

Engineering Sketch Pad (ESP)



Exercise Solutions

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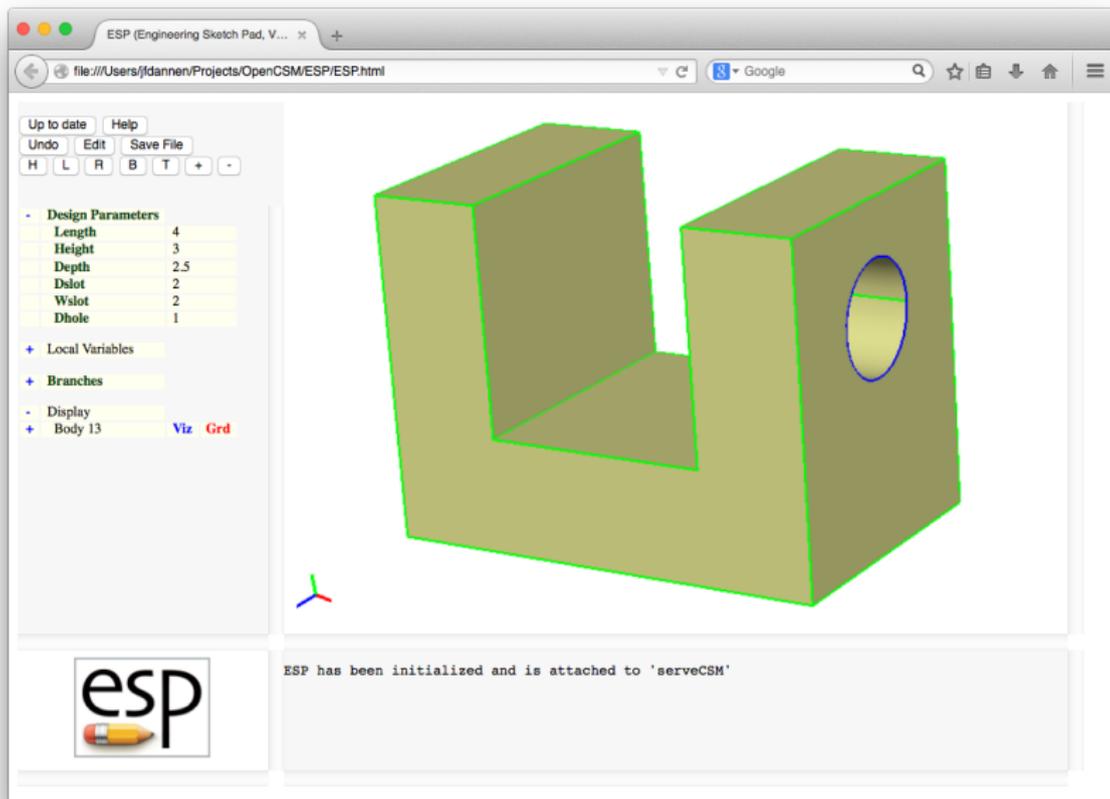
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updated for v1.19

Session 2 Solutions

Solids Fundamentals (1)



ESP (Engineering Sketch Pad, V...)

file:///Users/ldannen/Projects/OpenCSM/ESP/ESP.html

Google

Up to date Help

Undo Edit Save File

H L R B T + -

- Design Parameters

Length	4
Height	3
Depth	2.5
Slot	2
Wslot	2
Dhole	1
- Local Variables
- Branches
- Display
- Body 13 Viz Grd

ESP has been initialized and is attached to 'serveCSM'

Length	length in (X -direction)	4.00
Height	height of the two legs (Y -direction)	3.00
Depth	depth (in Z -direction)	2.50
Dslot	depth of slot (in Y -direction)	2.00
Wslot	width of slot (in X -direction)	2.00
	slot is centered in X -direction	
Dhole	diameter of hole	1.00
	hole is centered in Z -direction	
	center of hole is down Dhole from top	

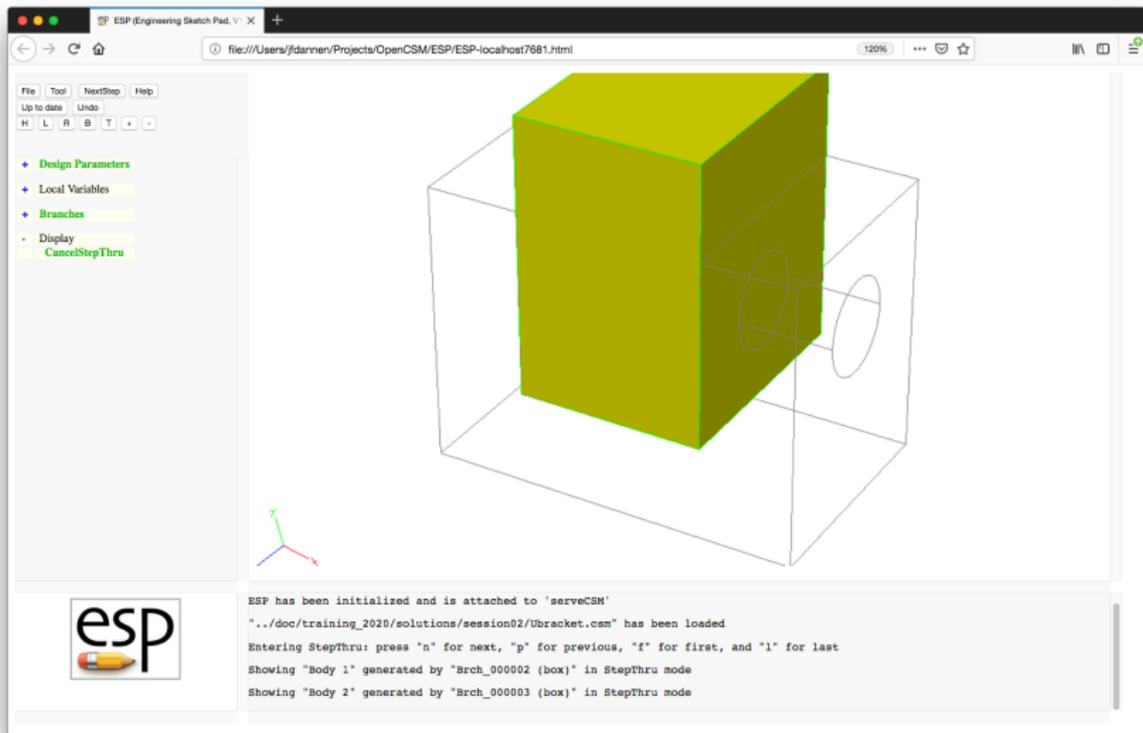


U-shaped Bracket — Step 1

File Tool NextStep Help
Up to date Undo
H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

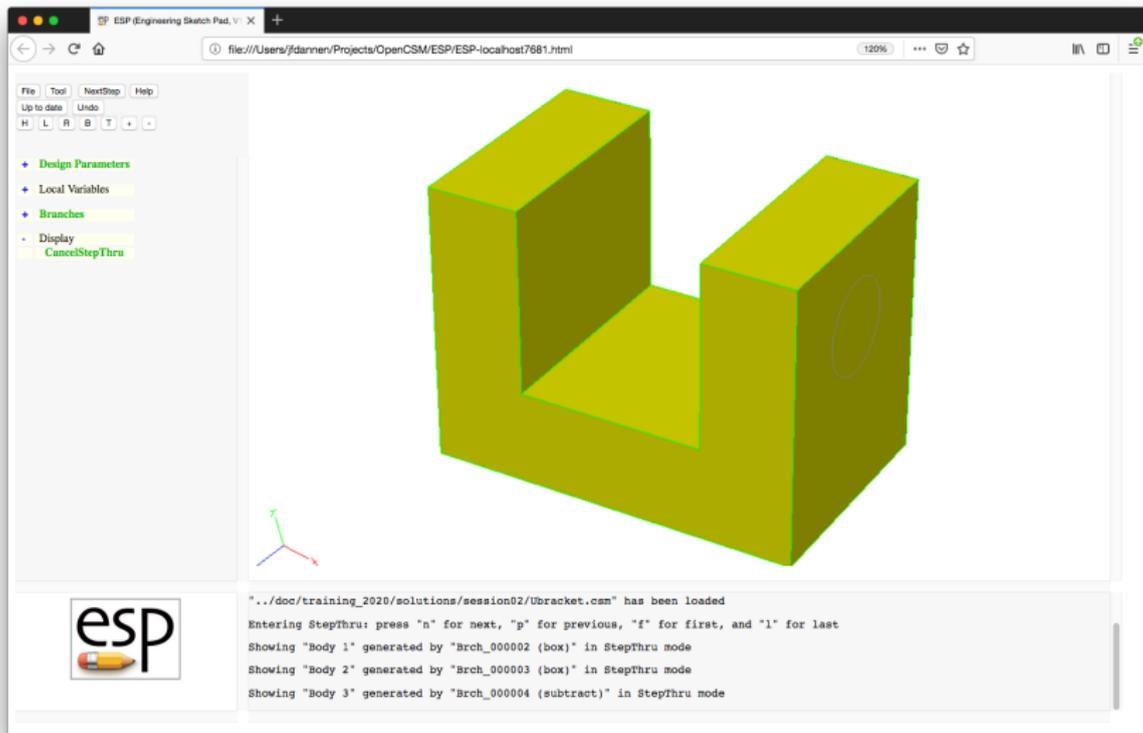
ESP has been initialized and is attached to 'serveCSM'
"./doc/training_2020/solutions/session02/Ubracket.csm" has been loaded
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000002 (box)" in StepThru mode



File Tool NextStep Help
 Up to date Undo
 H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

ESP has been initialized and is attached to 'serveCSM'
 "../doc/training_2020/solutions/session02/Ubracket.csm" has been loaded
 Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
 Showing "Body 1" generated by "Brch_000002 (box)" in StepThru mode
 Showing "Body 2" generated by "Brch_000003 (box)" in StepThru mode

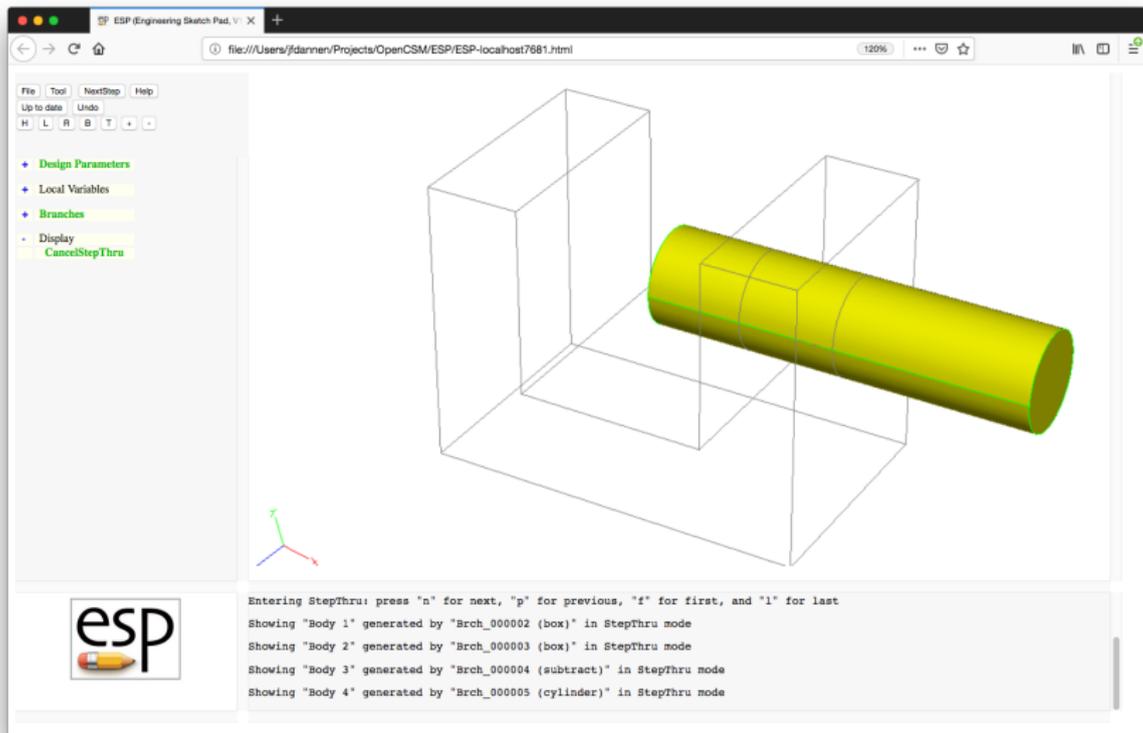


File Tool NextStep Help
Up to date Undo
H L R B T +

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

```

"../doc/training_2020/solutions/session02/Ubracket.csm" has been loaded
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000002 (box)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (box)" in StepThru mode
Showing "Body 3" generated by "Brch_000004 (subtract)" in StepThru mode
    
```



File | Tool | NextStep | Help
 Up to date | Undo
 H | L | R | B | T | + | -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
 Showing "Body 1" generated by "Brch_000002 (box)" in StepThru mode
 Showing "Body 2" generated by "Brch_000003 (box)" in StepThru mode
 Showing "Body 3" generated by "Brch_000004 (subtract)" in StepThru mode
 Showing "Body 4" generated by "Brch_000005 (cylinder)" in StepThru mode



U-shaped Bracket — Step 5

File | Tool | NextStep | Help
Up to date | Undo
H | L | R | B | T | + | -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

Showing "Body 1" generated by "Brch_000002 (box)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (box)" in StepThru mode
Showing "Body 3" generated by "Brch_000004 (subtract)" in StepThru mode
Showing "Body 4" generated by "Brch_000005 (cylinder)" in StepThru mode
Showing "Body 5" generated by "Brch_000006 (subtract)" in StepThru mode



U-shaped Bracket — .csm File

```
# Ubracket
# written by John Dannenhoffer

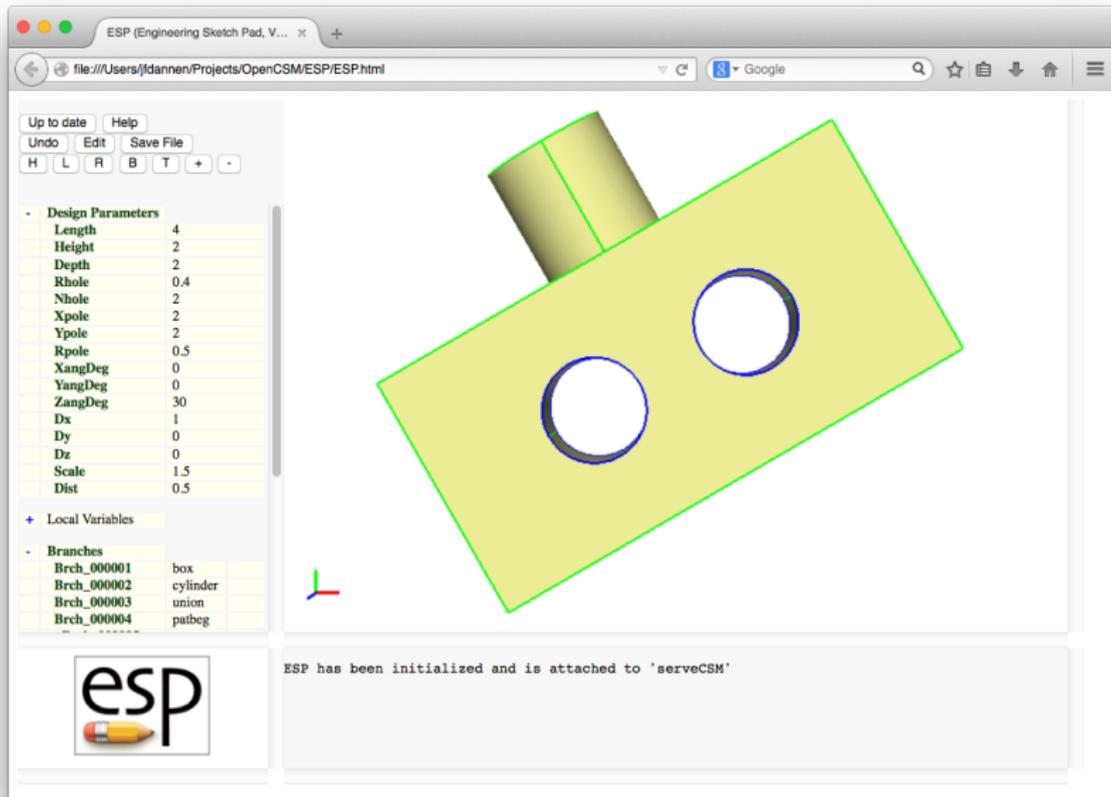
# design parameters
DESPMTR Length 4.00 # length
DESPMTR Height 3.00 # height
DESPMTR Depth 2.50 # depth
DESPMTR Dslot 2.00 # depth of slot
DESPMTR Wslot 2.00 # width of slot
DESPMTR Dhole 1.00 # diameter of hole

# bracket shape
SET thick (Length-Wslot)/2

BOX 0 0 0 Length Height Depth
BOX thick Height-Dslot 0 Length-2*thick Height Depth
SUBTRACT

# hole
CYLINDER Length/2 Height-Dhole Depth/2 \
3*Length/2 Height-Dhole Depth/2 Dhole/2
SUBTRACT

END
```



ESP (Engineering Sketch Pad, V...)

file:///Users/ldannen/Projects/OpenCSM/ESP/ESP.html

Up to date | Help

Undo | Edit | Save File

H | L | R | B | T | + | -

- Design Parameters

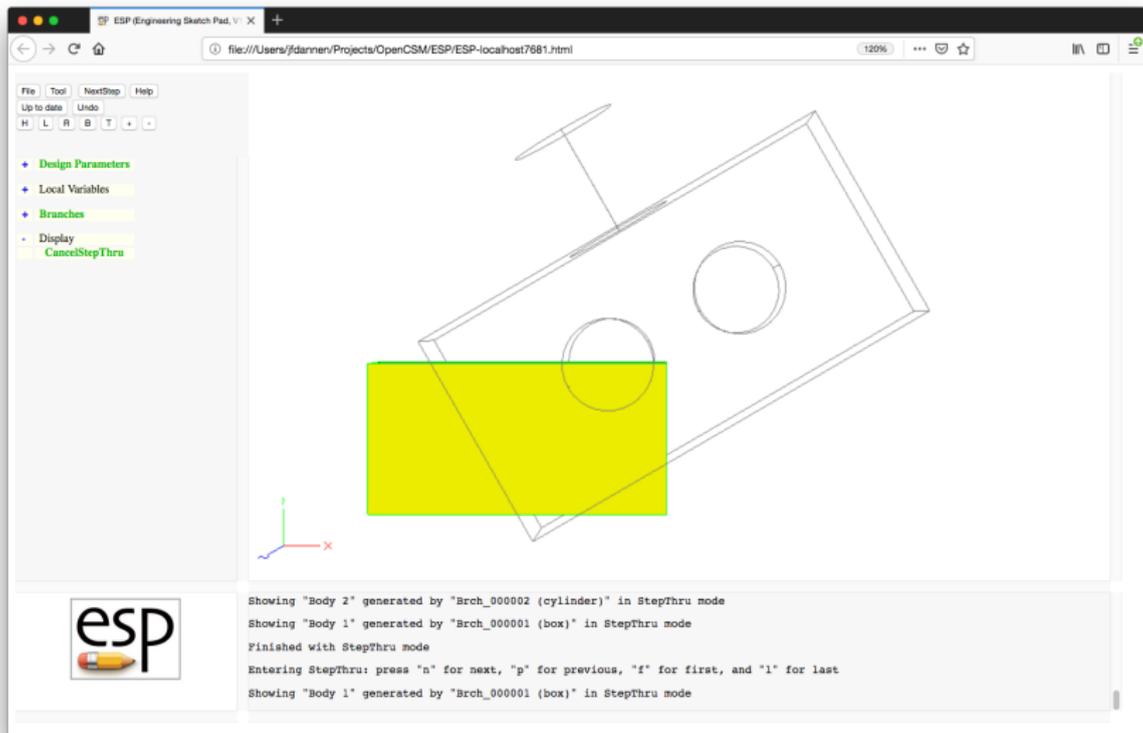
Length	4
Height	2
Depth	2
Rhole	0.4
Nhole	2
Xpole	2
Ypole	2
Rpole	0.5
XangDeg	0
YangDeg	0
ZangDeg	30
Dx	1
Dy	0
Dz	0
Scale	1.5
Dist	0.5
- Local Variables
- Branches

Brch_000001	box
Brch_000002	cylinder
Brch_000003	union
Brch_000004	patbeg

ESP has been initialized and is attached to 'serveCSM'

Box		
Length	length of box	4.0
Height	height of box	2.0
Depth	depth of box anchored at $X = Z = 0$ centered at $Y = 0$	2.0
Holes		
Rhole	radii of the holes	0.4
Nhole	number of holes holes are equally spaced	2
Pole		
Xpole	X -location of top of pole	2.0
Ypole	Y -location of top of pole	2.0
Rpole	radius of pole	0.5

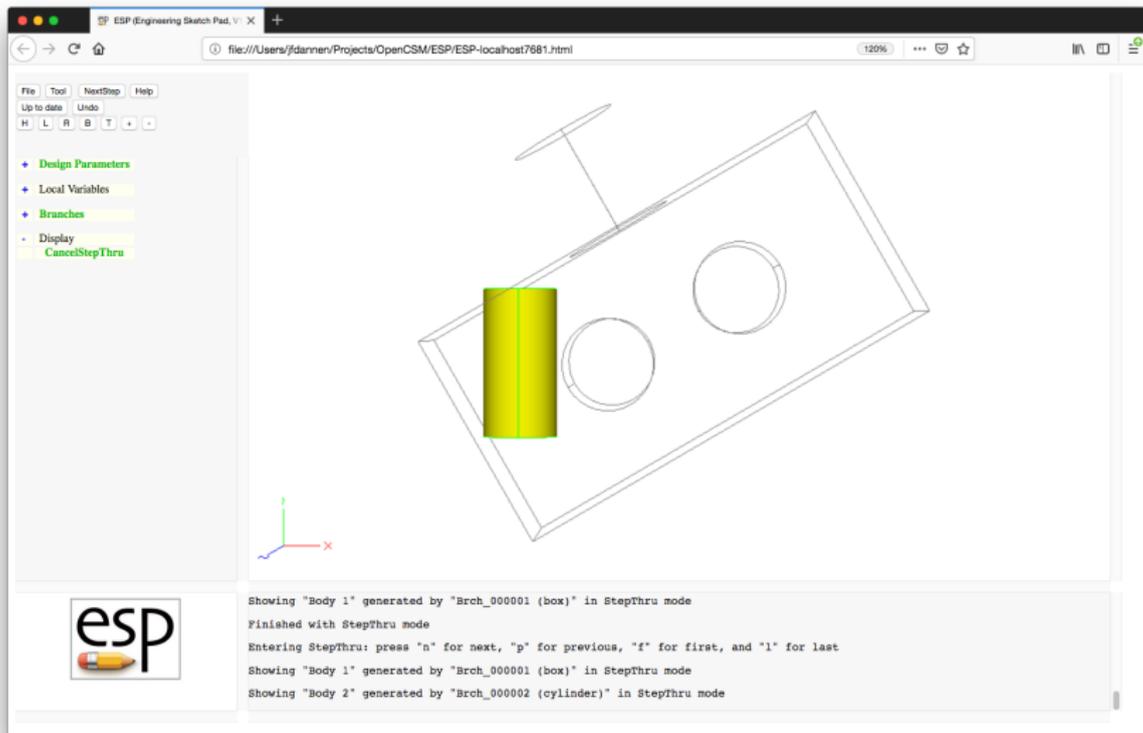
Rotation about origin		
XangDeg	<i>X</i> rotation (deg)	0.
YangDeg	<i>Y</i> rotation (deg)	0.
ZangDeg	<i>Z</i> rotation (deg)	30.
Translation		
Dx		1.0
Dy		0.0
Dz		0.0
Scaling		
Scale	overall scaling factor	1.5



File | Tool | NextStep | Help
 Up to date | Undo
 H | L | R | B | T | + | -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

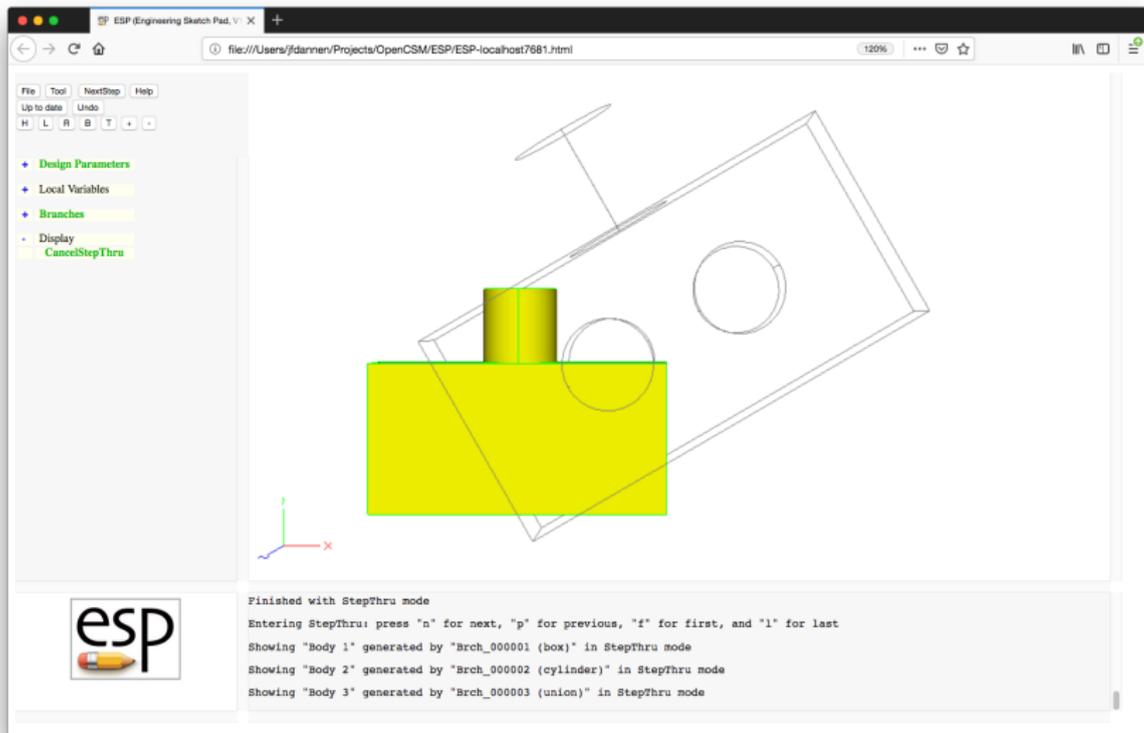
Showing "Body 2" generated by "Brch_000002 (cylinder)" in StepThru mode
 Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode
 Finished with StepThru mode
 Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
 Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode



