Engineering Sketch Pad (ESP)

Training Session 3
Solids Fundamentals (2)

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updated for v1.19

Overview

- Miscellaneous Branches
- Manipulating the Stack
    - GROUP
    - STORE, RESTORE
- Grown Bodys
    - EXTRUDE
    - REVOLVE
    - RULE
    - BLEND
- Creating a Waffle
    - UDPRIM WAFFLE
- Homework Exercises

Miscellaneous Branches (1)

- `SET` — set the value of a Local Variable to the given expression
- `MARK` — push a Mark onto the Stack
- `SELECT` — select entity for which @-parameters are evaluated
    - see “help” for details
- `PROJECT` — find the first projection from a given point (in space) in a given direction

Miscellaneous Branches (2)

- `DUMP` — write file that contains the Body (not Group) on the top of the Stack
  - if `remove` is not zero, the Body is popped off the Stack
  - if `toMark` is not zero, all Bodys since the Mark are written
- The types of files that can be written by `DUMP` include:
  - `.brep` or `.BREP` — `OpenCASCADE` output
  - `.bstl` or `.BSTL` — binary stereolithography output
  - `.egads` or `.EGADS` —`EGADS` output
  - `.egg` or `.EGG` — EGG restart output
  - `.igs` or `.IGS` — IGES output
  - `.sens` or `.SENS` — sensitivity information
  - `.step` or `.STEP` — STEP output
  - `.stl` or `.STL` — ASCII stereolithography output
  - `.stp` or `.STP` — STEP output
  - `.tess` or `.TESS` — ASCII tessellation output
  - `.ugrid` or `.UGRID` — ASCII AFLR3 output

Manipulating the Stack (1)

- During the build process, `OpenCSM` maintains a last-in-first-out (LIFO) “Stack” that can contain Bodys, Marks, and Sketches.
- The `.csm` statements are executed in a stack-like way, taking their inputs from the Stack and depositing their results onto the Stack.
- Bodys can be grouped with the `GROUP` statement
  - all the Bodys back to the Mark (or the beginning of the Stack) are put into a single Group
  - some operations, such as the transformations, `ATTRIBUTE`, and `STORE` operate on all Bodys in the Group simultaneously
  - Bodys and be ungrouped by giving `GROUP` a negative argument

Manipulating the Stack (2)

- The Group on the top of the Stack can be “popped” off the Stack with a `STORE $name index` command
  - if the `name` is alpha-numeric, the Group is stored in a named storage location, with the given `index` (from 0 to 99)
  - if the `name` is a dot (.), the Group is not stored (just popped off the Stack)
  - if the `name` is two dots (..), all the Groups back to the Mark are popped off the Stack (and not stored)
  - if the `name` is three dots (...), everything is popped off the Stack

Manipulating the Stack (3)

- Groups can be read from a named storage location and “pushed” onto the Stack with the `RESTORE $name index` command
- The `RESTORE` command is considered a primitive, so its Attributes are put on all the Bodys and all their Faces
- `RESTORE .` now duplicates the Body (not Group) on the top of the stack

Manipulating the Stack (4)

- Assume that the Stack contains: 5 7 9 12 (top)
- If one wants to reverse the top two Bodys, use
  - `STORE temp 1`
    - Stack now contains: 5 7 9
    - storage `temp 1` contains 12
  - `STORE temp 2`
    - Stack now contains: 5 7
    - storage `temp 2` contains 9
  - `RESTORE temp 1`
    - Stack now contains: 5 7 12
  - `RESTORE temp 2`
    - Stack now contains: 5 7 12 9

Manipulating the Stack (5)

- Assume that the Stack contains: 5 7 9 12 (top)
- If one wants to put a mark between the 7 and 9, use
  - `STORE temp 1`
    - Stack now contains: 5 7 9
    - storage `temp 1` contains 12
  - `STORE temp 2`
    - Stack now contains: 5 7
    - storage `temp 2` contains 9
  - `MARK`
    - Stack now contains: 5 7 mark
  - `RESTORE temp 2`
    - Stack now contains: 5 7 mark 9
  - `RESTORE temp 1`
    - Stack now contains: 5 7 mark 9 12

Miscellaneous Branches (6)

- If you want to duplicate the Group on the top of the Stack, use STORE and RESTORE
- Depending on the value of keep in the STORE command, the Group on the top of the Stack is either kept (like a “copy”) or popped off the Stack (like a “cut”)
  - not using the keep option to duplicate the Body on the top of the Stack

    ```
    STORE   temp
    RESTORE temp
    RESTORE temp
    ```

  - using the keep option to duplicate the Body on the top of the Stack

    ```
    STORE   temp 0 1
    RESTORE temp
    ```

  - or (new in v1.19)

    ```
    RESTORE .
    ```

Setting Array Values

- Use the DIMENSION statment to set the size of the array
  - DIMENSION creates a Branch, so its arguments can be any expression
- Use the SET statement to define the values
  - if name of array is given, set all the values
    - if more values are given than needed, excess are ignored
    - if fewer values are given than needed, last value is repeated

```
CFGPMTR   numRows 3
CONPMTR   numCols 2
DIMENSION array   numRows numCols
SET       array   "5;2"
```

creates: array $= [5, 2, 2, 2, 2, 2]$

- A single array element can be assigned with

```
SET       array[2,1]  3
```

Grown Primitives (from SheetBodys)

