC, and therefore has access to an extensive and well-supported library of fast geometry manipulation tools including NURBS (Non-Uniform Rational B-Spline) curves and surfaces.

*occ_airconics* offers a fully cross platform and open source porting of core classes from the popular AirCONICS (**A** ircraft **CON** figuration through **I** ntegrated **C** rossdisciplinary **S** cripting) plug-in for Rhinoceros 3D. Users of the original *AirCONICS* software should be aware however that the functionality of the original API has changed in *occ_airconics* to fit with the environments and ideologies of CPython and *pythonocc*. In particular, the base classes `AirconicsShape` and `AirconicsCollection` are added (see API reference for details).

Installation of *occ_airconics* requires a recent version of *PythonOCC*, and is compatible with the latest version, 0.17, available from the *conda* package - see Installation for more information.

Refer to the examples and API reference for a demonstration of the usage of *occ_airconics*. Contributions are welcome, and developers should refer to the Open CASCADE and pythonocc API documentation for guidelines on manipulation of underlying geometry kernel.

Enjoy *occ_airconics*!

Contents:

CHAPTER 1

# Examples

## 1.1 Airfoil

This example on building an airfoil NURBS curve with occ_airconics is included in the occ_airconics core Qt viewer examples.

First import the primitives module in which the Airfoil class is contained and the `pythonocc-core` Qt viewer:

```
from airconics import primitives
# Visualisation with Python-OCC (ensure plot windows are set to qt)
from OCC.Display.SimpleGui import init_display
display, start_display, add_menu, add_function_to_menu = init_display()
```

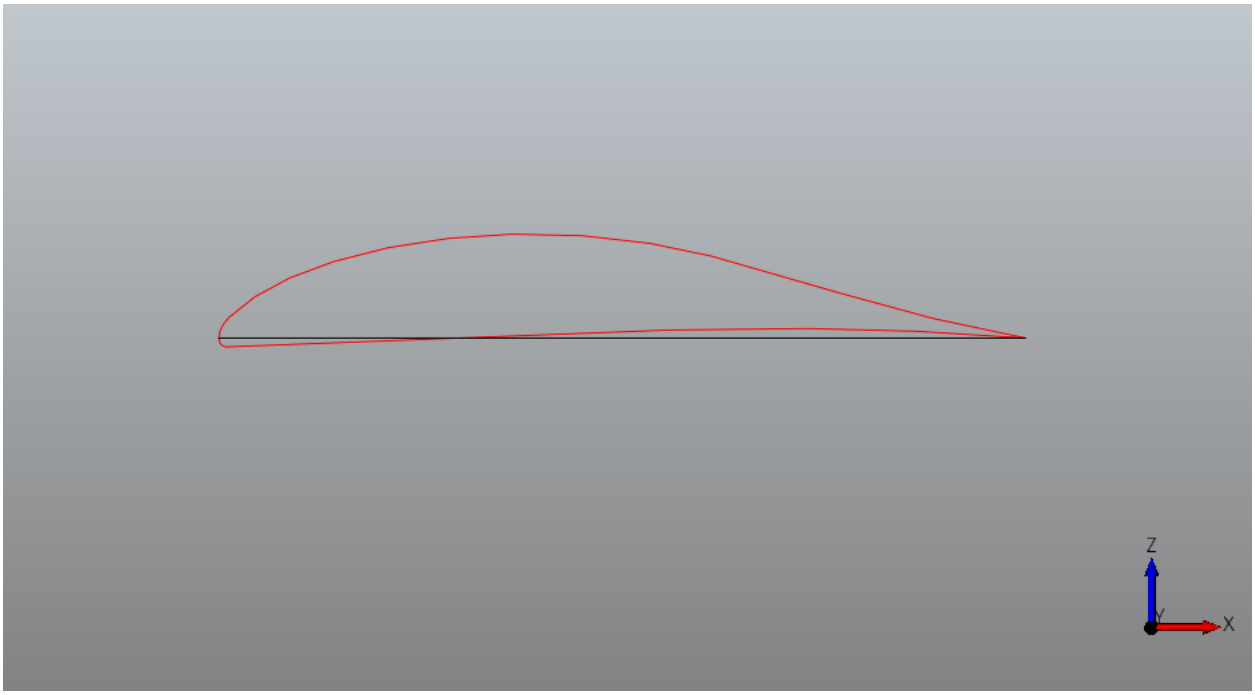
Next, define the inputs to Airfoil class. In this example, we'll use the `SeligProfile` type airfoil, leading edge point in origin, unit chord along x axis, no rotation around the x or y axes.

*Note: This class also supports construction of NACA 4 digit profiles using input keyword `NACA4Profile`. See Airfoil API reference.*

```
LEPoint = [0., 0., 0.]
ChordLength = 1
Rotation = 0
Twist = 0
AirfoilSeligName = 'dae11'

# Instantiate class to set up a generic airfoil with these basic parameters
Af = primitives.Airfoil(LEPoint, ChordLength, Rotation, Twist,
                        SeligProfile=AirfoilSeligName)
```

Finally, display the curve and chord line

```
display.DisplayShape(Af.Curve, update=True)
display.DisplayShape(Af.ChordLine, update=True)
start_display()
```




## 1.2 Transonic Airliner

In this example, the transonic airliner geometry example from the Rhinoceros Airconics plugin [1] is shown. All renderings are static images here, but represent interactive renderings when run as an IPython notebook available here. Interactive shapes can be viewed by clicking the shape hyperlinks however, as produced by the *PythonOCC x3dom* renderer.

For examples using the *pythonocc-core* Qt viewer, refer to the *occ-airconics* examples/core directory

```
from airconics import liftingsurface, engine, fuselage_oml
import airconics.AirCONICStools as act
from airconics.Addons.WebServer.TornadoWeb import TornadoWebRenderer
from IPython.display import display
```

### 1.2.1 Parameter Definitions

Parameters used here correspond to a geometry similar to that of the Boeing 787-8

```
Propulsion=1
EngineDia=2.9
FuselageScaling=[55.902, 55.902, 55.902]
WingScaleFactor=44.56
WingChordFactor=1.0
Topology=1
EngineSpanStation=0.31
EngineCtrBelowLE=0.3558
EngineCtrFwdOfLE=0.9837
Scarf_deg=3

# Derived Parameters
FuselageHeight = FuselageScaling[2]*0.105
```

```
FuselageLength = FuselageScaling[0]
FuselageWidth  = FuselageScaling[1]*0.106
WingApex = [0.1748*FuselageLength,0,-0.0523*FuselageHeight]
# Fin:
FinChordFact = 1.01
FinScaleFact = WingScaleFactor/2.032
# TailPlane
TPChordFact = 1.01
TPScaleFact = WingScaleFactor * 0.388
# Engine:
NacelleLength = 1.95*EngineDia
```

### 1.2.2 Wing, Transonic Airliner

Formulation of lifting surfaces in `occ_airconics` (and AirCONICS) follows the suggestions in Sobester [2] in which geometry–attached curvilinear functionals are used instead of parameters for shape definition. That is, \(G(\bf{f}, \bf{X})\), where

$$\qquad \textbf{f} = \left[ f_1(\textbf{X}_1), f_2(\textbf{X}_2), ... f_m(\textbf{X}_m)\right],$$ and

$$\textbf{X}_i = \left[x_1^i, x_2^i,...\right], \forall i = 1,...m$$

as opposed to the conventional \(G(\bf{X})\) formulation where the shape \(G\) changes in response to changes in design parameters \(\textbf{X}\). The functions \(f_i\) are defined by:

$$Sweep (\epsilon)$$

$$Chord (\epsilon)$$

$$Rotation (\epsilon)$$

$$Twist (\epsilon)$$

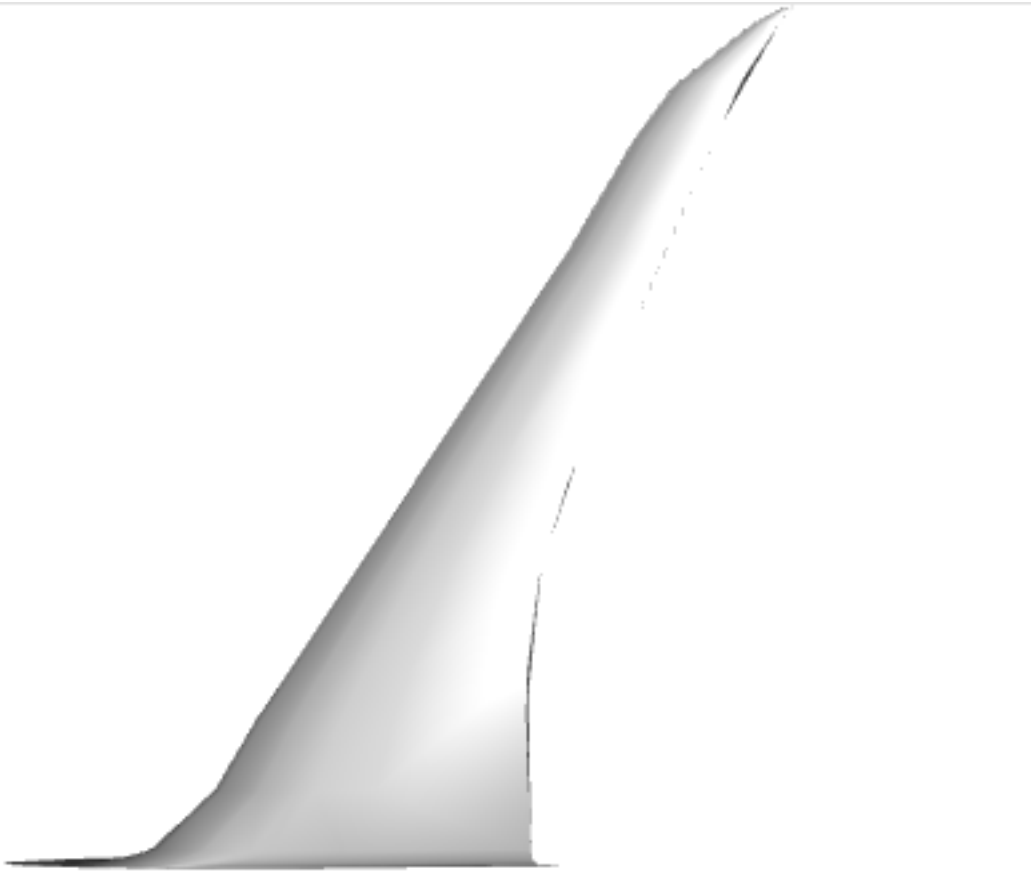
$$Airfoil (\epsilon)$$

where \(\epsilon\) represents the spanwise coordinate ranging from 0 at the root of the wing to 1 at the tip. Output of the airfoil function uses the `airconics.primitives.Airfoil` class here, which fits a NURBS curve to airfoil coordinates.

