Engineering Sketch Pad (ESP)

Training Session 10
Putting It All Together

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updated for v1.19

Multi-X Models

- During the design of an aircraft, various coupled models are needed
  - different disciplines
    - structures
    - controls
    - aerodynamics
    - ...
  - different fidelities
    - conceptual design
    - preliminary design
    - detailed design
- There needs to be communication between these models

Computational Aircraft Prototype Syntheses (CAPS)

- In order to support multi-fidelity and multi-disciplinary analyses, the CAPS program has been developed
    - funded by the AFRL
- CAPS uses geometries (and sensitivities) generated by ESP
- CAPS provides interfaces to many analysis programs, including:
    - aerodynamics (at various fidelities)
    - structures (at various fidelities)
    - ...
- There is a companion training course for CAPS that can be offered if there is sufficient interest

Multiple Views

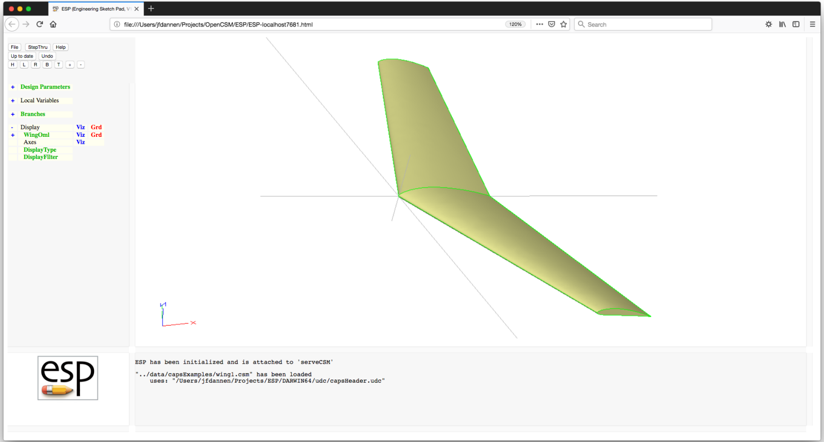
- One of the strengths of ESP is to be able to have multiple models of a single configuration
  - driven by a single set of Design Parameters
  - attributed so that "common" features could be linked together
- This capability has been used by the CAPS program
  - a set of "views" have been created, which can be used if the model is constructed and annotated in a consistent way
    - for AVL, SansLIP, SU2, Astros, ...
    - implemented as a series of UDCs

Overview

- Analysis of Simple Wing (`wing1`)
  - basic assumptions (orientation, ...)
  - required Bodys
  - required attributes (naming vs. meta-data)
- Analysis of wing with flaps (`wing2`)
  - required Bodys
  - required attributes (naming vs. meta-data)
- Analysis of wing structure `wing3`)
  - required Bodys
  - required attributes (naming vs. meta-data)
- Full aircraft model (`transport`)

wing1.csm

Isolated Wing: Outer Mold Line (OML) Only



Design Parameters for `wing1`

File can be found at `$ESP_ROOT/training/ESP/data/session10`

`wing:area`	10.0	wing area
`wing:aspect`	6.00	aspect ratio
`wing:taper`	0.60	taper ratio
`wing:sweep`	20.0	deg (of leading edge)
`wing:thick`	0.12	thickness ratio, frac of local chord
`wing:camber`	0.04	maximum camber, frac of local chord
`wing:washout`	5.00	deg (down at tip)
`wing:dihedral`	4.00	deg

“Possible” Analyses (Views) for `wing1`

- `VIEW:Concept` — conceptual design
- `VIEW:VLM` — vortex lattice method
- `VIEW:CFDInviscid` — inviscid CFD analysis
- `VIEW:CFDViscous` — viscous CFD analysis

Basic Assumptions

- Configuration files defines the necessary Bodys
- Bodys are oriented such that:
    - x points out the tail
    - y points out the right wing
    - z points up

Required Bodys (for Aerodynamic Analyses)

- Outer Mold Lines (OMLs) for each component
  - `FuseOml` (a SolidBody)
  - `WingOml` (a SolidBody)
  - `HtailOml` (a SolidBody)
  - `VtailOml` (a SolidBody)

Required Attributes on `WingOml`

- Body
  - `tagComp` with value `$leftWing` or `$riteWing`
- Faces
  - `tagComp` with value `$leftWing` or `$riteWing`
  - `tagType` with value `$root`, `$tip`, `$upper`, `$lower`, or `$trailingEdge`
- Edges
  - `tagType` with value `$root`, `$leadingEdge` (with supporting `tagComp`), or `$trailingEdge` (with supporting `tagComp`)