- Pops one or more SheetBodys from the Stack
- Pushes the resultant SolidBody onto the Stack
- Supported grown features include:
  - `EXTRUDE` — in a given direction for a given distance
  - `REVOLVE` — around a given axis for a given angular displacement
  - `RULE` — connect all the SheetBodys back to the Mark by straight lines
    - the first and/or last Xsect can be a NodeBody
  - `BLEND` — connect all the SheetBodys back to the Mark with smooth curves
    - the first and/or last Xsect can be a NodeBody
    - at the bounding Nodes, the user can specify the radius of curvature in two orthogonal directions
  - `SWEEP` — a SheetBody along a given WireBody
    - this is often problematic in `OpenCASCADE`
  - `LOFT` — similar to `BLEND`, but with less control

Grown Primitives (from WireBodys)

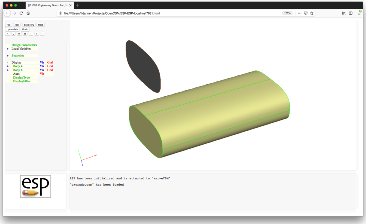
- Pops one or more WireBodys from the Stack
- Pushes the resultant SheetBody onto the Stack
- Supported grown features include:
  - `EXTRUDE` — in a given direction for a given distance
  - `REVOLVE` — around a given axis for a given angular displacement
  - `RULE` — connect all the WireBodys back to the Mark by straight lines
    - the first and/or last Xsect can be a NodeBody
  - `BLEND` — connect all the WireBodys back to the Mark with smooth curves
    - the first and/or last Xsect can be a NodeBody

Grown Primitives (from NodeBodys)

- Pops one or more NodeBodys from the Stack
- Pushes the resultant WireBody onto the Stack
- Supported grown features include:
  - `EXTRUDE` — in a given direction for a given distance
  - `REVOLVE` — around a given axis for a given angular displacement
  - `RULE` — connect all the NodeBodys back to the Mark by straight lines
  - `BLEND` — connect all the NodeBodys back to the Mark with smooth curves

Grown Primitive — EXTRUDE

Note: Original Xsect (SheetBody) and result of EXTRUDE are shown



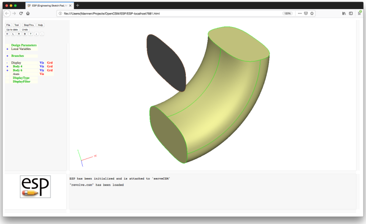
```
ESP has been initialized and is attached to 'serveCSM'
"extrude.csm" has been loaded
```

```
# extrude

UDPRIM   supell rx 2 ry_n 1 ry_s 1 n 3
ROTATEY 90 0 0
STORE   sections

RESTORE sections
TRANSLATE 0 4 0

RESTORE sections
EXTRUDE 8 0 0

END
```

- Face-order is: (1) orig Xsect, (2) copy of Xsect, (3) Face from first Xsect Edge, (4) Face from second Xsect Edge, . . .

Grown Primitive — REVOLVE

Note: Original Xsect (SheetBody) and result of REVOLVE are shown



```
ESP has been initialized and is attached to 'serveCSM'
"revolve.csm" has been loaded
```

```
# revolve

UDPRIM  supell rx 2 ry_n 1 ry_s 1 n 3
ROTATEY 90 0 0
STORE   sections

RESTORE sections
TRANSLATE 0 4 0

RESTORE sections
REVOLVE 0 4 0   0 0 1   90

END
```

- Face-order is: (1) orig Xsect, (2) copy of Xsect, (3) Face from first Xsect Edge, (4) Face from second Xsect Edge, . . .

Special Note on REVOLVE

- To revolve a Xsect to make a body of revolution:
  - do not use:

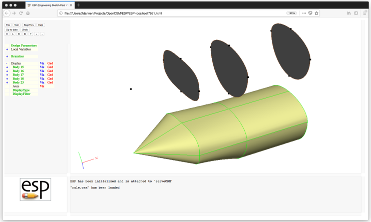
    ```
    # make whole Body
    REVOLVE   0 0 0   0 1 0   360
    ```

  - use instead:

    ```
    # make half on Body
    REVOLVE   0 0 0   0 1 0   180

    # mirror for second half
    RESTORE   .
    MIRROR    0   0   1   0

    # put it all together
    JOIN     0    0
    ```

Grown Primitive — RULE

Note: Original Xsects (SheetBodys) and result of RULE are shown



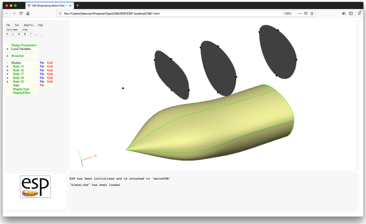
```
ESP has been initialized and is attached to 'serveCSM'
"rule.csm" has been loaded
```

- Face-order on later slide

```
# rule

MARK
   POINT   0 0 0

   UDPRIM   supell rx 2 ry_n 1 ry_s 1 n 3
   ROTATEY 90 0 0
   TRANSLATE 3 0 0

   UDPRIM   supell rx 2 ry_n 1 ry_s 2
   ROTATEY 90 0 0
   TRANSLATE 6 0 0

   UDPRIM   supell rx 2 ry_n 1 ry_s 2
   ROTATEY 90 0 0
   TRANSLATE 10 0 0
GROUP
STORE   sections

RESTORE sections
TRANSLATE 0 4 0

MARK
   RESTORE sections
RULE

END
```

Grown Primitive — BLEND

Note: Original Xsects (SheetBodys) and result of BLEND are shown



```
ESP has been initialized and is attached to 'serveCSM'
"blend.csm" has been loaded
```

```
# blend

MARK
   POINT  0 0 0

   UDPRIM  supell rx 2 ry_n 1 ry_s 1 n 3
   ROTATEY 90 0 0
   TRANSLATE 3 0 0

   UDPRIM  supell rx 2 ry_n 1 ry_s 2
   ROTATEY 90 0 0
   TRANSLATE 6 0 0

   UDPRIM  supell rx 2 ry_n 1 ry_s 2
   ROTATEY 90 0 0
   TRANSLATE 10 0 0
GROUP
STORE  sections

RESTORE sections
TRANSLATE 0 4 0

MARK
   RESTORE sections
BLEND

END
```