The screenshot shows the ESP (Engineering Sketch Pad) software interface. The main window displays a 3D model of a rectangular box with a yellow cylinder inside. The interface includes a menu bar (File, Tool, NextStep, Help), a toolbar (Up to date, Undo, H, L, R, B, T, +, -), and a left sidebar with design parameters (Design Parameters, Local Variables, Branches, Display, CancelStepThru). The bottom status bar shows a log of actions:

```

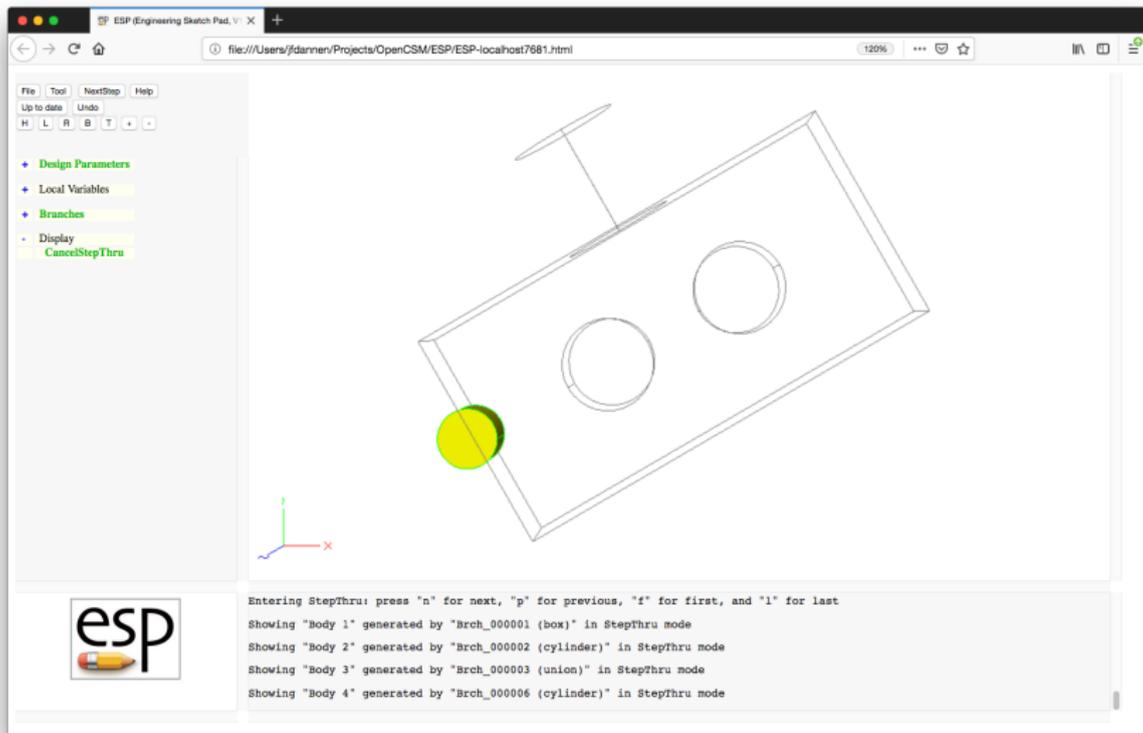
Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode
Finished with StepThru mode
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode
Showing "Body 2" generated by "Brch_000002 (cylinder)" in StepThru mode
  
```



File | Tool | NextStep | Help
 Up to date | Undo
 H | L | R | B | T | + | -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

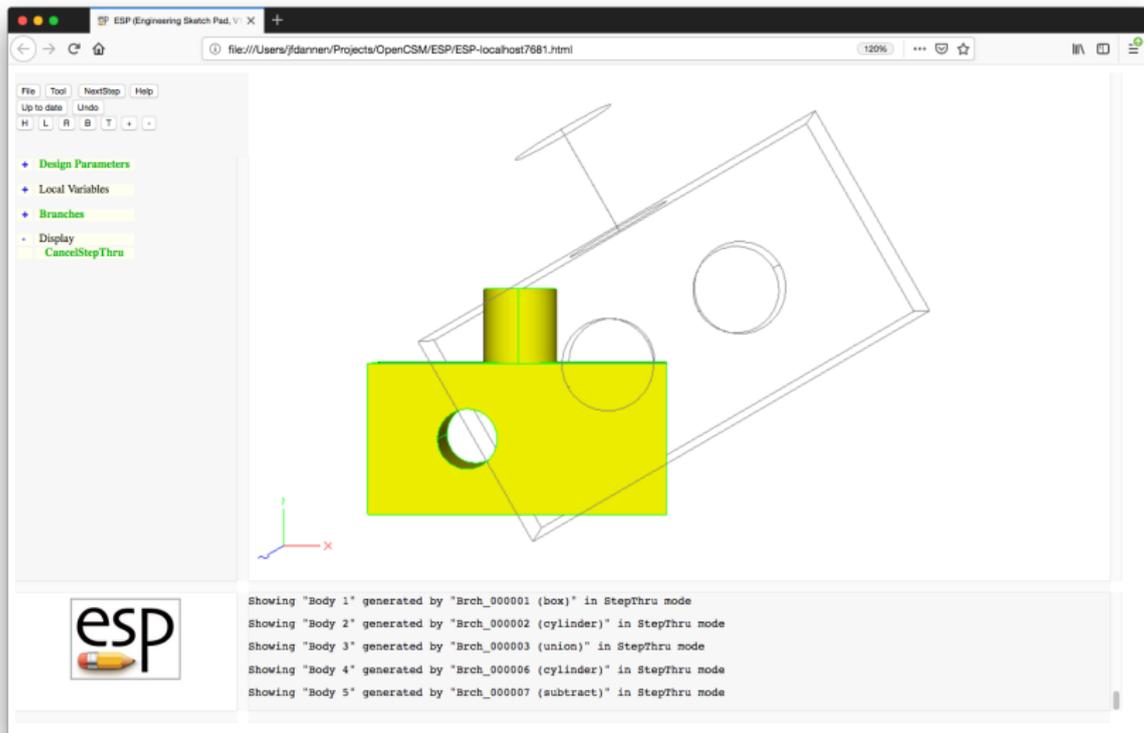
Finished with StepThru mode
 Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
 Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode
 Showing "Body 2" generated by "Brch_000002 (cylinder)" in StepThru mode
 Showing "Body 3" generated by "Brch_000003 (union)" in StepThru mode



File Tool NextStep Help
 Up to date Undo
 H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

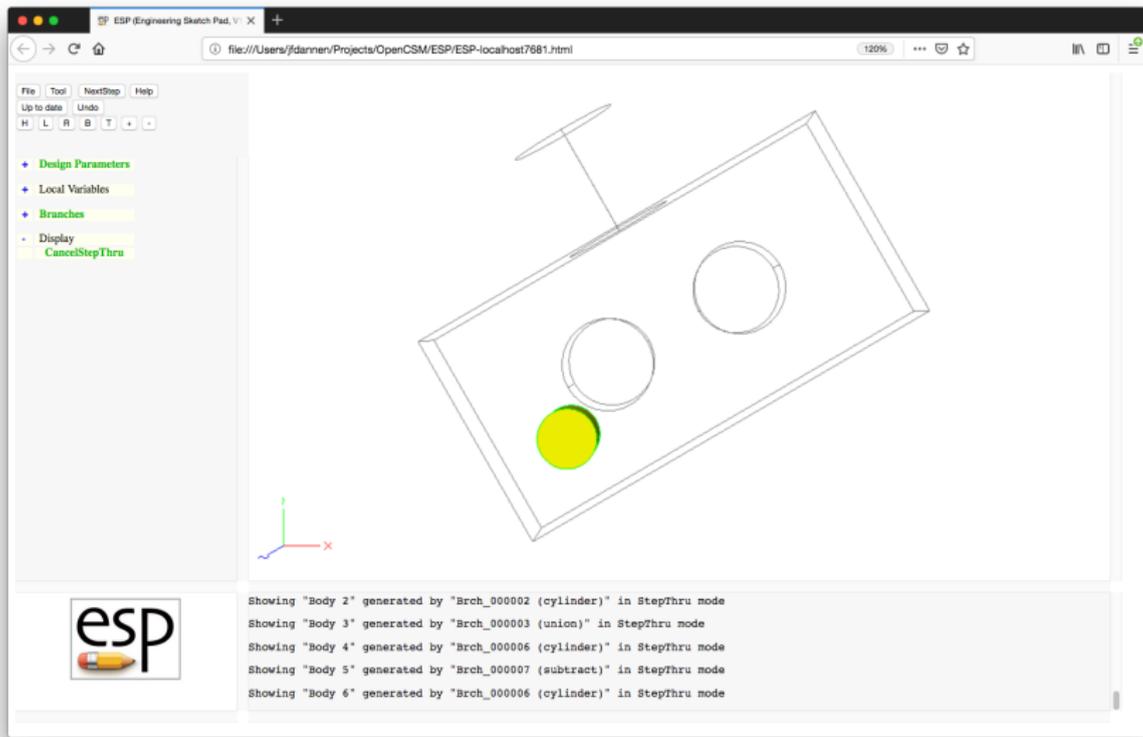
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
 Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode
 Showing "Body 2" generated by "Brch_000002 (cylinder)" in StepThru mode
 Showing "Body 3" generated by "Brch_000003 (union)" in StepThru mode
 Showing "Body 4" generated by "Brch_000006 (cylinder)" in StepThru mode



File Tool NextStep Help
Up to date Undo
H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

Showing "Body 1" generated by "Brch_000001 (box)" in StepThru mode
Showing "Body 2" generated by "Brch_000002 (cylinder)" in StepThru mode
Showing "Body 3" generated by "Brch_000003 (union)" in StepThru mode
Showing "Body 4" generated by "Brch_000006 (cylinder)" in StepThru mode
Showing "Body 5" generated by "Brch_000007 (subtract)" in StepThru mode

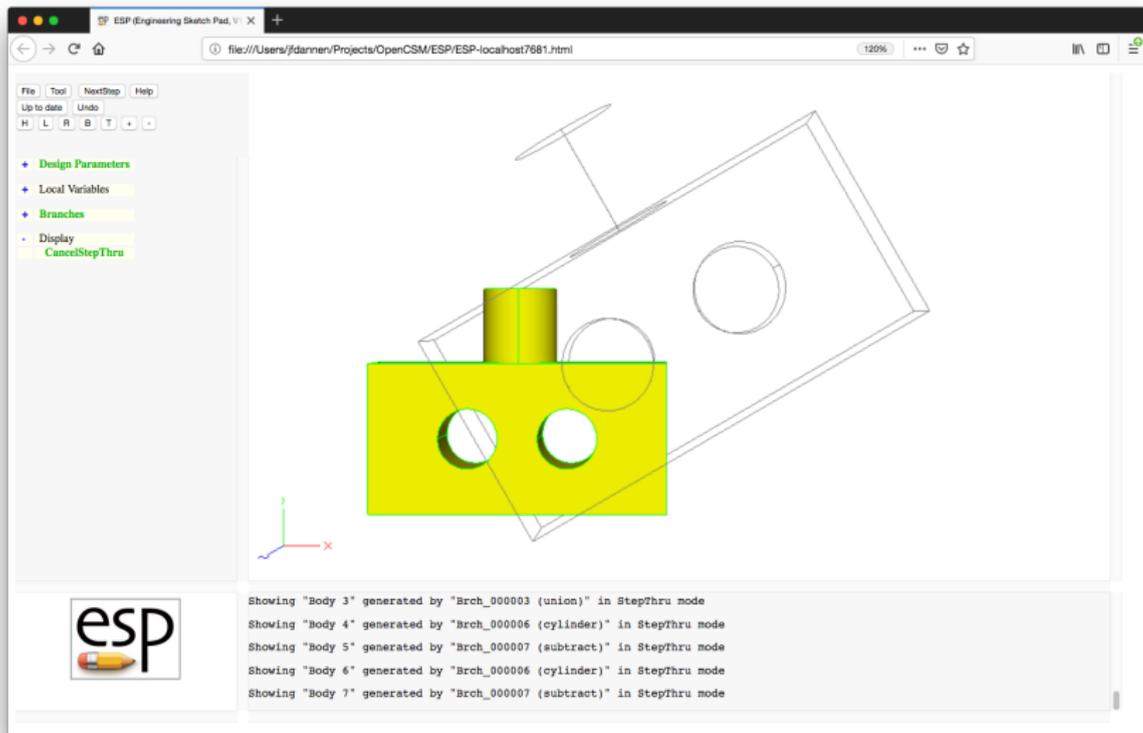


The screenshot displays the ESP (Engineering Sketch Pad) software interface. The main window shows a 3D model of a rectangular block with a circular hole and a cylindrical protrusion. The interface includes a menu bar (File, Tool, NextStep, Help), a toolbar (Up to date, Undo, H, L, R, B, T, +, -), and a status bar at the bottom. The status bar contains the ESP logo and a list of bodies generated in StepThru mode.

File Tool NextStep Help
 Up to date Undo
 H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

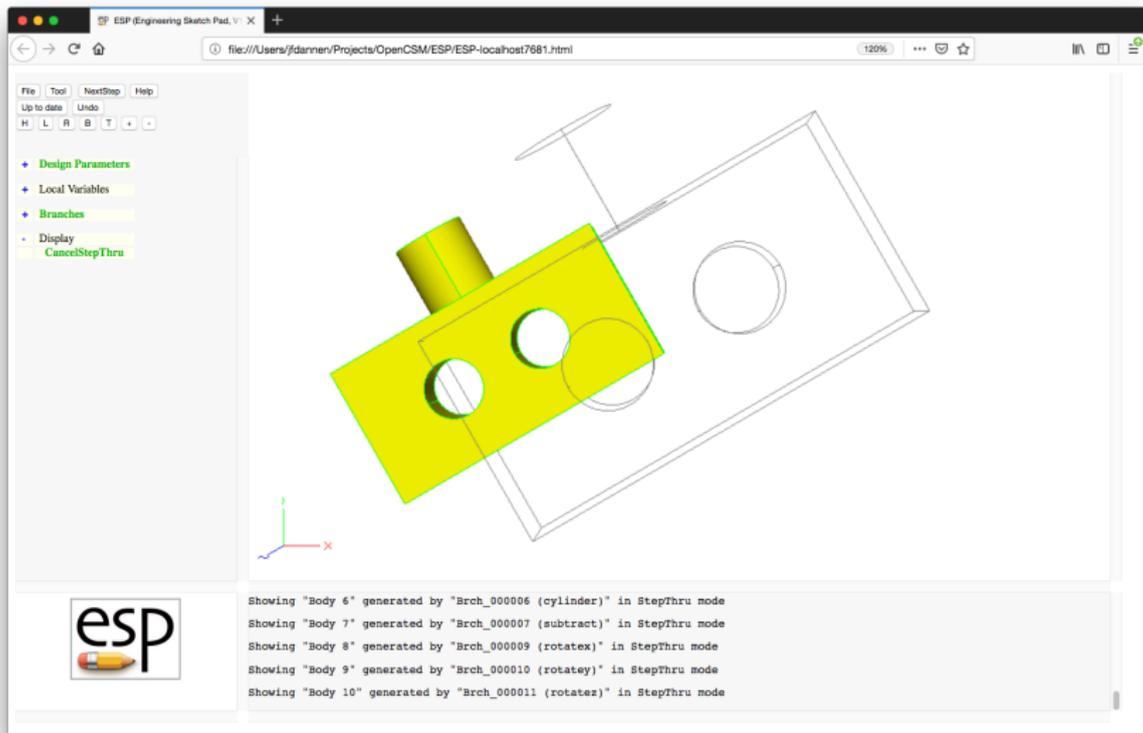
Showing "Body 2" generated by "Brch_000002 (cylinder)" in StepThru mode
 Showing "Body 3" generated by "Brch_000003 (union)" in StepThru mode
 Showing "Body 4" generated by "Brch_000006 (cylinder)" in StepThru mode
 Showing "Body 5" generated by "Brch_000007 (subtract)" in StepThru mode
 Showing "Body 6" generated by "Brch_000006 (cylinder)" in StepThru mode



File Tool NextStep Help
Up to date Undo
H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

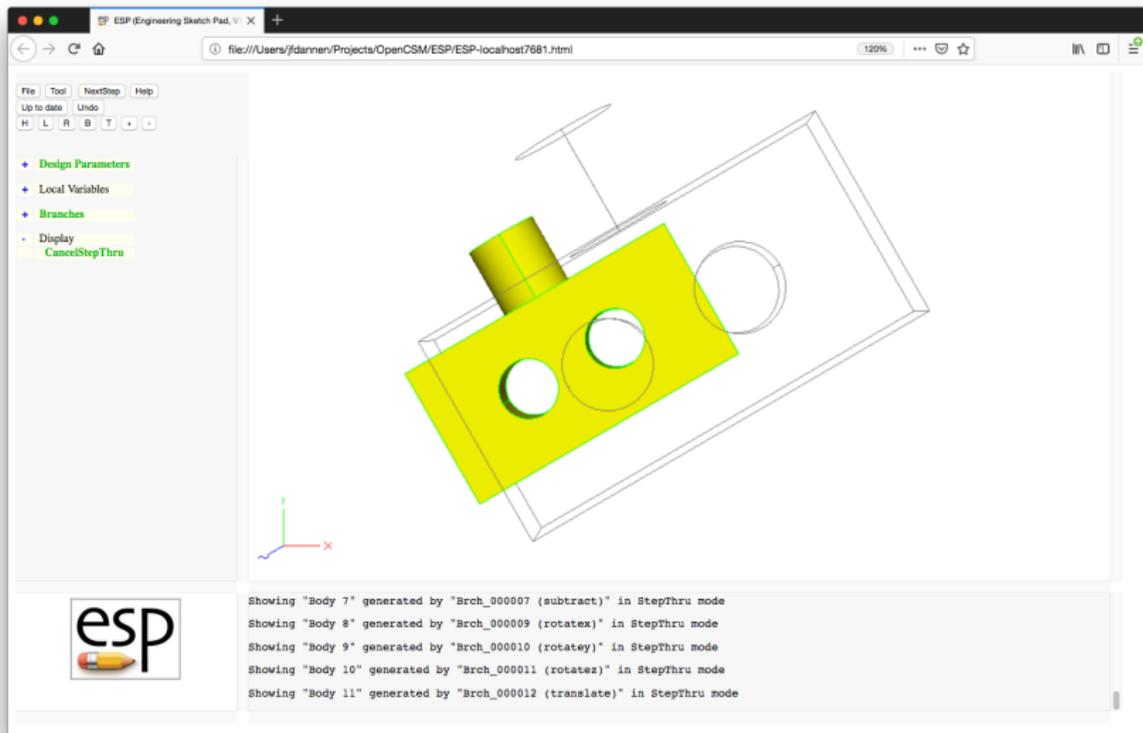
Showing "Body 3" generated by "Brch_000003 (union)" in StepThru mode
Showing "Body 4" generated by "Brch_000006 (cylinder)" in StepThru mode
Showing "Body 5" generated by "Brch_000007 (subtract)" in StepThru mode
Showing "Body 6" generated by "Brch_000006 (cylinder)" in StepThru mode
Showing "Body 7" generated by "Brch_000007 (subtract)" in StepThru mode



File | Tool | NextStep | Help
 Up to date | Undo
 H | L | R | B | T | + | -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

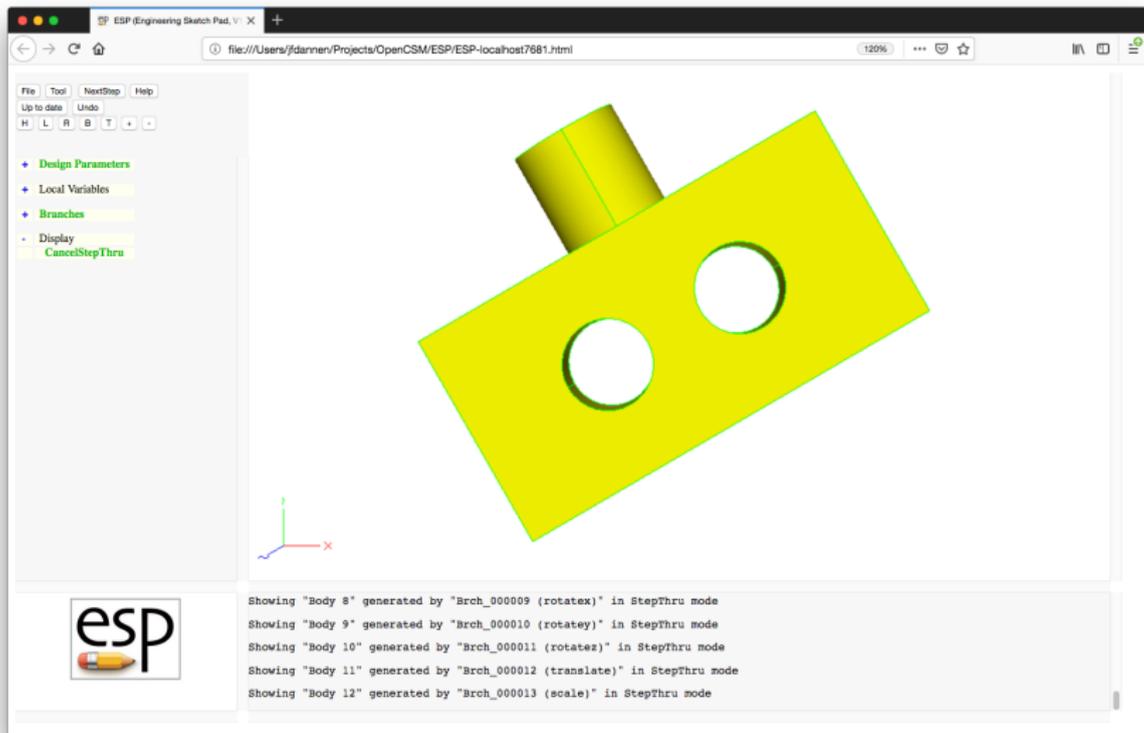
Showing "Body 6" generated by "Brch_000006 (cylinder)" in StepThru mode
 Showing "Body 7" generated by "Brch_000007 (subtract)" in StepThru mode
 Showing "Body 8" generated by "Brch_000009 (rotatex)" in StepThru mode
 Showing "Body 9" generated by "Brch_000010 (rotatay)" in StepThru mode
 Showing "Body 10" generated by "Brch_000011 (rotatex)" in StepThru mode



File Tool NextStep Help
Up to date Undo
H L R B T + -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

Showing "Body 7" generated by "Brch_000007 (subtract)" in StepThru mode
Showing "Body 8" generated by "Brch_000009 (rotatex)" in StepThru mode
Showing "Body 9" generated by "Brch_000010 (rotatey)" in StepThru mode
Showing "Body 10" generated by "Brch_000011 (rotatez)" in StepThru mode
Showing "Body 11" generated by "Brch_000012 (translate)" in StepThru mode



File | Tool | NextStep | Help
 Up to date | Undo
 H | L | R | B | T | + | -

- + Design Parameters
- + Local Variables
- + Branches
- Display
 - CancelStepThru

Showing "Body 8" generated by "Brch_000009 (rotatex)" in StepThru mode
 Showing "Body 9" generated by "Brch_000010 (rotatex)" in StepThru mode
 Showing "Body 10" generated by "Brch_000011 (rotatex)" in StepThru mode
 Showing "Body 11" generated by "Brch_000012 (translate)" in StepThru mode
 Showing "Body 12" generated by "Brch_000013 (scale)" in StepThru mode



Simple Block — .csm File (1)

```
# block
# written by John Dannenhoffer
```

```
DESPMTR Length 4.0
DESPMTR Height 2.0
DESPMTR Depth 2.0
DESPMTR Rhole 0.4
DESPMTR Nhole 2
DESPMTR Xpole 2.0
DESPMTR Ypole 2.0
DESPMTR Rpole 0.5
DESPMTR XangDeg 0.
DESPMTR YangDeg 0.
DESPMTR ZangDeg 30.
DESPMTR Dx 1.0
DESPMTR Dy 0.0
DESPMTR Dz 0.0
DESPMTR Scale 1.5
DESPMTR Dist 0.5
```

```
# base block
```

```
BOX 0.0 -Height/2 0.0 Length Height Depth
```



Simple Block — .csm File (2)

```
# post
CYLINDER Xpole      0.0      Depth/2  Xpole      Ypole      Depth/2  Rpole
UNION

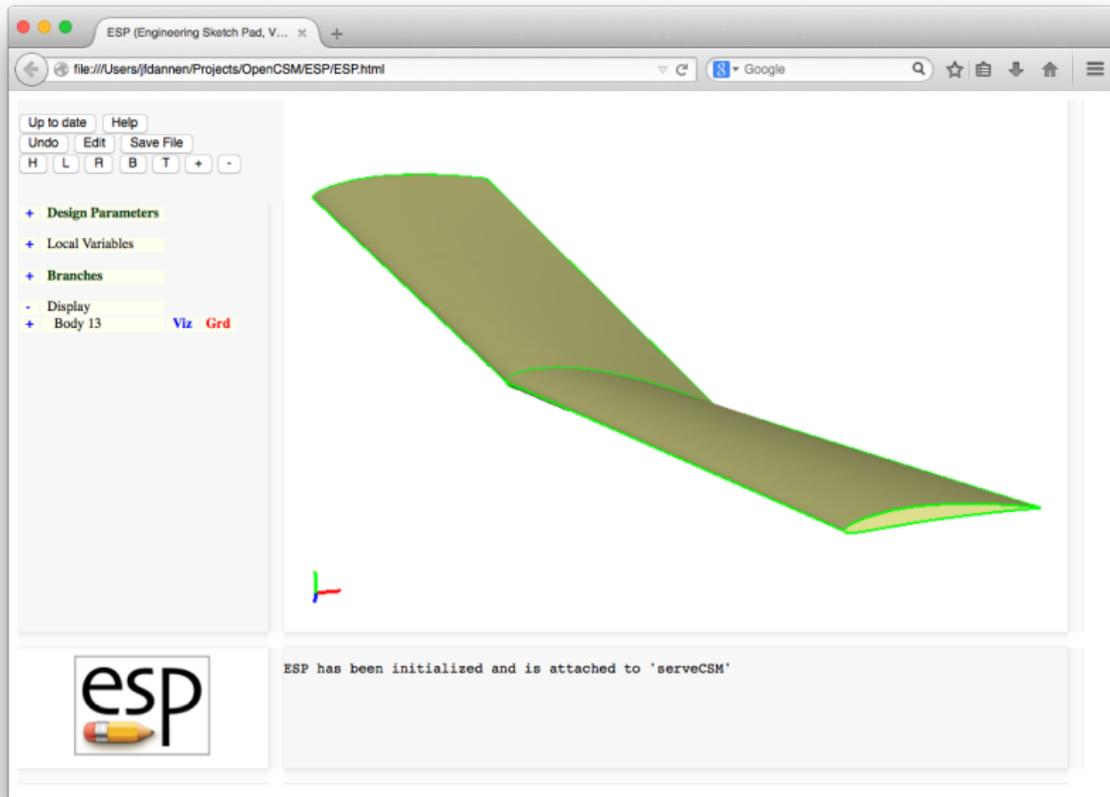
# Nhole holes
PATBEG   ihole      Nhole
      SET      xhole  Length*ihole/(Nhole+1)
      CYLINDER xhole  0.0      0.0      xhole      0.0      Depth      Rhole
SUBTRACT
PATEND

# transformations
ROTATEX  XangDeg    0.0      0.0
ROTATEY  YangDeg    0.0      0.0
ROTATEZ  ZangDeg    0.0      0.0
TRANSLATE Dx        Dy        Dz
SCALE    Scale

END
```

Session 3 Solutions

Solids Fundamentals (2)



The screenshot shows the ESP (Engineering Sketch Pad) web application interface. The browser window title is "ESP (Engineering Sketch Pad, V...". The address bar shows the file path: "file:///Users/ldannen/Projects/OpenCSM/ESP/ESP.html". The browser's search bar contains "Google".