The following code demonstrates construction of a wing using built in examples for a transonic airliner wing and tailplane (below).

```
# Import all example functional definitions for the Common Research Model (CRM) Wing:
from airconics.examples.wing_example_transonic_airliner import *

# Position of the apex of the wing
P = WingApex

# Class definition
NSeg = 11
ChordFactor = 1
ScaleFactor = 50

# Generate (surface building is done during construction of the class)
Wing = liftingsurface.LiftingSurface(P, mySweepAngleFunctionAirliner,
                                        myDihedralFunctionAirliner,
                                        myTwistFunctionAirliner,
                                        myChordFunctionAirliner,
                                        myAirfoilFunctionAirliner,
                                        SegmentNo=NSeg,
```

```
                                        ScaleFactor=WingScaleFactor,
                                        ChordFactor=WingChordFactor)

# Evaluate the root chord:
RootChord = Wing.RootChord

# Display
renderer = TornadoWebRenderer()
Wing.Display(renderer)
display(renderer)
```



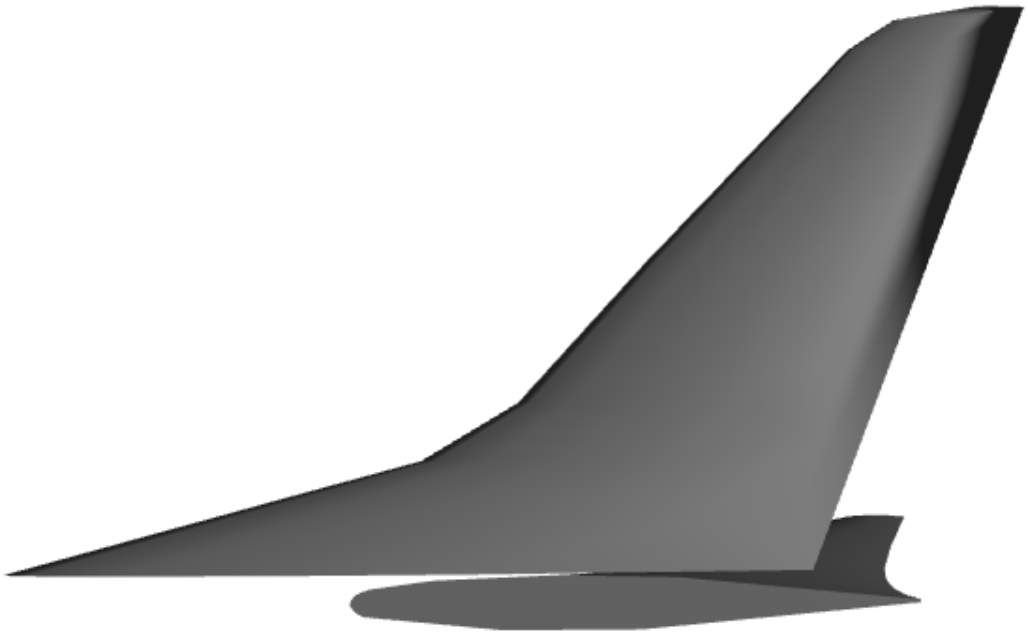
Interactive x3dom output

### 1.2.3 Tailplane, Transonic Airliner

The same `Lifting Surface` class is used here to generate the fin and tailplane of the aircraft, using a different set of input functionals (also defined in `airconics.examples`).

```
from OCC.gp import gp_Ax1, gp_Pnt, gp_Dir
from airconics.examples.tailplane_example_transonic_airliner import *

# Position of the apex of the fin
P = [36.98-0.49-0.02, 0.0, 2.395-0.141]

SegmentNo = 10
```

```
Fin = liftingsurface.LiftingSurface(P, mySweepAngleFunctionFin,
                                    myDihedralFunctionFin,
                                    myTwistFunctionFin,
                                    myChordFunctionFin,
                                    myAirfoilFunctionFin,
                                    SegmentNo=SegmentNo,
                                    ChordFactor=FinChordFact,
                                    ScaleFactor=FinScaleFact)

#    Create the rotation axis centered at the apex point in the x direction
RotAxis = gp_Ax1(gp_Pnt(*P), gp_Dir(1, 0, 0))


Fin.RotateComponents(RotAxis, 90)

# Position of the apex of the tailplane
P = [43, 0.000, 1.633+0.02]

SegmentNo = 100
ChordFactor = 1.01
ScaleFactor = 17.3

TP = liftingsurface.LiftingSurface(P, mySweepAngleFunctionTP,
                                   myDihedralFunctionTP,
                                   myTwistFunctionTP,
                                   myChordFunctionTP,
                                   myAirfoilFunctionTP,
                                   SegmentNo=SegmentNo,
                                   ChordFactor=TPChordFact,
                                   ScaleFactor=TPScaleFact)

# Display
renderer = TornadoWebRenderer()
Fin.Display(renderer)
TP.Display(renderer)
display(renderer)
```



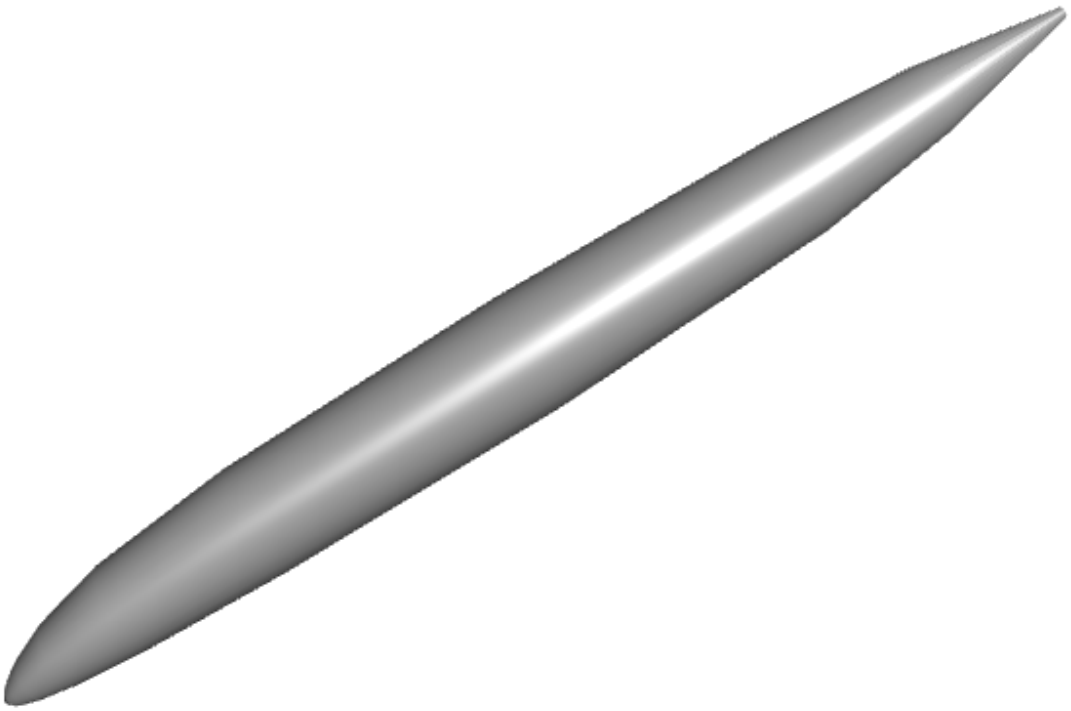
Interactive x3dom Fin

### 1.2.4 Fuselage Transonic Airliner

Fuselage shapes are created following the parameterisation used in Sobester [3]. That is, the outer mould line (OML) is split into a `Nose`, `Central` and `Tail` section, the length of which is described on input to `Fuselage` class as a percentage of the total length. Rib curves are then formed by fitting a NURBS curve to the intersection points of sectional planar cuts and the guide curves of the extremeties of the OML e.g. Port, top and bottom curves. The OML is fitted in `occ_airconics` using the Open CASCADE `ThruSections` loft.

```
NoseLengthRatio=0.182
TailLengthRatio=0.293

Fus = fuselage_oml.Fuselage(NoseLengthRatio, TailLengthRatio,
                            Scaling=FuselageScaling,
                            NoseCoordinates=[0., 0., 0],
                            CylindricalMidSection=False,
                            Maxi_attempt=5)

# Display
renderer = TornadoWebRenderer()
Fus.Display(renderer)
display(renderer)
```

```
('Surface fit attempt ', 1)
('Attempting thrusections surface fit with network density                setup ', array([35, 30, 15,
Network surface fit succesful on attempt 1
```



Interactive x3dom Fuselage

### 1.2.5 Wing-Body Fairing:

The wing-body fairing is here created as a simple ellipsoid shape around the root section of the wing.

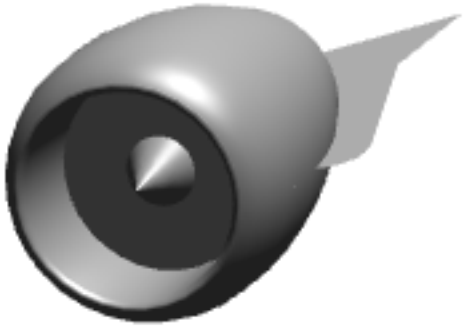
*Note that this component will be displayed only in the final model.*

```
# WingBodyFairing: A simple ellipsoid:
from airconics.base import AirconicsShape
WTBFZ = RootChord*0.009 #787: 0.2
WTBFheight = 1.8*0.1212*RootChord #787:2.7
WTBFwidth = 1.08*FuselageWidth
WTBFXCentre = WingApex[0] + RootChord/2.0 + RootChord*0.1297 # 787: 23.8
WTBFlength = 1.167*RootChord #787:26

WBF_shape = act.make_ellipsoid([WTBFXCentre, 0, WTBFZ], WTBFlength, WTBFwidth, WTBFheight)
WBF = AirconicsShape(components={'WBF': WBF_shape})
```

### 1.2.6 Engine + Pylon

First, obtain the wing section and chord at which the engine will be fitted, then fit then engine. The default inputs to the Engine class produce a turbofan engine with Nacelle similar to that of the RR Trent 1000 / GEnx and its pylon (**currently a flat plate only**).

```
from airconics import engine

EngineSection, Chord = act.CutSect(Wing['Surface'], EngineSpanStation)
CEP = Chord.EndPoint()
Centreloc = [CEP.X()-EngineCtrFwdOfLE*NacelleLength,
             CEP.Y(),
             CEP.Z()-EngineCtrBelowLE*NacelleLength]

eng =  engine.Engine(Chord,
                     CentreLocation=Centreloc,
                     ScarfAngle=Scarf_deg,
                     HighlightRadius=EngineDia/2.0,
                     MeanNacelleLength=NacelleLength)

# Display
renderer = TornadoWebRenderer()
eng.Display(renderer)
display(renderer)
```



Interactive x3dom Engine

### 1.2.7 Miscelaneous operations

```
# Trim the inboard section of the main wing:
CutCirc = act.make_circle3pt([0,WTBFwidth/4.,-45], [0,WTBFwidth/4.,45], [90,WTBFwidth/4.,0])
CutCircDisk = act.PlanarSurf(CutCirc)
Wing['Surface'] = act.TrimShapebyPlane(Wing['Surface'], CutCircDisk)

#Mirror the main wing and tailplane using class methods:
```

```
Wing2 = Wing.MirrorComponents(plane='xz')
TP2 = TP.MirrorComponents(plane='xz')
eng2 = eng.MirrorComponents(plane='xz')
```

```
can work? True
error status: - Ok
Note: MirrorComponents currently mirrors only the shape
components, other attributes will not be mirrored

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components, other attributes will not be mirrored

Note: MirrorComponents currently mirrors only the shape
components, other attributes will not be mirrored
```
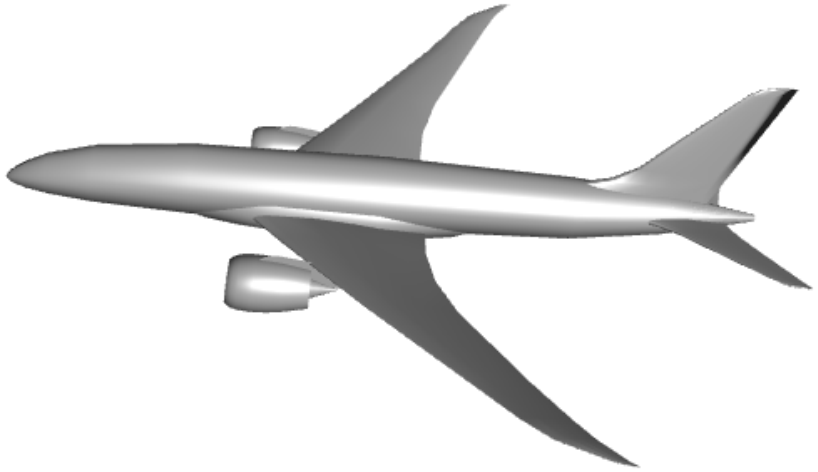

### 1.2.8 Ipython Cell Renderer:

Now render the finished airliner model:

```
from airconics.Addons.WebServer import TornadoWeb
renderer = TornadoWeb.TornadoWebRenderer()
#    display all entities:
# Fuselage and wing-body fairing
Fus.Display(renderer)
WBF.Display(renderer)

# #The Wings:
Wing.Display(renderer)
Wing2.Display(renderer)

#The Tailplane:
TP.Display(renderer)
TP2.Display(renderer)

#The Fin:
Fin.Display(renderer)

#The Engines:
eng.Display(renderer)
eng2.Display(renderer)

# Finally show the renderer
display(renderer)
```



Interactive x3dom Airliner

## 1.3 Topology model

This is a work in progress towards a topologically flexible model based on the tree-type definition described in Sobester [1]. Note the geometry is not currently defined by the tree however, the tree is simply stored as a result of adding components - this is for demonstration only, and the process is yet to be automated.