- Face-order on later slide

Bodys Produced by `RULE` and `BLEND`

- If the first and last Xsects are both WireBodys
  - a SheetBody is produced that is open on both ends
- If the first or last Xsect is a WireBody
  - a SheetBody is produced that is open on one end and closed on the other
- Otherwise
  - a SolidBody is produced

Face-order for `RULE` and `BLEND`

- (1) first Xsect (or empty if POINT)
- (2) last Xsect (or empty if POINT)
- (3) Face from first Xsect Edge between first and second Xsects
- (4) Face from first Xsect Edge between second and third Xsects
- . . .
- (n) Face from second Xsect Edge between first and second Xsects
- . . .

RULE and BLEND

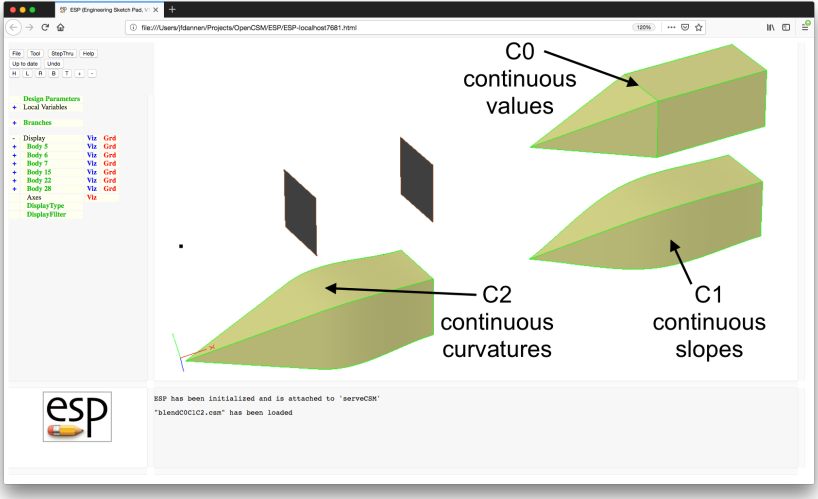
- RULE and BLEND require that all Xsects have the same number of Segments, ordered in the same way
  - new Faces are made by combining all the first Segments, . . .
- BLEND allows user-selectable continuity in blend direction
  - C2 - curvature continuity (the default)
  - C1 - slope continuity (obtained with Xsect repeated once)
  - C0 - value continuity (obtained with Xsect repeated twice)
- Xsects can be automatically reordered to help eliminate twist by setting `reorder` to a non-zero value
  - positive to start from first Xsect
  - negative to start from last Xsect
- Users can manually reorder Xsects with the REORDER command (applied to a Xsect)
  - Reordering only changes the order of Segments, not their shapes

BLEND Continuity (1)

```
# blendC0C1C2

# original Xsects (top left)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
GROUP
TRANSLATE -3 +1 0

# Body with C0 at second Xsect (top rite)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1
   UDPRIM box  dy 1  dz 1
   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
BLEND
TRANSLATE +3 +1 0
```

```
# Body with C1 at second Xsect (bottom rite)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1
   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
BLEND
TRANSLATE -3 -1 0

# Body with C2 at second Xsect (bottom left)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
BLEND
TRANSLATE +3 -1 0

END
```

BLEND Continuity (2)



C0 continuous values

C2 continuous curvatures

C1 continuous slopes

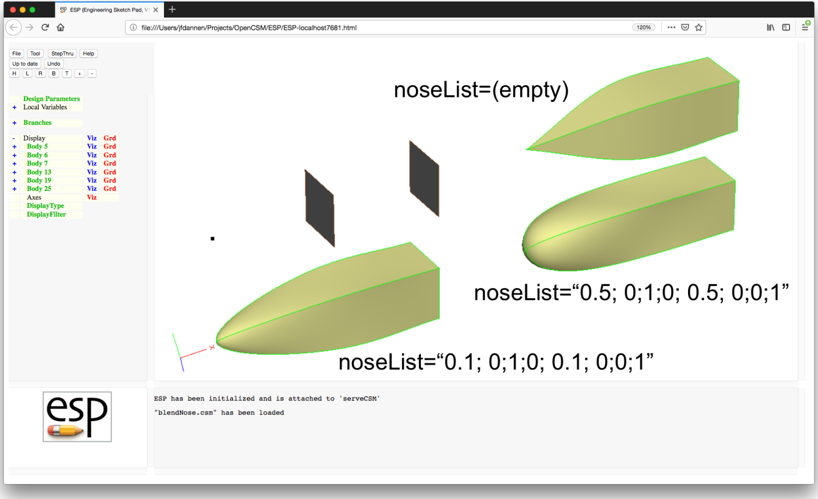
```
ESP has been initialized and is attached to 'serveCSM'
"blendC0C1C2.csm" has been loaded
```

BLEND Nose/Tail Treatment (1)

```
# blendC0C1C2

# original Xsects (top left)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
GROUP
TRANSLATE -3 +1 0

# Body with pointed nose (top rite)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
BLEND
TRANSLATE +3 +1 0
```

```
# Body with slightly rounded nose (bottom left)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
BLEND "0.1; 0;1;0; 0.1; 0;0;1"
TRANSLATE -3 -1 0

# Body with rounded nose (bottom rite)
MARK
   POINT  -2  0  0

   UDPRIM box  dy 1  dz 1

   UDPRIM box  dy 1  dz 1
   TRANSLATE +2 0 0
BLEND "0.5; 0;1;0; 0.5; 0;0;1"
TRANSLATE +3 -1 0

END
```