The interface includes a toolbar with buttons for "Up to date", "Help", "Undo", "Edit", and "Save File". Below the toolbar are navigation buttons: "H", "L", "R", "B", "T", "+", and "-".

The left sidebar contains a tree view with the following items:

- + Design Parameters
- + Local Variables
- + Branches
- Display
- + Body 13 Viz Grd

The main workspace displays a 3D model of a wing, rendered in a dark green color with a bright green outline. A small 3D coordinate system (red, green, blue axes) is visible in the bottom-left corner of the workspace.

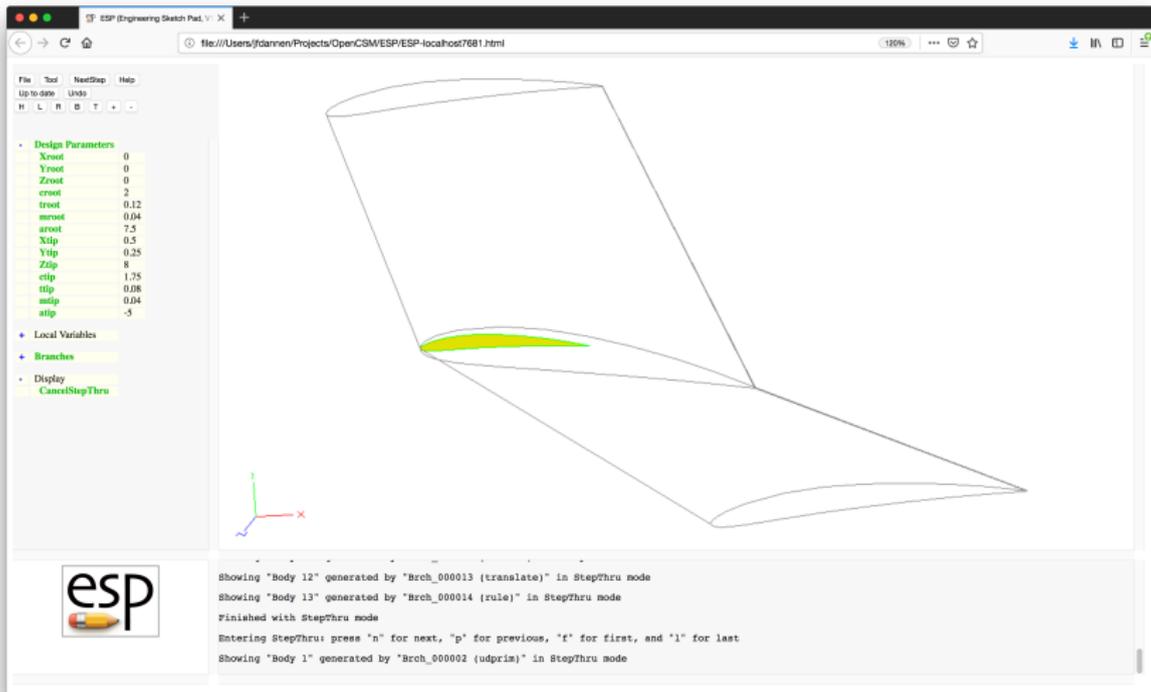
At the bottom left of the interface is the "esp" logo, which consists of the lowercase letters "esp" next to a stylized pencil icon.

The bottom right of the interface features a status bar with the text: "ESP has been initialized and is attached to 'serveCSM'".

Xroot	X-coordinate of root leading edge	0.00
Yroot	Y-coordinate of root leading edge	0.00
Zroot	Z-coordinate of root leading edge	0.00
croot	chord of root	2.00
troot	thickness/chord of root	0.12
mroot	camber/chord of root	0.04
aroot	angle of attack of root (deg)	7.50
Xtip	X-coordinate of tip leading edge	0.50
Ytip	Y-coordinate of tip leading edge	0.25
Ztip	Z-coordinate of tip leading edge	8.00
ctip	chord of tip	1.75
ttip	thickness/chord of tip	0.08
mtip	camber/chord of tip	0.04
atip	angle of attack of tip (deg)	-5.00

- What happens if you switch from RULE to BLEND?
- What happens if we change the sequence of transformations from SCALE, ROTATEZ, TRANSLATE to ROTATEZ, SCALE, TRANSLATE?
- What happens if we do the TRANSLATE first?
- Could you change the Design Parameters to `area`, `aspectRatio`, `taperRatio`, `sweep`, and `twist`?

$$AR = \frac{b^2}{S} \quad S = b(c_{\text{tip}} + c_{\text{root}})/2 \quad \tau = \frac{c_{\text{tip}}}{c_{\text{root}}}$$

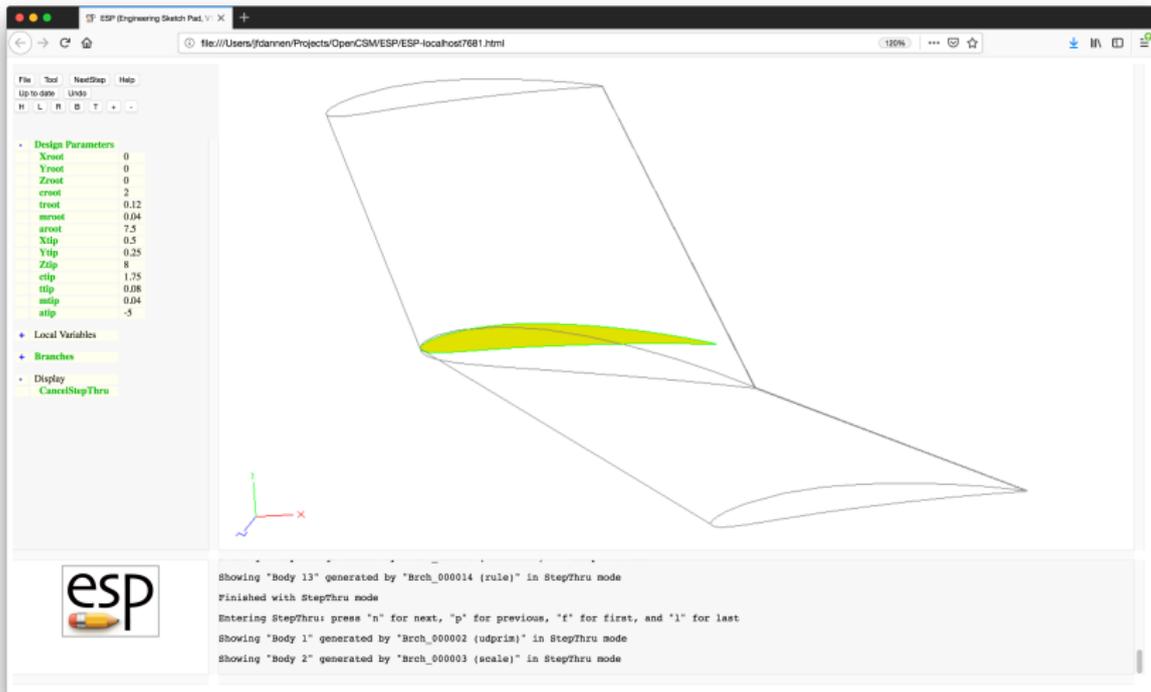


File | Tool | NextStep | Help
Up to date Undo
H L R B T + -

- Design Parameters

Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
srroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
stip	-5
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 12" generated by "Brch_000013 (translate)" in StepThru mode
Showing "Body 13" generated by "Brch_000014 (rule)" in StepThru mode
Finished with StepThru mode
Entering StepThru: press 'n' for next, 'p' for previous, 'f' for first, and 'l' for last
Showing "Body 1" generated by "Brch_000002 (udprim)" in StepThru mode



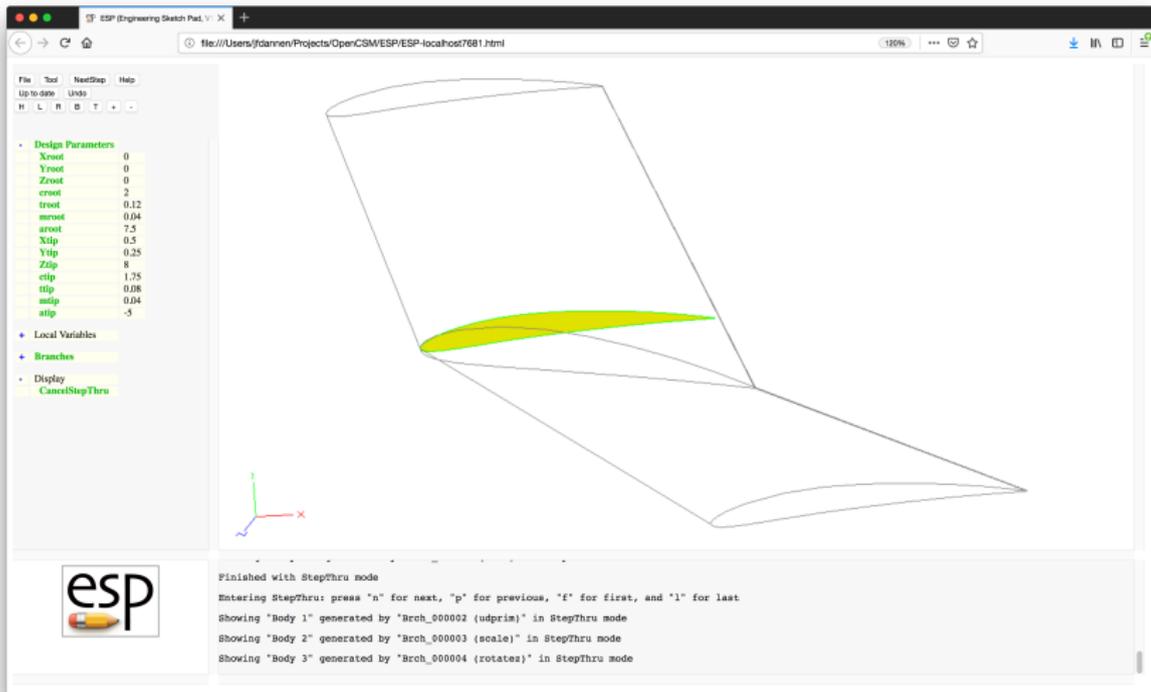
The screenshot shows the ESP Engineering Sketch Pad interface. The main window displays a 3D wireframe model of a wing with a yellow-green shaded surface. The left sidebar contains a 'Design Parameters' list:

- Xroot: 0
- Yroot: 0
- Zroot: 0
- crroot: 2
- trroot: 0.12
- mrroot: 0.04
- aroot: 7.5
- Xtip: 0.5
- Ytip: 0.25
- Ztip: 8
- ctip: 1.75
- ttip: 0.08
- mtip: 0.04
- atip: -5

Below the parameters are sections for 'Local Variables', 'Branches', and 'Display' (with 'CancelStepThru' checked). The bottom status bar shows the following text:

```

Showing "Body 13" generated by "Brch_000014 (rule)" in StepThru mode
Finished with StepThru mode
Entering StepThru press 'n' for next, 'p' for previous, 'f' for first, and 'l' for last
Showing "Body 1" generated by "Brch_000002 (udprim)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (scale)" in StepThru mode
    
```



The screenshot shows the ESP Engineering Sketch Pad interface. The main window displays a 3D wireframe model of a wing with a yellow-green surface. The left sidebar contains a 'Design Parameters' list:

- Design Parameters
 - Xroot 0
 - Yroot 0
 - Zroot 0
 - crroot 2
 - trroot 0.12
 - srroot 0.04
 - aroot 7.5
 - Xtip 0.5
 - Ytip 0.25
 - Ztip 8
 - ctip 1.75
 - ctip 0.08
 - mtip 0.04
 - atip -5
- Local Variables
- Branches
- Display
 - CancelStepThru

The bottom status bar shows the following text:

```

Finished with StepThru mode
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000002 (udpris)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (scale)" in StepThru mode
Showing "Body 3" generated by "Brch_000004 (rotates)" in StepThru mode
  
```



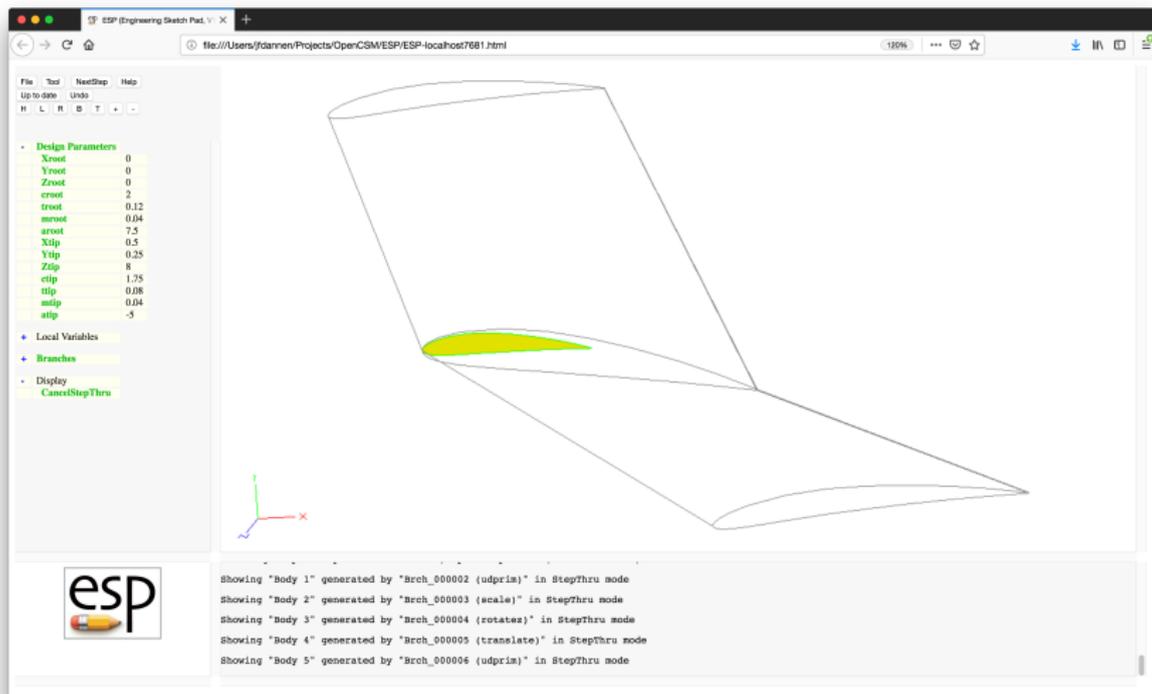
Simple Wing — Step 4

The screenshot shows the ESP Engineering Sketch Pad interface. The main window displays a 3D model of a wing with a yellow-green top surface. The left sidebar contains a 'Design Parameters' list:

- Design Parameters
 - Xroot 0
 - Yroot 0
 - Zroot 0
 - crroot 2
 - trroot 0.12
 - srroot 0.04
 - aroot 7.5
 - Xtip 0.5
 - Ytip 0.25
 - Ztip 8
 - ctip 1.75
 - ctip 0.08
 - mtip 0.04
 - stip -5
- Local Variables
- Branches
- Display
 - CancelStepThru

Below the parameters is a small 3D coordinate system icon. At the bottom of the window, there is a console area with the ESP logo and the following text:

```
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000002 (udprim)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (scale)" in StepThru mode
Showing "Body 3" generated by "Brch_000004 (rotatez)" in StepThru mode
Showing "Body 4" generated by "Brch_000005 (translate)" in StepThru mode
```



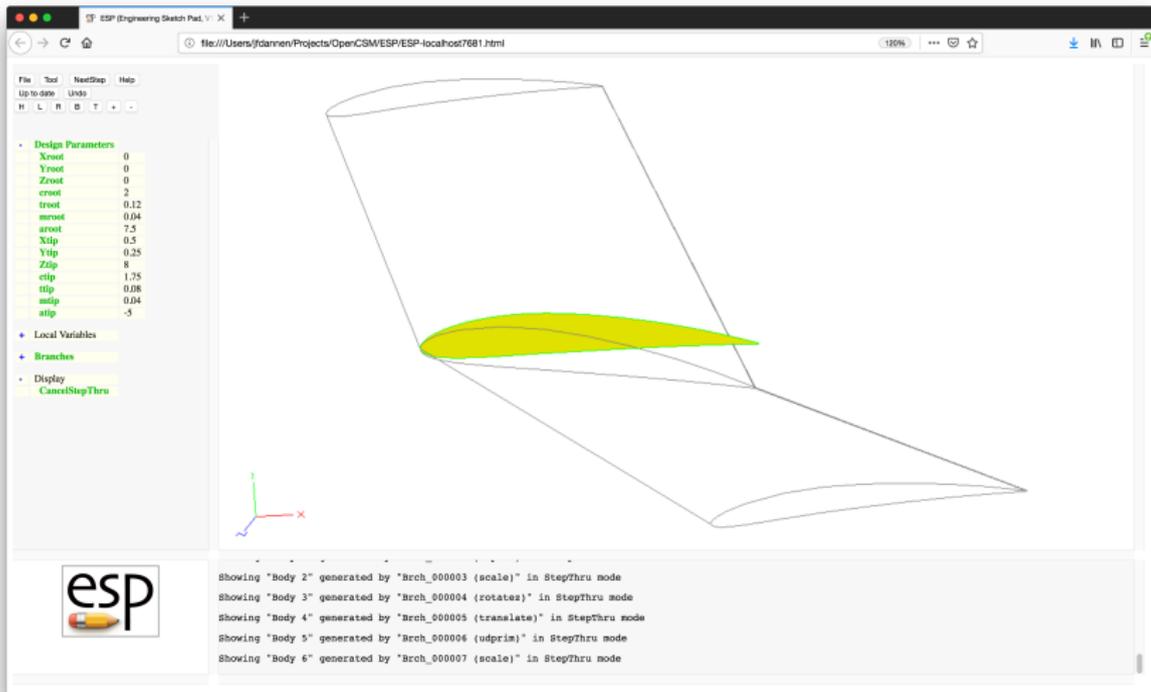
The screenshot shows the ESP Engineering Sketch Pad interface. The main window displays a 3D wireframe model of a wing with a yellow-green shaded airfoil section. The left sidebar contains a 'Design Parameters' list with the following values:

Parameter	Value
Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
mrroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
stip	-5

Below the parameters are sections for 'Local Variables', 'Branches', and 'Display' (with 'CancelStepThru' checked). At the bottom of the interface, a log shows the following messages:

```

Showing "Body 1" generated by "Brch_000002 (udprim)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (scale)" in StepThru mode
Showing "Body 3" generated by "Brch_000004 (rotates)" in StepThru mode
Showing "Body 4" generated by "Brch_000005 (translate)" in StepThru mode
Showing "Body 5" generated by "Brch_000006 (udprim)" in StepThru mode
  
```

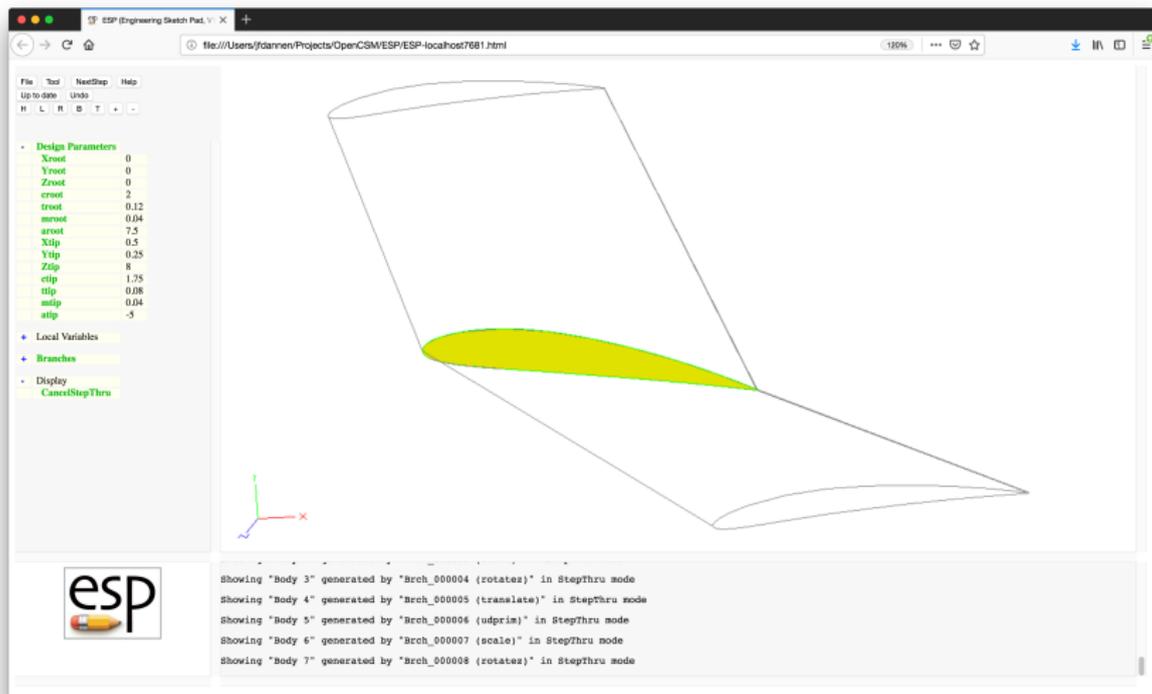


The screenshot displays the ESP Engineering Sketch Pad interface. The main window shows a 3D model of a wing, which is highlighted in yellow. The wing is shown within a wireframe bounding box. The interface includes a menu bar (File, Tool, NextStep, Help), a toolbar, and a browser address bar showing the file path: file:///Users/foannen/Projects/Open-CSM/ESP/ESP-localhost7681.html. The left sidebar contains a tree view with sections for Design Parameters, Local Variables, Branches, and Display. The Design Parameters section lists various parameters and their values.

Parameter	Value
Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
mrroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
atip	-5

The bottom of the interface shows a list of bodies and their generation methods:

- Showing "Body 2" generated by "Brch_000003 (scale)" in StepThru mode
- Showing "Body 3" generated by "Brch_000004 (rotatez)" in StepThru mode
- Showing "Body 4" generated by "Brch_000005 (translate)" in StepThru mode
- Showing "Body 5" generated by "Brch_000006 (udprim)" in StepThru mode
- Showing "Body 6" generated by "Brch_000007 (scale)" in StepThru mode



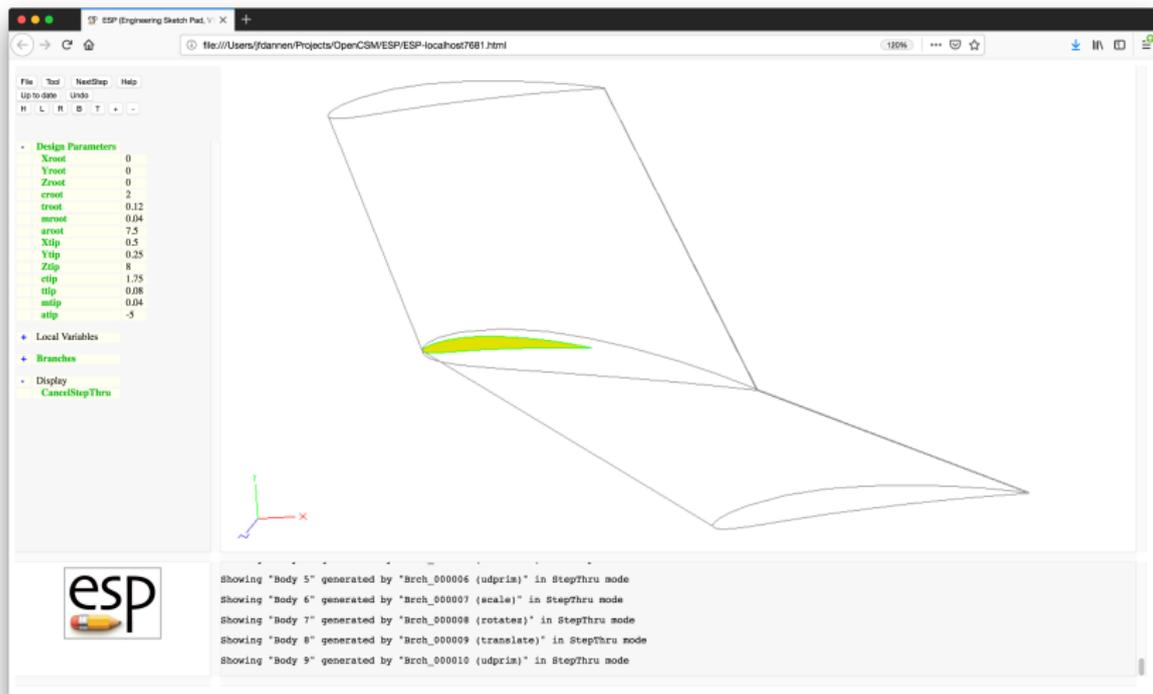
The screenshot displays the ESP Engineering Sketch Pad interface. The main window shows a 3D model of a wing, which is highlighted in yellow. The wing is positioned within a wireframe bounding box. The interface includes a menu bar (File, Tool, NextStep, Help), a toolbar, and a browser address bar showing the file path: file:///Users/foannen/Projects/Open-CSM/ESP/ESP-localhost7681.html. The left sidebar contains a tree view with sections for Design Parameters, Local Variables, Branches, and Display. The Design Parameters section lists various parameters and their values.

