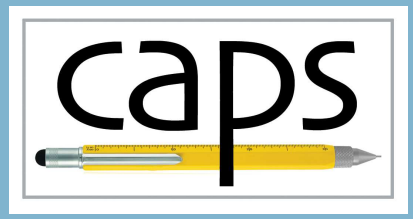
Computational Aircraft Prototype Syntheses



Training Session 2
CAPS Geometry

ESP v1.18

Marshall Galbraith
galbramc@mit.edu

Bob Haimes
haimes@mit.edu

Massachusetts Institute of Technology

John F. Dannenhoffer, III
jfdannen@syr.edu

Syracuse University

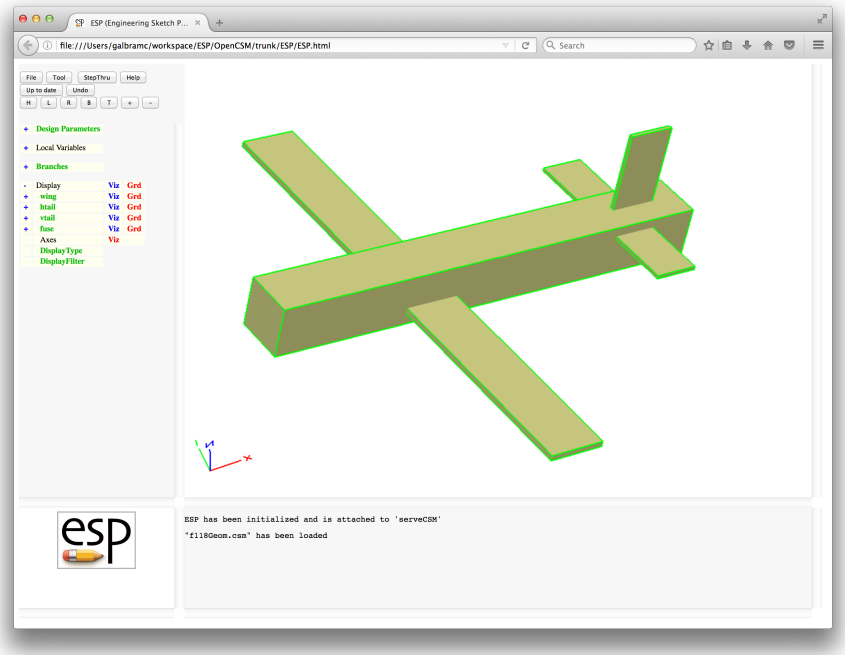
Overview

- Loading and viewing geometry via pyCAPS
  - loadCAPS
- Accessing/modifying DESPMTR
  - set/getGeometryVal
  - saveGeometry
- Accessing SET and @values using OUTPMTR
  - getGeometryOutVal
- Directing bodies to AIMs
  - Attribute `capsAIM`
  - Attribute `capsIntent`
- Suggested Exercises