BLEND Nose/Tail Treatment (2)



noseList=(empty)

noseList=“0.5; 0;1;0; 0.5; 0;0;1”

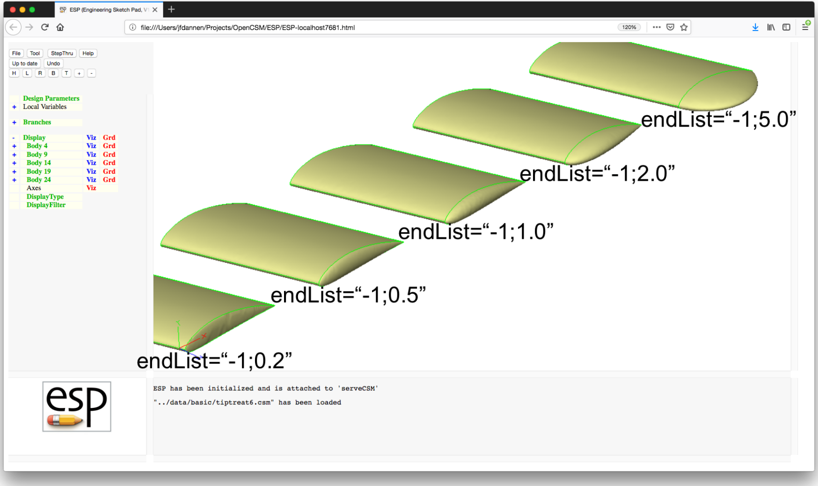
noseList=“0.1; 0;1;0; 0.1; 0;0;1”

```
ESP has been initialized and is attached to 'serveCSM'
"blendNose.csm" has been loaded
```

BLEND Wingtip Treatement (1)

- If the first Xsect is a SheetBody with 2 or 3 Edges and the begList contains 2 entries:
    - begList[1] = -1
    - begList[2] = the aspect ratio of an approximate ellipse that spans between the first and second Xsect Edge
- The same applies to the last Xsect and endList

BLEND Wingtip Treatement (2)



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/tiptreat6.csm" has been loaded
```

Building a Waffle (1)

- Called with `.csm` statement:
  `UDPRIM waffle depth <number> filename <name_of_file>`
- Valid statements in file are:
  - `CPOINT` — create a construction point (not in final waffle)
  - `CLINE` — create a construction line (not in final waffle)
  - `POINT` — create a waffle point
  - `LINE` — create one or more waffle segments
  - `PATBEG/PATEND` — create a pattern (loop)
- Keywords can be in lowercase or UPPERCASE
- Coordinates of existing point `<pname>` are given by
  - `x@<pname>` and `y@<pname>`

Building a Waffle (2)

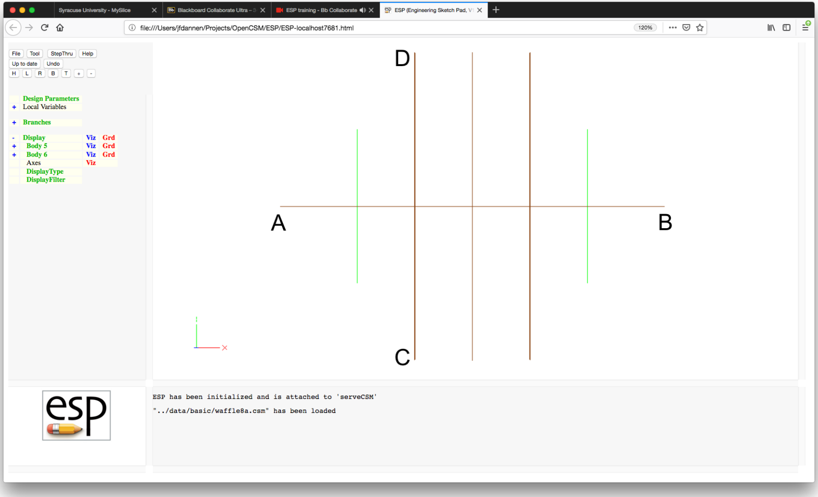
- Variants of `CPOINT` and `POINT`
  - `POINT <pname> AT <xloc> <yloc>`
    - create point at `<xloc,yloc>`
  - `POINT <pname> ON <lname> FRAC <fracDist>`
    - creates point on `<lname>` at given fractional distance
  - `POINT <pname> ON <lname> XLOC <x>`
    - creates point on `<lname>` at given `<x>`
  - `POINT <pname> ON <lname> YLOC <y>`
    - creates point on `<lname>` at given `<y>`
  - `POINT <pname> ON <lname> PERP <pname2>`
    - creates point on `<lname>` that is closest to `<pname2>`
  - `POINT <pname> ON <lname> XSECT <lname2>`
    - creates point at intersection of `<lname>` and `<lname2>`
  - `POINT <pname> OFF <lname> <dist> <pname2>`
    - creates point `<dist>` to the left of `<lname>` at `<pname2>`

Building a Waffle (3)

- Variants of `CLINE` and `LINE`
  - `LINE . <pname1> <pname2> <attrName1=attrValue1>...`
    - creates unnamed line between `<pname1>` and `<pname2>` with given attribute(s) (if any)
  - `LINE <lname> <pname1> <pname2> <attrName1=attrValue1>`
    - creates line named `<lname>` between `<pname1>` and `<pname2>` with given attribute(s) (if any)

Waffle Example (1)

SolidBody in green; Waffle in brown


Syracuse University - MySlice
Blackboard Collaborate Ultra
ESP training - Bb Collaborate
ESP (Engineering Sketch Pad, V
file:///Users/jfdannen/Projects/OpenCSM/ESP/ESP-localhost7681.html
120%
File
Tool
StepThru
Help
Up to date
Undo
H
L
R
B
T
+
-
Design Parameters
+ Local Variables
+ Branches
- Display Viz Grd
+ Body 5 Viz Grd
+ Body 6 Viz Grd
Axes Viz
DisplayType
DisplayFilter
D
A
B
C
esp