Dissection of `wing1.csm` (1)

File can be found at `$ESP_ROOT/training/ESP/data/session10`

- Definition of VIEWs to be supported
- Definition of COMPonents that are defined
- Definition of Design Parameters
- Call to `capsHeader`
- Construction of `WingOml` (with attributes)
- Call to `capsViews`

Dissection of wing1.csm (2)

```
# wing1
# written by John Dannenhoffer

# define the views
CFGPMTR   VIEW:Concept        1
CFGPMTR   VIEW:VLM            0
CFGPMTR   VIEW:CFDInviscid    0
CFGPMTR   VIEW:CFDViscous     0

# define components to be used
CFGPMTR   COMP:Wing           1

# Design Parameters for OML
DESPMTR   wing:area      10.0      # wing area
DESPMTR   wing:aspect    6.00      # aspect ratio
DESPMTR   wing:taper     0.60      # taper ratio
DESPMTR   wing:sweep     20.0      # deg (of leading edge)
DESPMTR   wing:thickr    0.12      # thickness ratio at root
DESPMTR   wing:camberr   0.06      # camber    ratio at root
DESPMTR   wing:thickt    0.16      # thickness ratio at tip
DESPMTR   wing:cambert   0.02      # camber    ratio at tip
DESPMTR   wing:alphat   -5.00      # setting angle   at tip
DESPMTR   wing:dihedral  4.00      # deg
DESPMTR   wing:xroot     0.00      # xloc at root LE
DESPMTR   wing:yroot     0.00      # yloc at root LE
DESPMTR   wing:zroot     0.00      # zloc at root LE

# Define length units of the geometry
ATTRIBUTE capsLength     $ft
```

Dissection of wing1.csm (3)

```
# convert VIEW:* variables into make* variables
UDPRIM    $/capsHeader

# wing local variables
SET       wing:span      sqrt(wing:aspect*wing:area)
SET       wing:chordr    2*wing:area/wing:span/(1+wing:taper)
SET       wing:chordt    wing:chordr*wing:taper
SET       wing:ytip     -wing:span/2
SET       wing:xtip     -wing:ytip*tand(wing:sweep)
SET       wing:ztip     -wing:ytip*tand(wing:dihedral)
SET       wing:mac       sqrt(wing:area/wing:aspect)

# make wing OML
IFTHEN    makeWingOml EQ 1
    # lay out left wing
    MARK
        # root
        UDPRIM    naca      thickness  wing:thickr   camber  wing:camberr   sharpte  SHARP_TE
        SCALE     wing:chordr
        ROTATEX   90  0  0

        # left tip
        UDPRIM    naca      thickness  wing:thickt   camber  wing:cambert   sharpte  SHARP_TE
        SCALE     wing:chordt
        ROTATEX   90  0  0
        ROTATEY   wing:alphat  0           0
        TRANSLATE wing:xtip    wing:ytip   wing:ztip
    RULE
        ATTRIBUTE tagComp  $leftWing
    SET       ruledBody @nbody
```

Dissection of wing1.csm (4)

```
SELECT    FACE ruledBody  1
    ATTRIBUTE tagType  $root
SELECT    FACE ruledBody  2
    ATTRIBUTE tagType  $tip
SELECT    FACE ruledBody  3
    ATTRIBUTE tagType  $upper
SELECT    FACE ruledBody  4
    ATTRIBUTE tagType  $lower
SELECT    EDGE  ruledBody 3 ruledBody 4 1
    ATTRIBUTE tagComp  $leftWing
    ATTRIBUTE tagType  $leadingEdge
IFTHEN    SHARP_TE EQ 0
    SELECT    FACE  ruledBody 5
        ATTRIBUTE tagType  $trailingEdge
ELSE
    SELECT    EDGE  ruledBody 3 ruledBody 4 2
        ATTRIBUTE tagComp  $leftWing
        ATTRIBUTE tagType  $trailingEdge
ENDIF
```

