Engineering Sketch Pad (ESP) Training
Session 8: Writing a UDP

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Revised for v1.11

Overview

- Review of EGADS geometry and topology models
- EGADS documentation
- Steps to writing a UDP
- Sample UDP
    - structure of code
    - code walk-through
    - stand-alone execution
    - execution as a UDP
- Tire UDP

Boundary Representation – BRep

Top Down ↓

Topological Entity	Geometric Entity	Function
Model		
Body	Solid, Sheet, Wire	
Shell		
Face	**surface**	$(x, y, z) = \mathbf{f}(u, v)$
Loop		
Edge	**curve**	$(x, y, z) = \mathbf{g}(t)$
Node	**point**	

↑ *Bottom Up*

- *Solids* are open at machine precision – tolerances
  - Node points that bound Edges may not be on the curve
  - Edge curves that bound the Faces (through Loops) may not be on the underlying surface

EGADS Documentation

Included in ESP distribution

- Overview
- Objects
  - Geometry
  - Topology
  - Tessellation — Others
- API
  - Utility & IO Functions
  - Attribution
  - Geometry
  - Topology
  - Tessellation
  - High-Level Functions

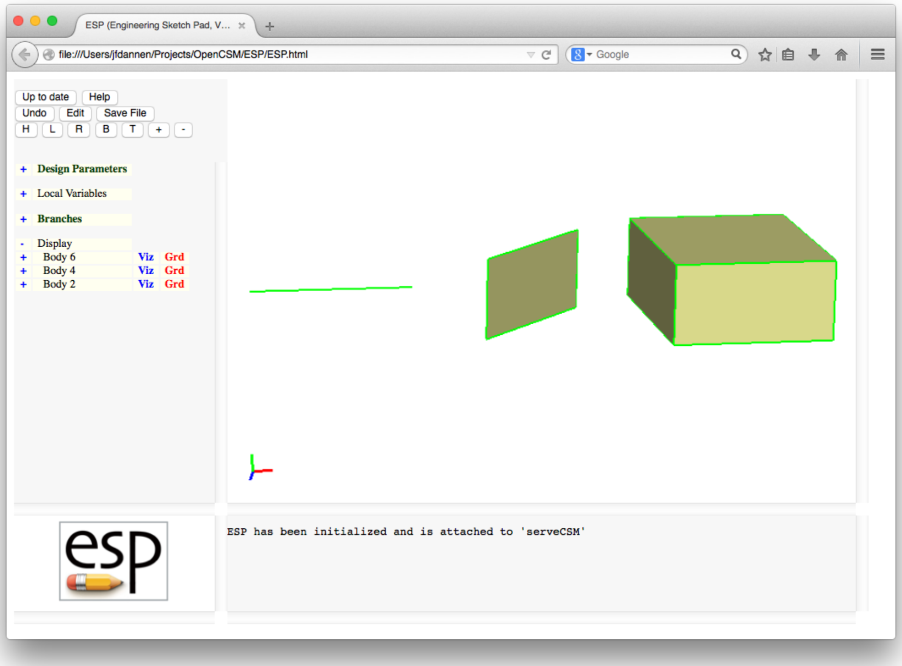
Steps to Writing a UDP

- **Draw a picture**
- Define input and output parameters
  - name (case-insensitive)
  - type (`ATTRSTRING`, `ATTRINT`, `-ATTRINT`, `ATTRREAL`, `-ATTRREAL`, `ATTRREALSEN`)
  - size
  - default value(s)
- Build the Body (stand-alone)
  - bottom-up
  - top-down
  - combination
- Test stand-alone with `vTess`
- Write a `.csm` file
- Test the UDP

Sample UDP

- Inputs:
  - `dx` — `ATTRREALSEN`, default=0
  - `dy` — `ATTRREALSEN`, default=0
  - `dz` — `ATTRREALSEN`, default=0
- Outputs:
  - `area` — `-ATTRREAL`, default=0
  - `volume` — `-ATTRREAL`, default=0
- Notes:
  - if `dx`, `dy`, and `dz` are all positive, create a box
  - if two of `dx`, `dy`, and `dz` are positive, create a plate
  - if one of `dx`, `dy`, and `dz` is positive, create a beam
  - otherwise, raise an error