```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/waffle8a.csm" has been loaded
```

Waffle Example (2)

```
# SolidBody
CYLINDER  0  0  0  3  0  0  1
STORE     SolidBody

# get bounding box of SolidBody
RESTORE   SolidBody
SET       xmin  @xmin
SET       xmax  @xmax
SET       ymin  @ymin
SET       ymax  @ymax
SET       zmin  @zmin
SET       zmax  @zmax
STORE     .
```

Waffle Example (3)

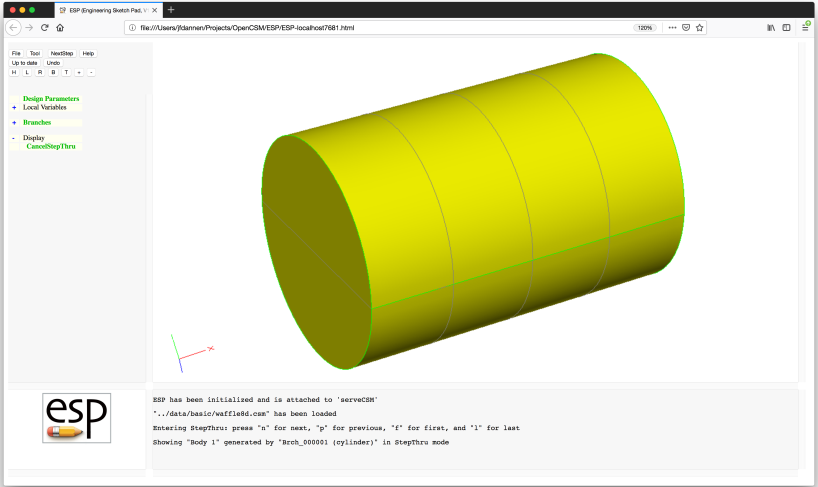
```
# Waffle (centered on SolidBody)
UDPRIM    waffle   filename <<   depth zmax-zmin+2
   POINT  A AT  xmin-1  (ymin+ymax)/2
   POINT  B AT  xmax+1  (ymin+ymax)/2
   LINE   AB  A  B  type=symmetry

   PATBEG  i  3
      POINT  C AT   xmin+i/4*(xmax-xmin) ymin-1
      POINT  D AT   xmin+i/4*(xmax-xmin) ymax+1
      LINE   .  C  D  type=!$bulkhead_+i
   PATEND
>>
TRANSLATE 0  0  zmin-1
STORE     Waffle
```

Waffle Example (4)

```
# score the SolidBody by the Waffle and extract Faces
RESTORE   SolidBody
RESTORE   Waffle
SUBTRACT
EXTRACT   0

# generate the internal structure
RESTORE   SolidBody
RESTORE   Waffle
INTERSECT

# put them together
JOIN

END
```

Waffle Example (5)

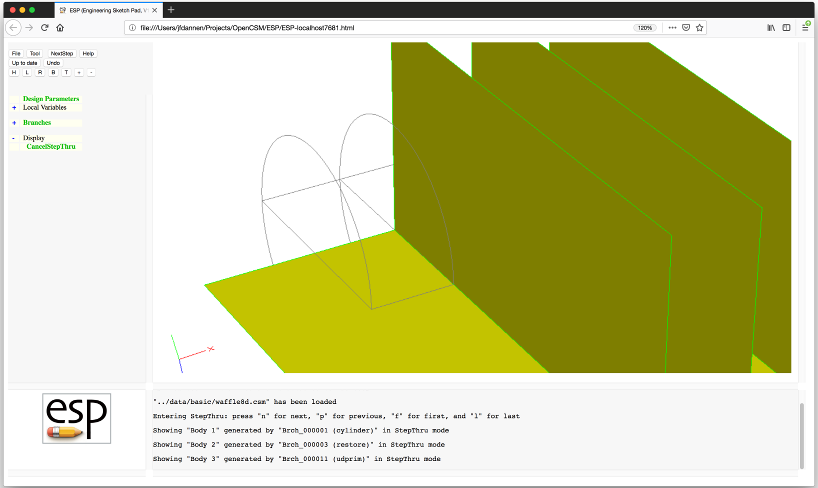
Original SolidBody
(Grey lines are only part of final configuration.)



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/waffle8d.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_000001 (cylinder)" in StepThru mode
```

Waffle Example (6)