Dissection of wing1.csm (5)

```
    # right wing too
    STORE     LeftWing 0 1
    RESTORE   LeftWing
        ATTRIBUTE tagComp $riteWing
        SELECT    EDGE  $tagType $leadingEdge
        IFTHEN    @iedge GT 0
            SELECT EDGE  $tagType $leadingEdge
                ATTRIBUTE tagComp $riteWing
        ENDIF
        SELECT    EDGE  $tagType $trailingEdge
        IFTHEN    @iedge GT 0
            SELECT EDGE  $tagType $trailingEdge
                ATTRIBUTE tagComp $riteWing
        ENDIF
        CATBEG   $edge_not_found
        CATEND
    MIRROR    0   1  0
    JOIN

    SELECT    EDGE  ruledBody 3 ruledBody 3 1
        ATTRIBUTE tagType  $root
    SELECT    EDGE  ruledBody 4 ruledBody 4 1
        ATTRIBUTE tagType  $root

    STORE     WingOml
ENDIF

# now generate the needed views
UDPRIM    $/capsViews

END
```

New Design Parameters for `wing2`

File can be found at `$ESP_ROOT/training/ESP/data/session10`

`wing:hinge[i,1]`	deflection (degrees)
`wing:hinge[i,2]`	x/c at y-min end
`wing:hinge[i,3]`	$y/(b/2)$ at y-min end
`wing:hinge[i,4]`	z/t at y-min end
`wing:hinge[i,5]`	x/c at y-max end
`wing:hinge[i,6]`	$y/(b/2)$ at y-max end
`wing:hinge[i,7]`	z/t at y-max end
`wing:hinge[i,8]`	gap when cutting out for CFD
`wing:hinge[i,9]`	group (used to link controls in VLM)

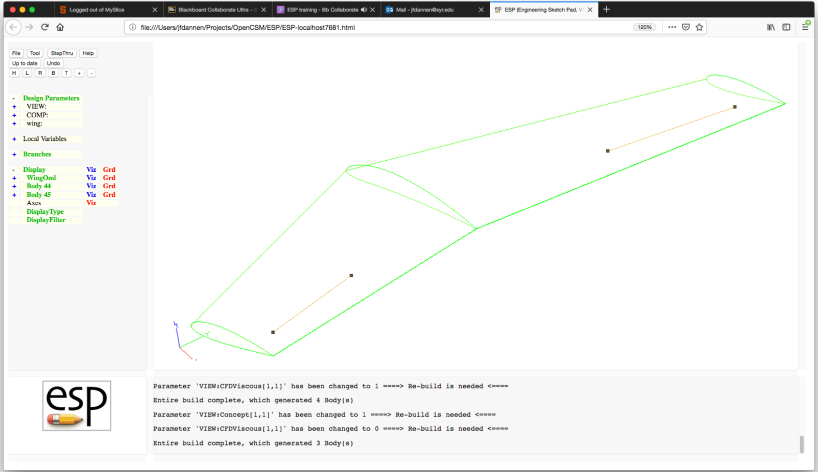
Required Bodys (for Control Analyses)

- Outer Mold Lines (OMLs) for each component
  - `FuseOml` (a SolidBody)
  - `WingOml` (a SolidBody)
  - `HtailOml` (a SolidBody)
  - `VtailOml` (a SolidBody)
- Hinge lines for each control surface i on each component
  - `WingHinge` i (a WireBody)
  - `HtailHinge` i (a WireBody)
  - `VtailHinge` i (a WireBody)

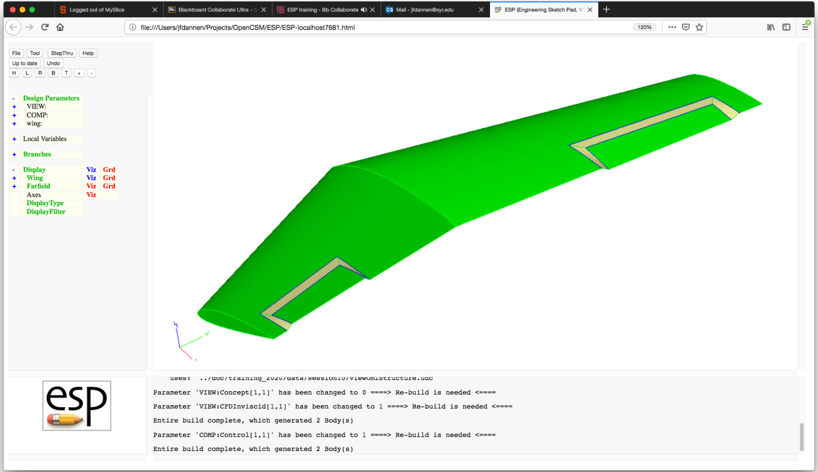
Required Attributes on `WingHinge` i

- Body
  - (none required)
- Edges
  - `tagComp` with value `$wing`
  - `tagType` with value `$hinge`
  - `tagIndex` with value i
  - `deflect` with value equal to deflection angle (in degrees), positive according to right-hand rule
  - `xoverc1` with value equal to x/c at the y-min end
  - `xoverc2` with value equal to x/c at the y-max end
  - `gap` with value equal to gap size when cutting out control surface for CFD