Parameter	Value
Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
srroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ctip	0.08
mtip	0.04
stip	-5

Below the 3D model is a small 3D coordinate system with red, green, and blue axes. At the bottom of the interface, there is a console window displaying the following text:

```

Showing "Body 3" generated by "Brch_000004 (rotates)" in StepThru mode
Showing "Body 4" generated by "Brch_000005 (translate)" in StepThru mode
Showing "Body 5" generated by "Brch_000006 (udpri)" in StepThru mode
Showing "Body 6" generated by "Brch_000007 (scale)" in StepThru mode
Showing "Body 7" generated by "Brch_000008 (rotates)" in StepThru mode
  
```



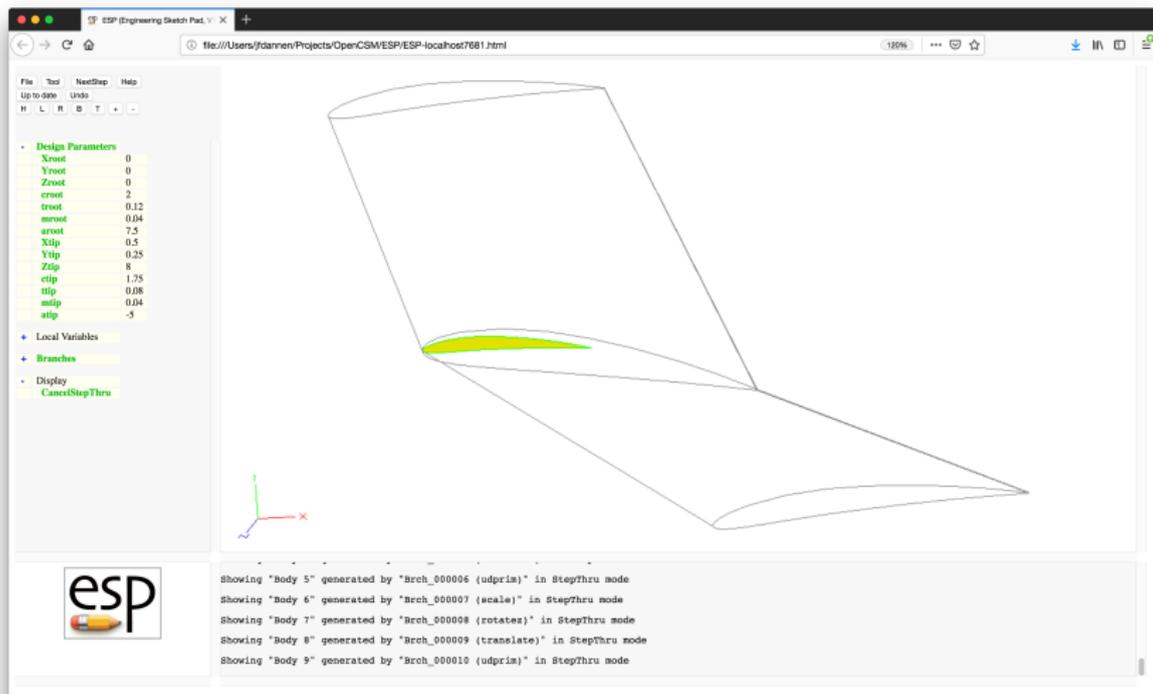
The screenshot displays the ESP Engineering Sketch Pad interface. The main window shows a 3D wireframe model of a wing with a yellow-green shaded airfoil section. The left sidebar contains a 'Design Parameters' list with the following values:

Parameter	Value
Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
mrroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
atip	-5

Below the parameters are sections for 'Local Variables', 'Branches', and 'Display', with 'CancelStepThru' listed under 'Display'. At the bottom of the interface, a log shows the following messages:

```

Showing "Body 5" generated by "Brch_000006 (udprim)" in StepThru mode
Showing "Body 6" generated by "Brch_000007 (scale)" in StepThru mode
Showing "Body 7" generated by "Brch_000008 (rotates)" in StepThru mode
Showing "Body 8" generated by "Brch_000009 (translate)" in StepThru mode
Showing "Body 9" generated by "Brch_000010 (udprim)" in StepThru mode
  
```



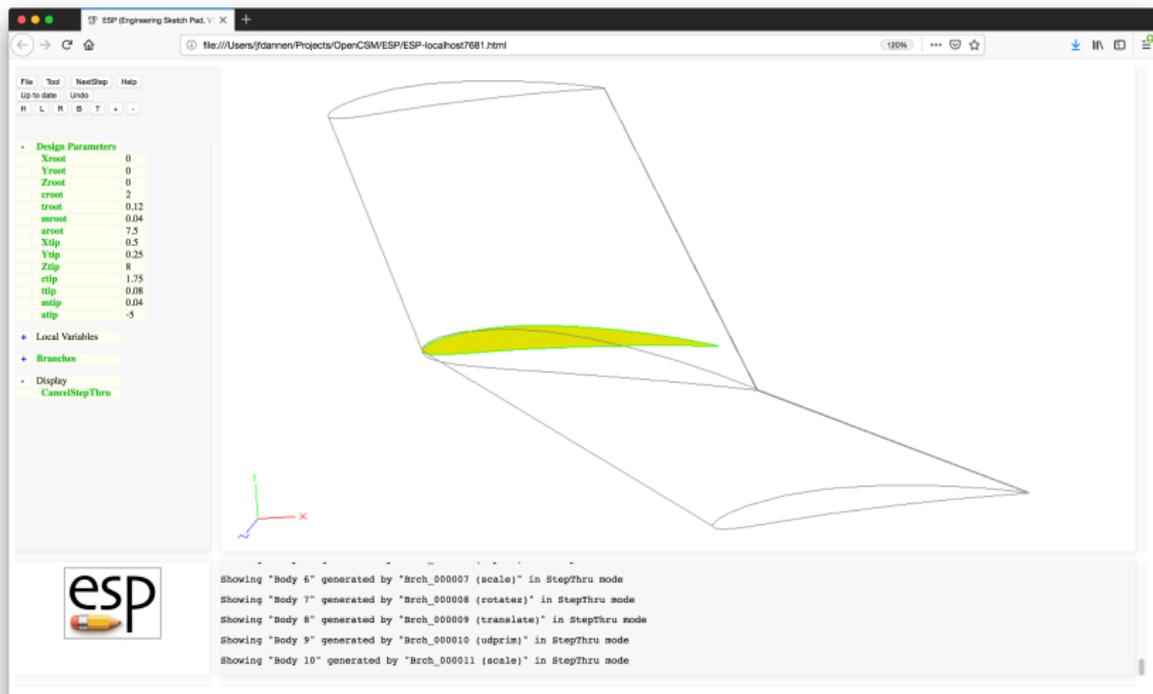
The screenshot shows the ESP Engineering Sketch Pad interface. The main window displays a 3D wireframe model of a wing with a yellow-green shaded airfoil section. The left sidebar contains a 'Design Parameters' list with the following values:

Parameter	Value
Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
mrroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
stip	-5

Below the parameters are sections for 'Local Variables', 'Branches', and 'Display', with 'CancelStepThru' listed under 'Display'. At the bottom of the interface, a log shows the following messages:

```

Showing "Body 5" generated by "Brch_000006 (udprim)" in StepThru mode
Showing "Body 6" generated by "Brch_000007 (scale)" in StepThru mode
Showing "Body 7" generated by "Brch_000008 (rotates)" in StepThru mode
Showing "Body 8" generated by "Brch_000009 (translate)" in StepThru mode
Showing "Body 9" generated by "Brch_000010 (udprim)" in StepThru mode
  
```



The screenshot displays the ESP Engineering Sketch Pad interface. The main window shows a 3D wireframe model of a wing structure. A yellow-green shaded area represents the wing's surface. The interface includes a menu bar (File, Tool, NextStep, Help), a toolbar, and a left-hand panel with sections for Design Parameters, Local Variables, Branches, and Display. A coordinate system is visible in the bottom-left corner of the 3D view.

Design Parameters

Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
mrroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
atip	-5

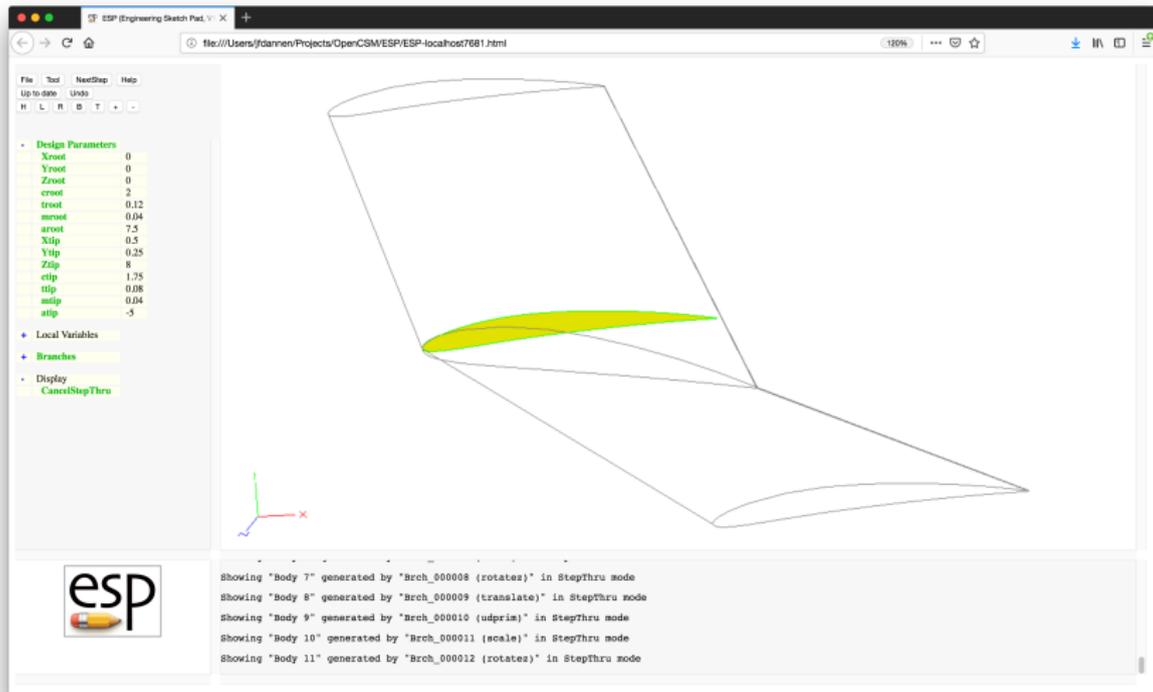
Local Variables

Branches

Display

CancelStepThru

Showing "Body 6" generated by "Brch_000007 (scale)" in StepThru mode
 Showing "Body 7" generated by "Brch_000008 (rotatez)" in StepThru mode
 Showing "Body 8" generated by "Brch_000009 (translate)" in StepThru mode
 Showing "Body 9" generated by "Brch_000010 (udprim)" in StepThru mode
 Showing "Body 10" generated by "Brch_000011 (scale)" in StepThru mode



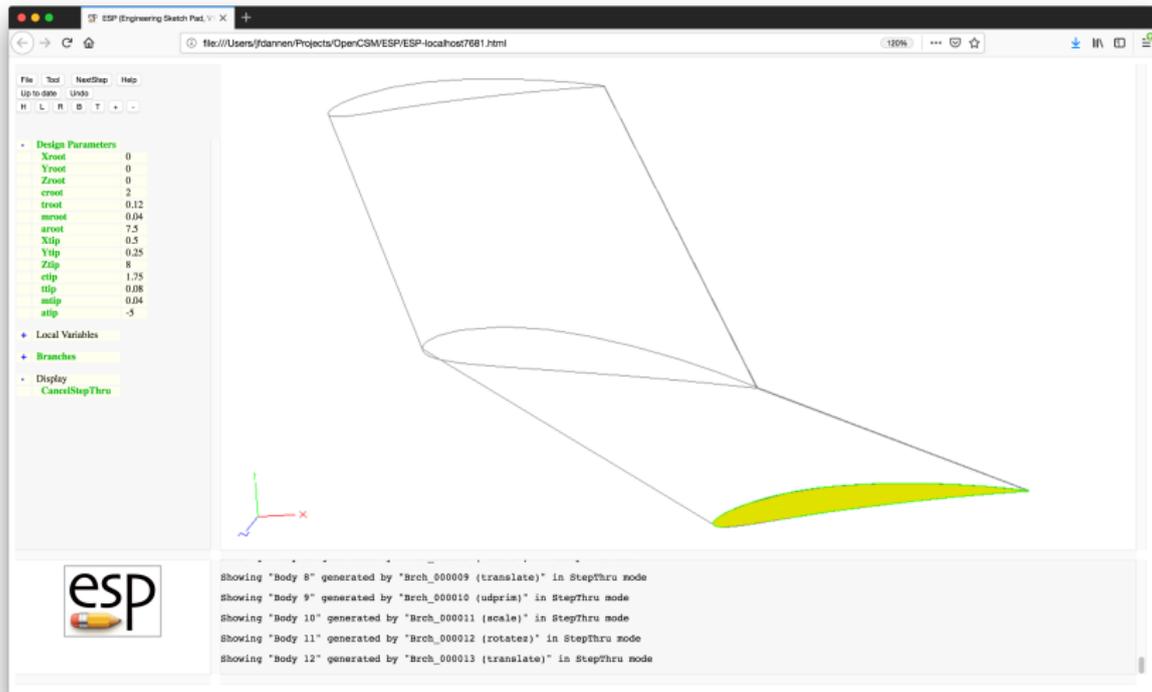
The screenshot shows the ESP Engineering Sketch Pad interface. The main window displays a 3D model of a wing, which is highlighted in yellow. The wing is shown within a wireframe bounding box. The interface includes a menu bar (File, Tool, NextStep, Help), a toolbar, and a left-hand panel with the following sections:

- Design Parameters:**

Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
mrroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
stip	-5
- Local Variables**
- Branches**
- Display**
 - CancelStepThru

At the bottom of the interface, there is a console window displaying the following text:

```
Showing "Body 7" generated by "Brch_000008 (rotatez)" in StepThru mode
Showing "Body 8" generated by "Brch_000009 (translate)" in StepThru mode
Showing "Body 9" generated by "Brch_000010 (udprism)" in StepThru mode
Showing "Body 10" generated by "Brch_000011 (scale)" in StepThru mode
Showing "Body 11" generated by "Brch_000012 (rotatez)" in StepThru mode
```

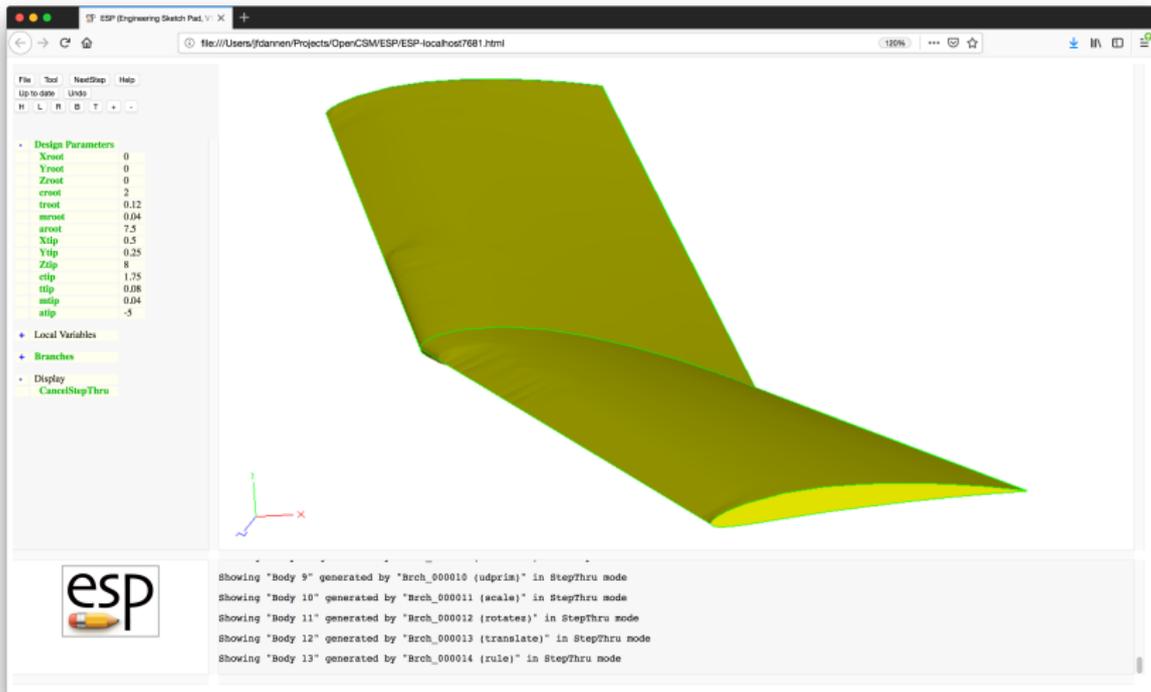


File Tool NextStep Help
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- Design Parameters

Xroot	0
Yroot	0
Zroot	0
crroot	2
trroot	0.12
srroot	0.04
aroot	7.5
Xtip	0.5
Ytip	0.25
Ztip	8
ctip	1.75
ttip	0.08
mtip	0.04
stip	-5
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 8" generated by "Brch_000009 {translate}" in StepThru mode
 Showing "Body 9" generated by "Brch_000010 {udprim}" in StepThru mode
 Showing "Body 10" generated by "Brch_000011 {scale}" in StepThru mode
 Showing "Body 11" generated by "Brch_000012 {rotatez}" in StepThru mode
 Showing "Body 12" generated by "Brch_000013 {translate}" in StepThru mode



The screenshot displays the ESP Engineering Sketch Pad interface. The main window shows a 3D model of a wing, colored in a gradient from green to yellow. The left sidebar contains a tree view with the following sections:

- Design Parameters
 - Xroot: 0
 - Yroot: 0
 - Zroot: 0
 - crroot: 2
 - trroot: 0.12
 - srroot: 0.04
 - aroot: 7.5
 - Xtip: 0.5
 - Ytip: 0.25
 - Ztip: 8
 - ctip: 1.75
 - ctip: 0.08
 - mtip: 0.04
 - stip: -5
- Local Variables
- Branches
- Display
 - CancelStepThru

At the bottom of the interface, there is a console window with the following text:

```

Showing "Body 9" generated by "Brch_000010 (udprim)" in StepThru mode
Showing "Body 10" generated by "Brch_000011 (scale)" in StepThru mode
Showing "Body 11" generated by "Brch_000012 (rotates)" in StepThru mode
Showing "Body 12" generated by "Brch_000013 (translate)" in StepThru mode
Showing "Body 13" generated by "Brch_000014 (rule)" in StepThru mode
  
```

```
# wing
# written by John Dannenhoffer

# design parameters
DESPMTR  Xroot    0.00    # X-coordinte of root leading edge
DESPMTR  Yroot    0.00    # Y-coordinte of root leading edge
DESPMTR  Zroot    0.00    # Z-coordinte of root leading edge
DESPMTR  croot    2.00    # chord of root
DESPMTR  troot    0.12    # thickness/chord of root
DESPMTR  mroot    0.04    # camber/chord of root
DESPMTR  aroot    7.50    # angle of attack of root (deg)
DESPMTR  Xtip     0.50    # X-coordinte of tip leading edge
DESPMTR  Ytip     0.25    # Y-coordinte of tip leading edge
DESPMTR  Ztip     8.00    # Z-coordinte of tip leading edge
DESPMTR  ctip     1.75    # chord of tip
DESPMTR  ttip     0.08    # thickness/chord of tip
DESPMTR  mtip     0.04    # camber/chord of tip
DESPMTR  atip     -5.00    # angle of attack of tip (deg)
```

MARK

```
# rite wing tip
UDPRIM   naca   thickness  ttip   camber  mtip
SCALE    ctip
ROTATEZ  -atip  0         0
TRANSLATE Xtip  Ytip  -Ztip

# wing root
UDPRIM   naca   thickness  troot  camber  mroot
SCALE    croot
ROTATEZ  -aroot 0         0
TRANSLATE Xroot Yroot  Zroot

# left wing tip
UDPRIM   naca   thickness  ttip   camber  mtip
SCALE    ctip
ROTATEZ  -atip  0         0
TRANSLATE Xtip  Ytip   Ztip
```

ruled surface

RULE

END

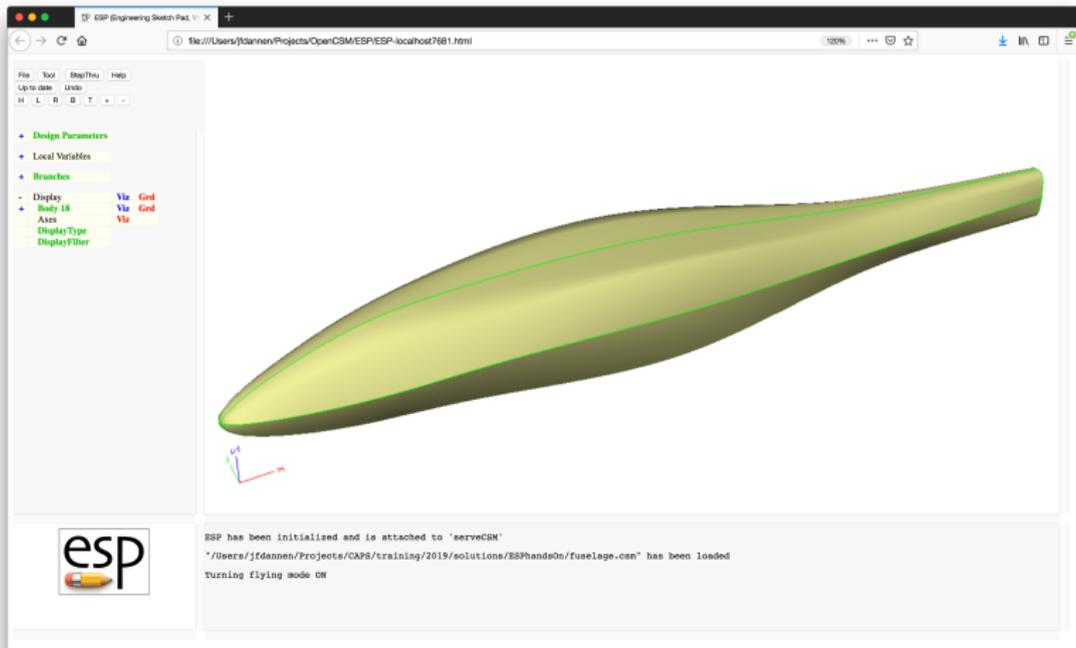


Simple Wing — Alternative DESPMTRs

```
DESPMTR  area      30.00    # wing area
DESPMTR  aspect    8.533    # aspect ratio
DESPMTR  taper     0.875    # taper ratio
DESPMTR  sweep     3.583    # wing sweep (deg)
DESPMTR  dihedral  1.791    # dihedral (deg)
```

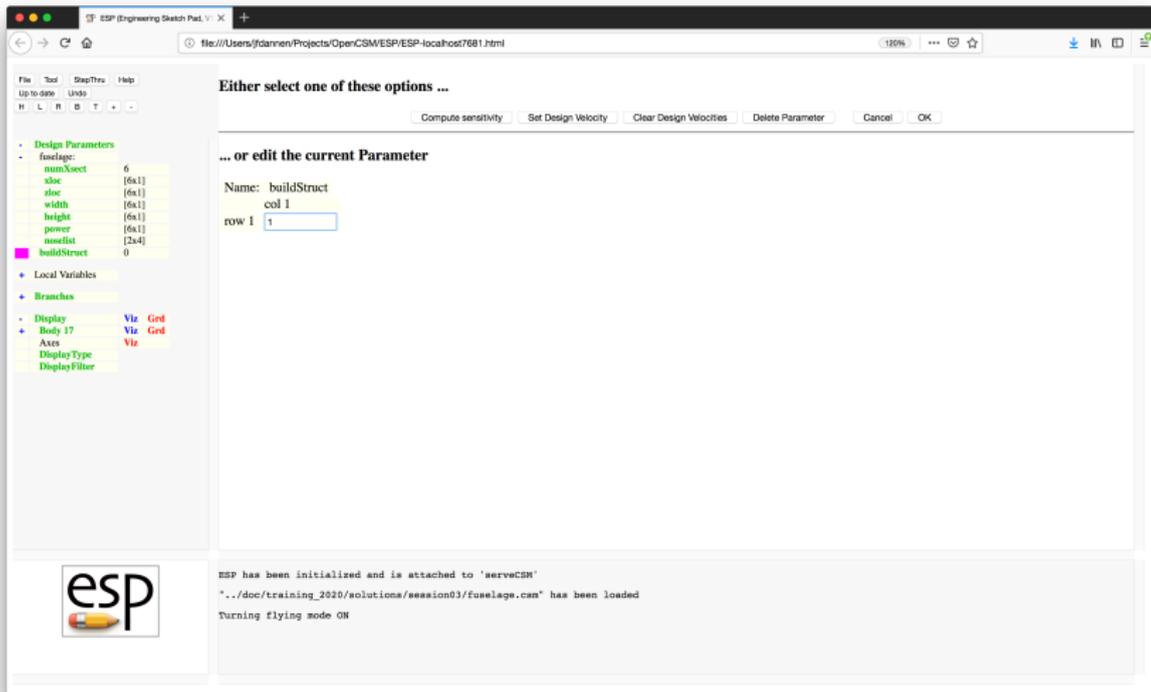
```
SET      span      sqrt(area*aspect)
SET      cmean     area/span
SET      croot     2*cmean/(1+taper)
SET      ctip      croot*taper
SET      Xtip      span/2*sind(sweep)
SET      Ytip      span/2*sind(dihedral)
SET      Ztip      span/2
```

- Fuselage by blending a series of super-ellipses (SUPELLs), where the dimensions of the X-sections are provided in arrays



xloc	width	zcent	height	power
0.0	0.0	0.0	0.0	2
1.0	1.0	0.1	1.0	2
4.0	1.6	0.4	2.0	3
8.0	1.6	0.4	2.0	3
12.0	1.0	0.3	1.2	2
16.0	0.8	0.2	0.4	2

- Can you make the radius at the nose 0.2 in a top view and 0.1 in a side view?
- Can you make the fuselage between the two sections whose power is 3 have a constant cross-section?
- Can you create a SheetBody that has a plane of symmetry and cross-sections at every y , starting at $y = 1/2$ and spaced with $\Delta y = 1$?
- Can you color the odd-numbered bulkheads red and even-numbered bulkheads blue?
- Can you color the Edges at the intersections of the symmetry plane and bulkheads white?

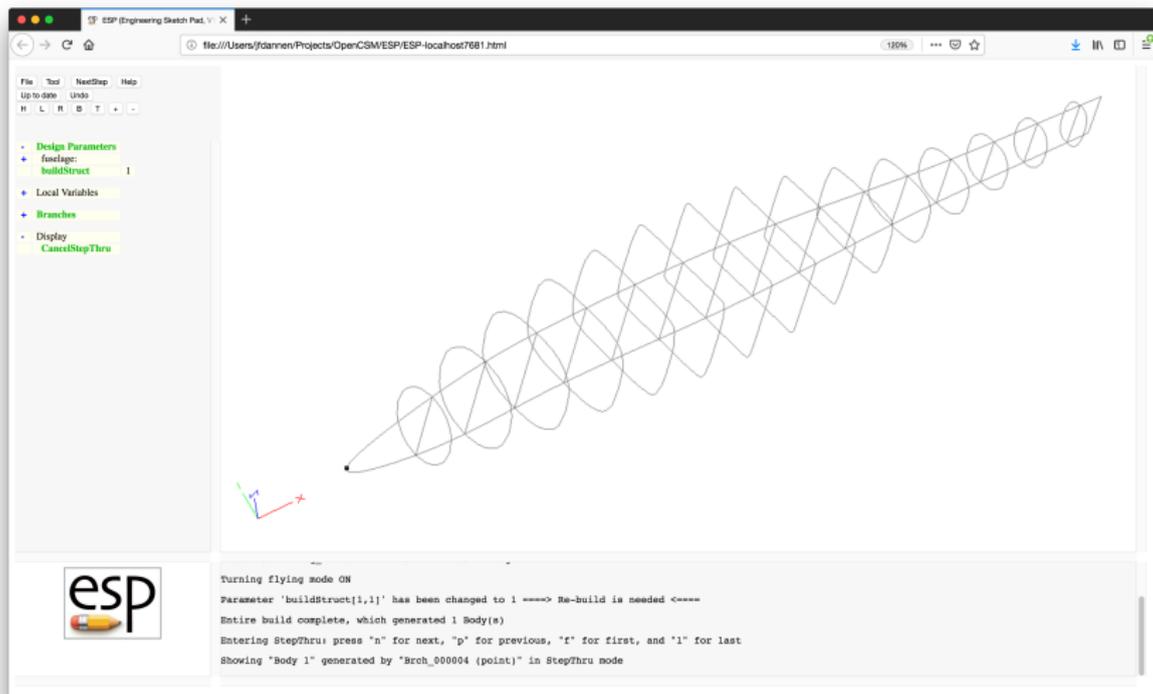


The screenshot shows the ESP (Engineering Sketch Pad) software interface. A dialog box is open with the title "Either select one of these options ...". The dialog contains several buttons: "Compute sensitivity", "Set Design Velocity", "Clear Design Velocities", "Delete Parameter", "Cancel", and "OK". Below these buttons, there is a section titled "... or edit the current Parameter". Under this section, the "Name:" is set to "buildStruct" and the "col" is set to "1". A text input field for "row 1" contains the number "1".