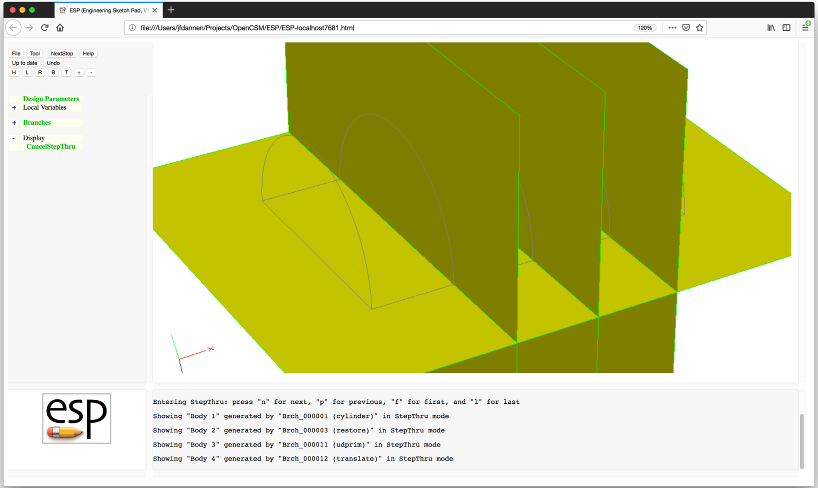
Original Waffle



```
"../data/basic/waffle8d.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_000001 (cylinder)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (restore)" in StepThru mode
Showing "Body 3" generated by "Brch_000011 (udprim)" in StepThru mode
```

Waffle Example (7)

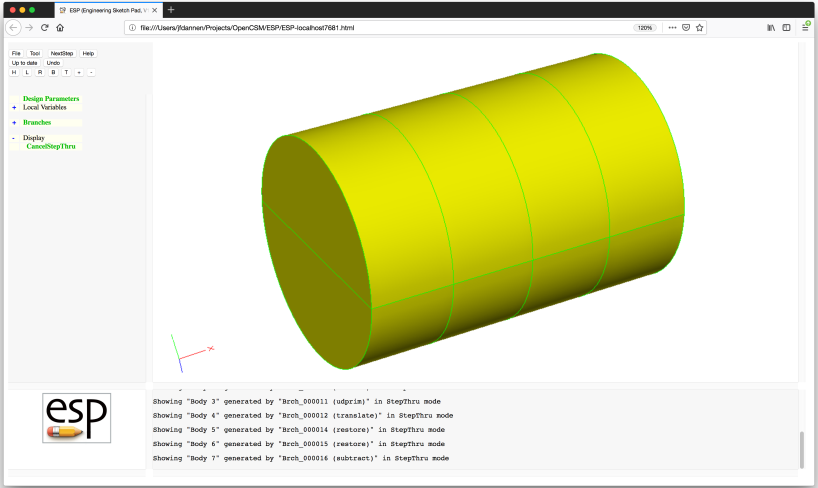
After TRANSLATing the Waffle



```
Entering StepThru: press "n" for next, "p" for previous, "f" for first, and "l" for last
Showing "Body 1" generated by "Brch_000001 (cylinder)" in StepThru mode
Showing "Body 2" generated by "Brch_000003 (restore)" in StepThru mode
Showing "Body 3" generated by "Brch_000011 (udprim)" in StepThru mode
Showing "Body 4" generated by "Brch_000012 (translate)" in StepThru mode
```

Waffle Example (8)

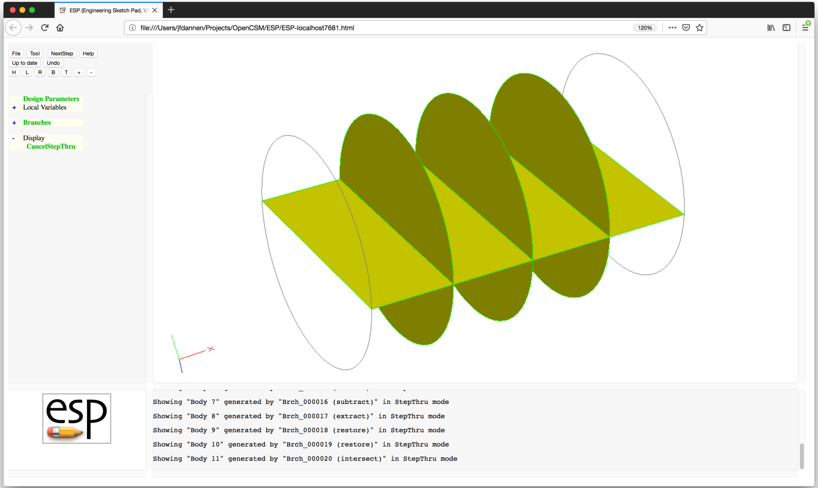
After SUBTRACTion of Waffle from SolidBody



```
Showing "Body 3" generated by "Brch_000011 (udprim)" in StepThru mode
Showing "Body 4" generated by "Brch_000012 (translate)" in StepThru mode
Showing "Body 5" generated by "Brch_000014 (restore)" in StepThru mode
Showing "Body 6" generated by "Brch_000015 (restore)" in StepThru mode
Showing "Body 7" generated by "Brch_000016 (subtract)" in StepThru mode
```

Waffle Example (9)