Sample UDP

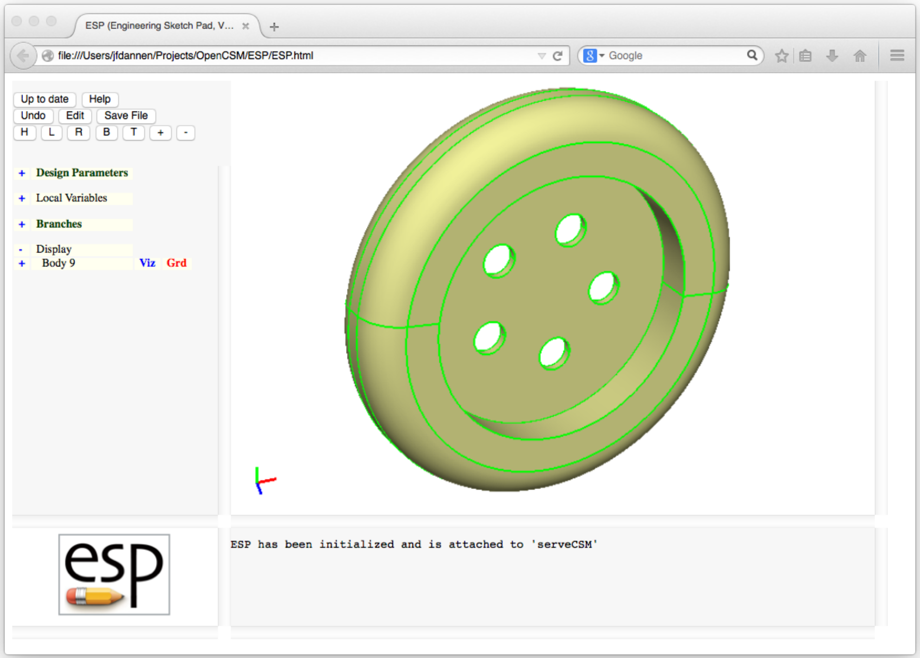


```
ESP has been initialized and is attached to 'serveCSM'
```

Code Walk-through

- Source file is `udpSample.c`
- To build under LINUX/OSX
  - `make -f sample.make`
- To build under Windows
  - `nmake -f sample.mak`
- To run stand-alone
  - `sample`
  - `$ESP_ROOT/bin/vTess sample.egads`
    - open browser on `$ESP_ROOT/bin/wv.html`
- To run in ESP
  - `$ESP_ROOT/bin/serveCSM sample`

Tire UDP: Finished Product



ESP has been initialized and is attached to 'serveCSM'