### 1.3.1 Transonic Airliner Topology

First, we'll try to add the previously created *transonic airliner* components to a `Topology`, including the number of descendant nodes that will be attached to each, and then display the resulting tree graph. The LISP representation of this tree could be described as

**Fuselage(Fin, Mirror[ (TailPlane, Wing(Engine))]**,

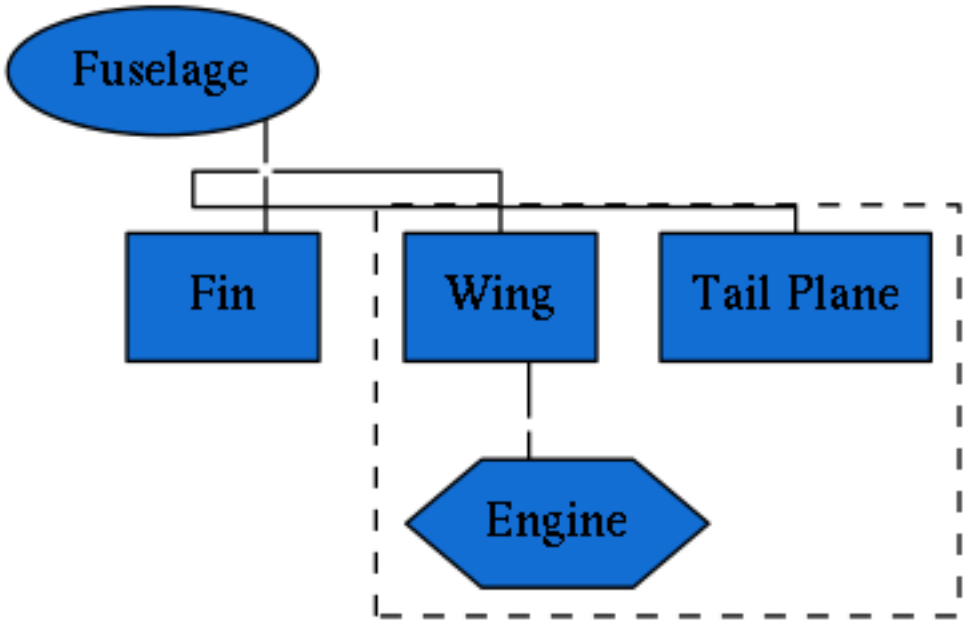
where opening brackets indicate that the following component is to be 'atttached' to the preceeding shape. Using the shorthand described in [1], this is equivalent to \(E(L, |L, L(P))\), where \(E\) is an enclosure/fuselage object, \(L\) is a lifting surface, \(|\) is a mirror plane and \(P\) is a propulsion unit [1]. Study the Airliner model above and recursively work through the components, starting from the fuselage, and think about the sub-components are attached to them to assert that this is true.

The \(xz\) mirror plane is included in this representation, between central objects (Fuselage, Fin) and the mirrored objects (Tail Plane, Wing, Engine). Notice that the dotted line box surrounds the entities that will be mirrored when `Topology.Build()` is called.

```
from airconics import Topology
from IPython.display import Image
import pydot
```

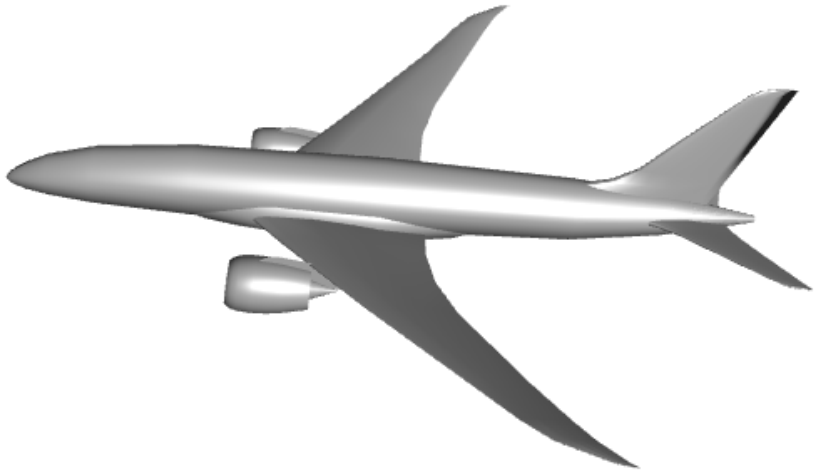
```
topo_renderer = TornadoWebRenderer()

topo = Topology()

# Note: no checks are done on the validity of the tree yet,
topo.AddPart(Fus, 'Fuselage', 3)
topo.AddPart(Fin, 'Fin', 0)

# Need to add a mirror plane here, arity zero
from OCC.gp import gp_Ax2, gp_Dir, gp_Pnt
xz_pln = gp_Ax2(gp_Pnt(0, 0, 0), gp_Dir(0, 1, 0))
topo.AddPart(xz_pln, 'Mirror', 0)

# These are the mirrored entities, with their arities
topo.AddPart(TP, 'Tail Plane', 0)
topo.AddPart(Wing, 'Wing', 1)
topo.AddPart(eng, 'Engine', 0)

# print the Topology (resembles a LISP tree)
print(topo)

# Create the graph with pydot
graph = pydot.graph_from_dot_data(topo.export_graphviz())
Image(graph.create_png())
```

```
Skipping geometry construction for Topology
E(L, |L, L(P))
```




```
# This line will mirror geometry 'under' (added after) the mirror plane
topo.Build()

topo.Display(topo_renderer)
display(topo_renderer)
```

```
<class 'OCC.gp.gp_Ax2'>
Note: MirrorComponents currently mirrors only the shape
components, other attributes will not be mirrored

Skipping geometry construction for AirconicsShape
<class 'OCC.gp.gp_Ax2'>
Note: MirrorComponents currently mirrors only the shape
components, other attributes will not be mirrored

Skipping geometry construction for AirconicsShape
<class 'OCC.gp.gp_Ax2'>
Note: MirrorComponents currently mirrors only the shape
components, other attributes will not be mirrored

Skipping geometry construction for AirconicsShape
Could not display shape type <class 'OCC.gp.gp_Ax2'>: skipping
```



Interactive x3dom Airliner

Let's try some further tests to the topology class representation using some other examples. For now, these are empty geometries, and inputs to the `Fuselage`, `LiftingSurface` and `Engine` classes are not yet included in the `Topology` tree.

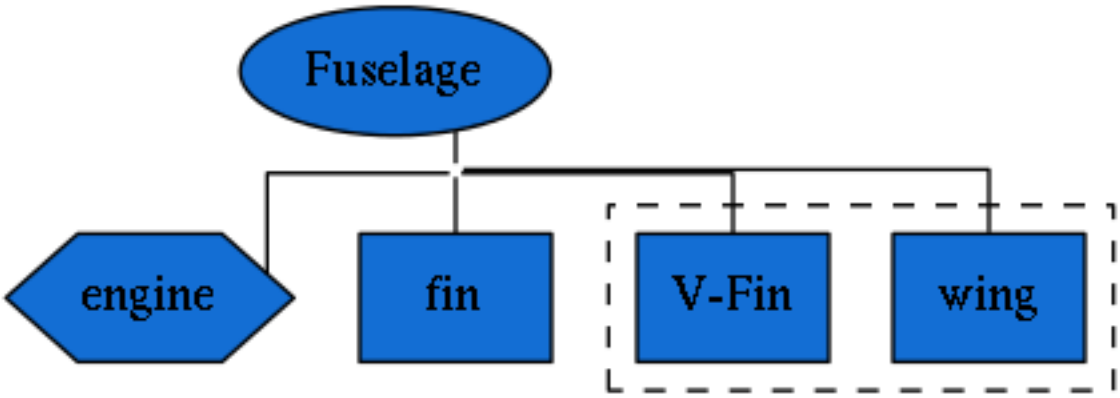
### 1.3.2 Predator UAV

**Photo source: US Air Force**

```
# Setup
# Create mock components, without generating any geometry
fus = Fuselage(construct_geometry=False)
engine = Engine(construct_geometry=False)
fin = LiftingSurface(construct_geometry=False)
mirror_pln = gp_Ax2()
wing = LiftingSurface(construct_geometry=False)
Vfin = LiftingSurface(construct_geometry=False)

# For now we must manually add parts and affinities
topo = Topology()
topo.AddPart(fus, 'Fuselage', 4)
topo.AddPart(engine, 'engine', 0)
topo.AddPart(fin, 'fin', 0)
topo.AddPart(mirror_pln, 'mirror_pln', 0)
topo.AddPart(wing, 'wing', 0)
topo.AddPart(Vfin, 'V-Fin', 0)

print(topo)

graph = pydot.graph_from_dot_data(topo.export_graphviz())
Image(graph.create_png())
```

```
Skipping geometry construction for Fuselage
No HChord specified to fit engine to: creating default
```

```
Skipping geometry construction for Engine
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Skipping geometry construction for Topology
E(P, L, |L, L)
```

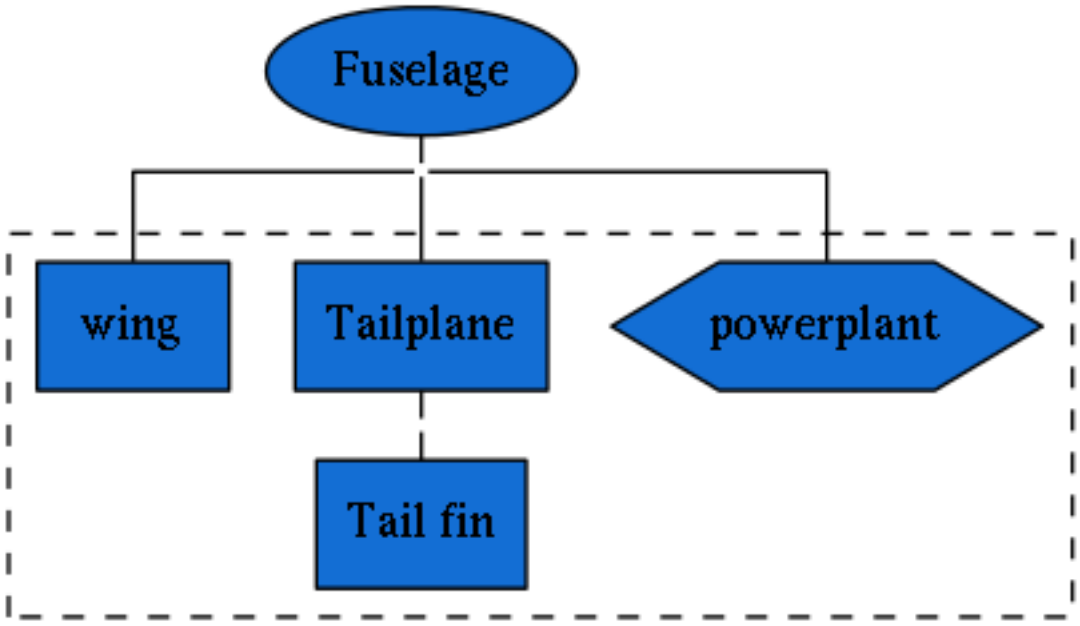



### 1.3.3 Fairchild Republic A-10 Thunderbolt

**Photo source: Airman Magazine 1999**

```
# Setup
# Create mock components, without generating any geometry
fus = Fuselage(construct_geometry=False)
mirror_pln = gp_Ax2()
engine = Engine(construct_geometry=False)
wing = LiftingSurface(construct_geometry=False)
tailplane = LiftingSurface(construct_geometry=False)
tail_fin = LiftingSurface(construct_geometry=False)

topo = Topology()
topo.AddPart(fus, 'Fuselage', 3)
topo.AddPart(mirror_pln, 'mirror', 0)
topo.AddPart(engine, 'powerplant', 0)
topo.AddPart(tailplane, 'Tailplane', 1)
topo.AddPart(tail_fin, "Tail fin", 0)
topo.AddPart(wing, "wing", 0)

print(topo)

graph = pydot.graph_from_dot_data(topo.export_graphviz())
Image(graph.create_png())
```

```
Skipping geometry construction for Fuselage
No HChord specified to fit engine to: creating default
Skipping geometry construction for Engine
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Skipping geometry construction for Topology
E(|P, L(L), L)
```