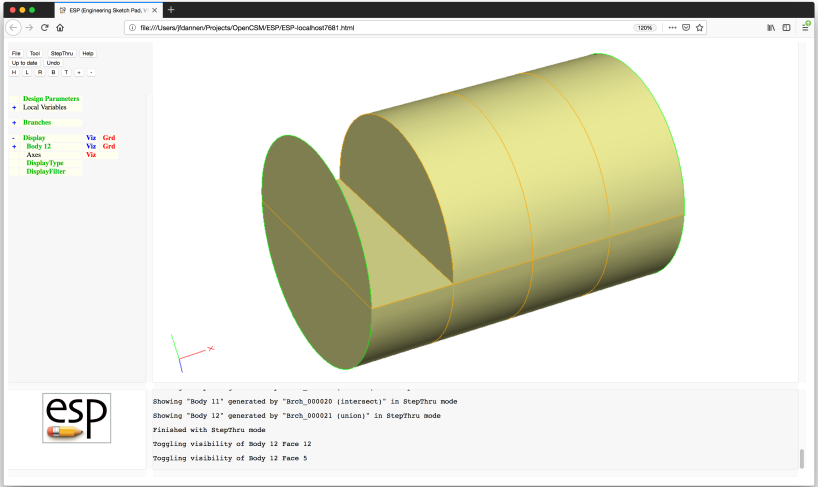
After INTERSECTion of SolidBody and Waffle



```
Showing "Body 7" generated by "Brch_000016 (subtract)" in StepThru mode
Showing "Body 8" generated by "Brch_000017 (extract)" in StepThru mode
Showing "Body 9" generated by "Brch_000018 (restore)" in StepThru mode
Showing "Body 10" generated by "Brch_000019 (restore)" in StepThru mode
Showing "Body 11" generated by "Brch_000020 (intersect)" in StepThru mode
```

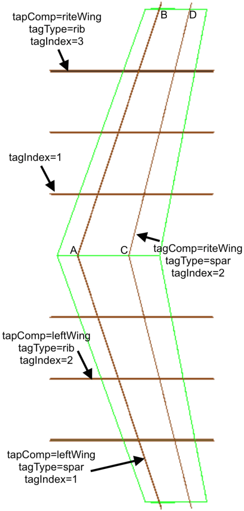
Waffle Example (10)

After UNION of scored SolidBody and interior Waffle (One Face shown transparent to see some of the internal structure.)



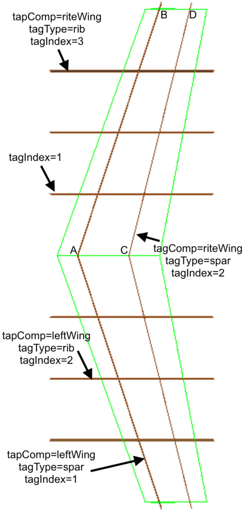
```
Showing "Body 11" generated by "Brch_000020 (intersect)" in StepThru mode
Showing "Body 12" generated by "Brch_000021 (union)" in StepThru mode
Finished with StepThru mode
Toggling visibility of Body 12 Face 12
Toggling visibility of Body 12 Face 5
```

Waffle for wing3 (1)



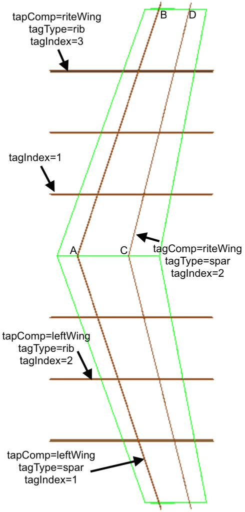
```
SET        xmin       @xmin-0.1
SET        xmax       @xmax+0.1
SET        ymin       0
SET        ymax       @ymax+0.1
SET        zmin       @zmin-0.1
SET        zmax       @zmax+0.1
STORE      .

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

# construction lines for spars
CPOINT A   AT           0+wing:spar1*croot 0
CPOINT B   AT  wing_xtip+wing:spar1*ctip  wing_ytip
CPOINT C   AT           0+wing:spar2*croot 0
CPOINT D   AT  wing_xtip+wing:spar2*ctip  wing_ytip

CLINE  AB      A  B
CLINE  CD      C  D
```

Waffle for **wing3** (2)



```
# 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
```

Waffle for **wing3** (3)



```
# 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
>>
```

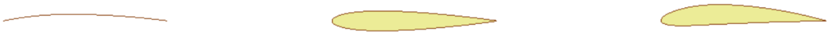
Homework Exercises

- Simple wing
- Simple fuselage
  - OML (outer mold line)
  - structure
- Starter files are in `$ESP_ROOT/training/ESP/data/session03`

Creating NACA Airfoils

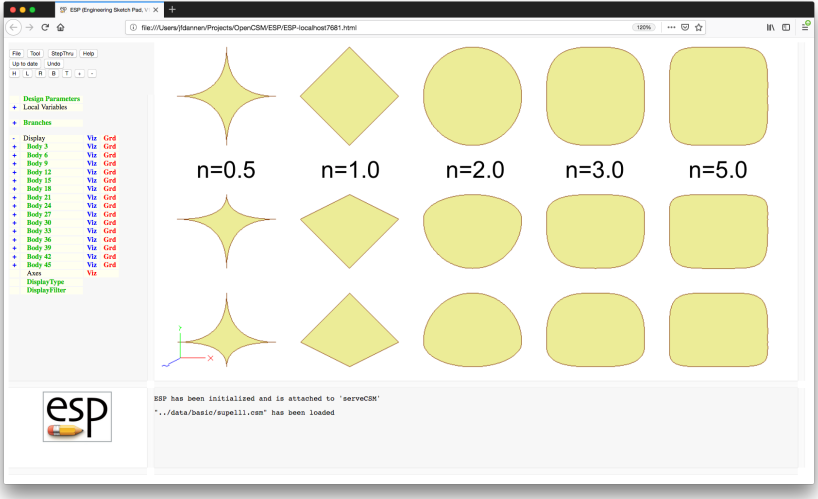
Generated with UDPRIM naca: thickness camber

```
# naca

UDPRIM naca thickness 0.00 camber 0.04
TRANSLATE -2 0 0

UDPRIM naca thickness 0.12 camber 0.00

UDPRIM naca thickness 0.12 camber 0.04
TRANSLATE +2 0 0

END
```