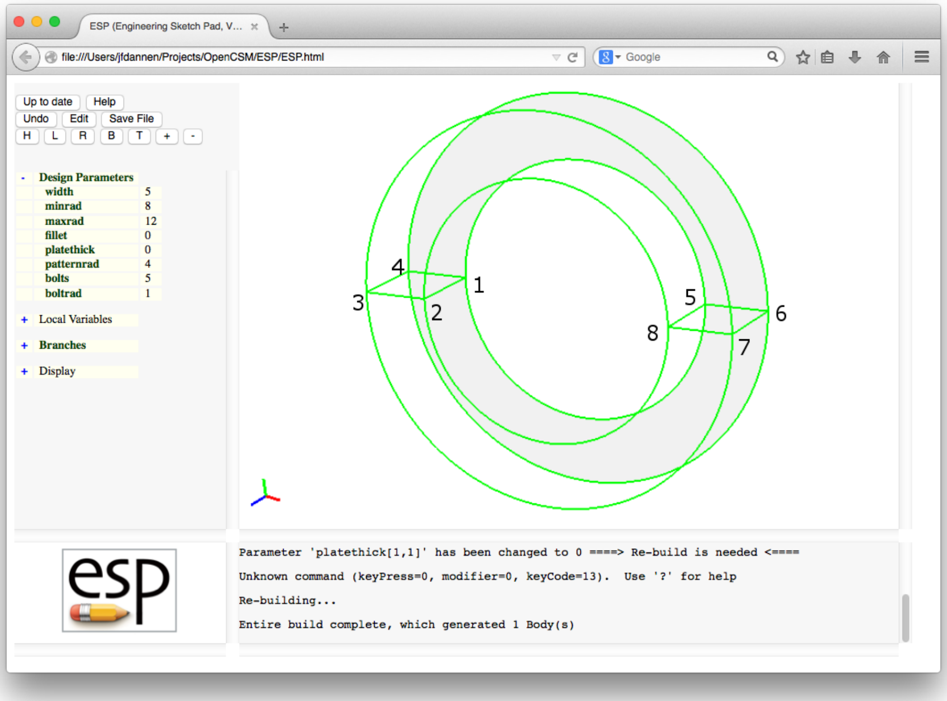
Tire UDP: Inputs and Outputs

Name	Description	Default
`width`	width of tire	0
`minrad`	minimum radius of tire	0
`maxrad`	maximum radius of tire	0
`fillet`	fillet radius at outside of tire	0 (for none)
`platethick`	wheel thickness	0 (for none)
`bolts`	number of bolt holes	0 (for none)
`patternrad`	radius of bolt hole circle	0
`boltrad`	radius of each bolt hole	0 (for none)
`volume`	volume	output

Tire UDP: Strategy (1)

- Draw a sketch, with Nodes, Edges, and Faces numbered
- Define the inputs and outputs
  - check size (scalar vs. multi-valued)
  - check validity
- Build basic tire from bottom up
  - 8 Nodes
  - 8 Edges (linear) at the equator
    - generate a linear curve
    - inverse evaluate at Nodes to get t_{beg} and t_{end}
    - make the Edge
  - 8 Edges (circular)
    - generate the circular curve
    - inverse evaluate at Nodes to get t_{beg} and t_{end}
    - ensure $t_{\text{end}} > t_{\text{beg}}$ by increasing t_{beg} by 2π if needed
    - make the Edge
  - . . .

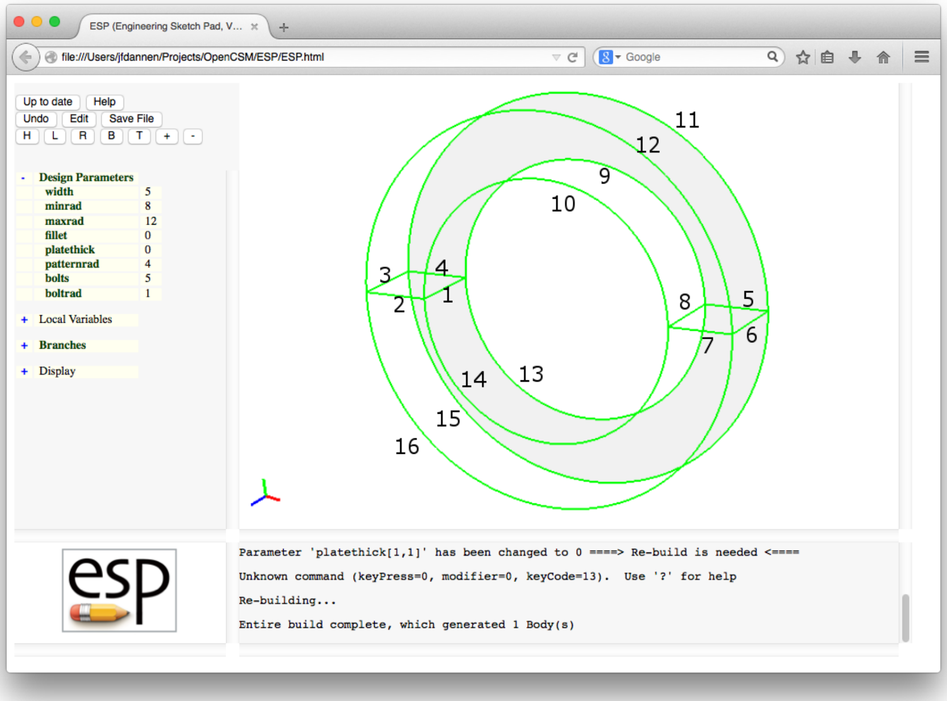
Tire UDP: Node Numbers


ESP (Engineering Sketch Pad, V...
file:///Users/jfdannen/Projects/OpenCSM/ESP/ESP.html
Google
Up to date
Help
Undo
Edit
Save File
H
L
R
B
T
+
-
Local Variables
Branches
Display
1
2
3
4
5
6
7
8