Fuselage
wing
Tailplane
powerplant
Tail fin

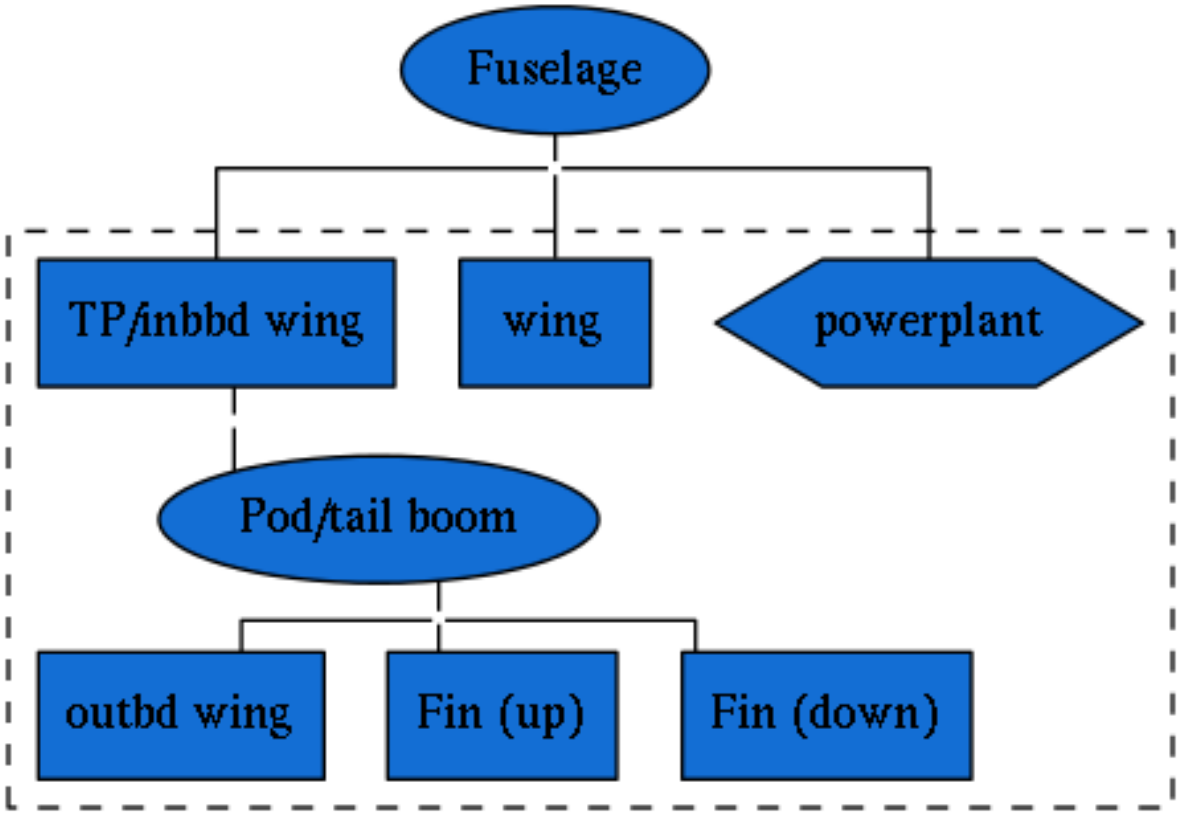
### 1.3.4 Scaled Composites Proteus


**Photo source: NASA**

```
# Setup
# Create mock components, without generating any geometry
fus = Fuselage(construct_geometry=False)
mirror_pln = gp_Ax2()
engine = Engine(construct_geometry=False)
wing_in = LiftingSurface(construct_geometry=False)
tailplane = LiftingSurface(construct_geometry=False)
pod = Fuselage(construct_geometry=False)
finup = LiftingSurface(construct_geometry=False)
findown = LiftingSurface(construct_geometry=False)
wing_out = LiftingSurface(construct_geometry=False)


topo = Topology()
topo.AddPart(fus, 'Fuselage', 3)
topo.AddPart(mirror_pln, 'mirror', 0)
topo.AddPart(engine, 'powerplant', 0)
topo.AddPart(wing, "wing", 0)
topo.AddPart(wing_in, "TP/inbbd wing", 1)
topo.AddPart(pod, 'Pod/tail boom', 3)
```

```
topo.AddPart(wing_out, "outbd wing", 0)
topo.AddPart(finup, "Fin (up)", 0)
topo.AddPart(findown, "Fin (down)", 0)

for node in topo._Tree:
    print(node)


graph = pydot.graph_from_dot_data(topo.export_graphviz())
Image(graph.create_png())
```

```
Skipping geometry construction for Fuselage
No HChord specified to fit engine to: creating default
Skipping geometry construction for Engine
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Skipping geometry construction for Fuselage
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Lifting Surface functional parameters not defined:
Initialising without geometry construction
Skipping geometry construction for LiftingSurface
Skipping geometry construction for Topology
(Fuselage, E, 3)
(mirror, |, 0)
(powerplant, P, 0)
(wing, L, 0)
(TP/inbbd wing, L, 1)
(Pod/tail boom, E, 3)
(outbd wing, L, 0)
(Fin (up), L, 0)
(Fin (down), L, 0)
```




## 1.4 References

[1] Sobester, A., "Four Suggestions for Better Parametric Geometries," 10th AIAA Multidisciplinary Design Optimization Conference, AIAA SciTech, American Institute of Aeronautics and Astronautics, jan 2014.

[2] Sobester, A., "Self-Designing Parametric Geometries," 56th AIAA/ASCE/AH- S/ASC Structures, Structural Dynamics, and Materials Conference, AIAA SciTech, American Institute of Aeronautics and Astronautics, jan 2015.

CHAPTER 2

# Installation

*occ_airconics* accesses the powerful Open CASCADE geometry kernel through the PythonOCC package. It is possible to build pythonocc-core from source by following their installation instructions, however a convenient and recommended alternative is to use the prebuilt conda packages suitable for win32/win64/osx64/linux64 users.

Note that *occ_airconics* is not currently available through PyPI.

## 2.1 Conda packages

*pythonocc-core* is listed as a dependency of *occ_airconics*, therefore users should simply add the appropriate conda channels to their `~/.condarc` file:

```
conda config --add channels dlr-sc     # the pythonocc-core channel

conda config --add channels prchambers # the occ_airconics channel
```

Or do this manually by editing their `~/.condarc` contents, e.g.:

```
channels:
    - https://conda.anaconda.org/dlr-sc
    - https://conda.anaconda.org/prchambers
    - defaults
```

Then install *occ_airconics* via

```
conda install occ_airconics
```

And that's it! *pythonocc-core* will be installed automatically.

## 2.2 Installation from source

Obtain and build a copy of *pythonocc-core* from GitHub following their instructions.

Then clone *occ_airconics* from GitHub with:

```
git clone https://github.com/p-chambers/occ_airconics
```

And install with

```
cd occ_airconics
python setup.py install
```

Or

```
pip install occ_airconics
```

Developers should also add the develop flag, i.e.

```
python setup.py install develop
```

CHAPTER 3

# occ_airconics API reference

## 3.1 airconics.base module

Base classes used by OCC_Airconics

Container classes (AirconicsBase, AirconicsShape, AirconicsCollection) which behaves like a dictionary of sub component shapes/parts with some extended functionality.

Created on Mon Apr 18 10:26:22 2016

@author: pchambers

**class** airconics.base.**AirconicsBase**(**args*, ***kwargs*)

Bases: _abcoll.MutableMapping, object

Base container class from which other base classes are derived from. This is a an abstract base class and should not be used directly by users.

### Notes

When properly defined in inherited functions, this class should behave like a dictionary.

As this class inherits from MutableMapping, any class inherting from AirconicsBase must also define the abstract methods of Mutable mapping, i.e. __setitem__, __getitem__, __len__, __iter__, __delitem__

### Methods

| | |
|---|---|
| *Build*(*args, **kwargs) | |
| *Display*(*args, **kwargs) | |
| *Write*(*args, **kwargs) | |
| clear(() -> None. Remove all items from D.) | |
| get((k[,d]) -> D[k] if k in D, ...) | |
| items(() -> list of D's (key, value) pairs, ...) | |
| iteritems(() -> an iterator over the (key, ...) | |
| iterkeys(() -> an iterator over the keys of D) | |
| itervalues(...) | |
| keys(() -> list of D's keys) | |
| pop((k[,d]) -> v, ...) | If key is not found, d is returned if given, otherwise KeyError is raised. |

Continued on next page

Table 3.1 – continued from previous page

| | |
|---|---|
| popitem(() -> (k, v), ...) | as a 2-tuple; but raise KeyError if D is empty. |
| setdefault((k[,d]) -> D.get(k,d), ...) | |
| update(([E, ...) | If E present and has a .keys() method, does: for k in E: D[k] = E[k] |
| values(() -> list of D's values) | |

**Build**(**args*, ***kwargs*)

**Display**(**args*, ***kwargs*)

**Write**(**args*, ***kwargs*)

**class** airconics.base.**AirconicsCollection**(*parts={}*, *construct_geometry=False*, **args*, ***kwargs*)

Bases: *airconics.base.AirconicsBase*

Base class from which collections of parts defined by other Airconics classes will be stored.

AirconicsCollection represents a collection of 'parts' (i.e. AirconicsShapes') which are logically grouped. For example, an aircraft comprised of multiple parts (engine, lifting surfaces, fuselage) all of which may contain sub 'components' and are therefore instances of AirconicsShapes'

**Parameters** **parts** : dictionary

(name: part) pairs, where name is a string for accessing the part, and 'part' is an AirconicsShape derived class e.g. Fuselage, LiftingSurface or Engine instance

**See also:**

*AirconicsShape*

#### Notes

**Derived classes should call the AirconicsCollection init with** super(DerivedClass, self).__init__(self, *args, **kwargs)

#### Attributes

| | |
|---|---|
| _Parts | (Airconics Container) Mapping of name(string):component(AirconicsShape) pairs. Note that this should not be interacted with directly, and instead users should use assignment or the AddPart method: :Example: >>> a = AirconicsCollection() >>> a['name'] = part >>> #OR: a.AddPart('name', part) This also supports mapping of attributes to parts, i.e: :Example: >>> a['name'] == a._Parts.name # returns True |

#### Methods

| | |
|---|---|
| *AddPart*(part[, name]) | Adds a component to self |
| *Build*() | Does nothing for AirconicsCollection. |
| *Display*(context[, material, color]) | Displays all Parts of the engine to input context |
| *Write*(filename[, single_export]) | Writes the Parts contained in this instance to file specified by filename. |
| clear(() -> None. Remove all items from D.) | |
| get((k[,d]) -> D[k] if k in D, ...) | |
| items(() -> list of D's (key, value) pairs, ...) | |

Continued on next page

Table 3.2 – continued from previous page

| | |
|---|---|
| iteritems(() -> an iterator over the (key, ...) | |
| iterkeys(() -> an iterator over the keys of D) | |
| itervalues(...) | |
| keys(() -> list of D's keys) | |
| pop((k[,d]) -> v, ...) | If key is not found, d is returned if given, otherwise KeyError is raised. |
| popitem(() -> (k, v), ...) | as a 2-tuple; but raise KeyError if D is empty. |
| setdefault((k[,d]) -> D.get(k,d), ...) | |
| update(([E, ...) | If E present and has a .keys() method, does: for k in E: D[k] = E[k] |
| values(() -> list of D's values) | |

**AddPart**(*part*, *name=None*)

Adds a component to self

**Parameters** **part** : TopoDS_Shape

**name** : string

**Build**()

Does nothing for AirconicsCollection.

This method allows AirconicsColection to be instantiated alone, as Build is called in the __init__. 'Build' Should be redefined by all derived classes.

#### Notes

•If Class.Build is not redefined in a derived class, confusion may

arise as no geometry will result from passing construct_geometry=True

**Display**(*context*, *material=<Mock id='140416365252048'>*, *color=None*)

Displays all Parts of the engine to input context

**Parameters** **context** : OCC.Display.OCCViewer.Viewer3d or WebRenderer

The display context - should have a Display or DisplayShape method

**meterial** : OCC.Graphic3d_NOM_* type

The material for display: note some renderers do not allow this

**Write**(*filename*, *single_export=True*)

Writes the Parts contained in this instance to file specified by filename.

One file is produced, unless single_export is False when one file is written for each Part.

**filename** [string] the BASE.ext name of the file e.g. 'airliner.stp'. Note the part name will be prepended to the base name of each output file

**single_export** [bool] returns a single output file if true, otherwise writes one file per part

**Returns** **status** : list

The flattened list of error codes returned by writing each part

**See also:**

*AirconicsBase*

#### Notes

•Calls the .Write method belonging to each Part

**class** airconics.base.**AirconicsShape**(*components={}*, *construct_geometry=False*, **args*, ***kwargs*)

Bases: *airconics.base.AirconicsBase*

Base class from which airconics parts will be made.

AirconicsShapes represent a 'part' of an aircraft e.g. the engine, which consists of a group of logically shape 'components' but with no relative or relational contact information: class methods are intended to manipulate the part as a whole.