On the left side of the interface, a tree view shows the following structure:

- Design Parameters
 - fuselage:
 - numXsect 6
 - side (6x1)
 - zloc (6x1)
 - width (6x1)
 - height (6x1)
 - power (6x1)
 - nosefit [2x4]
 - buildStruct 0
- Local Variables
- Branches
 - Display Viz Grid
 - Body 17 Viz Grid
 - Axes Viz
 - Display Type
 - Display Filter

At the bottom left of the interface is the ESP logo. At the bottom right, a status message reads: "ESP has been initialized and is attached to 'serveCSM'. './doc/training_2020/solutions/session03/fuselage.csm' has been loaded. Turning flying mode ON."



The screenshot shows the ESP Engineering Sketch Pad interface. The main workspace displays a 3D wireframe model of a fuselage, which is a series of overlapping elliptical shapes along a central axis, tapering towards the right. A 3D coordinate system with red, green, and blue axes is visible in the bottom-left corner of the workspace.

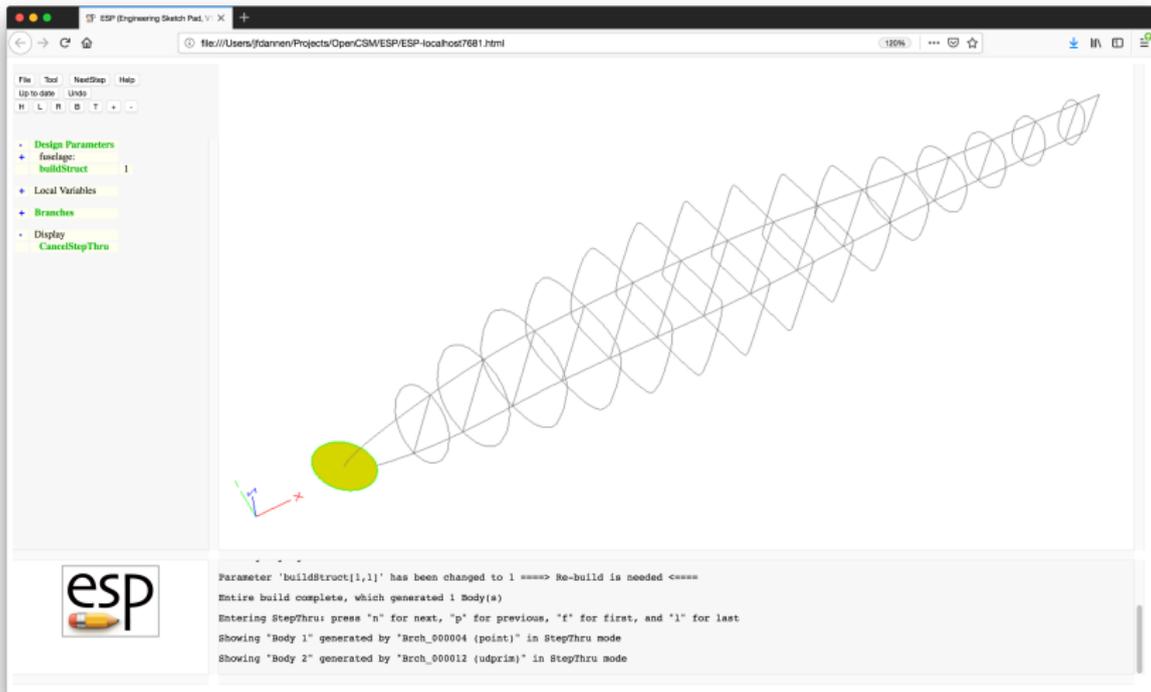
The left sidebar contains a tree view with the following sections:

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru



```

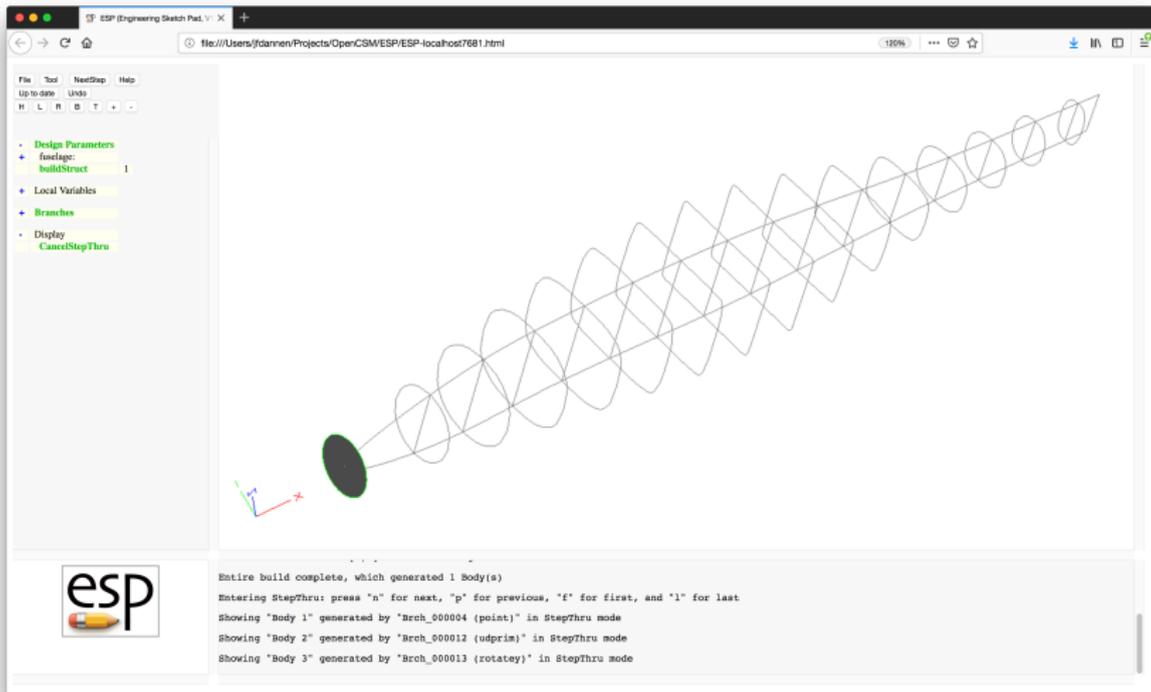
Turning flying mode ON
Parameter 'buildStruct[1,1]' has been changed to 1 ==> Re-build is needed <====
Entire build complete, which generated 1 Body(s)
Entering StepThru press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000004 (point)" in StepThru mode
  
```



File | Tool | NextStep | Help
Up to date Undo
M L R B T +

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

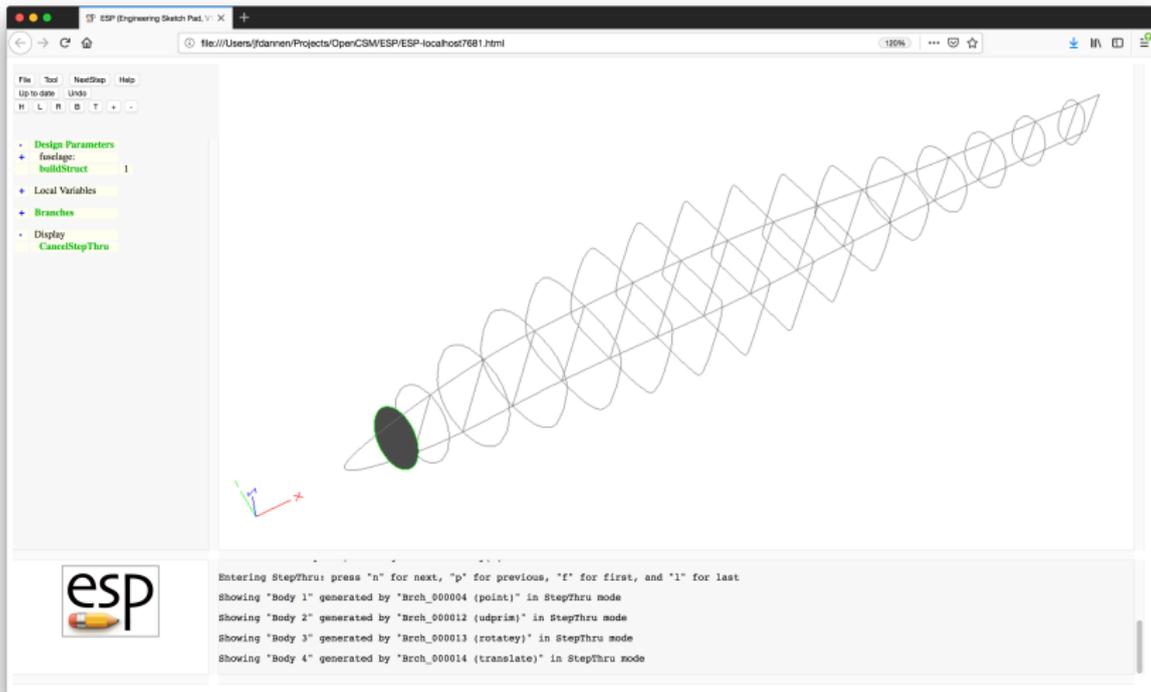
Parameter 'buildStruct[1,1]' has been changed to 1 ==> Re-build is needed <==>
 Entire build complete, which generated 1 Body(s)
 Entering StepThru press 'n' for next, 'p' for previous, 'f' for first, and 'l' for last
 Showing "Body 1" generated by "Brch_000004 (point)" in StepThru mode
 Showing "Body 2" generated by "Brch_000012 (udprim)" in StepThru mode



File | Tool | NextStep | Help
 Up to date Undo
 H L R B T + -

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

entire build complete, which generated 1 Body(s)
 Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
 Showing "Body 1" generated by "Brch_000004 (point)" in StepThru mode
 Showing "Body 2" generated by "Brch_000012 (udprim)" in StepThru mode
 Showing "Body 3" generated by "Brch_000013 (rotatery)" in StepThru mode



The screenshot shows the ESP Engineering Sketch Pad interface. The main workspace displays a wireframe model of a fuselage, which is a series of overlapping elliptical shapes along a central axis. A dark green oval is visible at the front of the fuselage. A 3D coordinate system with red, green, and blue axes is located in the bottom-left corner of the workspace.

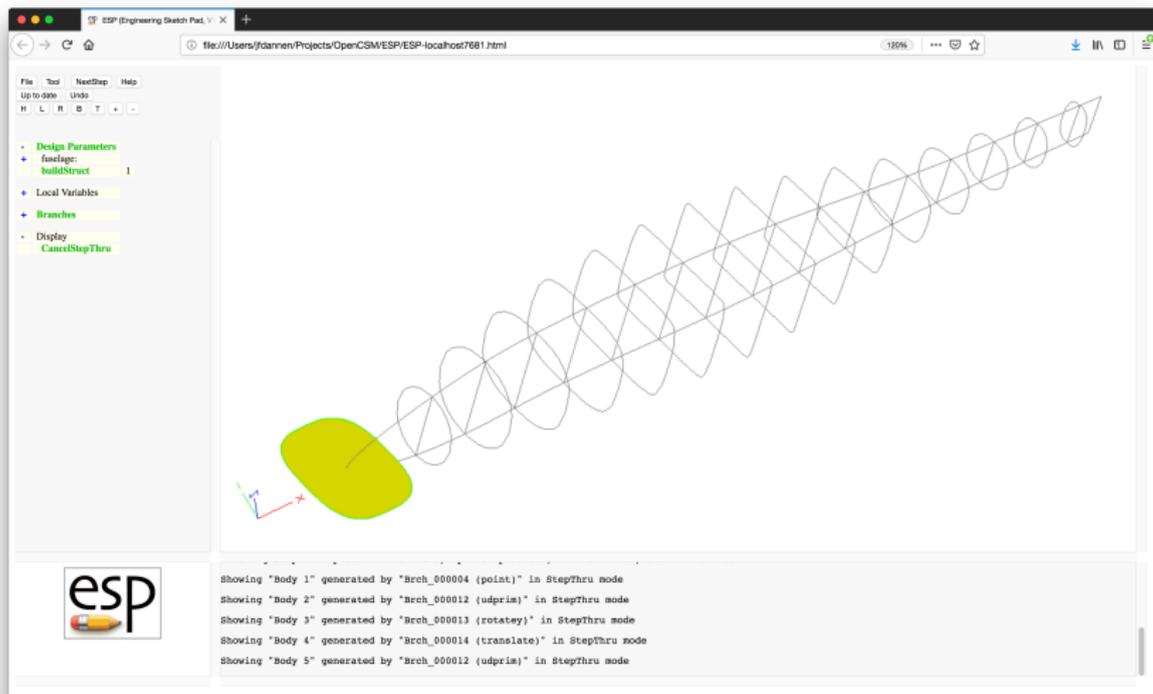
The left sidebar contains the following sections:

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

The bottom status bar displays the ESP logo and a list of bodies shown during the StepThru process:

```

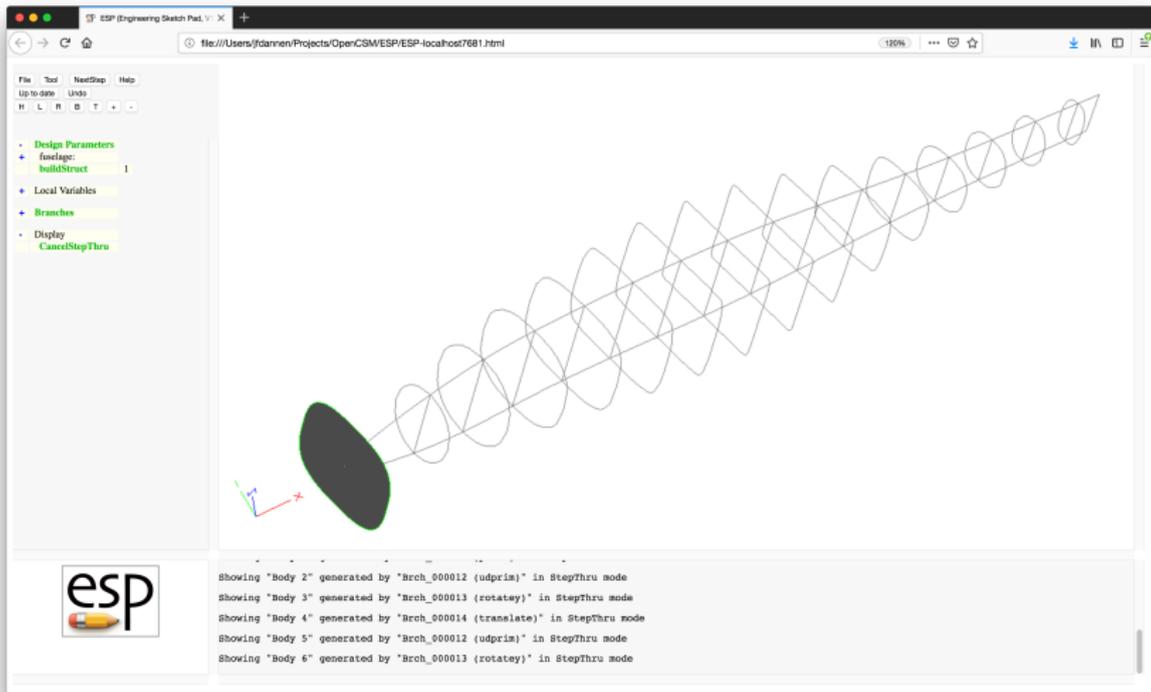
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000004 (point)" in StepThru mode
Showing "Body 2" generated by "Brch_000012 (udprim)" in StepThru mode
Showing "Body 3" generated by "Brch_000013 (rotatex)" in StepThru mode
Showing "Body 4" generated by "Brch_000014 (translate)" in StepThru mode
  
```

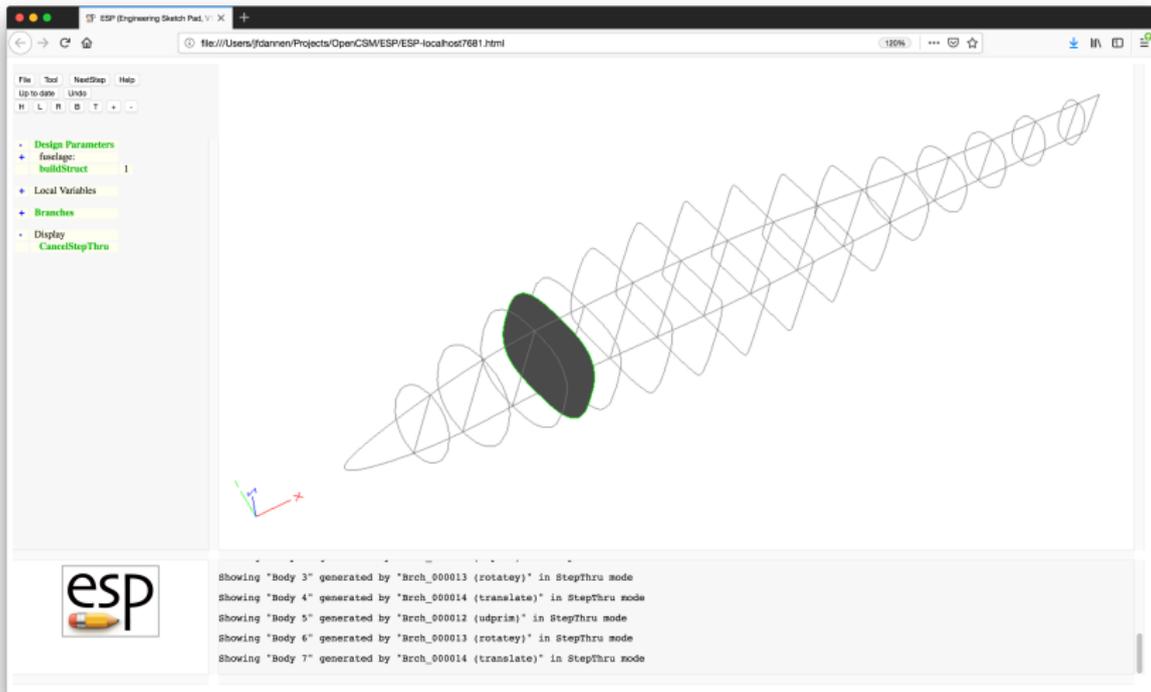


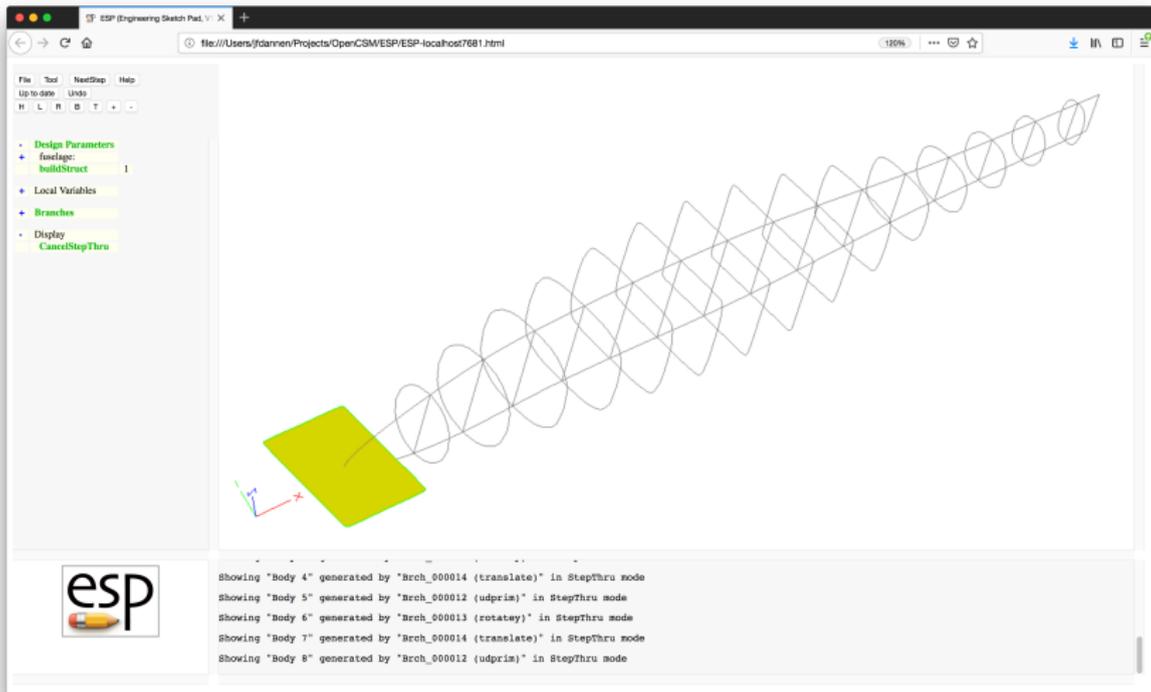
File | Tool | NextStep | Help
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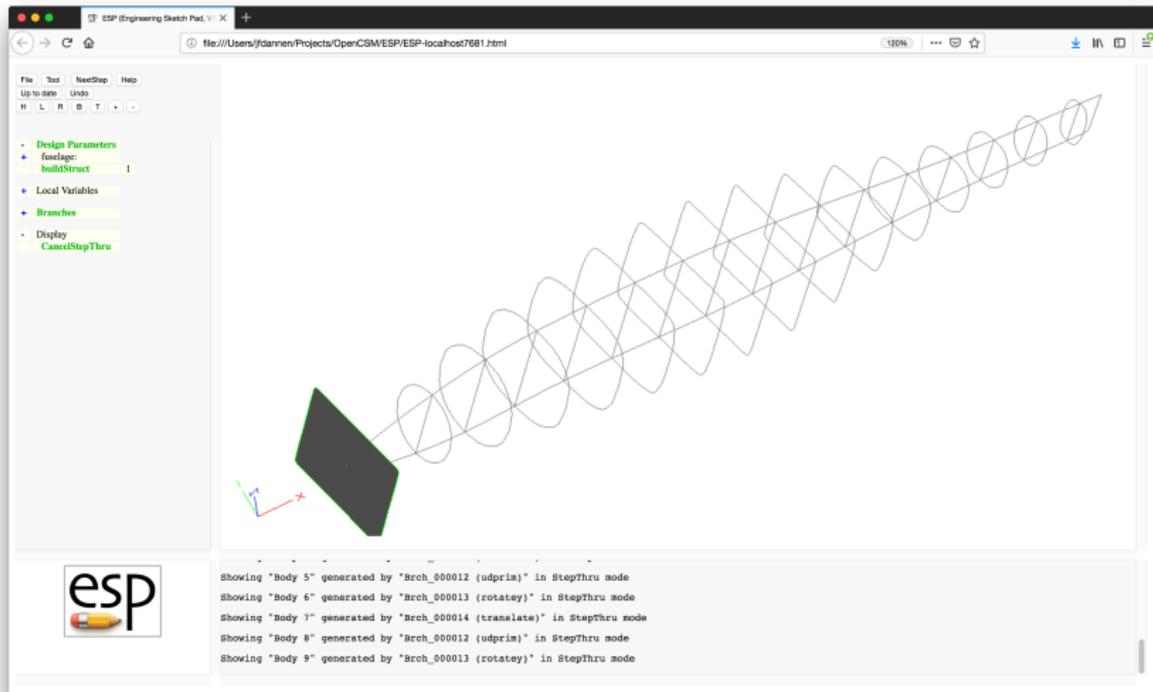
- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 1" generated by "Brch_000004 (point)" in StepThru mode
 Showing "Body 2" generated by "Brch_000012 (udprim)" in StepThru mode
 Showing "Body 3" generated by "Brch_000013 (rotatex)" in StepThru mode
 Showing "Body 4" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 5" generated by "Brch_000012 (udprim)" in StepThru mode





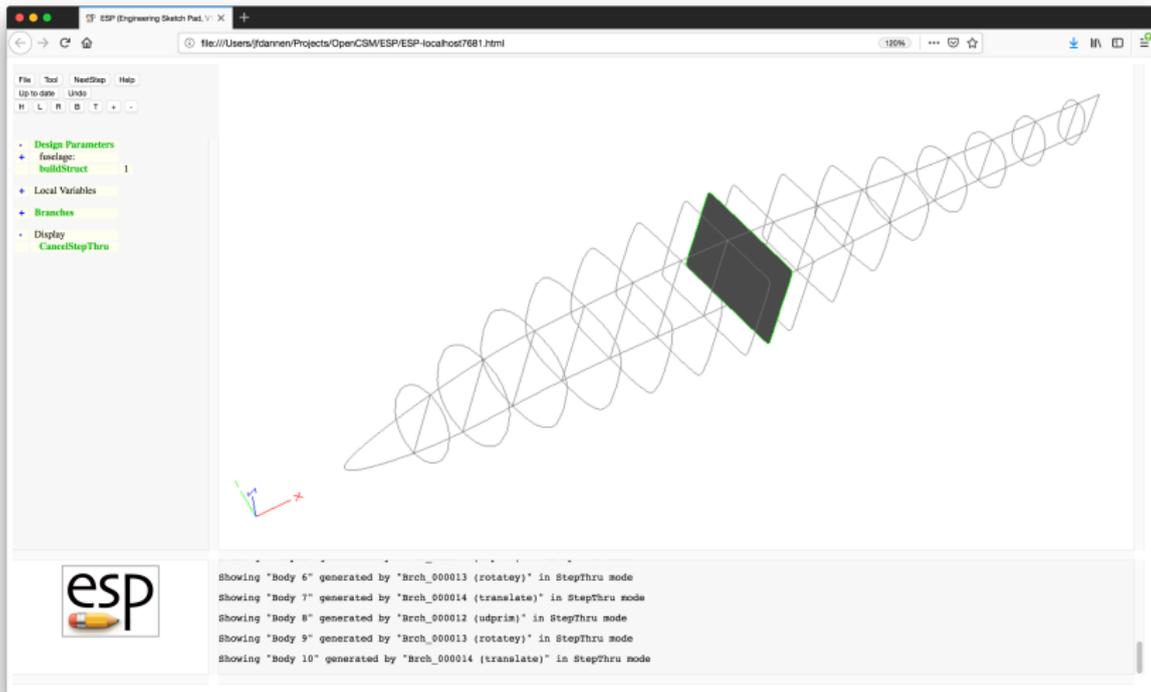




File | Tool | NextStep | Help
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- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 5" generated by "Brch_000012 (udprim)" in StepThru mode
 Showing "Body 6" generated by "Brch_000013 (rotatey)" in StepThru mode
 Showing "Body 7" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 8" generated by "Brch_000012 (udprim)" in StepThru mode
 Showing "Body 9" generated by "Brch_000013 (rotatey)" in StepThru mode