-	Design Parameters	
	width	5
	minrad	8
	maxrad	12
	fillet	0
	platethick	0
	patternrad	4
	bolts	5
	boltrad	1

```
Parameter 'platethick[1,1]' has been changed to 0 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```

Edge Numbers for Tire UDP



ESP (Engineering Sketch Pad, V...

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

-	Design Parameters	
	width	5
	minrad	8
	maxrad	12
	fillet	0
	platethick	0
	patternrad	4
	bolts	5
	boltrad	1

+ Local Variables

+ Branches

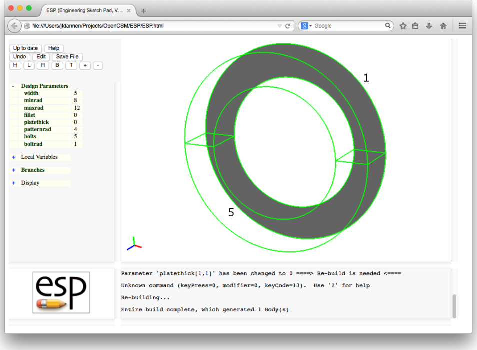
+ Display

```
Parameter 'platethick[1,1]' has been changed to 0 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```

Tire UDP: Strategy (2)

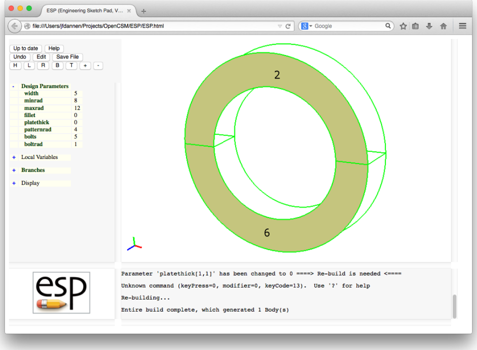
- Continue bottom up build
  - 4 Faces (planar)
    - make a Loop of 4 Edges
    - make the (planar) Face
  - 4 Faces (cylindrical)
    - make cylindrical surface
    - make a PCurve for each Edge that bounds Face
    - make a Loop of 4 Edges and 4 PCurves
    - make the (cylindrical) Face
  - 1 Shell that combines the 8 Faces
  - 1 Solid Body from the Shell

Tire UDP: Face Numbers



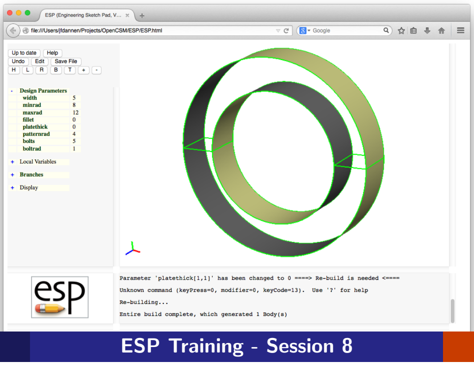
Design Parameters	
width	5
minrad	8
maxrad	12
fillet	0
platethick	0
patternrad	4
bolts	5
boltrad	1

```
Parameter 'platethick[1,1]' has been changed to 0 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```



Design Parameters	
width	5
minrad	8
maxrad	12
fillet	0
platethick	0
patternrad	4
bolts	5
boltrad	1

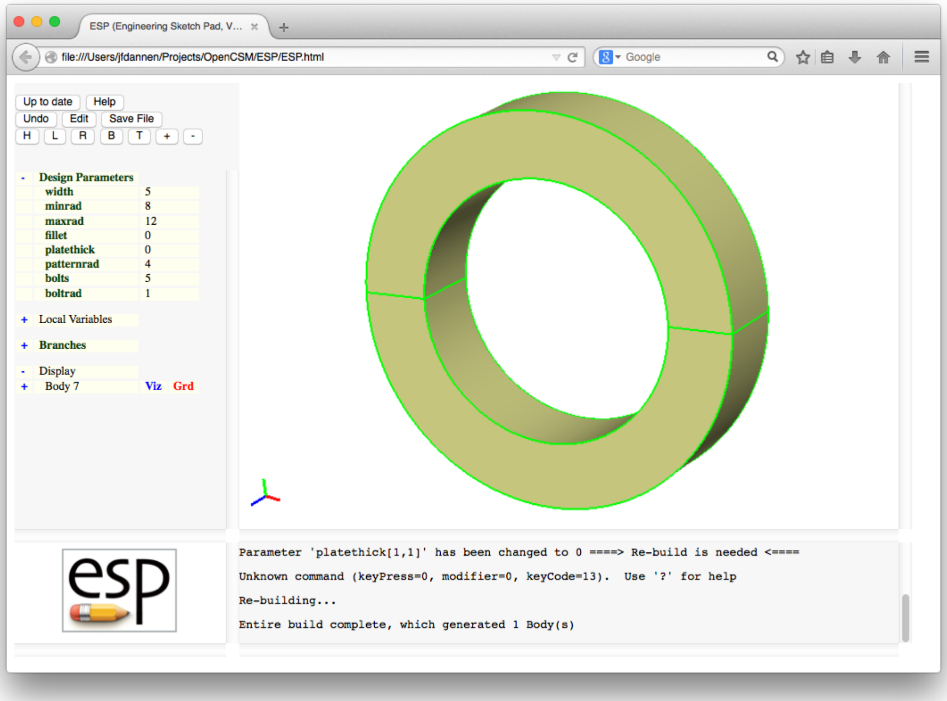
```
Parameter 'platethick[1,1]' has been changed to 0 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```