This is intended as a base class, but can be used as a simple amorphic collection of shape components.

**Example**

```
>>> shape = Airconics()
>>> shape['wing'] = wing  # OR
>>> shape.AddComponent(wing, 'WingSurface')
```

**Parameters** **components** : dictionary of components to be added as attributes

To add attributes directly. Values must be OCC.TopoDS.TopoDS_Shape

**construct_geometry** : bool

If true, Build method will be called on construction. Defaults to False for AirconicsShape, as the Build method only prints. Derived classes should pass construct_geometry=True if a Build method should be called on construction

****kwargs** : All other keyword arguments will be added as an attribute

to the resulting class calling super(subclass, self).__init__

**See also:**

*AirconicsCollection*

#### Notes

**Derived classes should call the AirconicsCollection init with** super(DerivedClass, self).__init__(self, *args, **kwargs)

#### Attributes

| | |
|---|---|
| _Components | (Airconics Container) Mapping of name(string):component(TopoDS_Shape) pairs. Note that this should not be interacted with directly, and instead users should use assignment or the AddComponent method: :Example: >>> a = AirconicsShape() >>> a['name'] = shape >>> #OR: a.AddComponent('name', shape) This also supports mapping of attributes to parts, i.e: :Example: >>> a['name'] == a._Components.name # returns True |

#### Methods

| | |
|---|---|
| *AddComponent*(component[, name]) | Adds a component to self |
| *Build*() | Does nothing for AirconicsShape. |
| *Display*(context[, material, color]) | Displays all components of this instance to input context |
| *DisplayBBox*(display[, single]) | Displays the bounding box on input display. |
| *Extents*([tol, as_vec]) | Returns the extents of the bounding box encapsulating all shapes in |
| *MirrorComponents*([plane, axe2]) | Returns a mirrored version of this airconics shape |
| *PrintComponents*() | Lists the names of components in self |
| *RemoveComponent*(name) | Removes a named component from self |
| *RotateComponents*(ax, deg) | Rotation of each component in self._Components around ax by |
| *ScaleComponents_Uniformal*(factor[, origin]) | General scaling and translation of components in self |
| *TransformComponents_Nonuniformal*(scaling, vec) | General scaling and translation of components in self |
| *TranslateComponents*(vec) | Apply translation by vec to each component in self |
| *Write*(filename[, single_export]) | Writes the Components in this Airconics shape to filename using file |
| clear(() -> None. Remove all items from D.) | |
| get((k[,d]) -> D[k] if k in D, ...) | |
| items(() -> list of D's (key, value) pairs, ...) | |
| iteritems(() -> an iterator over the (key, ...) | |
| iterkeys(() -> an iterator over the keys of D) | |
| itervalues(...) | |
| keys(() -> list of D's keys) | |
| pop((k[,d]) -> v, ...) | If key is not found, d is returned if given, otherwise KeyError is raised |
| popitem(() -> (k, v), ...) | as a 2-tuple; but raise KeyError if D is empty. |
| setdefault((k[,d]) -> D.get(k,d), ...) | |
| update(([E, ...) | If E present and has a .keys() method, does: for k in E: D[k] = E[k] |
| values(() -> list of D's values) | |

**AddComponent**(*component*, *name=None*)

Adds a component to self

**Parameters** **component** : TopoDS_Shape

**name** : string

**Build**()

Does nothing for AirconicsShape.

This method allows AirconicsShape to be instantiated alone, as Build is called in the __init__. 'Build' Should be redefined by all derived classes

### Notes

•If Class.Build is not redefined in a derived class, confusion may

arise as no geometry will result from passing construct_geometry=True

**Display**(*context*, *material=<Mock id='140416365252048'>*, *color=None*)

Displays all components of this instance to input context

**Parameters** **context** : OCC.Display.OCCViewer.Viewer3d or WebRenderer

The display context - should have a Display or DisplayShape method

**meterial** : OCC.Graphic3d_NOM_* type (default=ALUMINIUM)

The material for display: note some renderers do not allow this

**color** : string

The color for all components in this shape

**DisplayBBox**(*display*, *single=True*)
Displays the bounding box on input display.

**Parameters** **display** : OCC.Display.OCCViewer.Viewer3d

Note that this function only currently works with the OCC core viewer as the bounding box is an AIS_Shape handle

**single** : bool (default True)

If false, separate bounding boxes will be draw for each component

**Extents**(*tol=1e-06*, *as_vec=False*)
Returns the extents of the bounding box encapsulating all shapes in self.__Components__

**Parameters** **tol** : scalar (default 1e-6)

tolerance of the triangulation used in the bounding box extents

**as_vec** : bool (default True)

Returns two OCC.gp.gp_Vec objects if True

**Returns** **extents** : tuple of scalar or OCC.gp.gp_Vec

Type depends on input 'as_vec'. If as_vec is false, this returns a tuple xmin, ymin, zmin, xmax, ymax, zmax; otherwise, the min and max vectors will be returned as OCC types.

**MirrorComponents**(*plane='xz'*, *axe2=None*)
Returns a mirrored version of this airconics shape

**Parameters** **plane** : string (default='xz')

The plane in which to mirror components

**axe2** : OCC.gp.gp_Ax2

The axes through which to mirror (overwrites input 'plane')

**Returns** **mirrored** : AirconicsShape

the mirrored shape

#### Notes

Due to problem with swig and deepcopy, the mirrored object is the base class 'AirconicsShape", not the original type. This is will remove other subclass-derived attributes and methods

It is also expected that the remaining attributes and methods will not be required or meaningful after mirroring, however this behaviour may change in future versions

**PrintComponents**()
Lists the names of components in self

**RemoveComponent**(*name*)
Removes a named component from self

**Parameters** **name** : string

**RotateComponents**(*ax*, *deg*)
Rotation of each component in self._Components around ax by angle deg

**Parameters** **ax** : OCC.gp.gp_Ax1

The axis of rotation

**deg** : scalar

Rotation in degrees

**ScaleComponents_Uniformal**(*factor*, *origin=<Mock name='mock()' id='140416175453328'>*)
General scaling and translation of components in self (applies act.transform_nonuniformal)

**Parameters** **origin** : gp_Pnt

The origin of the scaling operation

**factor** : scalar

The scaling factor to apply in x,y,z

**TransformComponents_Nonuniformal**(*scaling*, *vec*)
General scaling and translation of components in self (applies act.transform_nonuniformal)

**Parameters** **scaling** : list or array, length 3

[x, y, z] scaling factors

**vec** : List of x,y,z or gp_Vec

the translation vector (default is [0,0,0])

**TranslateComponents**(*vec*)
Apply translation by vec to each component in self

**Parameters** **vec** : OCC.gp.gp_vec

vector through which components will be translated

**Write**(*filename*, *single_export=True*)
Writes the Components in this Airconics shape to filename using file format specified in extension of filename. Currently stl only (TODO: step, iges)

**Parameters** **filename** : string

the BASE.ext name of the file e.g. 'airliner.stp'. Note the Component name will be prepended to the base name of each output file

**single_export** : bool

Writes a single output file if true, otherwise writes one file per component

**Returns** **status** : list of int

error status of the file output of EACH component

#### Notes

File format is extracted from filename.

stl file write will prepend filename onto the Component name to be written to file (cannot write multiple files )

## 3.2 Primitives

**class** airconics.primitives.**Airfoil**(*LeadingEdgePoint=[0.0, 0.0, 0.0], ChordLength=1, Rotation=0, Twist=0, SeligProfile=None, Naca4Profile=None, Naca5Profile=None, CRMProfile=None, CRM_Epsilon=0.0, InterpProfile=None, Epsilon=0, Af1=None, Af2=None, Eps1=0, Eps2=1, EnforceSharpTE=False*)

Bases: object

Class for defining a range of spline-fitted airfoil curves

**Parameters** **LeadingEdgePoint** : array of float (,3)

(x, y, z) origin of the airfoil LE

**ChordLength** : scalar

Length of the airfoil chord

**Rotation** : scalar

Angle (deg) at which the base airfoil is inclined (angle of attack, rotation around y axis)

**Twist** : scalar

Angle (deg) at which the base airfoil is twisted (dihedral, rotation around x axis)

**SeligProfile** : string

Name of the Selig airfoil: see http://m-selig.ae.illinois.edu/ads/coord_database.html

**NACA4Profile** : string

Name of the airfoil in NACA 4 format

**NACA5Profile** : string

Name of the airfoil in NACA 5 format. TODO: NACA5 profile not yet implemented

**CRM_Profile** : bool

If true, airfoil profile will be interpolated from Common Research Model (CRM). Must also declare 'CRMEpsilon' variable.

**CRM_Epsilon** : float

Spanwise fraction between 0 and 1 to interpolate profile from CRM

**InterpProfile** : bool

If True, a set of points between Af1 and Af2 will be interpolated for BSpline curve fitting (see AddInterp2)

**Eps** : scalar

Spanwise coordinate between Eps1 and Eps2 (used if InterpProfile is True)

**Af1** : airconics.Airfoil

The Airfoil located at spanwise location Eps1. Af1.x and Af1.z. (used if InterpProfile is True)

**Af2** : airconics.Airfoil

The Airfoil located at spanwise location Eps2. (used if InterpProfile is True)

**Eps1** : scalar

Spanwise coordinate location of Airfoil Af1. Expected to range from 0 (root of a lifting surface) to 1 (tip of a lifting surface) (used if InterpProfile is True)

**Eps2** : scalar

Spanwise coordinate location of Airfoil Af2. Expected to range from 0 (root of a lifting surface) to 1 (tip of a lifting surface), and also expected to be greater than Eps1 (used if InterpProfile is True)

**EnforceSharpTE** : bool

Enforces sharp trailing edge (NACA airfoils only)

#### Notes

- NACA5 profiles are not yet supported in OCC_AirCONICS.
- Preference is that users allow the class constructor to handle building the Airfoil i.e. pass all physical definitions as class arguments.
- Although the physical attributes can changed i.e. rotation, twist, ChordLength, LeadingEdgePoint etc., it is the users responsibility to rebuild the Airfoil with the 'Add***Airfoil' afterwards

#### Attributes

| | |
|---|---|
| points | (array of scalar, shape (N, 2)) The x-z coordinates of points on the airfoils surface |
| Curve - OCC.Geom.Handle_Geom_BsplineCurve | The generated airfoil spline |

#### Methods

| |
|---|
| `AddAirfoilFromSeligFile` |
| `AddCRMLinear` |
| `AddLinear2` |
| `AddNACA4` |

**`AddAirfoilFromSeligFile`**(*SeligProfile*, *Smoothing=1*)

Adds an airfoil generated by fitting a NURBS curve to a set of points whose coordinates are given in a Selig formatted file

**Parameters** **SeligProfile** : string

base selig airfoil name e.g. 'b707a'.

**Smoothing** : int (default=1)

TODO: Airfoil curve smoothing

**Returns** None

#### Notes

See Selig database online for other available base names

**AddCRMLinear**(*CRM_Epsilon*, *Smoothing=1*)
Linearly interpolate airfoil curve from CRM

**Parameters** **CRM_Epsilon** : scalar

Spanwise coordinate at which to sample the CRM airfoil database (range between 0 and 1)

**Smoothing** : int

TODO: Airfoil curve smoothing

**Returns** None

**AddLinear2**(*Eps*, *Af1*, *Af2*, *Eps1=0*, *Eps2=1*)
Interpolates the bspline control points fitted between two other Airfoil objects.

Interpolates the x and z values of an Airfoil at spanwise location Eps between Af1 (at Eps1) and Af2 (at Eps2). The BSpline Curve is then fitted to the resulting points with Airfoil._fitAirfoiltoPoints, and transformed to the orientation specified in self.Rotation, self.Twist, self.ChordLength and self.LEPoint via the _TransformAirfoil function.

**Parameters** **Eps** : scalar

Spanwise coordinate between Eps1 and Eps2

**Af1** : airconics.Airfoil

The Airfoil located at spanwise location Eps1. Af1.x and Af1.z

**Af2** : airconics.Airfoil

The Airfoil located at spanwise location Eps2.