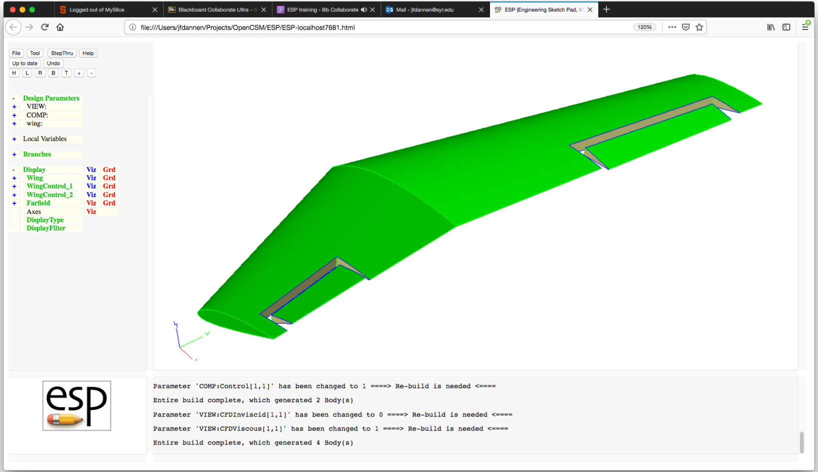
Conceptual View of Control Surfaces



Inviscid Model for Control Surfaces



Viscous Model for Control Surfaces



Dissection of `wing2.csm` (1)

File can be found at `$ESP_ROOT/training/ESP/data/session10`

- Definition of VIEWs to be supported
- Definition of COMPonents that are defined
- Definition of Design Parameters
- Call to `capsHeader`
- Construction of `WingOml` (with attributes)
- Construction of `WingHinges` (with attributes)
- Call to `capsViews`

Dissection of wing2.csm (2)

```
# wing2
# written by John Dannenhoffer

# define the views
CFGPMTR   VIEW:Concept        1
CFGPMTR   VIEW:VLM            0
CFGPMTR   VIEW:CFDInviscid    0
CFGPMTR   VIEW:CFDViscous     0

# define components to be used
CFGPMTR   COMP:Wing           1
CFGPMTR   COMP:Control        0

# Design Parameters for OML
DESPMTR   wing:area      10.0      # wing area
DESPMTR   wing:aspect    6.00      # aspect ratio
DESPMTR   wing:taper     0.60      # taper ratio
DESPMTR   wing:sweep     20.0      # deg (of leading edge)
DESPMTR   wing:thickr    0.12      # thickness ratio at root
DESPMTR   wing:camberr   0.06      # camber    ratio at root
DESPMTR   wing:thickt    0.16      # thickness ratio at tip
DESPMTR   wing:cambert   0.02      # camber    ratio at tip
DESPMTR   wing:alphat   -5.00      # setting angle   at tip
DESPMTR   wing:dihedral  4.00      # deg
DESPMTR   wing:xroot     0.00      # xloc at root LE
DESPMTR   wing:yroot     0.00      # yloc at root LE
DESPMTR   wing:zroot     0.00      # zloc at root LE
```

Dissection of wing2.csm (3)

```
# Design Parameters for controls
DIMENSION wing:hinge        2 9 1
#                           theta   ymin                     ymax                  gap   grp
DESPMTR   wing:hinge       "-10.0;  0.75; -0.90;  0.50;   0.75; -0.50; 0.50;  0.10; 1;  \ left aileron
                            +10.0;  0.75;  0.50;  0.50;   0.75;  0.90; 0.50;  0.10; 2"  #  rite aileron

# Define length units of the geometry
ATTRIBUTE capsLength     $ft

# convert VIEW:* variables into make* variables
UDPRIM    $/capsHeader

# wing local variables
SET       wing:span       sqrt(wing:aspect*wing:area)
SET       wing:chordr     2*wing:area/wing:span/(1+wing:taper)
SET       wing:chordt     wing:chordr*wing:taper
SET       wing:ytip      -wing:span/2
SET       wing:xtip      -wing:ytip*tand(wing:sweep)
SET       wing:ztip      -wing:ytip*tand(wing:dihedral)
SET       wing:mac        sqrt(wing:area/wing:aspect)
```