F-118 Boxter Geometry

session02/f118-A.csm

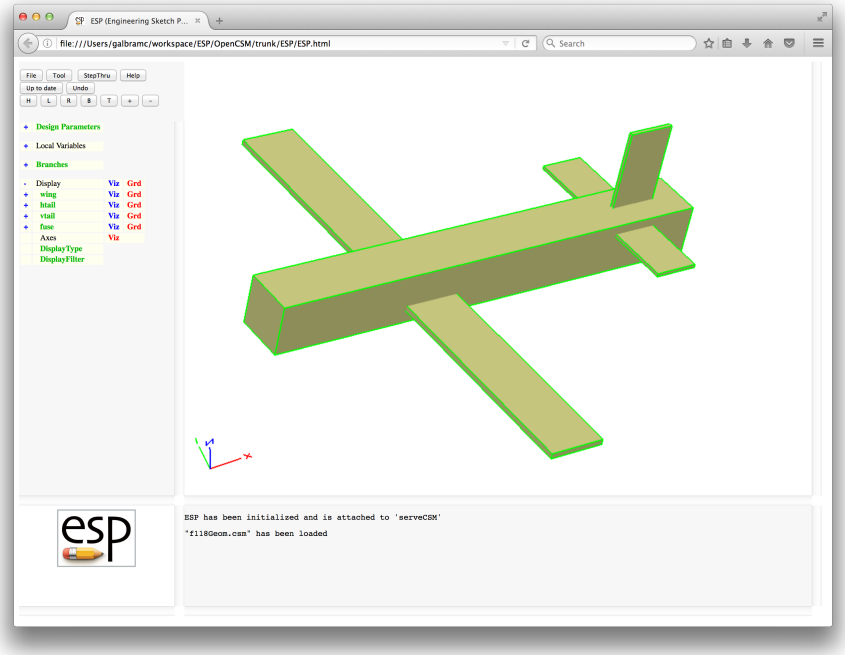
```
# F-118A Boxster

# wing design parameters
DESPMTR   wing:area         4240    # area
DESPMTR   wing:aspect       9.00    # aspect ratio
DESPMTR   wing:thick        0.10    # thickness ratio
DESPMTR   wing:xroot        54.0    # xloc at root LE
DESPMTR   wing:zroot        -5.0    # zloc at root LE

# horizontal tail design parameters
DESPMTR   htail:area        1210    # htail area
DESPMTR   htail:aspect      4.15    # htail aspect ratio
DESPMTR   htail:thick       0.08    # htail thickness
DESPMTR   htail:xroot        145    # xloc of root LE
DESPMTR   htail:zroot          5    # zloc of root LE

# vertical tail design parameters
DESPMTR   vtail:area         610    # vtail area
DESPMTR   vtail:aspect      1.80    # vtail aspect ratio
DESPMTR   vtail:thick       0.08    # vtail thickness
DESPMTR   vtail:xroot        150    # xloc of root LE
DESPMTR   vtail:zroot          9    # zloc of root LE

# fuselage design parameters
DESPMTR   fuse:length        180    # fuselage length
DESPMTR   fuse:width          20    # width  of fuselage
DESPMTR   fuse:height         20    # height of mid fuselage
```



F-118 Boxter Geometry

session02/f118-A.csm

```
#------------------------------------------------
# set available output parameters
OUTPMTR  wing:wet
OUTPMTR  wing:volume

OUTPMTR  htail:wet
OUTPMTR  htail:volume

OUTPMTR  vtail:wet
OUTPMTR  vtail:volume

OUTPMTR  fuse:wet
OUTPMTR  fuse:volume

#================================================
# Wing
SET       wing:span      sqrt(wing:aspect*wing:area)
SET       wing:chord     wing:area/wing:span

BOX  wing:xroot  -wing:span/2  wing:zroot   wing:chord  wing:span  wing:chord*wing:thick
SELECT body
    ATTRIBUTE _name   $Wing

SET  wing:wet    @area
SET  wing:volume @volume
```



Importing pyCAPS

session02/f118_1_Geom.py

```
#-----------------------------------------------------------------------#

# Allow print statement to be compatible between Python 2 and 3
from __future__ import print_function

# Import pyCAPS class
from pyCAPS import capsProblem

#-----------------------------------------------------------------------#

# Initialize capsProblem object
myProblem = capsProblem()
```

- capsProblem provides the context for an CAPS session
  - Multiple capsProblems may be instantiated, but cannot interact

Loading Geometry with pyCAPS

- Geometry loaded with loadCAPS
- Returns pyCAPS.capsGeometry instance
- Visualize with capsViewer using viewGeometry

session02/f118_1_Geom.py

```
# Initialize capsProblem object
myProblem = capsProblem()

# Load geometry [.csm] file
# loadCAPS returns a class allowing interaction with bodies on the stack
# The geometry is not built with loadCAPS
filename = "f118-A.csm"
print ('\n==> Loading geometry from file "'+filename+'"...')
f118 = myProblem.loadCAPS(filename)

# The same geometry instance is available via myProblem.geometry
assert(f118 == myProblem.geometry)

# Build and view the geometry with the capsViewer
print ('\n==> Bulding and viewing geometry...')
f118.viewGeometry()

# Close CAPS (optional)
myProblem.closeCAPS()
```