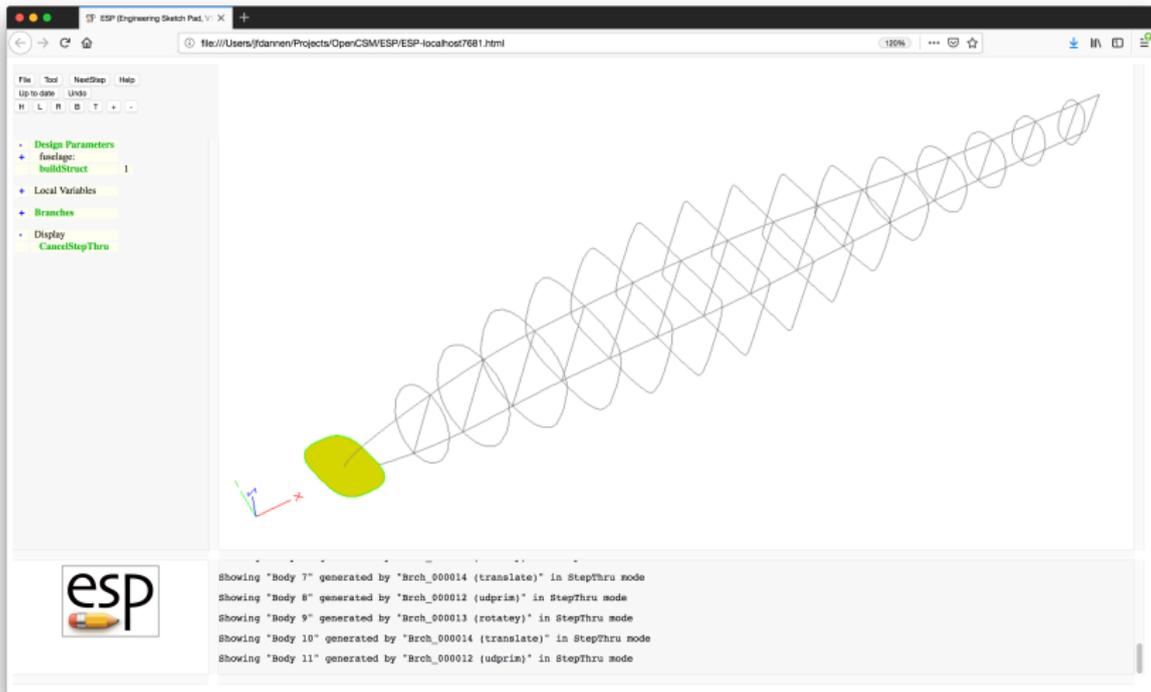


The screenshot shows the ESP Engineering Sketch Pad interface. The main workspace displays a wireframe model of a fuselage with a black rectangular cutout. The left sidebar contains the following sections:

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

The bottom console window displays the following text:

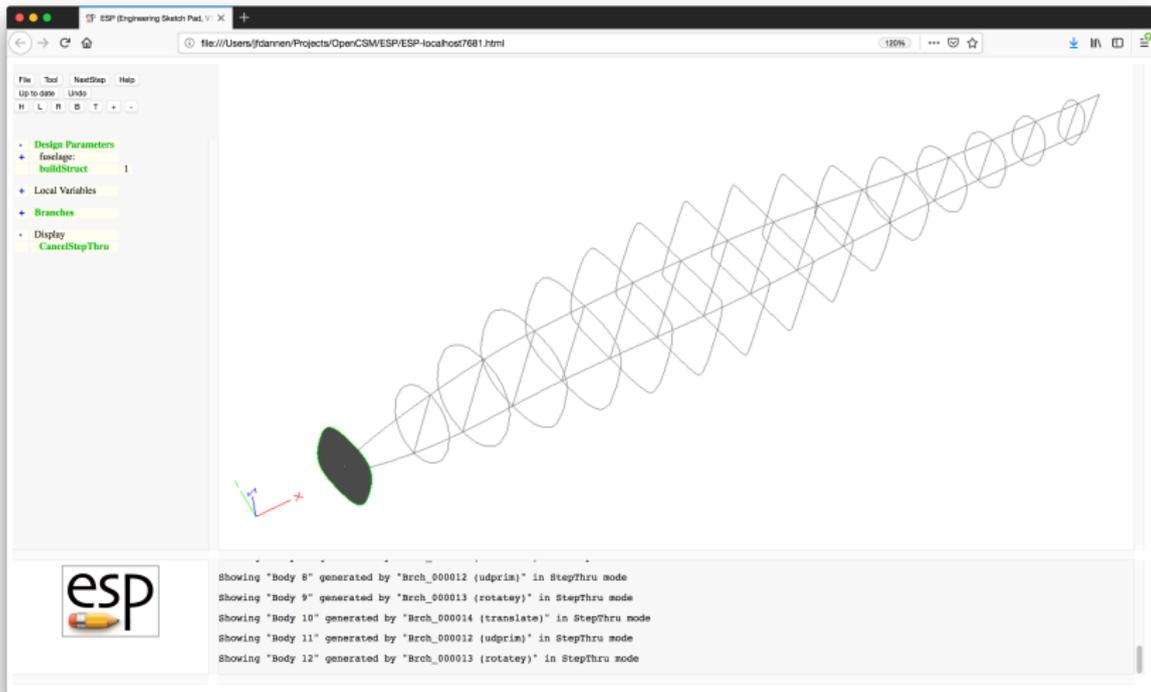
```
Showing "Body 6" generated by "Brch_000013 (rotate)" in StepThru mode
Showing "Body 7" generated by "Brch_000014 (translate)" in StepThru mode
Showing "Body 8" generated by "Brch_000012 (udprim)" in StepThru mode
Showing "Body 9" generated by "Brch_000013 (rotate)" in StepThru mode
Showing "Body 10" generated by "Brch_000014 (translate)" in StepThru mode
```



File | Tool | NextStep | Help
Up to date Undo
M L R B T + -

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

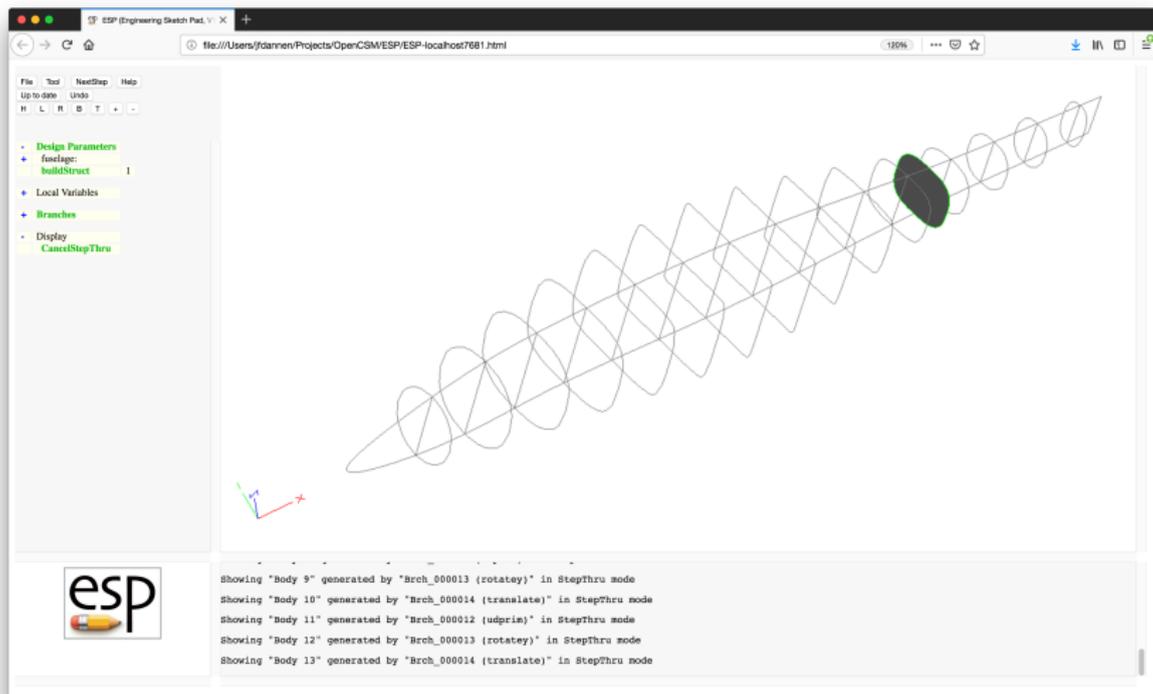
Showing "Body 7" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 8" generated by "Brch_000012 (udprim)" in StepThru mode
 Showing "Body 9" generated by "Brch_000013 (rotatex)" in StepThru mode
 Showing "Body 10" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 11" generated by "Brch_000012 (udprim)" in StepThru mode



File Tool NextStep Help
Up to 9999 Undo
M L R B T + -

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

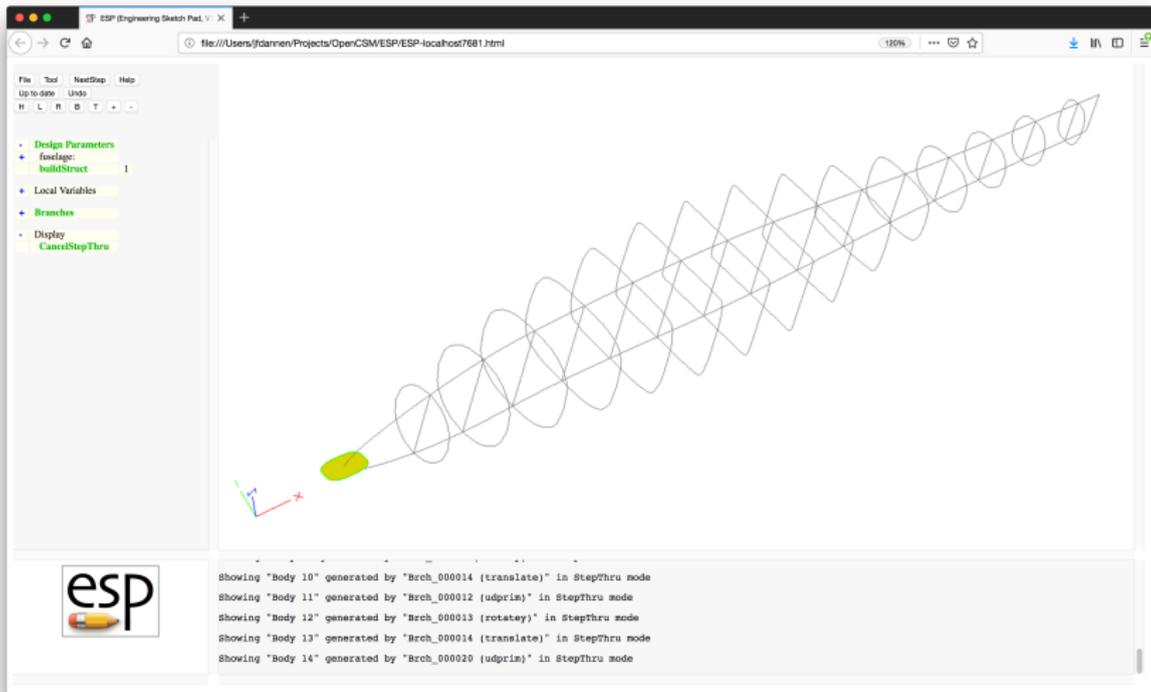
Showing "Body 8" generated by "Brch_000012 (udprim)" in StepThru mode
Showing "Body 9" generated by "Brch_000013 (rotatey)" in StepThru mode
Showing "Body 10" generated by "Brch_000014 (translate)" in StepThru mode
Showing "Body 11" generated by "Brch_000012 (udprim)" in StepThru mode
Showing "Body 12" generated by "Brch_000013 (rotatey)" in StepThru mode



File Tool NextStep Help
Up to 9999 Undo
H L R B T

- Design Parameters
 - fueLage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

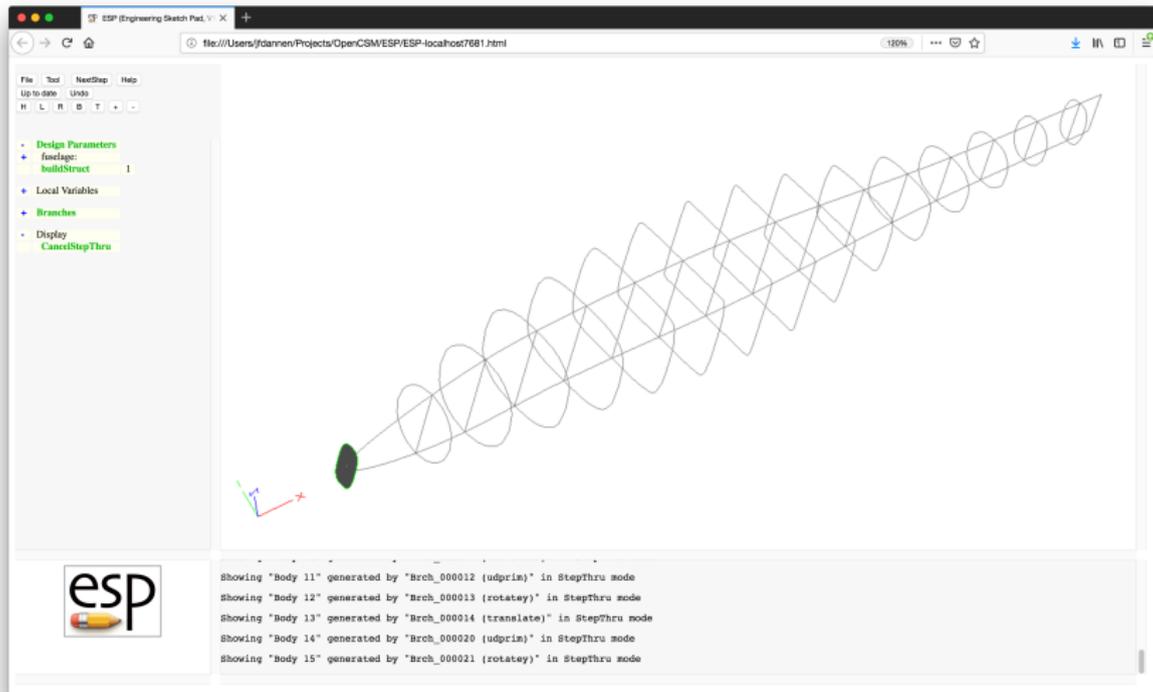
Showing "Body 9" generated by "Brch_000013 (rotatey)" in StepThru mode
 Showing "Body 10" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 11" generated by "Brch_000012 (udpris)" in StepThru mode
 Showing "Body 12" generated by "Brch_000013 (rotatey)" in StepThru mode
 Showing "Body 13" generated by "Brch_000014 (translate)" in StepThru mode



File | Tool | NextStep | Help
Up to date Undo
H L R B T + -

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

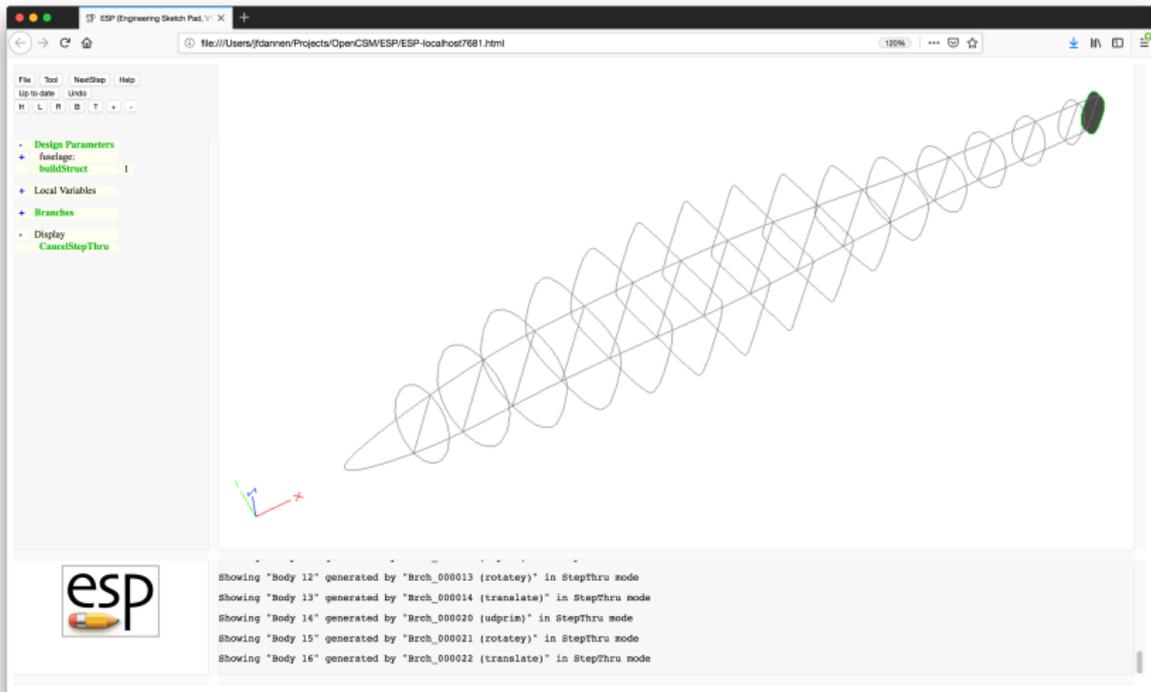
Showing "Body 10" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 11" generated by "Brch_000012 (udprin)" in StepThru mode
 Showing "Body 12" generated by "Brch_000013 (rotatey)" in StepThru mode
 Showing "Body 13" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 14" generated by "Brch_000020 (udprin)" in StepThru mode



File Tool NextStep Help
Up to date Undo
H L R B T

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

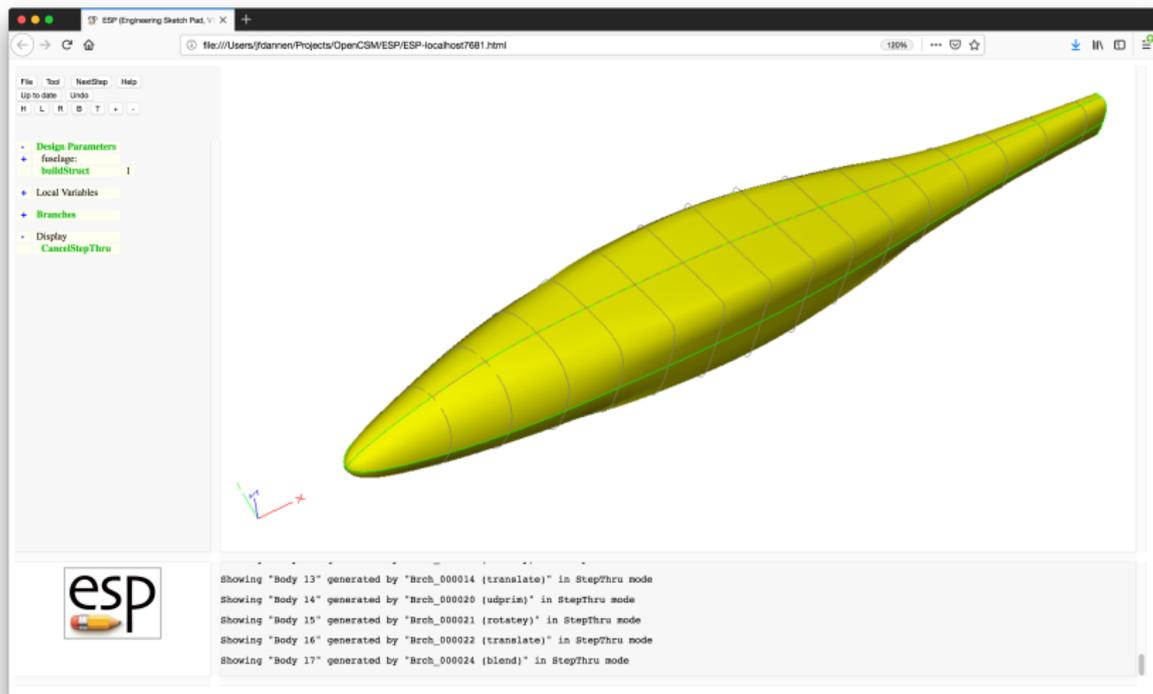
Showing "Body 11" generated by "Brch_000012 (udprim)" in StepThru mode
 Showing "Body 12" generated by "Brch_000013 (rotatey)" in StepThru mode
 Showing "Body 13" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 14" generated by "Brch_000020 (udprim)" in StepThru mode
 Showing "Body 15" generated by "Brch_000021 (rotatey)" in StepThru mode

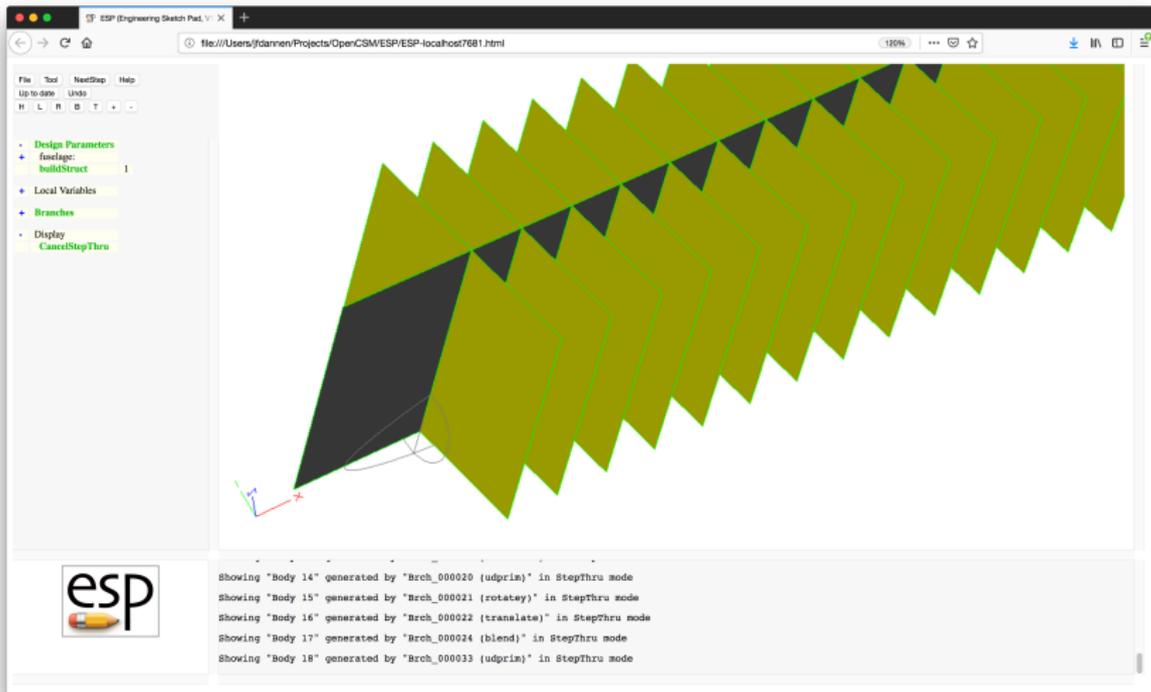


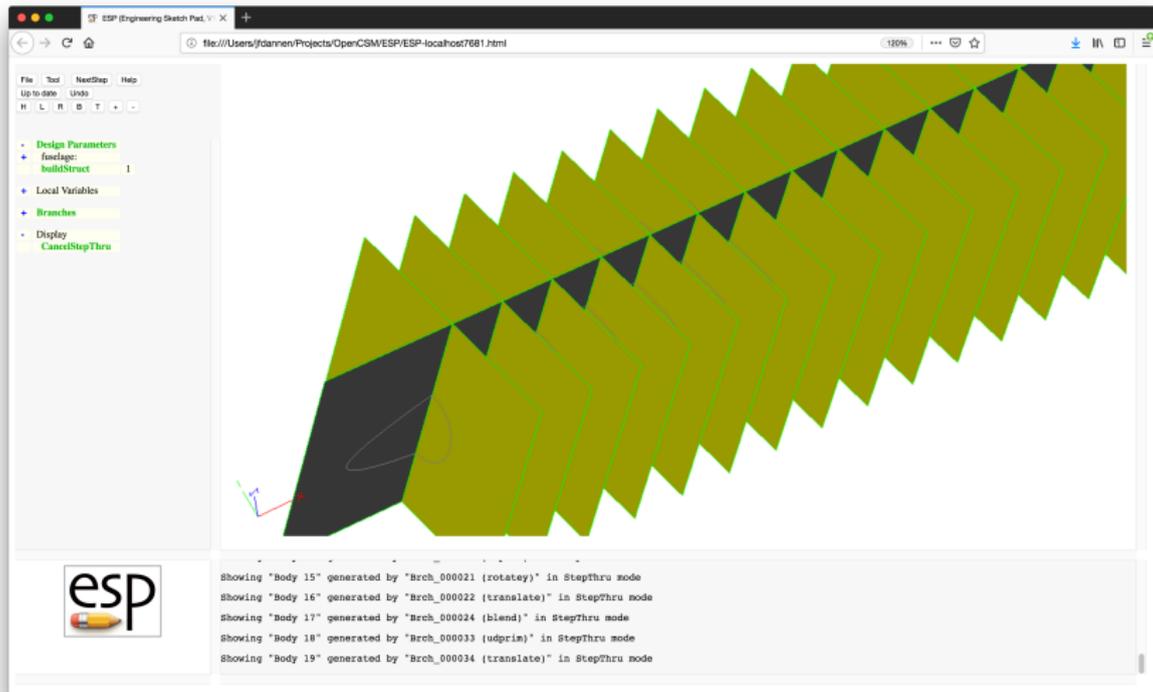
File | Tool | NextStep | Help
Up to 9999 Undo
M L R B T + -

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 12" generated by "Brch_000013 (rotatey)" in StepThru mode
 Showing "Body 13" generated by "Brch_000014 (translate)" in StepThru mode
 Showing "Body 14" generated by "Brch_000020 (udgrin)" in StepThru mode
 Showing "Body 15" generated by "Brch_000021 (rotatey)" in StepThru mode
 Showing "Body 16" generated by "Brch_000022 (translate)" in StepThru mode