Design Parameters	
width	5
minrad	8
maxrad	12
fillet	0
platethick	0
patternrad	4
bolts	5
boltrad	1

```
Parameter 'platethick[1,1]' has been changed to 0 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```

Tire UDP after Bottom-up Build


ESP (Engineering Sketch Pad, V...
file:///Users/jfdannen/Projects/OpenCSM/ESP/ESP.html
Up to date
Help
Undo
Edit
Save File
H
L
R
B
T
+
-
Viz
Grd

Design Parameters	
width	5
minrad	8
maxrad	12
fillet	0
platethick	0
patternrad	4
bolts	5
boltrad	1

+ Local Variables

+ Branches

- Display

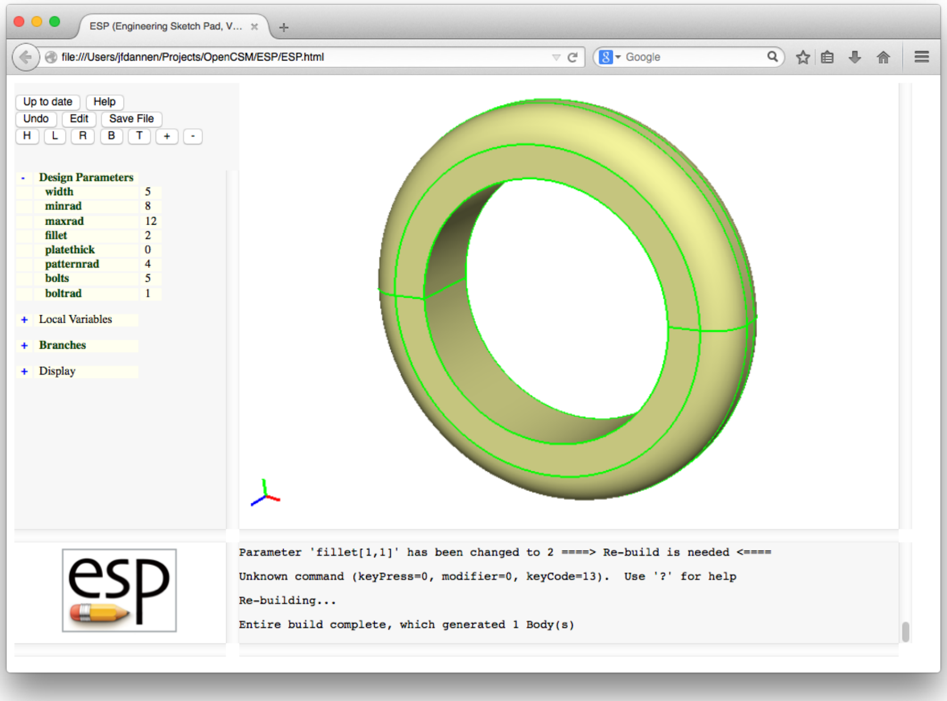
+ Body 7