Overview

- Loading and viewing geometry via pyCAPS
  - loadCAPS
- Accessing/modifying DESPMTR
  - set/getGeometryVal
  - saveGeometry
- Accessing SET and @values using OUTPMTR
  - getGeometryOutVal
- Directing bodies to AIMs
  - Attribute `capsAIM`
  - Attribute `capsIntent`
- Suggested Exercises

Modifying Geometry DESPMTR with pyCAPS

- DESPMTR are modified/accessed with set/getGeometryVal

session02/f118-A.csm

```
# fuselage design parameters
DESPMTR   fuse:length       180    # fuselage length
DESPMTR   fuse:width         20    # width  of fuselage
DESPMTR   fuse:height        20    # height of mid fuselage
```

session02/f118_2_DESPMTR.py

```
# Load geometry [.csm] file
filename = "f118-A.csm"
print ('\n==> Loading geometry from file "'+filename+'"...')
f118 = myProblem.loadCAPS(filename)

# Set wide fuselage
f118.setGeometryVal("fuse:width", 60)
```

Modifying Geometry DESPMTR with pyCAPS

- DESPMTR are modified/accessed with set/getGeometryVal

session02/f118-A.csm

```
# horizontal tail design parameters
DESPMTR   htail:area       1210    # htail area
DESPMTR   htail:aspect     4.15    # htail aspect ratio
DESPMTR   htail:thick      0.08    # htail thickness
DESPMTR   htail:xroot       145    # xloc of root LE
DESPMTR   htail:zroot         5    # zloc of root LE
```

session02/f118_2_DESPMTR.py

```
# Double the htail:area
htail_area = f118.getGeometryVal("htail:area")
f118.setGeometryVal("htail:area", htail_area*2)

print ("--> old htail:area = ", htail_area)
print ("--> new htail:area = ", f118.getGeometryVal("htail:area"))

# Build and view the geometry with the capsViewer
print ('\n==> Bulding and viewing geometry...')
f118.viewGeometry()
```

Modifying Geometry DESPMTR with pyCAPS

- DESPMTR are modified/accessed with set/getGeometryVal

session02/f118_2_DESPMTR.py

```
# Build the Canard variant

# Reset the fuselage
f118.setGeometryVal("fuse:width", 20)

htail_area = f118.getGeometryVal("htail:area")
wing_area  = f118.getGeometryVal("wing:area")

# Swap wing and htail area
f118.setGeometryVal("htail:area", wing_area)
f118.setGeometryVal("wing:area", htail_area/2)

# Rebuild and view geometry
print ('\n==> Bulding and viewing geometry...')
f118.viewGeometry()
```

Saving Geometry with pyCAPS

- Modified geometry can be saved with saveGeometry
  - Available extensions: .egads .stp .step .igs .iges .brep

session02/f118_2_DESPMTR.py

```
# Build and view the geometry with the capsViewer
print ('\n==> Bulding and viewing geometry...')
f118.viewGeometry()
```

session02/f118_3_Save.py

```
# Build and save geometry
print ('\n==> Bulding and saving geometry...')
f118.saveGeometry("f118_3_Save_Wide.egads")
```

- View geometry with:
  - serveCSM f118_3_Save_Wide.egads
  - serveCSM f118_3_Save_Canard.egads

Overview

- Loading and viewing geometry via pyCAPS
  - loadCAPS
- Accessing/modifying DESPMTR
  - set/getGeometryVal
  - saveGeometry
- Accessing SET and @values using OUTPMTR
  - getGeometryOutVal
- Directing bodies to AIMs
  - Attribute `capsAIM`
  - Attribute `capsIntent`
- Suggested Exercises