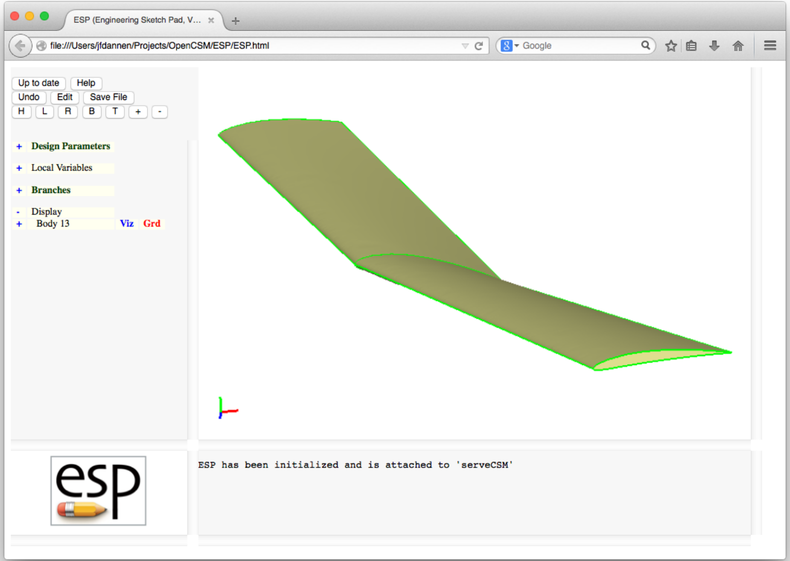
Generated with UDPRIM supell: rx, ry, n

Generated with $ESP_ROOT/data/basic/supell1.csm



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/supell1.csm" has been loaded
```

Simple Wing (1)



```
ESP has been initialized and is attached to 'serveCSM'
```

Simple Wing (2)

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

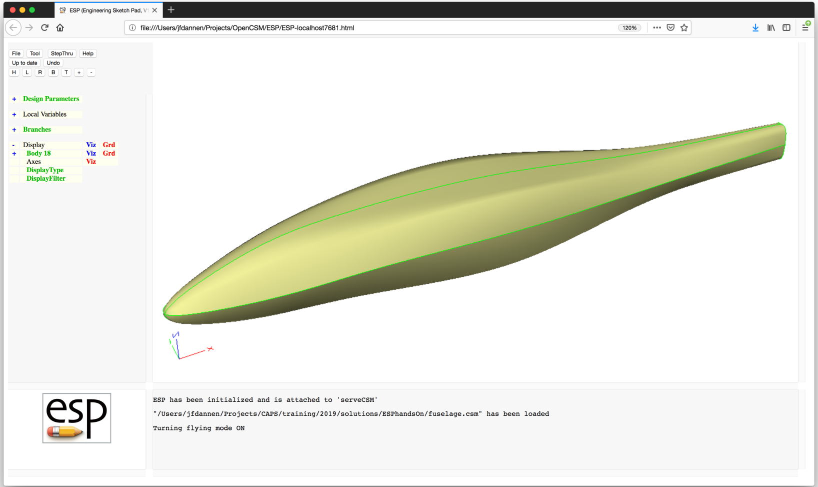
Simple Wing (3)

- 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`?

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

Simple Fuselage (1)

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



```
ESP has been initialized and is attached to 'serveCSM'
"/Users/jfdannen/Projects/CAPS/training/2019/solutions/ESPhandsOn/fuselage.csm" has been loaded
Turning flying mode ON
```

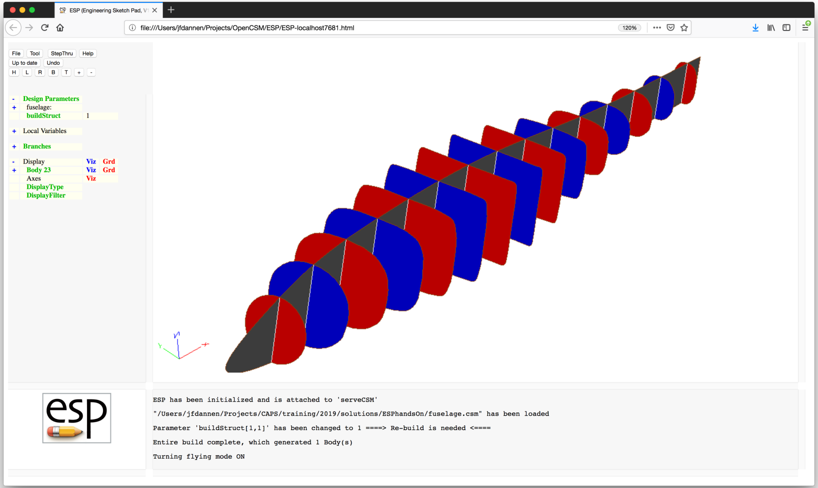
Simple Fuselage (2)

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

Simple Fuselage (3)

- 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?

Simple Fuselage (4)


ESP (Engineering Sketch Pad, V
file:///Users/jfdannen/Projects/OpenCSM/ESP/ESP-localhost7681.html
120%
File
Tool
StepThru
Help
Up to date
Undo
H
L
R
B
T
+
-
Y
X
esp

- Design Parameters
+ fuselage:
  buildStruct 1

+ Local Variables

+ Branches

- Display Viz Grd
+ Body 23 Viz Grd
  Axes Viz
  DisplayType
  DisplayFilter

```
ESP has been initialized and is attached to 'serveCSM'
"/Users/jfdannen/Projects/CAPS/training/2019/solutions/ESPhandsOn/fuselage.csm" has been loaded
Parameter 'buildStruct[1,1]' has been changed to 1 ====> Re-build is needed <====
Entire build complete, which generated 1 Body(s)
Turning flying mode ON
```