Dissection of wing2.csm (4)

```
# make wing OML
IFTHEN    makeWingOml EQ 1
    # lay out left wing
    MARK
        # root
        UDPRIM    naca      thickness  wing:thickr   camber  wing:camberr   sharpte  SHARP_TE
        SCALE     wing:chordr
        ROTATEX   90  0  0

        # left tip
        UDPRIM    naca      thickness  wing:thickt   camber  wing:cambert   sharpte  SHARP_TE
        SCALE     wing:chordt
        ROTATEX   90  0  0
        ROTATEY   wing:alphat  0           0
        TRANSLATE wing:xtip    wing:ytip   wing:ztip
    RULE
        ATTRIBUTE tagComp  $leftWing
    SET       ruledBody @nbody

    SELECT    FACE ruledBody  1
        ATTRIBUTE tagType  $root
    SELECT    FACE ruledBody  2
        ATTRIBUTE tagType  $tip
    SELECT    FACE ruledBody  3
        ATTRIBUTE tagType  $upper
    SELECT    FACE ruledBody  4
        ATTRIBUTE tagType  $lower
    SELECT    EDGE  ruledBody 3 ruledBody 4 1
        ATTRIBUTE tagComp  $leftWing
        ATTRIBUTE tagType  $leadingEdge
```

Dissection of `wing2.csm` (5)

```
IFTHEN    SHARP_TE EQ 0
    SELECT    FACE  ruledBody 5
        ATTRIBUTE tagType  $trailingEdge
ELSE
    SELECT    EDGE  ruledBody 3 ruledBody 4 2
        ATTRIBUTE tagComp  $leftWing
        ATTRIBUTE tagType  $trailingEdge
ENDIF

# right wing too
STORE     LeftWing 0 1
RESTORE   LeftWing
    ATTRIBUTE tagComp $riteWing
    SELECT    EDGE  $tagType $leadingEdge
    IFTHEN    @iedge GT 0
        SELECT EDGE  $tagType $leadingEdge
            ATTRIBUTE tagComp $riteWing
    ENDIF
    SELECT    EDGE  $tagType $trailingEdge
    IFTHEN    @iedge GT 0
        SELECT EDGE  $tagType $trailingEdge
            ATTRIBUTE tagComp $riteWing
    ENDIF
    CATBEG   $edge_not_found
    CATEND
MIRROR    0   1  0
JOIN
```

Dissection of wing2.csm (6)

```
    SELECT    EDGE  ruledBody 3 ruledBody 3 1
        ATTRIBUTE tagType  $root
    SELECT    EDGE  ruledBody 4 ruledBody 4 1
        ATTRIBUTE tagType  $root

    STORE     WingOml
ENDIF

# make wing hinge lines
IFTHEN    makeWingOml EQ 1  AND  makeWingHinge EQ 1
    PATBEG    ihinge  wing:hinge.nrow
        SET       y_ibd   wing:hinge[ihinge,3]*(-wing:ytip)
        BOX       -1000  y_ibd  -1000  2000  0  2000
        RESTORE   WingOml
        INTERSECT
        SET       x_ibd   @xmin+wing:hinge[ihinge,2]*(@xmax-@xmin)
        STORE     .
        BOX       x_ibd  y_ibd  -1000  0  0  2000
        RESTORE   WingOml
        INTERSECT
        SET       z_ibd   @zmin+wing:hinge[ihinge,4]*(@zmax-@zmin)
        STORE     .
```