Accessing Geometry OUTPMTR with pyCAPS

- OUTPMTR values are accessed with getGeometryOutVal

session02/f118-A.csm

```
#------------------------------------------------
# set available output parameters
OUTPMTR  wing:wet
OUTPMTR  wing:volume
```

```
BOX  wing:xroot  -wing:span/2  wing:zroot   wing:chord  wing:span  wing:chord*wing:thick
SELECT body
    ATTRIBUTE _name   $Wing

SET  wing:wet    @area
SET  wing:volume @volume
```

session02/f118_4_OUTPMTR.py

```
# Load geometry [.csm] file
filename = "f118-A.csm"
print ('\n==> Loading geometry from file "'+filename+'"...')
f118 = myProblem.loadCAPS(filename)

# Build and print all available output parameters
print ("--> wing:wet    =", f118.getGeometryOutVal("wing:wet"    ) )
print ("--> wing:volume =", f118.getGeometryOutVal("wing:volume" ) )
```

Accessing Geometry OUTPMTR with pyCAPS

- None returned for any OUTPMTR not SET

session02/f118-A.csm

```
OUTPMTR  fuse:wet
OUTPMTR  fuse:volume
```

```
BOX  0  -fuse:width/2  -fuse:height/2   fuse:length  fuse:width  fuse:height
SELECT body
    ATTRIBUTE _name   $Fuselage

# fuse:wet and fuse:volume not set
```

session02/f118_4_OUTPMTR.py

```
# Accessing OUTPMTR that has not been set
print ("--> fuse:wet    =", f118.getGeometryOutVal("fuse:wet"    ) )
print ("--> fuse:volume =" , f118.getGeometryOutVal("fuse:volume" ) )
```

Accessing Geometry OUTPMTR with pyCAPS

- Accessing non-OUTPMTR gives CAPS_NOTFOUND error

session02/f118-A.csm

```
#-----------------------------------------------
# set available output parameters
OUTPMTR  wing:wet
OUTPMTR  wing:volume

OUTPMTR  htail:wet
OUTPMTR  htail:volume

OUTPMTR  vtail:wet
OUTPMTR  vtail:volume

OUTPMTR  fuse:wet
OUTPMTR  fuse:volume

#===============================================
# Wing
SET       wing:span      sqrt(wing:aspect*wing:area)
SET       wing:chord     wing:area/wing:span
```

session02/f118_4_OUTPMTR.py

```
# Attempt to get a SET value not defined as OUTPMTR
print ("--> wing:span   =", f118.getGeometryOutVal("wing:span"   ) )
```

Overview

- Loading and viewing geometry via pyCAPS
  - loadCAPS
- Accessing/modifying DESPMTR
  - set/getGeometryVal
  - saveGeometry
- Accessing SET and @values using OUTPMTR
  - getGeometryOutVal
- Directing bodies to AIMs
  - Attribute `capsAIM`
  - Attribute `capsIntent`
- Suggested Exercises

Directing Bodies to AIMs with pyCAPS

- `capsAIM` attribute
  - String semicolon separated AIM names
  - AIMs suitable to use the body
- `capsIntent` attribute
  - Optional string used to direct bodies to AIM instance
  - String semicolon separated names
  - Multiple bodies may have the same `capsIntent`

session02/f118-B.csm

```
# Htail
SET       htail:span      sqrt(htail:aspect*htail:area)
SET       htail:chord     htail:area/htail:span

BOX  htail:xroot  -htail:span/2  htail:zroot   htail:chord  htail:span  htail:chord*htail:thick
SELECT body
    ATTRIBUTE capsAIM    $masstranAIM;astrosAIM
    ATTRIBUTE capsIntent $htail;tail
    ATTRIBUTE _name      $Htail
```

Directing Bodies to AIMs with pyCAPS

- Loading AIM with loadAIM
  - aim: The name of the AIM to load
  - analysisDir: Directory to write files if any (must be unique)
  - altName: Alternative name to track multiple instances of the same type of AIM
- No `capsIntent` loads the all bodies with matching `capsAIM`

session02/f118_5_AIM.py

```
# capsAIM == $masstranAIM
masstranAll = myProblem.loadAIM(aim = "masstranAIM",
                                analysisDir="masstranALL", altName="All")

# The AIM instance is also available in the capsProblem.analysis dict
assert(masstranAll == myProblem.analysis["All"])

# Show the geometry used by the AIM
print("==> Geometry used by masstranAll instance with no capsIntent")
masstranAll.viewGeometry()
```