**Eps1** : scalar

Spanwise coordinate location of Airfoil Af1. Expected to range from 0 (root of a lifting surface) to 1 (tip of a lifting surface)

**Eps2** : scalar

Spanwise coordinate location of Airfoil Af2. Expected to range from 0 (root of a lifting surface) to 1 (tip of a lifting surface), and also expected to be greater than Eps1

**AddNACA4**(*Naca4Profile*, *Smoothing=1*)
Adds a NACA 4 digit airfoil to the current document

**Parameters** **Naca4Profile** : string

Naca 4 profile identifier. Should be length 4 string, however also accepts negative camber i.e. '-5310' gives a flipped camber airfoil (primarily used for box wing)

**Smoothing - int**

TODO: fair airfoil curve

**Returns** None

**points**

## 3.3 LiftingSurface

**class** airconics.liftingsurface.**LiftingSurface**(*ApexPoint=<Mock name='mock()' id='140416175035344'>*, *SweepFunct=False*, *DihedralFunct=False*, *TwistFunct=False*, *ChordFunct=False*, *AirfoilFunct=False*, *ChordFactor=1*, *ScaleFactor=1*, *OptimizeChordScale=0*, *LooseSurf=1*, *SegmentNo=11*, *TipRequired=False*, *max_degree=8*, *continuity=<Mock id='140416175034896'>*, *construct_geometry=True*)

Bases: *airconics.base.AirconicsShape*

Airconics class for defining lifting surface shapes

**Parameters** **ApexPoint - array, length 3**

Foremost point of the wing (x direction). Updating will rebuild the geometry.

**SweepFunct - function**

function defining the leading edge sweep vs epsilon spanwise variable coordinate between 0 and 1 (curvilinear attached coordinates). Updating will rebuild the geometry.

**DihedralFunct - function**

function defining the leading edge dihedral vs epsilon spanwise variable coordinate between 0 and 1 (curvilinear attached). Updating will rebuild the geometry.

**TwistFunc - function**

function defining the sectional twist vs epsilon spanwise variable coordinate between 0 and 1 (curvilinear attached). Updating will rebuild the geometry.

**ChordFunct - function**

function defining the leading edge chord vs epsilon spanwise variable coordinate between 0 and 1 (curvilinear attached) Updating will rebuild the geometry.

**AirfoilFunct - function**

function defining the sectional Airfoil (see primitives.Airfoil) vs epsilon spanwise variable coordinate between 0 and 1 (curvilinear attached). Updating will rebuild the geometry.

**ChordFactor - int (default = 1)**

Scaling factor applied in chordwise direction. Updating will rebuild the geometry.

**ScaleFactor - int (default = 1)**

Scaling factor applied in all directions (uniform). Updating will rebuild the geometry.

**OptimizeChordScale - int or bool (default = 0)**

TODO: Not yet used.

**LooseSurf - (default = 1)**

TODO:

**NSegments - int (default = 11)**

Number of segments to sample the wing defined by input functions. Updating will rebuild the geometry.

**TipRequired - bool (default = False)**

TODO: Not yet used adds the wing tip face to components if true

**max_degree - (default = 8)**

maximum degree of the fitted NURBS surface

**continuity - OCC.GeomAbs.GeomAbs_XX Type**

the order of continuity i.e. C^0, C^1, C^2... would be GeomAbs_C0, GeomAbs_C1, GeomAbs_C2 ...

**construct_geometry** : bool

If true, Build method will be called on construction

**See also:**

*airconics.primitives.Airfoil*, *airconics.examples.wing_example_transonic_airliner*

### Notes

- Output surface is stored in self['Surface']
-
- See airconics.examples.wing_example_transonic_airliner for example input functions

### Attributes

| | |
|---|---|
| self['Surface'] | (TopoDS_Shape) The generated lifting surface |
| Sections | (list of airconics.primitives.Airfoil objects) The rib curves from which the main surface is lofted. Updating any of the spanwise functions (ChordFunct, TwistFunct, etc...), SpanFactor, ChordFactor Raises an error if attempting to write over it manually. |
| RootChord | (Scalar) The length of the Root Chord. Updated by GenerateLiftingSurface |
| AR | (Scalar) The Aspect ratio of the Lifting Surface. Updated on call to Build |
| LSP_area | (Scalar) the projected area of the lifting surface. Updated on call to Build |
| SA | (Scalar) The wetted area of the lifting surface. Updated on call to Build |
| ActualSemiSpan | (Scalar) Calculated semi span of the lifting surface. Updated on call to Build |

### Methods

| |
|---|
| AddComponent |
| Build |
| CalculateAspectRatio |
| CalculateProjectedArea |
| CalculateSemiSpan |
| CreateConstructionGeometry |
| Display |

Continued on next page

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| |
|---|
| DisplayBBox |
| Extents |
| Fit_BlendedTipDevice |
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| GenerateSectionCurves |
| MirrorComponents |
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| TransformComponents_Nonuniformal |
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| Write |
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| get |
| items |
| iteritems |
| iterkeys |
| itervalues |
| keys |
| pop |
| popitem |
| setdefault |
| update |
| values |

**AirfoilFunct**

**ApexPoint**

**Build**()

Builds the section curves and lifting surface using the current

Uses the current ChordFactor, ScaleFactor, NSegments, ApexPoint, and all spanwise variation functions (e.g. ChordFunct) defined in self to produce a surface

**See also:**

*airconics.examples.wing_example_transonic_airliner*

### Notes

Called on initialisation of a lifting surface class.

**Example**

```
>>> Wing = liftingsurface.LiftingSurface(P,
                                         mySweepAngleFunction,
                                         myDihedralFunction,
                                         myTwistFunction,
                                         myChordFunction,
                                         myAirfoilFunction)
>>> Surface = Wing['Surface']
```

**CalculateAspectRatio**()
Calculates and returns the aspect ratio of this lifting surface

Uses information about the wings projected area and the current bounding box. If the project area (LSP_Area) is zero, this will be calculated.

**Returns** **AR** : Scalar

Aspect ratio, calculated by b^2 / A, where b is the semi span and A is the project area of this lifting surface

**See also:**

`airconics.LiftingSurface.ProjectedArea`, `airconics.LiftingSurface.SemiSpan`

**CalculateProjectedArea**()
Calculates the projected area of the current lifting surface

From Airconics documentation: In some cases the projected section cannot all be lofted in one go (it happens when parts of the wing fold back onto themselves), so we loft them section by section and compute the area as a sum.

**CalculateSemiSpan**()
Calculates and returns the span of this lifting surface.

Uses the OCC bounding box algorithm.

**Returns** **ActualSemiSpan** : Scalar

**ChordFactor**

**ChordFunct**

**CreateConstructionGeometry**()
Creates the plane and vector used for projecting wetted area

**DihedralFunct**

**Fit_BlendedTipDevice**(*rootchord_norm*, *spanfraction=0.1*, *cant=40*, *transition=0.1*, *sweep=40*, *taper=0.7*)
Fits a blended wing tip device [1],

**Parameters** **rootchord_norm** : scalar

The root chord of the straight part of the winglet, normalised by the tip chord of this lifting surface.

**spanfraction** : scalar

span of the winglet normalised by the span of the main wing

**cant** : scalar (default 40)

Angle (deg) of the wing tip from vertical

**transition** : scalar

The percentage along the span at which the transition to a straight segment is located

**sweep** : scalar

Sweep angle of the wing tip (uniform along the straight section)

**taper** : scalar

ratio of the tip chord to the root chord of the straight segment

#### References

[1] L. B. Gratzer, “Blended winglet,” Google Patents, 1994

**GenerateLeadingEdge**()
Epsilon coordinate attached to leading edge defines sweep Returns airfoil leading edge points

**GenerateLiftingSurface**()
Builds a lifting surface (wing, tailplane, etc.) with the Chord and Scale factors, and section list defined in self.

This function should be called after GenerateSectionCurves. Note that both operations are performed with ‘Build’, which should be used preferentially

**Returns** None

#### Notes

Adds a (‘Surface’: Shape) key value pair to self.

**GenerateSectionCurves**()
Generates the loft section curves based on the current functional parameters and ChordFactor of the object.

Uses self._AirfoilFunct, _ChordFunct etc. and other attributes to update the content of self._Sections.

**Returns** None

**NSegments**

**ScaleFactor**

**Sections**

**SweepFunct**

**TwistFunct**

## 3.4 Fuselage

**class** airconics.fuselage_oml.**Fuselage**(*NoseLengthRatio=0.182, TailLengthRatio=0.293, Scaling=[55.902, 55.902, 55.902], NoseCoordinates=[0.0, 0.0, 0], CylindricalMidSection=False, SimplificationReqd=False, Maxi_attempt=5, construct_geometry=True*)
Bases: *airconics.base.AirconicsShape*

AirCONICS Fuselage class: builds a parameterised instance of an aircraft fuselage

**Parameters** **NoseLengthRatio** : Scalar

The fraction of nose to fuselage length (default 0.182)

**TailLengthRatio** : Scalar

The fraction of tail to fuselage length (default 0.293)

**Scaling** : array, length 3

(x, y, z) scaling factor

**NoseCoordinates** : array of float

Location of nose apex

**CylindricalMidSection** : bool

If True, fuselage will have a cylindrical midsection

**SimplificationReqd** : bool

TODO

**MaxFittingAtempts** : integer

Maximum number of times to attempt to fit surface to guide curves

**construct_geometry** : bool

If true, Build method will be called on construction

### Notes

Geometry building is done on initialisation of a Fuselage instance. It is therefore not expected that users will do this through the BuildFuselageOML function

### Methods

| |
|---|
| AddComponent |
| AirlinerFuselagePlanView |
| AirlinerFuselageSideView |
| Build |
| BuildFuselageOML |
| CockpitWindowContours |
| Display |
| DisplayBBox |
| Extents |
| FuselageLongitudinalGuideCurves |
| MakeWindow |
| MirrorComponents |
| PrintComponents |
| RemoveComponent |
| RotateComponents |
| ScaleComponents_Uniformal |
| TransformComponents_Nonuniformal |
| TransformOML |
| TranslateComponents |
| WindowContour |
| Write |
| clear |
| get |
| items |
| iteritems |
| iterkeys |
| itervalues |
| keys |

Continued on next page

Table 3.6 – continued from previous page

| |
|---|
| pop |
| popitem |
| setdefault |
| update |
| values |

**AirlinerFuselagePlanView**(*NoseLengthRatio*, *TailLengthRatio*)
Internal function. Defines the control polygons of the fuselage in side view

**AirlinerFuselageSideView**(*NoseLengthRatio*, *TailLengthRatio*)
Internal function. Defines the control polygons of the fuselage in side view

**Build**()
Overrides the AirconicsShape empty Build method.

Calls BuildFuselageOML, which has been maintained for older versions.

**BuildFuselageOML**(*Max_attempt=5*)
Builds the Fuselage outer mould line Notes —– It is not expected that users will interact with this directly. Use the Fuslage class initialisation fuction instead

**CockpitWindowContours**(*Height=1.62*, *Depth=5*)
This function is currently not tested

**FuselageLongitudinalGuideCurves**(*NoseLengthRatio*, *TailLengthRatio*)
Internal function. Defines the four longitudinal curves that outline the fuselage (outer mould line).

**MakeWindow**(*Xwc*, *Zwc*)
Makes at Window centered at Wxc Zwc using the bspline wire returned by WindowContour

THIS FUNCTION IS IN DEVELOPMENT AND NOT YET TESTED FULLY

**Parameters** **Xwc** : scalar

The window center x coordinate

**Zwc** : scalar

The window center z coordinate

**Returns** **WinStbd** : TopoDS_Shape

The window surface cut out (starboard side)

**WinPort** : TopoDS_Shape

The window surface cut out (Port side)

#### Notes

Changes the contents of self['OML']. Makes both the port and starboard windows at the input location.

**TransformOML**()
Use parameters defined in self to scale and translate the fuselage

**WindowContour**(*WinCenter*)
Creates and returns the contour of the window at WinCenter

**Parameters** **WinCenter** : list or array, length 2

The [X, Z] coordinate of the center of the window

**Returns** **W_wire** : TopoDS_Wire

The wire of the B-spline contour

## 3.5 Engine

**class** aironics.engine.**Engine**(*HChord=0, CentreLocation=[0, 0, 0], ScarfAngle=3, HighlightRadius=1.45, MeanNacelleLength=5.67, construct_geometry=True*)

Bases: *aironics.base.AirconicsShape*

A class for generating aircraft engine and pylon geometries.

Currently only yields a turbofan engine with nacelle similar to that of an RR Trent 1000 / GEnx. Shapes produced include the nacelle, spinner cone, tail cone, Fan disk, Bypass disk, and pylon symmetry plane. The nacelle is produced by inclining an inlet disk by its scarf angle about the span- wise (y) axis and uniformly spacing airfoil 'ribs' before lofting a surface through them. The pylon is currently the symetry plane of a fully pylon only

**Parameters** **HChord** : OCC.Geom.Handle_Geom_TrimmedCurve

The chord line at which the engine will be fitted. The result of OCC.GC.GC_MakeSegment.Value() (can be return from helper function CutSect from AirCONICStools).