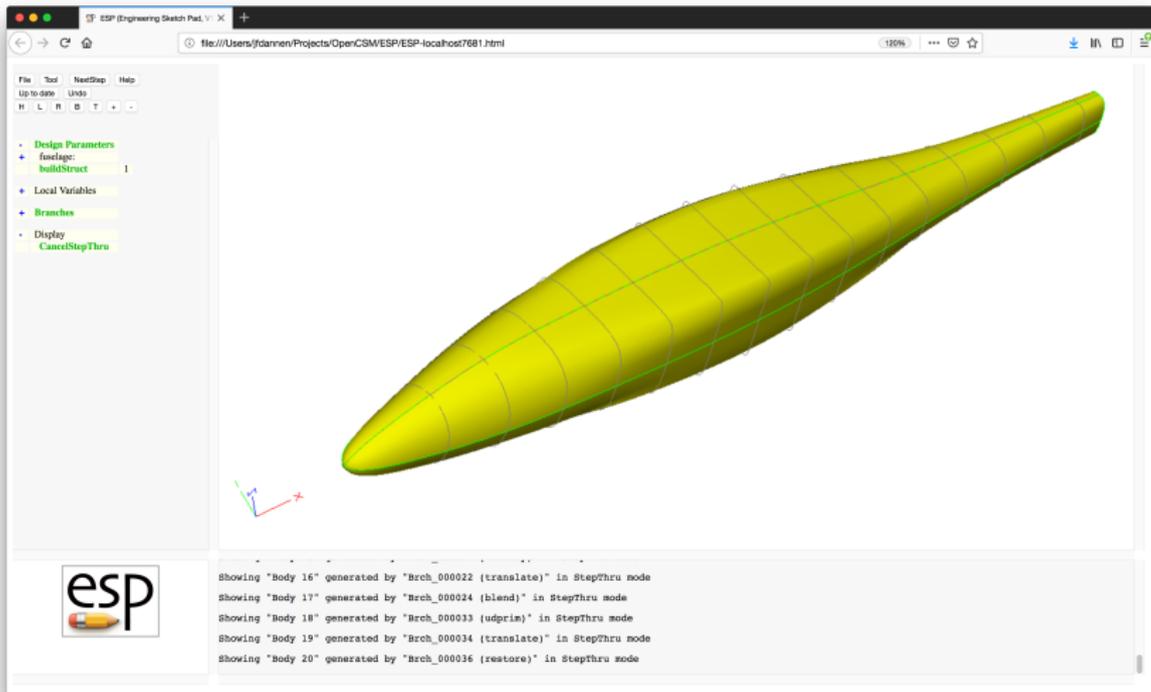


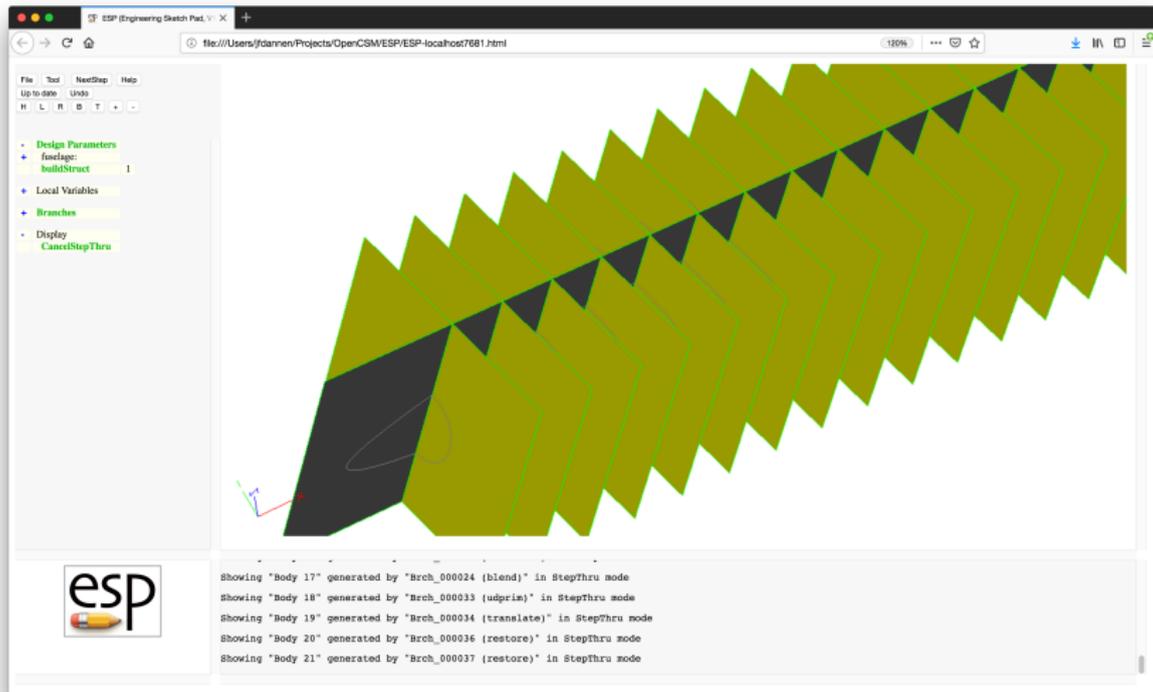


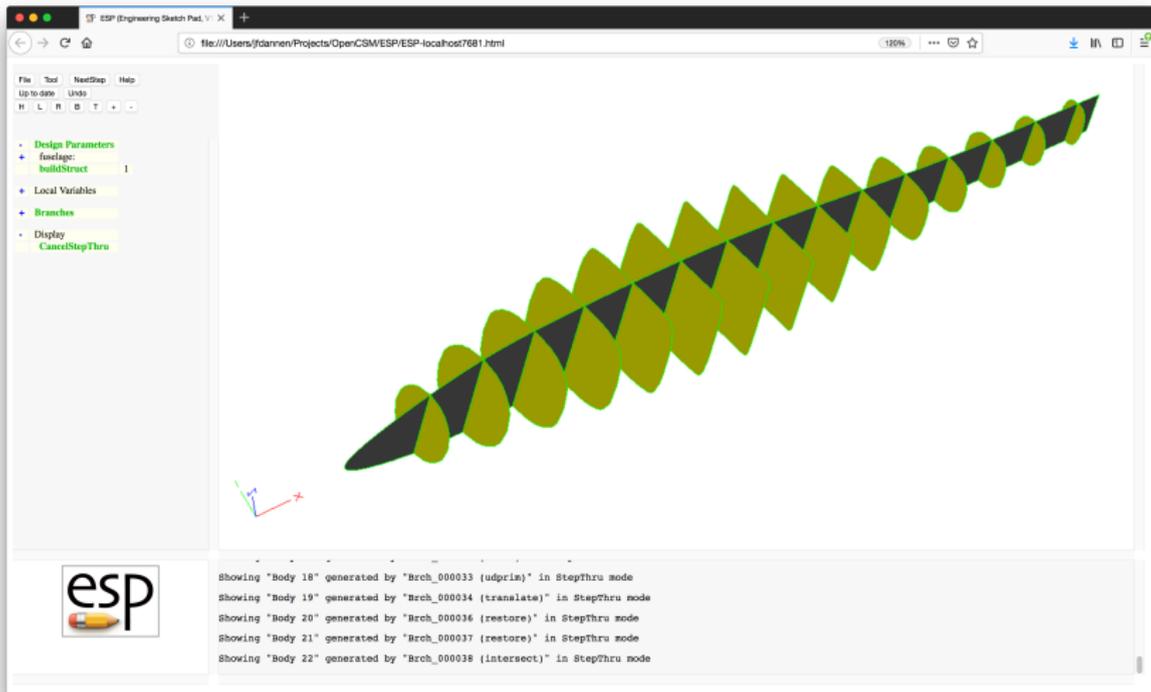
File | Tool | NextStep | Help
Up to date | Undo
M | L | R | B | T | +

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 15" generated by "Brch_000021 (rotate)" in StepThru mode
 Showing "Body 16" generated by "Brch_000022 (translate)" in StepThru mode
 Showing "Body 17" generated by "Brch_000024 (blend)" in StepThru mode
 Showing "Body 18" generated by "Brch_000033 (udprin)" in StepThru mode
 Showing "Body 19" generated by "Brch_000034 (translate)" in StepThru mode



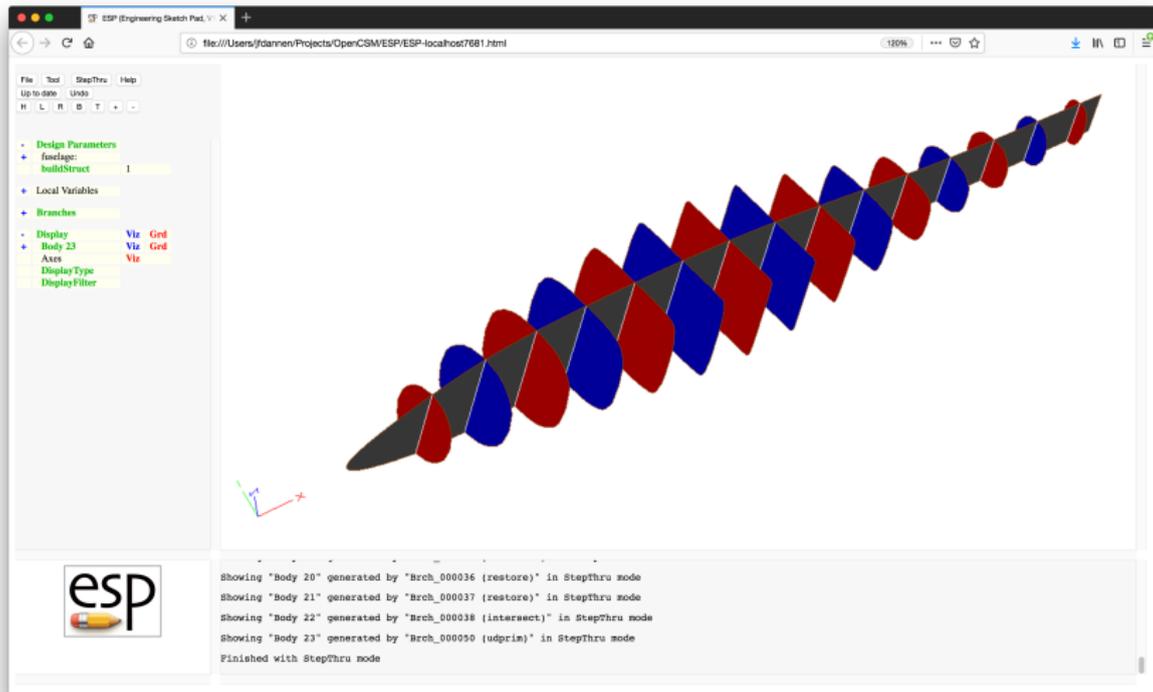




File Tool NextStep Help
Up to date Undo
H L R B T

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - CancelStepThru

Showing "Body 18" generated by "Brch_000033 (udpri)" in StepThru mode
 Showing "Body 19" generated by "Brch_000034 (translate)" in StepThru mode
 Showing "Body 20" generated by "Brch_000036 (restore)" in StepThru mode
 Showing "Body 21" generated by "Brch_000037 (restore)" in StepThru mode
 Showing "Body 22" generated by "Brch_000038 (intersect)" in StepThru mode



File Edit StepThru Help
Up to date Undo
M L R B T + -

- Design Parameters
 - fuselage:
 - buildStruct 1
- Local Variables
- Branches
- Display
 - Body 23 Via Red
 - Axes Via Red
 - DisplayType
 - DisplayFilter

Showing "Body 20" generated by "Brch_000036 (restore)" in StepThru mode
 Showing "Body 21" generated by "Brch_000037 (restore)" in StepThru mode
 Showing "Body 22" generated by "Brch_000038 (intersect)" in StepThru mode
 Showing "Body 23" generated by "Brch_000050 (udprn)" in StepThru mode
 Finished with StepThru mode



Simple Fuselage — .csm File (1)

```
# fuselageAlone
# written by John Dannenhoffer

# fuselage design Parameters
CFGPMTR                fuselage:numXsect 6
DIMENSION fuselage:xloc fuselage:numXsect 1 1
DIMENSION fuselage:zloc fuselage:numXsect 1 1
DIMENSION fuselage:width fuselage:numXsect 1 1
DIMENSION fuselage:height fuselage:numXsect 1 1
DIMENSION fuselage:power fuselage:numXsect 1 1
DIMENSION fuselage:noselist 2                4 1

DESPMTR fuselage:xloc "0; 1.0; 4.0; 8.0; 12.0; 16.0;"
DESPMTR fuselage:zloc "0; 0.1; 0.4; 0.4; 0.3; 0.2;"
DESPMTR fuselage:width "0; 1.0; 1.6; 1.6; 1.0; 0.8;"
DESPMTR fuselage:height "0; 1.0; 2.0; 2.0; 1.2; 0.4;"
DESPMTR fuselage:power "2; 2; 3; 3 3; 3;"
DESPMTR fuselage:noselist "0.2; 0; 1; 0;\
                           0.1; 0; 0; 1;"

CFGPMTR buildStruct 0 # set to 1 to build structure
```

```
# build fuselage OML
MARK

# sharp or rounded nose
SET isect 1
IFTHEN fuselage:width[isect] eq 0 and fuselage:height[isect] eq 0
    POINT fuselage:xloc[isect] 0 fuselage:zloc[isect]

# blunt nose
ELSE
    UDPRIM supell rx fuselage:width[isect]/2 \
                ry fuselage:height[isect]/2 \
                n fuselage:power[isect]
    ROTATEY 90 0 0
    TRANSLATE fuselage:xloc[isect] 0 fuselage:zloc[isect]
ENDIF
```

```
# intermediate sections
PATBEG jsect fuselage:numXsect-2
      SET isect jsect+1

      UDPRIM supell rx fuselage:width[isect]/2 ry fuselage:height[isect]/2 n fusela
      ROTATEY 90 0 0
      TRANSLATE fuselage:xloc[isect] 0 fuselage:zloc[isect]
PATEND

# sharp or rounded tail
SET isect fuselage:numXsect
IFTHEN fuselage:width[isect] eq 0 and fuselage:height[isect] eq 0
      POINT fuselage:xloc[isect] 0 fuselage:zloc[isect]

# blunt tail
ELSE
      UDPRIM supell rx fuselage:width[isect]/2 ry fuselage:height[isect]/2 n fusela
      ROTATEY 90 0 0
      TRANSLATE fuselage:xloc[isect] 0 fuselage:zloc[isect]
ENDIF

# blend the sections into the fuselage
BLEND fuselage:noselist
```

```
# optionally build the structure
IFTHEN    buildStruct EQ 1

# get the fuselage bounding box
SET  xmin  @xmin
SET  xmax  @xmax
SET  ymin  @ymin
SET  ymax  @ymax
SET  zmin  @zmin
SET  zmax  @zmax

# store OML for later use
STORE  fuseOML
```

```
# create a waffle that is "1" bigger than the OML
UDPRIM waffle depth zmax-zmin+2 filename <<

# symmetry plane
POINT A AT xmin-1 0
POINT B AT xmax+1 0
LINE . A B      tagType=symmetry

# make the bulkheads
PATBEG ibulk xmax-xmin-1
  POINT C AT ibulk+1/2 ymin-1
  POINT D AT x@C      ymax+1
  LINE . C D          tagType=bulkhead tagIndex=!val2str(ibulk,0)
PATEND

>>
```



Simple Fuselage — .csm File (6)

```
# translate the waffle down and store it
TRANSLATE 0 0 zmin-1
STORE fuseWaffle

# trim the waffle to the fuselage
RESTORE fuseOML
RESTORE fuseWaffle
INTERSECT

# alternate the bulkhead colors red/blue/red/...
SET color $red
PATBEG ibulk 99
    SELECT FACE $tagType $bulkhead $tagIndex val2str(ibulk,0)
        ATTRIBUTE _color color

    IFTHEN color EQ $red
        SET color $blue
    ELSE
        SET color $red
    ENDIF
PATEND
```

```
# this will get called when we run out of bulkheads
CATBEG $face_not_found
CATEND

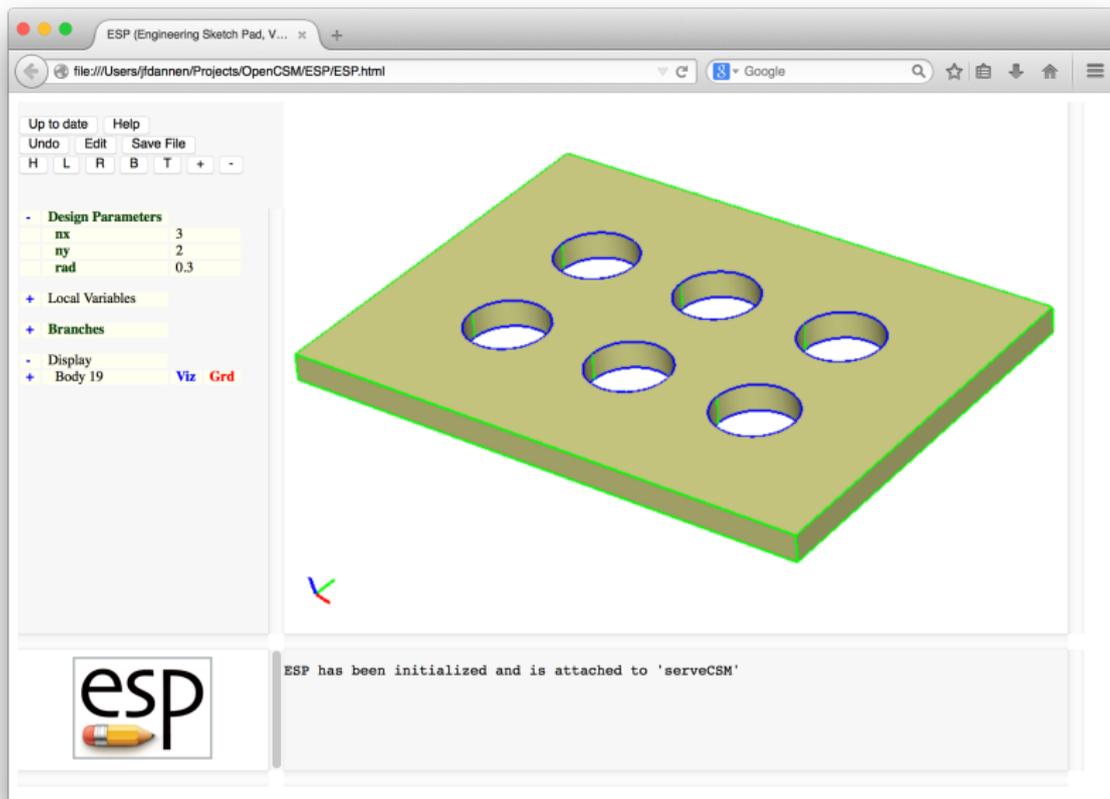
# make the bulkhead/symmetry Edges white
UDPRIM    editAttr  filename <<
    EDGE  ADJ2FACE  tagType=bulkhead
    AND   ADJ2FACE  tagType=symmetry
    SET   _color=white
>>

ENDIF

END
```

Session 5 Solutions

CSM Language (2)



The screenshot displays the ESP (Engineering Sketch Pad) software interface. The main window shows a 3D model of a rectangular plate with six circular holes. The interface includes a menu bar with options like 'Up to date', 'Help', 'Undo', 'Edit', and 'Save File'. A toolbar below the menu bar contains icons for 'H', 'L', 'R', 'B', 'T', '+', and '-'. On the left side, there is a design tree with sections for 'Design Parameters', 'Local Variables', 'Branches', and 'Display'. The 'Design Parameters' section lists:

Design Parameters	Value
nx	3
ny	2
rad	0.3

The 'Display' section shows 'Body 19' with 'Viz' and 'Grd' options. The status bar at the bottom indicates 'ESP has been initialized and is attached to 'serveCSM''. The ESP logo is visible in the bottom left corner of the interface.

nx	number of holes in X -direction	3.00
ny	number of holes in Y -direction	2.00
rad	radius of each hole	0.30
	distance between hole centers	1.00

- Can you make a single hole in the center of the plate?
- Can you change your solution to have the holes spaced so that they fill the plate?
- What if you make the radius of the hole too big?

```

# rect_pat
# written by John Dannenhoffer

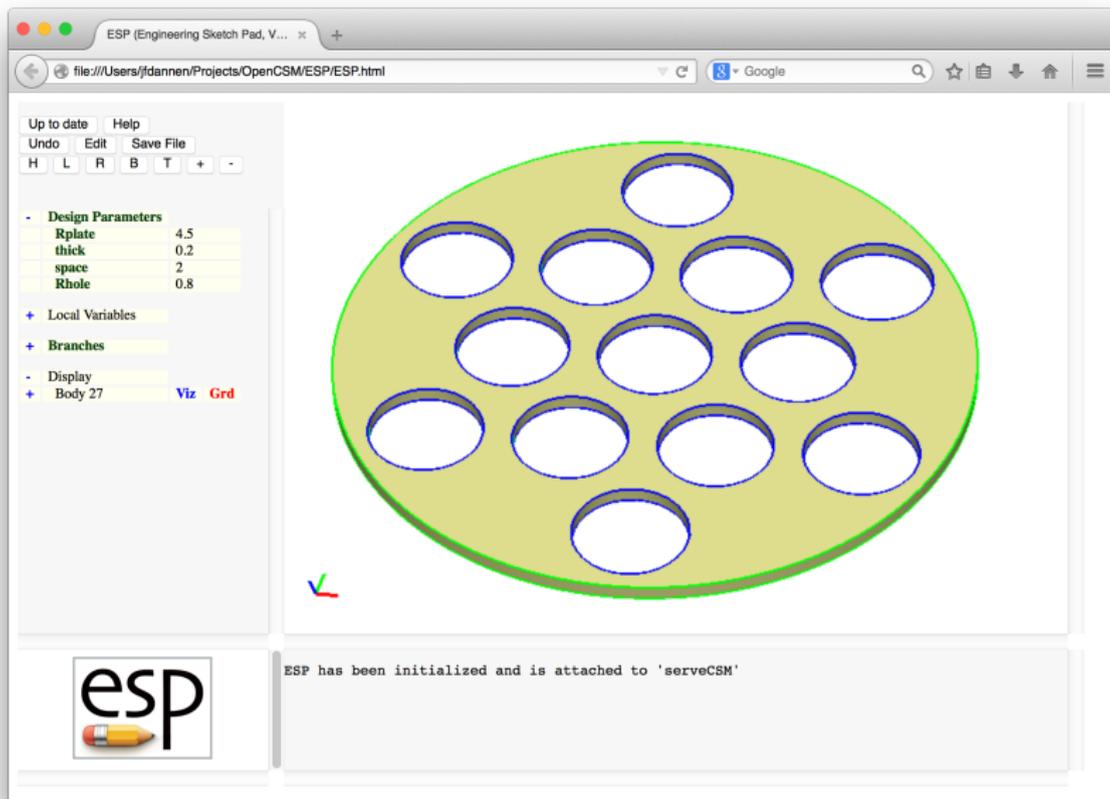
DESPMTR   nx           3
DESPMTR   ny           2
DESPMTR   rad          0.30
DESPMTR   space        1.00

# base plate (big enough to contain all holes)
BOX        0.00  0.00  -0.10  space*nx+1  space*ny+1  0.20

# 2D array of holes (with given spacing)
PATBEG ix nx
  PATBEG iy ny
    CYLINDER  ix*space  iy*space  -0.20 \
              ix*space  iy*space  +0.20  rad
  SUBTRACT
PATEND
PATEND

END

```



ESP (Engineering Sketch Pad, V...)

file:///Users/fldannen/Projects/OpenCSM/ESP/ESP.html

Up to date Help

Undo Edit Save File

H L R B T + -

- Design Parameters

Rplate	4.5
thick	0.2
space	2
Rhole	0.8
- + Local Variables
- + Branches
- Display
- + Body 27 Viz Grd

ESP has been initialized and is attached to 'serveCSM'

Rplate	radius of plate	4.50
thick	thickness of plate	0.20
space	distance between hole centers	2.00
Rhole	radius of holes	0.80
	number of holes selected automatically	

```
# round_pat
# written by John Dannenhoffer

# default design parameters
DESPMTR  Rplate    4.5000  # radius    of plate
DESPMTR  thick     0.2000  # thickness of plate
DESPMTR  space     2.0000  # distance between hole centers
DESPMTR  Rhole     0.8000  # radius of holes

# make sure holes do not intersect with each other
IFTHEN   space LT 2*Rhole
        THROW 999
ENDIF

# overall plate
CYLINDER 0 0 -thick/2 0 0 +thick/2 Rplate
```

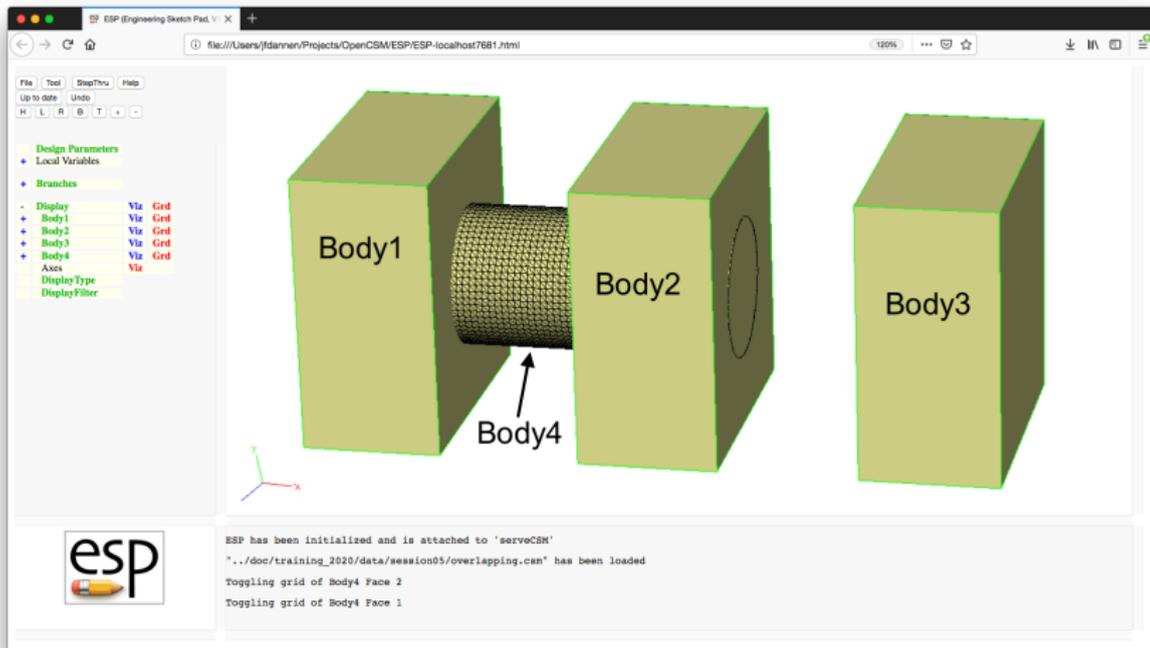
```
# pattern for holes
SET nr int(Rplate/space)

PATBEG iy 1+2*nr
  PATBEG ix 1+2*nr

    SET xc "(ix-nr-1)*space + (iy-nr-1)*space*cosd(60)"
    SET yc "(iy-nr-1)*space*sind(60)"
    SET r hypot(xc,yc)+Rhole

    # mask hole if not within circle
    IFTHEN r LT Rplate-0.001
      CYLINDER xc yc -thick xc yc +thick Rhole
      SUBTRACT
    ENDIF
  PATEND
PATEND

END
```



- Write `.csm` file to:
 - set `overlap1` to 1 if Bodys 1 and 4 overlap, otherwise set it to 0
 - set `overlap2` to 1 if Bodys 2 and 4 overlap, otherwise set it to 0
 - set `overlap3` to 1 if Bodys 3 and 4 overlap, otherwise set it to 0
- Try to use a pattern to do this compactly

```

# overlapping
# written by John Dannenhoffer

# Body 1
BOX      0  0  0  1  2  2
STORE    body 1

# Body 2
BOX      2  0  0  1  2  2
STORE    body 2

# Body 3
BOX      4  0  0  1  2  2
STORE    body 3

# Body 4
CYLINDER 0  1  1  3  1  1  0.5
STORE    body 4

```

```
# determine which or Bodys 1, 2, 3 intersect Body 4
PATBEG      ibody 3
  SET       !$overlap+ibody 1
  RESTORE   body  ibody
  RESTORE   body  4
  INTERSECT

  CATBEG    $did_not_create_body
    SET     !$overlap+ibody 0
  CATEND

  STORE    ...
PATEND
```

```
# show Bodys
RESTORE    body  1
ATTRIBUTE  _name $Body1

RESTORE    body  2
ATTRIBUTE  _name $Body2

RESTORE    body  3
ATTRIBUTE  _name $Body3

RESTORE    body  4
ATTRIBUTE  _name $Body4

END
```