Directing Bodies to AIMs with pyCAPS

- Loading masstranAIM with bodies
  `capsAIM` == $masstranAIM and `capsIntent` == $wing

session02/f118-B.csm

```
# Wing
SET       wing:span      sqrt(wing:aspect*wing:area)
SET       wing:chord     wing:area/wing:span

BOX  wing:xroot  -wing:span/2  wing:zroot   wing:chord  wing:span  wing:chord*wing:thick
SELECT body
    ATTRIBUTE capsAIM    $masstranAIM;astrosAIM
    ATTRIBUTE capsIntent $wing
    ATTRIBUTE _name      $Wing
```

session02/f118_5_AIM.py

```
# capsAIM == $masstranAIM and capsIntent == $wing
myProblem.loadAIM(aim = "masstranAIM", capsIntent="wing",
                  analysisDir="masstranWing", altName="Wing")

# Show the geometry used by the AIM
print("==> Geometry used by Wing instance with capsIntent='wing'")
myProblem.analysis["Wing"].viewGeometry()
```

Directing Bodies to AIMs with pyCAPS

- Loading masstranAIM with bodies
  `capsAIM` == $masstranAIM and `capsIntent` == $tail

session02/f118-B.csm

```
BOX  htail:xroot  -htail:span/2  htail:zroot   htail:chord  htail:span  htail:chord*htail:thick
SELECT body
    ATTRIBUTE capsAIM    $masstranAIM;astrosAIM
    ATTRIBUTE capsIntent $htail;tail
    ATTRIBUTE _name      $Htail
```

```
BOX  vtail:xroot  0  vtail:zroot   vtail:chord  vtail:chord*vtail:thick  vtail:span
SELECT body
    ATTRIBUTE capsAIM    $masstranAIM;astrosAIM
    ATTRIBUTE capsIntent $vtail;tail
    ATTRIBUTE _name      $Vtail
```

session02/f118_5_AIM.py

```
# capsAIM == $masstranAIM and capsIntent == $tail
masstranTail = myProblem.loadAIM(aim = "masstranAIM", capsIntent="tail",
                                 analysisDir="masstranTail", altName="Tail")
```

Directing Bodies to AIMs with pyCAPS

- Loading masstranAIM with bodies
  `capsAIM` == $masstranAIM and
  (`capsIntent` == $wing or `capsIntent` == $fuse)

session02/f118-B.csm

```
BOX  wing:xroot  -wing:span/2  wing:zroot   wing:chord  wing:span  wing:chord*wing:thick
SELECT body
    ATTRIBUTE capsAIM    $masstranAIM;astrosAIM
    ATTRIBUTE capsIntent $wing
    ATTRIBUTE _name      $Wing
```

```
BOX  0  -fuse:width/2  -fuse:height/2   fuse:length  fuse:width  fuse:height
SELECT body
    ATTRIBUTE capsAIM    $masstranAIM;astrosAIM
    ATTRIBUTE capsIntent $fuse
    ATTRIBUTE _name      $Fuselage
```

session02/f118_5_AIM.py

```
# capsAIM == $masstranAIM and (capsIntent == $wing or capsIntent == $fuse)
myProblem.loadAIM(aim = "masstranAIM", capsIntent=["wing","fuse"],
                  analysisDir="masstranWingFuse", altName="WingFuse")
```

Suggested Exercises

Fix f118-B.csm

- `SET` fuse:wet and fuse:volume in session02/f118-B.csm
- Add wing:span as OUTPMTR in session02/f118-B.csm
- Rerun session02/f118_4_OUTPMTR.py

Custom f118-A.csm

- Customize the f118-A.csm with setGeometryVal
  - Start from a copy of session02/f118_2_DESPMTR.py

Custom masstran analysis

- Load wing, htail and fuselage into a masstranAIM
  - Start from a copy of session02/f118_5_AIM.py

- Create your own