**CentreLocation** : list, length 3 (default=[0,0,0])

Location of the centre of the inlet highlight disk

**ScarfAngle** : scalar, deg (default=3)

angle of inclination of engine intake (rotated around y axis)

**HighlightRadius** : scalar (default=1.45)

Intake highlight radius

**MeanNacelleLength** : scalar (default=5.67)

Mean length of the nacelle, to be used as the airfoil rib chordlength

**construct_geometry** : bool

If true, Build method will be called on construction

**See also:**

*aironics.base.AirconicsShape*, *aironics.primitives.Airfoil*

#### Notes

•Also calls the initialiser of parent class AirconicsShape which stores all keywords as attributes

#### Attributes

| | |
|---|---|
| _Components | (dictionary of shapes) |

#### Methods

| AddComponent |
| --- |
| Build |
| BuildTurbofanNacelle |
| Display |
| DisplayBBox |
| Extents |
| MirrorComponents |
| PrintComponents |
| RemoveComponent |
| RotateComponents |
| ScaleComponents_Uniformal |
| TransformComponents_Nonuniformal |
| TranslateComponents |
| Write |
| clear |
| get |
| items |
| iteritems |
| iterkeys |
| itervalues |
| keys |
| pop |
| popitem |
| setdefault |
| update |
| values |

**Build**()
Currently only calls BuildTurbofanNacelle.

#### Notes

May add options for other engine types

**BuildTurbofanNacelle**()
The defaults yield a nacelle similar to that of an RR Trent 1000 / GEnx

#TODO: break this down into modular function calls

## 3.6 Topology

**class** airconics.topology.**Topology**(*parts={}*, *construct_geometry=False*)
Bases: *airconics.base.AirconicsCollection*

Class to define abstract aircraft topologies as extensible lists of lifting surfaces, enclosure, and propulsion type objects.

**Parameters parts - dictionary**

**Should contain the following,** {name: (Part, arity)}

**i.e. the string 'name' values are presented as a tuple or list of:**

**Part - TopoDS_Shape** The shape

**arity - int** the arity (number of descendant nodes) attached to part

A warning is raised if arities are not provided, in which case arity is assumed to be zero

### Notes

•warning will be raised if no affinities are provided

**example:** # (Wing is an airconics Lifting Surface instace): aircraft = Topology(parts={'Wing': (Wing['Surface'], 2)})

Although not enforced, parts should be added to this class recursively (from the top node first) to represent the aircraft's flattened topological tree suggested by Sobester [1]. It is the users responsibility to ensure the input nodes are a valid lisp tree for a correct graph to result (no checks are currently performed)

See Also: AirconicsCollection

### References

**[1] Sobester, A., "Four Suggestions for Better Parametric Geometries,"** 10th AIAA Multidisciplinary Design Optimization Conference, AIAA SciTech, American Institute of Aeronautics and Astronautics, jan 2014.

### Attributes

| | |
|---|---|
| _Tree - list | the list of LISP-like instructions (in the order they were called with AddPart) |

### Methods

| |
|---|
| AddPart |
| Build |
| Display |
| MirrorSubtree |
| Write |
| clear |
| export_graphviz |
| get |
| items |
| iteritems |
| iterkeys |
| itervalues |
| keys |
| pop |
| popitem |
| setdefault |
| update |
| values |

**AddPart** (*part*, *name*, *arity=0*)

Overloads the AddPart method of AirconicsCollection base class to append the arity of the input topology node

**Parameters** **part - LiftingSurface, Engine or Fuselage class instance**

the part to be added to the tree

**name - string**

name of the part (will be used to look up this part in self.aircraft)

**arity - int**

The number of terminals attached to this part; this will be randomized at a later stage

### Notes

This method is expected to be used recursively, therefore the order in which parts are added dictates the tree topology. The first item added will be the top of the tree.

See also: AirconicsCollection.AddPart

**Build**()

Recursively builds all sub components in the current topology tree if self.construct_geometry is true. Will also mirror components if a mirror node has been added, regardless of if construct_geometry is true.

Uses the the Build method of all sub components. Any user defined classes must therefore define the Build method in order for this to work correctly.

**MirrorSubtree**()

Mirrors the geometry where required, based on the current topology tree.

Does nothing is no mirror plane has been added

**export_graphviz**()

Returns a string, Graphviz script for visualizing the topology tree.

Currently only set up to allow a single mirror terminal

**Returns** **output** : string

The Graphviz script to plot the tree representation of the program.

### Notes

This function is originally from GPLearns _Program class, but has been modified. Can be visualised with pydot,

**Example**

```
>>> topo = Topology()      # Add some parts with topo.addPart
>>> graph = pydot.graph_from_dot_data(topo.export_graphviz())
>>> Image(graph.create_png())
```

May add a dependency on GPLearn later and overload the appropriate class methods.

## 3.7 AirCONICStools

Various geometry operations of geometric pythonocc primitives for OCC_AirCONICS

Created on Fri Dec 4 11:58:52 2015

@author: pchambers

airconics.AirCONICStools.**AddCone**(*BasePoint*, *Radius*, *height*, *direction=<Mock name='mock()' id='140416175556624'>*)

Generates a cone shape originating at BasePoint with base Radius and height (points in the direction of input 'direction)

**Parameters** **BasePoint** : OCC.gp.gp_Pnt or array length 3

The centre base point

**Radius** : scalar

Cone base radius

**height** : scalar

Cone height

**direction** : OCC.gp.gp_Dir (default: positive x direction)

the direction of the cones axis i.e. normal to the base: defaults to x axis

**Returns** **shape** : TopoDS_Shape

The generated Cone

airconics.AirCONICStools.**AddSurfaceLoft**(*objs*, *continuity=<Mock id='140416365104272'>*, *check_compatibility=True*, *solid=True*, *first_vertex=None*, *last_vertex=None*, *max_degree=8*, *close_sections=True*)

Create a lift surface through curve objects

**Parameters** **objs** : list of python classes

Each obj is expected to have an obj.Curve attribute : see airconics.primitives.airfoil class

**continuity** : OCC.GeomAbs.GeomAbs_XX type (default C2)

The order of continuity (C^0, C^1, C^2, G^0, ....)

**check_compatibility** : bool (default=True)

Adds a surface compatibility check to the builder

**solid** : bool (default=True)

Creates a solid object from the loft if True

**first_vertex** : TopoDS_Vertex (optional, default=None)

The starting vertex of the surface to add to the 'ThruSections' algorithm

**last_vertex** : TopoDS_Vertex (optional, default=None)

The end vertex of the surface to add to the 'ThruSections' algorithm

**max_degree** : int (default=8)

The order of the fitted NURBS surface

**close_sections** : bool (default=True):

Connects the start and end point of the loft rib curves if true. This has the same effect as adding an airfoil trailing edge.

**Returns** **shape** : TopoDS_Shape

The generated loft surface

#### Notes

Uses OCC.BRepOffsetAPI.BRepOffsetAPI_ThruSections. This function is ORDER DEPENDANT, i.e. add elements in the order through which they should be lofted

airconics.AirCONICStools.**BBox_FromExtents**(*xmin*, *ymin*, *zmin*, *xmax*, *ymax*, *zmax*)

Generates the Wire Edges defining the Bounding Box defined in the input arguments: Can be used to display the bounding box

airconics.AirCONICStools.**CalculateSurfaceArea**(*shape*)

Calculates the surface area of input shape

**Parameters** **shape** : TopoDS_Shape

**Returns** **Area** : scalar

Calculated surface area

airconics.AirCONICStools.**CutSect**(*Shape*, *SpanStation*)

**Parameters** **Shape** : TopoDS_Shape

The Shape to find planar cut section (parallel to xz plane)

**SpanStation** : scalar in range (0, 1)

y-direction location at which to cut Shape

**Returns** **Section** : result of OCC.BRepAlgoAPI.BRepAlgoAPI_Section (TopoDS_Shape)

The cut section of shape given a cut plane parallel to xz at input Spanstation.

**Chord** : result of OCC.GC.GC_MakeSegment.Value (Geom_TrimmedCurve)

The Chord line between x direction extremeties

airconics.AirCONICStools.**ExtrudeFace**(*face*, *vec=<Mock name='mock()' id='140416365157008'>*)

Extrudes a face by input vector

**Parameters** **face** : TopoDS_Face

**vec** : OCC.gp.gp_Vec

The offset vector to extrude through

**Returns** **shape** : TopoDS_Shape

The extruded shape

#### Notes

Uses BRepBuilderAPI_MakePrism

airconics.AirCONICStools.**FilletFaceCorners**(*face*, *radius*)
Fillets the corners of the input face

**Parameters** **face** : TopoDS_Face

**radius** : the Fillet radius

airconics.AirCONICStools.**Generate_InterpFunction**(*Values*, *EpsArray=None*, *uniform=True*)
Generates a lookup interpolation function.

Given an array of spanwise coordinates epsilon along a curvilinear leading-edge attached coordinate system, and a set of values describing e.g. Chord, Sweep at each station, generate and return a function f(epsilon) which will give the interpolated value.

**Parameters** **Values** : array of float

Values of e.g. chordlength, sweep at each spanwise location in EpsArray

**EpsArray** : array of float

Distribution of spanwise coordinates at which the Values are known

**uniform** : bool

If True, assumes that Values corresponds to uniformly distribution epsilon locations along the lifting surface span

**Returns** **f** : function

the function which returns the interpolated epsilon

airconics.AirCONICStools.**ObjectsExtents**(*breps*, *tol=1e-06*, *as_vec=False*)
Compute the extents in the X, Y and Z direction (in the current coordinate system) of the objects listed in the argument.

**Parameters** **breps** : list of TopoDS_Shape

The shapes to be added for bounding box calculation

**tol** : float (default=1e-6)

Tolerance for bounding box calculation

**as_vec** : bool (default=False)

If true, returns minimum and maximum points as tuple of gp_Vec

**Returns** **xmin, ymin, zmin, xmax, ymax, zmax** : scalar

the min and max points of bbox (returned if as_vec=False)

**( gp_Vec(xmin, ymin, zmin), gp_Vec(xmax, ymax, zmax) )** : tuple of gp_Vec

the min and max points of bbox (returned in as_vec=True)

#### Notes

Due to the underlying OCC.Bnd.Bnd_Box functions, the bounding box is calculated via triangulation of the shapes to avoid inclusion of the control points of NURBS curves in bounding box calculation

airconics.AirCONICStools.**PlanarSurf**(*geomcurve*)
Adds a planar surface to curve

**Parameters** **geomcurve** : OCC.Geom type curve

The edge of the profile

**Returns** **surf** : TopoDS_face

the planar surface

airconics.AirCONICStools.**SplitShapeFromProjection**(*shape*, *wire*, *direction*, *return_section=True*)

Splits shape by the projection of wire onto its face

**Parameters** **shape** : TopoDS_Shape

the brep to subtract from

**wire** : TopoDS_Wire

the tool to use for projection and splitting

**direction: OCC.gp.gp_Dir**

the direction to project the wire

**return_section** : bool

returns the split shape

**Returns** **newshape** : TopoDS_Shape

input shape with wire subtracted

**section** : the shape which was substracted

(returned only if return_section is true)

#### Notes

Currently assumes splits the first face only

airconics.AirCONICStools.**TrimShapebyPlane**(*Shape*, *Plane*, *pnt=<Mock name='mock()' id='140416175452816'>*)

Trims an OCC shape by plane. Default trims the negative y side of the plane

**Parameters** **Shape** : TopoDS_Shape

**Plane** : expect TopoDS_Face

**pnt** : point defining which side of the halfspace contains its mass

airconics.AirCONICStools.**Uniform_Points_on_Curve**(*curve*, *NPoints*)

Returns a list of uniformly spaced points on a curve

**Parameters** **crv** : OCC.Geom curve type

**NPoints** : int

number of sampling points along the curve

**class** airconics.AirCONICStools.**assert_isdone**(*to_check*, *error_statement*)

Bases: object

raises an assertion error when IsDone() returns false, with the error specified in error_statement -> this is from the pythonocc-utils utility-may not use it?

airconics.AirCONICStools.**boolean_cut**(*shapeToCutFrom*, *cuttingShape*, *debug=False*)

Boolean cut tool from PythonOCC-Utils

airconics.AirCONICStools.**coerce_handle**(*obj*)
coerces an object that has a GetHandle method to call this method and return its handle

airconics.AirCONICStools.**coslin**(*TransitionPoint*, *NCosPoints=24*, *NLinPoints=24*)
Creates a series of abscissas with cosine spacing from 0 to a TransitionPoint and a linear spacing thereafter, up to 1. The TransitionPoint corresponds to pi. Distribution suitable for airfoils defined by points. TransitionPoint must be in the range [0,1].