```
Parameter 'platethick[1,1]' has been changed to 0 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```

Tire UDP: Strategy (3)

- Modify the Body top-down
  - fillet on outer Edges
    - identify the 4 Edges
  - add wheel
    - cylinder that is “unioned” with the tire
  - add pattern of holes
    - cylinders that are “subtracted” from the wheel
- Compute and return the “output” variables
- Note: this entire UDP could have been written top-down, but was broken up to show the steps needed in bottom-up construction

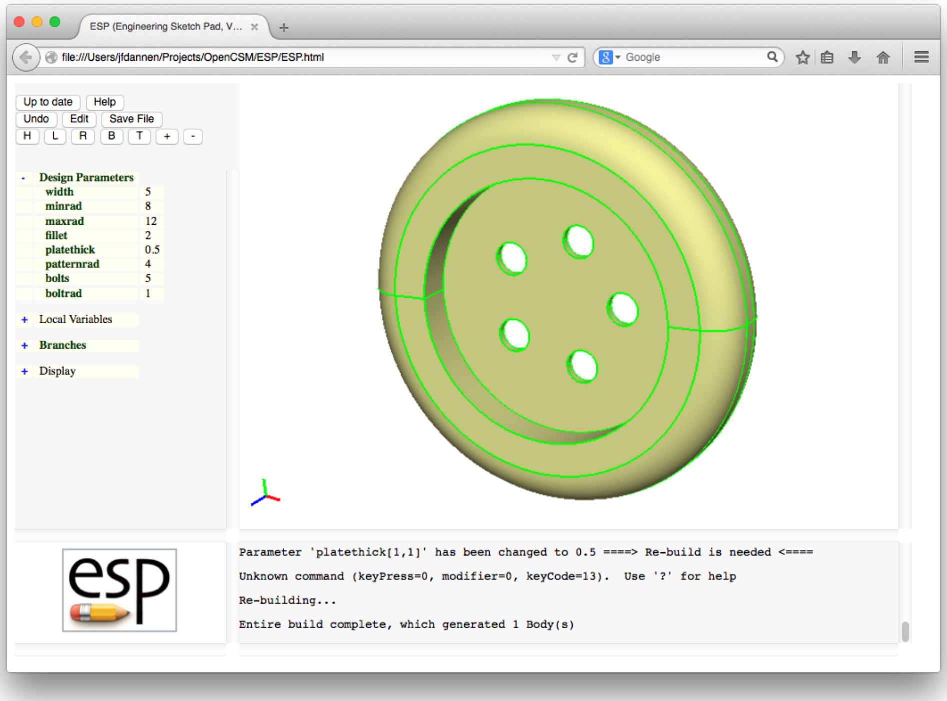
Tire UDP: after Filleting


ESP (Engineering Sketch Pad, V...
file:///Users/jfdannen/Projects/OpenCSM/ESP/ESP.html
Google
Up to date
Help
Undo
Edit
Save File
H
L
R
B
T
+
-
+ Local Variables
+ Branches
+ Display
esp

- Design Parameters	
width	5
minrad	8
maxrad	12
fillet	2
platethick	0
patternrad	4
bolts	5
boltrad	1

```
Parameter 'fillet[1,1]' has been changed to 2 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```

Tire UDP: after Wheel with Holes


ESP (Engineering Sketch Pad, V...
file:///Users/jfdannen/Projects/OpenCSM/ESP/ESP.html
Google
Up to date
Help
Undo
Edit
Save File
H
L
R
B
T
+
-
+ Local Variables
+ Branches
+ Display
esp

- Design Parameters	
width	5
minrad	8
maxrad	12
fillet	2
platethick	0.5
patternrad	4
bolts	5
boltrad	1

```
Parameter 'platethick[1,1]' has been changed to 0.5 ====> Re-build is needed <====
Unknown command (keyPress=0, modifier=0, keyCode=13).  Use '?' for help
Re-building...
Entire build complete, which generated 1 Body(s)
```

Muddy Cards

- Questions / suggestions about writing UDPs
- Questions / suggestions about whole course
- Overall effectiveness of course