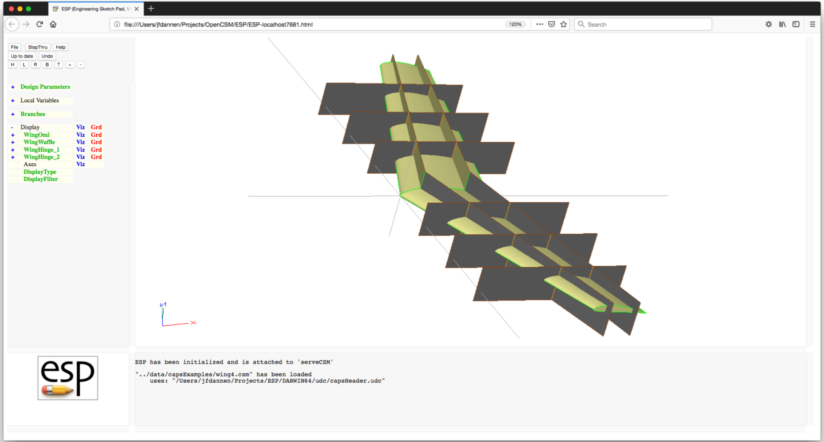
```
        SET       y_obd   wing:hinge[ihinge,6]*(-wing:ytip)
        BOX       -1000  y_obd  -1000  2000  0  2000
        RESTORE   WingOml
        INTERSECT
        SET       x_obd   @xmin+wing:hinge[ihinge,5]*(@xmax-@xmin)
        STORE     .
        BOX       x_obd  y_obd  -1000  0  0  2000
        RESTORE   WingOml
        INTERSECT
        SET       z_obd   @zmin+wing:hinge[ihinge,7]*(@zmax-@zmin)
        STORE     .

        SKBEG      x_ibd  y_ibd  z_ibd
            LINSEG x_obd  y_obd  z_obd
        SKEND
        SELECT    EDGE 1
            ATTRIBUTE tagComp  $wing
            ATTRIBUTE tagType  $hinge
            ATTRIBUTE tagIndex !val2str(wing:hinge[ihinge,9],0)
            ATTRIBUTE deflect   wing:hinge[ihinge,1]
            ATTRIBUTE xoverc1   wing:hinge[ihinge,2]
            ATTRIBUTE xoverc2   wing:hinge[ihinge,5]
            ATTRIBUTE gap       wing:hinge[ihinge,8]
            ATTRIBUTE compIndex !val2str(ihinge,0)
        STORE   WingHinge ihinge
    PATEND
ENDIF

# now generate the needed views
UDPRIM    $/capsViews

END
```

Isolated Wing: OML and Structures



New Design Parameters for `wing3`

`wing:spar1`	0.20	location of fwrd spar
`wing:spar2`	0.70	location of rwrd spar
`wing:nrib`	3.00	number of ribs per wing

“Possible” Analyses (Views) for `wing3`

- `VIEW:Concept` — conceptual design
- `VIEW:Structure` — built-up element model

Required Bodys (for Structural Analyses)

- Outer Mold Lines (OMLs) for each component
  - `FuseOml` (a SolidBody)
  - `WingOml` (a SolidBody)
  - `HtailOml` (a SolidBody)
  - `VtailOml` (a SolidBody)
- Waffle for each component
  - `FuseWaffle` (a SheetBody) — not yet supported
  - `WingWaffle` (a SheetBody)
  - `HtailWaffle` (a SheetBody) — not yet supported
  - `VtailWaffle` (a SheetBody) — not yet supported

Required Attributes of `WingWaffle`

- Body
  - (none required)
- Faces
  - `tagComp` with value `$leftwing`, `$riteWing`, or `$wing` (if on symmetry plane)
  - `tagType` with value `$spar` or `$rib`
  - `tagIndex` with different value for each spar and rib

Dissection of `wing3.csm` (1)

```
# wing3
# written by John Dannenhoffer

# define the views
CFGPMTR   VIEW:Concept          1
CFGPMTR   VIEW:VLM              0
CFGPMTR   VIEW:CFDInviscid      0
CFGPMTR   VIEW:CFDViscous       0
CFGPMTR   VIEW:OmlStructure     0
CFGPMTR   VIEW:ClampedStructure 0
CFGPMTR   VIEW:SupportStructure 0
CFGPMTR   VIEW:BoxStructure     0

# define components to be used
CFGPMTR   COMP:Wing            1

# Design Parameters for OML
DESPMTR   wing:area      10.0      # wing area
DESPMTR   wing:aspect    6.00      # aspect ratio
DESPMTR   wing:taper     0.60      # taper ratio
DESPMTR   wing:sweep     20.0      # deg (of leading edge)
DESPMTR   wing:thickr    0.12      # thickness ratio at root
DESPMTR   wing:camberr   0.06      # camber    ratio at root
DESPMTR   wing:thickt    0.16      # thickness ratio at tip
DESPMTR   wing:cambert   0.02      # camber    ratio at tip
DESPMTR   wing:alphat   -5.00      # setting angle   at tip
DESPMTR   wing:dihedral  4.00      # deg
DESPMTR   wing:xroot     0.00      # xloc at root LE
DESPMTR   wing:yroot     0.00      # yloc at root LE
DESPMTR   wing:zroot     0.00      # zloc at root LE
```