**Parameters** **TransitionPoint** : scalar

Point to transition from cosine to linear distribution in range (0, 1)

**NCosPoints** : int

Number of points to space by cosine law between 0 and TransitionPoint

**NLinPoints** : int

Number of points to space by linear law between TransitionPoint and 1

**Returns** **Abscissa** : numpy array

The generated abscissa

**NCosPoints** : int

Number of cosine points used (same as input)

airconics.AirCONICStools.**export_STEPFile**(*shapes*, *filename*)
Exports a .stp file containing the input shapes

**Parameters** **shapes** : list of TopoDS_Shape

Shapes to write to file

**filename** : string

The output filename

airconics.AirCONICStools.**export_STEPFile_Airconics**(*AirconicsShapes*, *filename*)
Writes a Step file with names defined in the AirconicsShapes. This function is not fully tested and should not yet be used.

#### Notes

Work in progress

airconics.AirCONICStools.**make_circle3pt**(*pt1*, *pt2*, *pt3*)
Makes a circle allowing python lists as input points

airconics.AirCONICStools.**make_edge**(**args*)

airconics.AirCONICStools.**make_ellipsoid**(*centre_pt*, *dx*, *dy*, *dz*)
Creates an ellipsoid from non-uniformly scaled unit sphere

airconics.AirCONICStools.**make_face**(**args*)

airconics.AirCONICStools.**make_pipe_shell**(*spine*, *profiles*, *support=None*)

airconics.AirCONICStools.**make_vertex**(**args*)

airconics.AirCONICStools.**make_wire**(**args*)

airconics.AirCONICStools.**mirror**(*brep*, *plane='xz'*, *axe2=None*, *copy=False*)
Originally from pythonocc-utils : might add dependency on this? Mirrors object

**Parameters** **brep** : OCC.TopoDS.TopoDS_Shape

The shape to mirror

**plane** : string (default = 'xz')

The name of the plane in which to mirror objects. Acceptable inputs are any of 'xy', 'yx' , 'zy', 'yz', 'yz', 'zy'. Overwritten if axe2 is defined.

**axe2** : OCC.gp.gp_Ax2

The axes through which to mirror (overwrites input 'plane')

**copy** : bool

**Returns** **BRepBuilderAPI_Transform.Shape** : TopoDS_Shape

The reflected shape

#### Notes

Pchambers: Added a functionality here to specify a plane using a string so that users could avoid interacting with core occ objects

airconics.AirCONICStools.**point_array_to_TColgp_PntArrayType**(*array*, *_type=<Mock id='140416365079952'>*)

Function to return curve from numpy array

**Parameters** **array** : array (Npts x 3) or list

Array of xyz points for which to fit a bspline

**_type** : type of TColgp array

**Tested inputs are,**

- TColgp_Array1OfPnt
- TColgp_HArray1OfPnt

See Notes for more information

**Returns** **pt_arr** : TCOLgp_Array1OfPnt

OCC type array of points

#### Notes

USe TColgp_Harray when interpolating a curve from points with the GeomAPI_Interpolate. Use TColgp_Array when interpolating a curve from points with the GeomAPI_PointsToBspline

airconics.AirCONICStools.**points_from_intersection**(*plane*, *curve*)

Find intersection points between plane and curve.

**Parameters** **plane** : Geom_Plane

The Plane

**curve** : Geom_*Curve

The Curve

**Returns** **P** : Point or list of points

A single intersection point (OCC.gp.gp_Pnt) if one intersection is found, or list of points if more than one is found.

- If No Intersection points were found, returns None

#### Notes

The plane is first converted to a surface As the GeomAPI_IntCS class requires this.

airconics.AirCONICStools.**points_to_BezierCurve**(*pnts*)
Creates a Bezier curve from an array of points.

**Parameters** **pnts** : array or list

x, y, z for an array of points. Allowable inputs are numpy arrays (with dimensions (Npoints x 3)), python list with elements [xi, yi, zi] or list of OCC.gp.gp_Pnt objects

**Returns** **crv** : OCC.Geom.Geom_BezierCurve

airconics.AirCONICStools.**points_to_bspline**(*pnts*, *deg=3*, *periodic=False*, *tangents=None*, *scale=False*, *continuity=<Mock id='140416365104272'>*)
Points to bspline: originally from pythonocc-utils, changed to allow numpy arrays as input

**Returns** **crv** : OCC.Geom.BSplineCurve

airconics.AirCONICStools.**project_curve_to_plane**(*curve*, *plane*, *direction*)
Computes and returns the cylindrically projected curve onto input plane

**Parameters** **curve - geom_Curve**

**plane - Geom_Plane**

**dir - gp_Dir (default None)**

The cylindrical projection direction. If None, the project will be normal to the plane

**Returns** **Hproj_curve** : Handle_Geom_Curve

airconics.AirCONICStools.**project_curve_to_surface**(*curve*, *surface*, *dir*)
Returns a curve as cylindrically projected onto the surface shape

**Parameters** **curve** : Geom_curve or TopoDS_Edge/Wire

**surface** : TopoDS_Shape

**dir** : gp_Dir

the direction of projection

**Returns** **res_curve** : geom_curve (bspline only?)

airconics.AirCONICStools.**rotate**(*brep*, *axe*, *degree*, *copy=False*)
Rotates the brep

Originally from pythonocc-utils : might add dependency on this?

**Parameters** **brep** : shape to rotate

**axe** : axis of rotation

**degree** : Number of degrees to rotate through

**copy** : bool (default=False)

**Returns** **BRepBuilderAPI_Transform.Shape** : Shape handle

The handle to the rotated shape

airconics.AirCONICStools.**scale_uniformal**(*brep*, *pnt*, *factor*, *copy=False*)
translate a brep over a vector : from pythonocc-utils

airconics.AirCONICStools.**transform_nonuniformal**(*brep, factors, vec=[0, 0, 0], copy=False*)
Nonuniformly scale brep with respect to pnt by the x y z scaling factors provided in 'factors', and translate by vector 'vec'

**Parameters** **factors** : List of factors [Fx, Fy, Fz]

Scaling factors with respect to origin (0,0,0)

**vec** : List of x,y,z or gp_Vec

the translation vector (default is [0,0,0])

#### Notes

•Only tested on 3d shapes

•Assumes factors are define with respect to the origin (0,0,0)

airconics.AirCONICStools.**translate_topods_from_vector**(*brep_or_iterable*, *vec*, *copy=False*)
Function Originally from pythonocc-utils, modified to work on objects

translates a brep over a vector

**Parameters** **brep** : the Topo_DS to translate

**vec** : the vector defining the translation

**copy** : copies to brep if True

## 3.8 *examples* Subpackage

Modules in this subpackage are to be used for reconstructing example Airconics shapes, e.g. the transonic airliner lifting surface functions. Created on Mon Jan 4 17:28:37 2016

Example script for generating a transonic airliner wing external geometry.

@author: pchambers

airconics.examples.wing_example_transonic_airliner.**myAirfoilFunctionAirliner**(*Epsilon*, *LE-P-oint*, *Chord-Funct*, *Chord-Fac-tor*, *Di-he-dral-Funct*, *Twist-Funct*)

Defines the variation of cross section as a function of Epsilon

airconics.examples.wing_example_transonic_airliner.**myChordFunctionAirliner**(*Epsilon*)

User-defined function describing the variation of chord as a function of the leading edge coordinate

airconics.examples.wing_example_transonic_airliner.**myDihedralFunctionAirliner**(*Epsilon*)

User-defined function describing the variation of dihedral as a function of the leading edge coordinate

airconics.examples.wing_example_transonic_airliner.**mySweepAngleFunctionAirliner**(*Epsilon*)

User-defined function describing the variation of sweep angle as a function of the leading edge coordinate

airconics.examples.wing_example_transonic_airliner.**myTwistFunctionAirliner**(*Epsilon*)

User-defined function describing the variation of twist as a function of the leading edge coordinate. The coefficients of the polynomial below come from the following twist values taken off the CRM (used for the AIAA drag prediction workshops): Epsilon = 0: twist = 4.24 Epsilon =0.3: twist = 0.593 Epsilon = 1: twist = -3.343

Created on Fri Jan 15 11:39:16 2016

Example functions for generating the lifting surfaces for the tail of a transport aircraft (fin and tailplane external geometry). Also, this shows that a specific planform can be reconstructed (the tail planform geometry here is an approximation of the B787 tail geometry).

# ==========
# AirCONICS # Aircraft CONfiguration through Integrated Cross-disciplinary Scripting # version 0.2 # Andras Sobester, 2015. # Bug reports to a.sobester@soton.ac.uk or @ASobester please. # ==========

@author: pchambers

airconics.examples.tailplane_example_transonic_airliner.**myAirfoilFunctionFin**(*Epsilon*, *LE-P-oint*, *Chord-Funct*, *Chord-Fac-tor*, *Di-he-dral-Funct*, *Twist-Funct*)

Defines the variation of cross section as a function of Epsilon

airconics.examples.tailplane_example_transonic_airliner.**myAirfoilFunctionTP**(*Epsilon*, *LEPoint*, *ChordFunct*, *ChordFactor*, *DihedralFunct*, *TwistFunct*)

Defines the variation of cross section as a function of Epsilon

airconics.examples.tailplane_example_transonic_airliner.**myChordFunctionFin**(*Epsilon*)

User-defined function describing the variation of the fin chord as a function of the leading edge coordinate

airconics.examples.tailplane_example_transonic_airliner.**myChordFunctionTP**(*Epsilon*)

User-defined function describing the variation of the tailplane chord as a function of the leading edge coordinate

airconics.examples.tailplane_example_transonic_airliner.**myDihedralFunctionFin**(*Epsilon*)

airconics.examples.tailplane_example_transonic_airliner.**myDihedralFunctionTP**(*Epsilon*)

airconics.examples.tailplane_example_transonic_airliner.**mySweepAngleFunctionFin**(*Epsilon*)

User-defined function describing the variation of the fin sweep angle as a function of the leading edge coordinate

airconics.examples.tailplane_example_transonic_airliner.**mySweepAngleFunctionTP**(*Epsilon*)

User-defined function describing the variation of the fin sweep angle as a function of the leading edge coordinate

airconics.examples.tailplane_example_transonic_airliner.**myTwistFunctionFin**(*Epsilon*)

airconics.examples.tailplane_example_transonic_airliner.**myTwistFunctionTP**(*Epsilon*)

Created on Fri Mar 11 11:36:51 2016

@author: pchambers

airconics.examples.boxwing.**myAirfoilFunctionBoxWing**(*Epsilon*, *LEPoint*, *ChordFunct*, *ChordFactor*, *DihedralFunct*, *TwistFunct*)

airconics.examples.boxwing.**myChordFunctionBoxWing**(*Epsilon*)

airconics.examples.boxwing.**myDihedralFunctionBoxWing**(*Epsilon*)

User-defined function describing the variation of dihedral as a function of the leading edge coordinate Notes —— Could also use numpy vectorize in this function

airconics.examples.boxwing.**mySweepAngleFunctionBoxWing**(*Epsilon*)

airconics.examples.boxwing.**myTwistFunctionBoxWing**(*Epsilon*)

CHAPTER 4

# Acknowledgements

**occ_airconics** began as fork of AirCONICS, and therefore large parts of the code, documentation, examples and manual are attributed to the AirCONICS developers. For more detail on AirCONICS, please refer to the accompanying reference book or recent papers:

[1] Sobester, A. and Forrester, A. I. J., Aircraft Aerodynamic Design: Geometry and Optimization, Wiley, 2014.

[2] Sobester, A., "Four Suggestions for Better Parametric Geometries," 10th AIAA Multidisciplinary Design Optimization Conference, AIAA SciTech, American Institute of Aeronautics and Astronautics, jan 2014.

[3] Sobester, A., "Self-Designing Parametric Geometries," 56th AIAA/ASCE/AH- S/ASC Structures, Structural Dynamics, and Materials Conference, AIAA SciTech, American Institute of Aeronautics and Astronautics, jan 2015.

CHAPTER 5

# Indices and tables

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