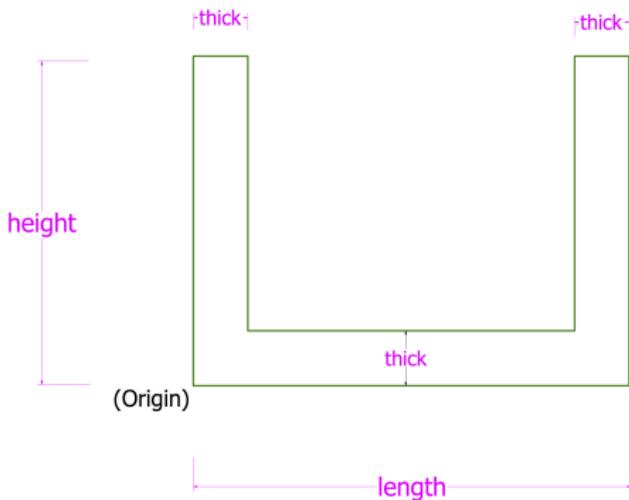
Session 7 Solutions

Sketcher Fundamentals



U-bracket (version 1)

Problem



Measurements

length = 4.00

height = 3.00

thick = 0.5



U-bracket (version 1)

Programmatic Solution

```
DESPMTR  length  4.00000
DESPMTR  height  3.00000
DESPMTR  thick   0.50000

SKBEG    0.0      0.0      0.0
  LINSEG length  0.0      0.0
  LINSEG length  height  0.0
  LINSEG length-thick height  0.0
  LINSEG length-thick thick  0.0
  LINSEG thick   thick   0.0
  LINSEG thick   height  0.0
  LINSEG 0.0     height  0.0
  LINSEG 0.0     0.0     0.0
SKEND
```



U-bracket (version 1)

Sketcher Solution

The screenshot displays the ESP Engineering Sketch Pack interface. The main workspace shows a green U-bracket sketch on a coordinate system. The left sidebar contains a tree view with the following sections:

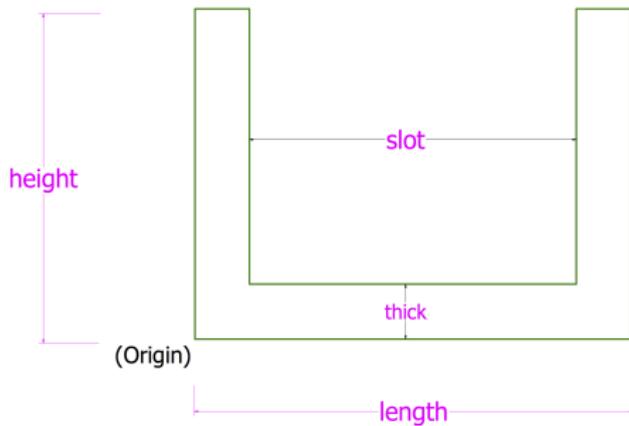
- Design Parameters
- Local Variables
- Branches
 - Brch_000001: d0deg
 - Brch_000017: d0rad
 - Brch_000028: select
 - Brch_000029: assort
 - Brch_000030: assort
 - Brch_000031: assort
 - Brch_000032: assort
 - Brch_000033: assort
 - Brch_000034: assort
 - Brch_000035: assort
 - Brch_000036: assort
 - Brch_000037: assort
- Display
 - Body 10: Via, Grid
 - Axis: Via, Grid
 - Display Type: DisplayFilter

The bottom status bar shows the following text:

```
ndof=16  ncon=16
Valid constraints at points
'a' (fix x)      'y' (fix y)
'p' (perp)      't' (tangent)
'a' (angle)
'u' (width)     'd' (depth)
Valid constraints on segments
'b' (horiz)     'v' (vertical)
'l' (incline)  'l' (length)
Valid constraints on circles
```

ESP has been initialized and is attached to 'nerveCRM'
'../data/training/session02/Ubracket1.csm' has been loaded

Problem

**Measurements**

length = 4.00

height = 3.00

thick = 0.5

slot = 2.00

Note: slot
is centered



U-bracket (version 2)

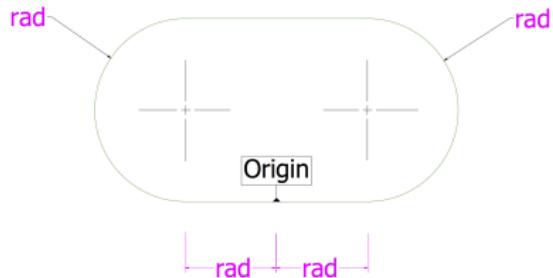
Programmatic Solution

```
DESPMTR  height      3.00000
DESPMTR  thick       0.50000
DESPMTR  slot        2.00000

SET      length      slot+2*thick

SKBEG    0.0          0.0      0.0
  LINSEG length      0.0      0.0
  LINSEG length      height  0.0
  LINSEG length-thick height  0.0
  LINSEG length-thick thick   0.0
  LINSEG thick        thick   0.0
  LINSEG thick        height  0.0
  LINSEG 0.0          height  0.0
  LINSEG 0.0          0.0     0.0
SKEND
```


Problem



Measurements:
rad = 0.50

Programmatic Solution

```

DESPMTR   rad           0.50000

SKBEG      0.0          0.0  0.0
  LINSEG   rad          0.0  0.0
  CIRARC   2*rad        rad  0.0   rad  2*rad  0.0
  LINSEG   -rad         2*rad  0.0
  CIRARC  -2*rad        rad  0.0  -rad   0.0  0.0
  LINSEG   0.0          0.0  0.0
SKEND

```

The screenshot displays the ESP Engineering Sketch Pack interface. The main workspace shows a green oval shape defined by several yellow constraint points. The left sidebar contains a tree view with the following sections:

- File
- Sketch
- StepThru
- Help
- Undo
- Redo
- Home
- Layers
- Tools
- Design Parameters
- Local Variables
- Branches
 - Brch_000001: d0deg
 - Brch_000010: d0rad
 - Brch_000011: r0select
 - Brch_000012: a0sort
 - Brch_000013: a0sort
 - Brch_000014: a0sort
 - Brch_000015: a0sort
 - Brch_000016: a0sort
 - Brch_000017: a0sort
 - Brch_000018: a0sort
 - Brch_000019: a0sort
 - Brch_000020: a0sort
- Display
 - Body 7: Via, Grid
 - Axis: Via, Grid
 - Display Type
 - Display Filter

The bottom-left panel shows the command log with the following text:

```

ndof=12  ncon=12
Valid constraints at points
'a' (fix x)      'y' (fix y)
'p' (perp)      't' (tangent)
'a' (angle)
'w' (width)     'd' (depth)
Valid constraints on segments
'b' (horiz)     'v' (vertical)
'l' (incline)  'l' (length)
Valid constraints on circles

```

The bottom-right panel displays the message: "ESP has been initialized and is attached to 'nerveCRM'". Below this, a file path is shown: ".../data/training/session02/oval.csm" has been loaded.

Problem

**Measurements:**

chord = 2.00

thick = 0.10

Note:

Circular Arcs



Biconvex airfoil (with arcs)

Programmatic Solution

```
DESPMTR  chord      2.00000
DESPMTR  thick      0.10000

SET      rad        radius(0,0,thick,chord,0)

SKBEG    0.0        0.0    0.0
  CIRARC chord/2    -thick  0.0  chord  0.0  0.0
  CIRARC chord/2    thick   0.0  0.0   0.0  0.0
SKEND
```



Biconvex airfoil (with arcs)

Sketcher Solution

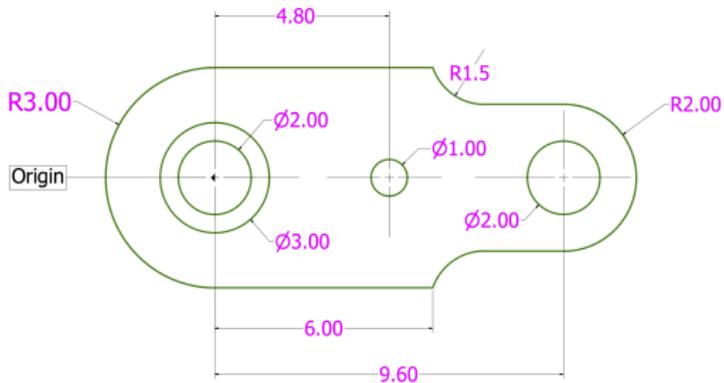
The screenshot displays the ESP Engineering Sketch Pack interface. The main workspace shows a green biconvex airfoil shape defined by several arcs and lines. The left sidebar contains a tree view with the following sections:

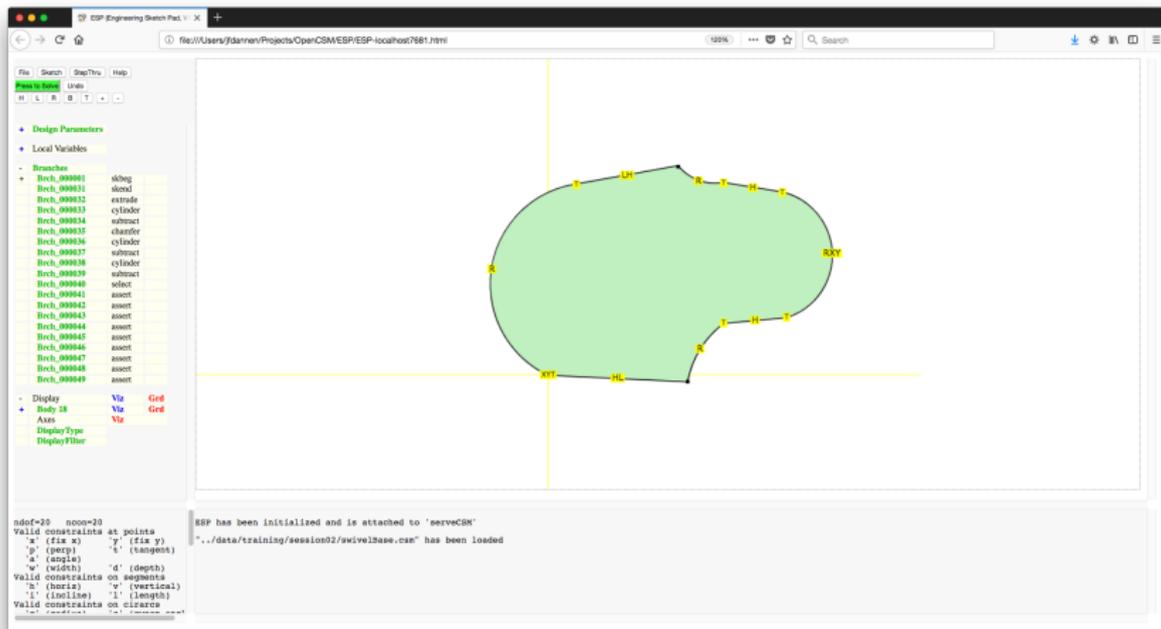
- Design Parameters
- Local Variables
- Branches
 - Brch_000001: sketch
 - Brch_000011: sketch
 - Brch_000012: reflect
 - Brch_000013: assort
 - Brch_000014: assort
 - Brch_000015: assort
 - Brch_000016: assort
 - Brch_000017: assort
 - Brch_000018: assort
 - Brch_000019: assort
 - Brch_000020: assort
 - Brch_000021: assort
- Display
 - Body 4: Via, Grid
 - Axis: Via, Grid
 - DisplayType: DisplayFilter

The bottom panel shows the following text:

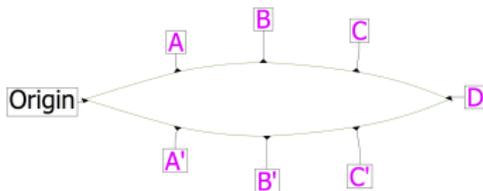
```
ndof=6  ncon=6
Valid constraints at points
'a' (fix x)      'y' (fix y)
'p' (perp)      't' (tangent)
'a' (angle)
'w' (width)     'd' (depth)
Valid constraints on segments
'b' (horiz)     'v' (vertical)
'l' (incline)  'l' (length)
Valid constraints on circles
```

ESP has been initialized and is attached to 'nerveCRM'
'../data/training/session02/biconvex_arcs.csm' has been loaded

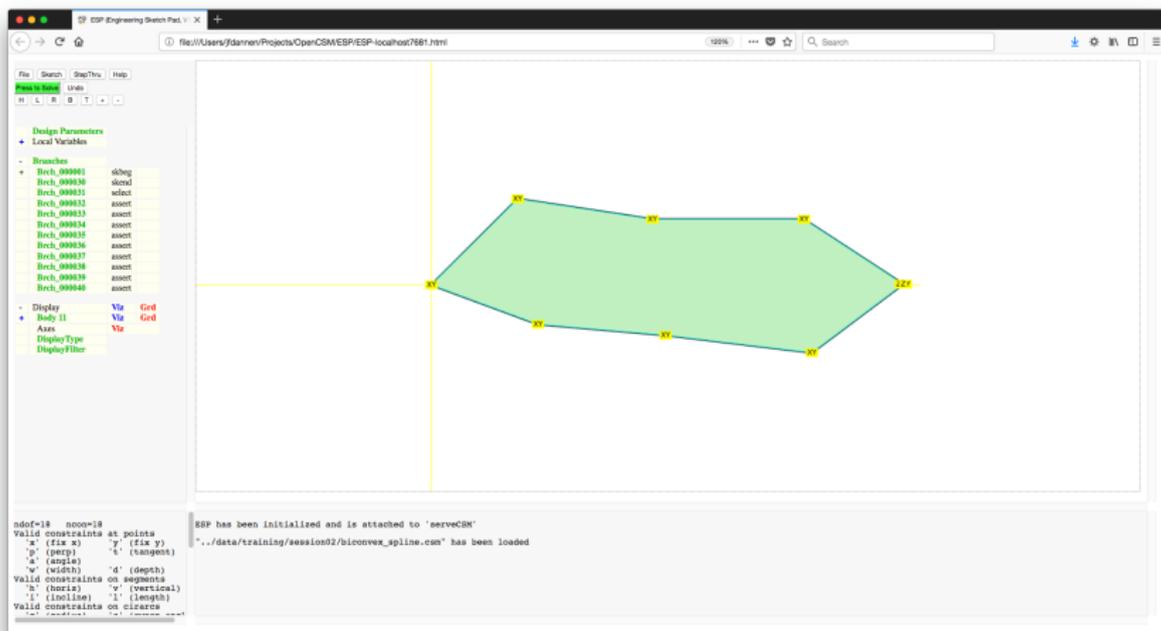




Problem



	<u>x</u>	<u>y</u>
A:	.255	.075
B:	.500	.100
C:	.745	.075
D:	1.00	0.00



The screenshot displays the ESP Engineering Sketch Pack interface. The main workspace shows a green biconvex airfoil shape defined by several vertices marked with 'X'. A vertical yellow line is positioned to the left of the airfoil, and a horizontal yellow line passes through the leftmost vertex. The left sidebar contains a 'Design Parameters' panel with a tree view showing 'Local Variables' and a list of branches (Brch_000001 to Brch_000048) with their respective constraint types (sketch, select, assert). Below this is a 'Display' section with checkboxes for 'Body II', 'Axes', 'DisplayType', and 'DisplayFilter'. The bottom panel shows a console window with the following text:

```

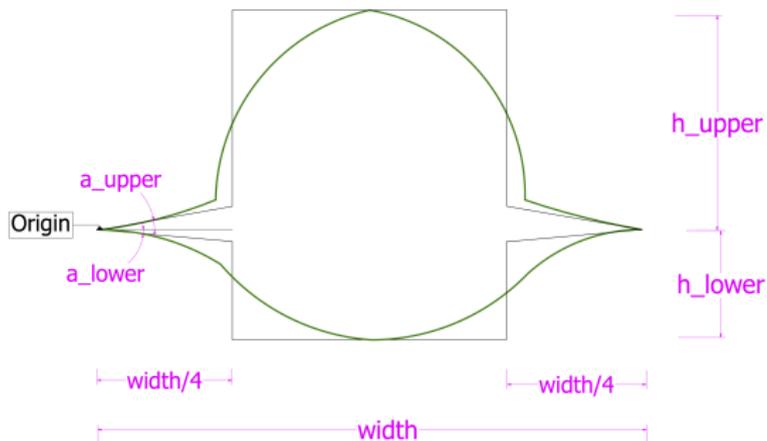
ndof=18  ncon=18
Valid constraints at points
'a' (fix x)      'y' (fix y)
'p' (perp)      't' (tangent)
'u' (angle)
'w' (width)     'd' (depth)
Valid constraints on segments
'b' (horiz)     'v' (vertical)
'l' (incline)  'l' (length)
Valid constraints on circles

```

Below the console window, a message states: "ESP has been initialized and is attached to 'nerveCRM'". A file path is visible in the top toolbar: ".../data/training/session02/biconvex_spline.csm" has been loaded.

Fuselage X-section (with Beziers)

Problem



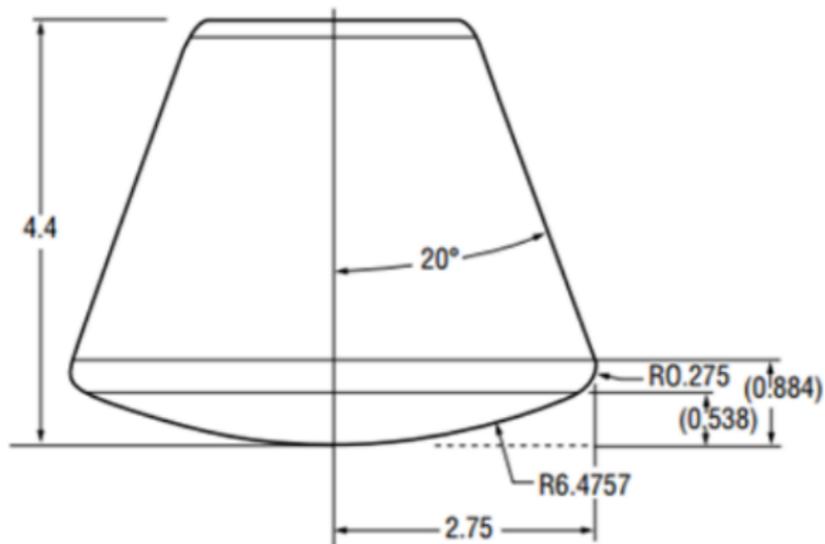
Measurements:

width = 5.00
 h_{upper} = 2.00
 h_{lower} = 1.00
 a_{upper} = 10°
 a_{lower} = 5°

Note:

4 Bezier Cubics

Problem



```
width      = 2.75000
baserad   = 6.47570
cornrad    = 0.27500
coneangle  = 20.00000
height     = 4.40000
```

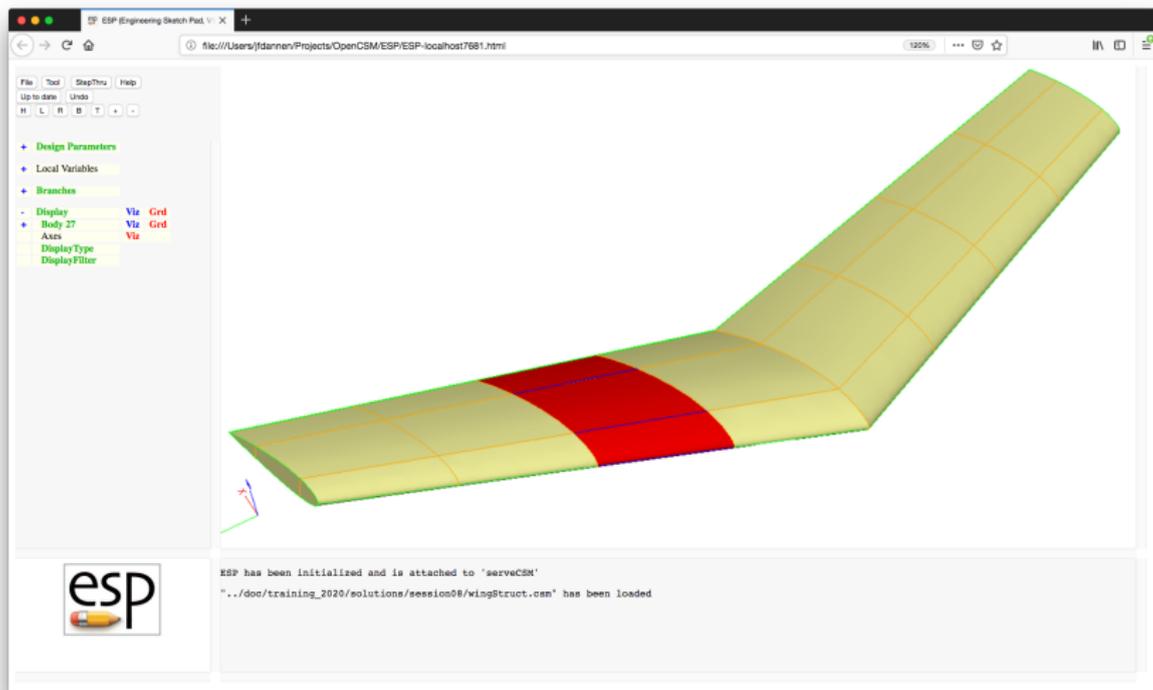

Session 8 Solutions

Selection & Attribution



Wing with structure

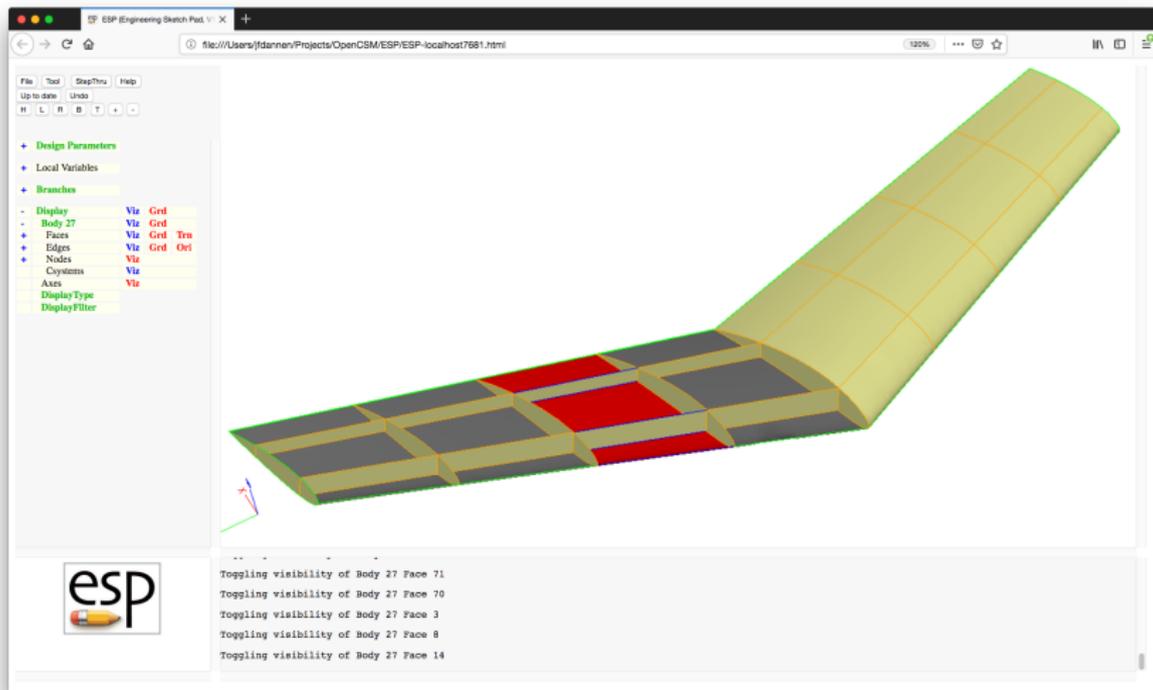
Structure is not shown





Wing with structure

Structure is shown for right wing



- Right wing upper skin panels (Faces)
 - `tagComp=riteWing`
 - `tagType=upper`
- Right wing lower skin panels (Faces)
 - `tagComp=riteWing`
 - `tagType=lower`
- Right wing leading edge (Edge)
 - `tagComp=riteWing`
 - `tagType=leadingEdge`
- Right wing trailing edge panels (Faces)
 - `tagComp=riteWing`
 - `tagType=trailingEdge`
- Right wing tip panels (Faces)
 - `tagComp=riteWing`
 - `tagType=tip`

- Right wing spars (Faces)
 - tagComp=riteWing
 - tagType=spar
 - tagIndex=1 for forward spar or tagIndex=2 for rearward spar
- Right wing ribs (Faces)
 - tagComp=riteWing
 - tagType=rib
 - tagIndex=1 for inboard rib, ..., tagIndex=3 for outboard rib
- Left wing is attributed similarly to right wing (Faces & Edges)
- Ribs at the wing root (Faces)
 - tagComp=rootWing
 - tagType=rib
 - tagIndex=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:camherr   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

CFGPMTR   SHARP_TE      0        # make the trailing edge blunt

```

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

# 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
# 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:alpat  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
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
```



wingStruct.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
```

```
# make wing waffle
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
UDPARG     waffle        depth zmax-zmin filename <<
```

```
# 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

# 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 EF E F tagComp=leftWing tagType=spar tagIndex=1

POINT G AT x@G -y@G
POINT H AT x@H -y@H
LINE GH G H 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
```

```
# trim the waffle to be the ribs and spars
RESTORE  WingOml
RESTORE  WingWaffle
INTERSECT

# score the wing skin with the waffle
RESTORE  WingOml
RESTORE  WingWaffle
SUBTRACT
EXTRACT  0

# combine the two
UNION
```

- Put the Attribute LoadPoint=leftTip on the Node that is at the intersection of the forward spar, wing tip, and upper skin on the left wing

```
UDPRIM      editAttr  filename <<
NODE  ADJ2FACE  tagComp=leftWing  tagType=spar  tagIndex=1
AND    ADJ2FACE  tagComp=leftWing  tagType=upper
AND    ADJ2FACE  tagComp=leftWing  tagType=tip
SET                                LoadPoint=leftTip
>>
```

- For the upper and lower skin panels on the rite wing that are between the first and second rib, make their color red and their grid white

```
UDPRIM   editAttr  filename <<
FACE HAS   tagComp=riteWing tagType=upper
AND ADJ2FACE tagType=rib tagIndex=1
AND ADJ2FACE tagType=rib tagIndex=2
SET       _color=red
SET       _bcolor=red
SET       _gcolor=white

FACE HAS   tagComp=riteWing tagType=lower
AND ADJ2FACE tagType=rib tagIndex=1
AND ADJ2FACE tagType=rib tagIndex=2
SET       _color=red
SET       _bcolor=red
SET       _gcolor=white

>>
```

- Make the Edges blue that are between two red panels

```
UDPRIM    editAttr  filename <<
EDGE      ADJ2FACE  _color=red
AND       ADJ2FACE  tagType=spar
SET                               _color=blue

EDGE      HAS       tagType=leadingEdge
AND       ADJ2FACE  _color=red
SET                               _color=blue
>>
```