Dissection of `wing3.csm` (2)

```
# Design Parameters for structure
DESPMTR   wing:spar1     0.20      # location of fwrd spar
DESPMTR   wing:spar2     0.70      # location of rwrd spar
CFGPMTR   wing:nrib      3.00      # number of ribs per wing

# Define length units of the geometry
ATTRIBUTE capsLength     $ft

# convert VIEW:* variables into make* variables
UDPRIM    $/capsHeader

# wing local variables
SET       wing:span sqrt(wing:aspect*wing:area)
SET       wing:chordr    2*wing:area/wing:span/(1+wing:taper)
SET       wing:chordt    wing:chordr*wing:taper
SET       wing:ytip     -wing:span/2
SET       wing:xtip     -wing:ytip*tand(wing:sweep)
SET       wing:ztip     -wing:ytip*tand(wing:dihedral)
SET       wing:mac       sqrt(wing:area/wing:aspect)
```

Dissection of wing3.csm (3)

```
# make wing OML
IFTHEN    makeWingOml EQ 1
    # lay out left wing
    MARK
        # root
        UDPRIM    naca      thickness  wing:thickr   camber  wing:camberr   sharpte  SHARP_TE
        SCALE     wing:chordr
        ROTATEX   90  0  0

        # left tip
        UDPRIM    naca      thickness  wing:thickt   camber  wing:cambert   sharpte  SHARP_TE
        SCALE     wing:chordt
        ROTATEX   90  0  0
        ROTATEY   wing:alphat  0           0
        TRANSLATE wing:xtip    wing:ytip   wing:ztip
    RULE
        ATTRIBUTE tagComp  $leftWing
    SET       ruledBody @nbody

    SELECT    FACE ruledBody  1
        ATTRIBUTE tagType  $root
    SELECT    FACE ruledBody  2
        ATTRIBUTE tagType  $tip
        ATTRIBUTE tagIndex $1
    SELECT    FACE ruledBody  3
        ATTRIBUTE tagType  $upper
    SELECT    FACE ruledBody  4
        ATTRIBUTE tagType  $lower
```

Dissection of wing3.csm (4)

```
SELECT    EDGE  ruledBody 3 ruledBody 4 1
    ATTRIBUTE tagComp  $leftWing
    ATTRIBUTE tagType  $leadingEdge
IFTHEN    SHARP_TE EQ 0
    SELECT    FACE  ruledBody 5
        ATTRIBUTE tagType  $trailingEdge
ELSE
    SELECT    EDGE  ruledBody 3 ruledBody 4 2
        ATTRIBUTE tagComp  $leftWing
        ATTRIBUTE tagType  $trailingEdge
ENDIF

# right wing too
STORE     LeftWing 0 1
RESTORE   LeftWing
    ATTRIBUTE tagComp $riteWing
    SELECT    FACE  $tagType $tip
    ATTRIBUTE tagIndex $2
    SELECT    EDGE  $tagType $leadingEdge
    IFTHEN    @iedge GT 0
        SELECT EDGE  $tagType $leadingEdge
            ATTRIBUTE tagComp $riteWing
    ENDIF
    SELECT    EDGE  $tagType $trailingEdge
    IFTHEN    @iedge GT 0
        SELECT EDGE  $tagType $trailingEdge
            ATTRIBUTE tagComp $riteWing
    ENDIF
    CATBEG    $edge_not_found
    CATEND
MIRROR    0   1  0
JOIN
```

Dissection of `wing3.csm` (5)

```
    SELECT    EDGE  ruledBody 3 ruledBody 3 1
        ATTRIBUTE tagType  $root
    SELECT    EDGE  ruledBody 4 ruledBody 4 1
        ATTRIBUTE tagType  $root

    STORE     WingOml
ENDIF

# make wing waffle
IFTHEN    makeWingWaffle EQ 1
    RESTORE   WingOml
    SET       xmin       @xmin-0.1
    SET       xmax       @xmax+0.1
    SET       ymin       0
    SET       ymax       @ymax+0.1
    SET       zmin       @zmin-0.1
    SET       zmax       @zmax+0.1
    STORE     .

    UDPARG    waffle     depth wing:nrib     # ensures rebuild
    UDPARG    waffle     depth wing:spar1
    UDPARG    waffle     depth wing:spar2
    UDPRIM    waffle     depth zmax-zmin  filename <<
```

Dissection of wing3.csm (6)

```
# construction lines for spars
CPOINT A   AT         0+wing:spar1*wing:chordr 0
CPOINT B   AT  wing:xtip+wing:spar1*wing:chordt -wing:ytip
CPOINT C   AT         0+wing:spar2*wing:chordr 0
CPOINT D   AT  wing:xtip+wing:spar2*wing:chordt -wing:ytip

CLINE  AB      A  B
CLINE  CD      C  D

# rite spars
POINT  E   ON  AB   YLOC  ymin
POINT  F   ON  AB   YLOC  ymax
LINE   EF  E   F  tagComp=riteWing  tagType=spar  tagIndex=1

POINT  G   ON  CD   YLOC  ymin
POINT  H   ON  CD   YLOC  ymax
LINE   GH  G   H  tagComp=riteWing  tagType=spar tagIndex=2

# rite ribs
PATBEG  irib  wing:nrib
    CPOINT  I  AT  xmin  -wing:ytip*irib/(wing:nrib+1)
    CPOINT  J  AT  xmax  y@I
    LINE    .   I  J  tagComp=riteWing  tagType=rib   tagIndex=!val2str(irib,0)
PATEND
```

Dissection of `wing3.csm` (7)

```
        # root rib
        CPOINT  I  AT  xmin  0
        CPOINT  J  AT  xmax  y@I
        LINE    .   I  J  tagComp=rootWing  tagType=rib   tagIndex=0

        # left spars
        POINT  E   AT  x@E  -y@E
        POINT  F   AT  x@F  -y@F
        LINE   FE  F   E  tagComp=leftWing  tagType=spar  tagIndex=1

        POINT  G   AT  x@G  -y@G
        POINT  H   AT  x@H  -y@H
        LINE   HG  H   G  tagComp=leftWing  tagType=spar tagIndex=2

        # left ribs
        PATBEG  irib  wing:nrib
            CPOINT  I  AT  xmin  wing:ytip*irib/(wing:nrib+1)
            CPOINT  J  AT  xmax  y@I
            LINE    .   I  J  tagComp=leftWing  tagType=rib   tagIndex=!val2str(irib,0)
        PATEND
>>
    TRANSLATE  0  0  zmin
    STORE     WingWaffle
ENDIF

# now generate the needed views
UDPRIM    $/capsViews

END
```

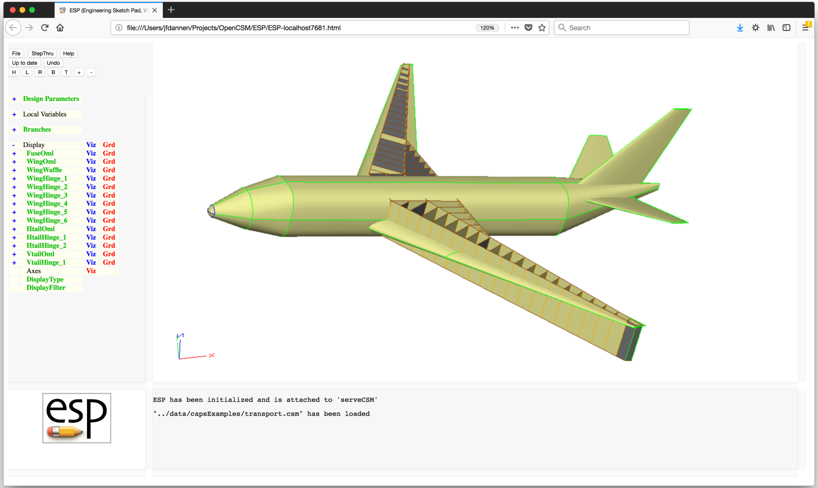
Full Transport Configuration

File found at `$ESP_ROOT/training/ESP/data/session10`

- Design Parameters associated with fuselage and tail
  - similar to wing
- Construction of fuselage and tail
  - similar to wing

transport.csm

Isolated Transport: OML, Structures, and Controls



Summary

- `ESP` is a powerful geometry-generating system that was designed for the analysis of complex configurations
  - supports multiple linked models
  - supports persistent attribution
  - provides sensitivities
  - can easily be coupled with other systems
- For `CAPS`, a set of "views" were defined; but these are only an example
- Each organization will want to develop a set of rules and conventions that are consistent with the rest of the organization's design systems

Final Thoughts

- ESP is freely available for download from acdl.mit.edu/ESP
- Based upon user requests, new and improved features are added continually
- Send bug reports to jfdannen@syr.edu or haimes@mit.edu
- Also send success stories to jfdannen@syr.edu or haimes@mit.edu

- Thank you for attending; send comments about the course to jfdannen@syr.edu or haimes@mit.edu