Engineering Sketch Pad (ESP)

Training Session 8
Selection & Attribution

John F. Dannenhoffer, III
jfdannen@syr.edu
Syracuse University

Bob Haimes
haimes@mit.edu
Massachusetts Institute of Technology

updated for v1.18

Overview

- Purpose and Types of Attributes
- Setting Attributes
- Viewing Attributes: DisplayFilter
- Selecting Entities
- Attributes That are Automatically Set
- Csystem
- Editing Attributes: `UDPRIM editAttr`
- Homework Exercise

Attribute Overview

- Attributes are meta-data that can be used to tag any entity
- Attributes can be applied to:
  - Bodys
  - Faces
  - Edges
  - Nodes
- Attributes can be:
  - one or more integers (reserved for internal use)
  - one or more floating-point numbers
  - a character string

Attribute Rules

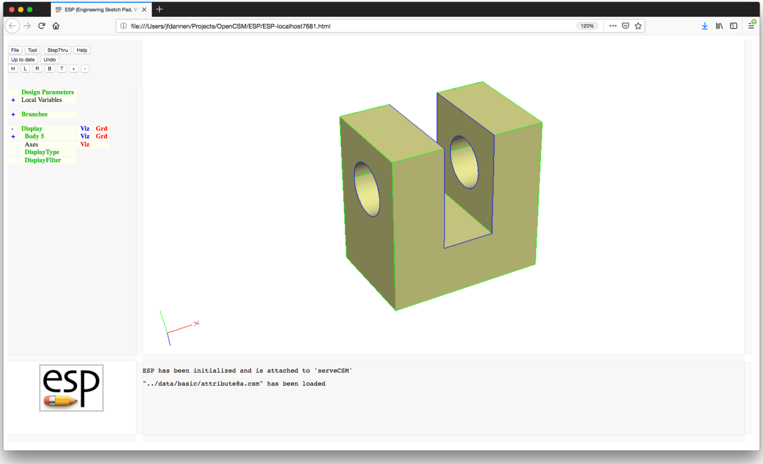
- Attributes are defined for any Branch that produces a Body
- Attributes are defined by an `ATTRIBUTE` statement
- Attribute names must not start with a period (which is reserved for `EGADS`) or an underscore (which is reserved for `OpenCSM`)
- If the first character of the value is a dollar-sign, then the Attribute will contain a character string
- Otherwise the Attribute will contain one or more real (double) values
    - if the value is the name of a multi-valued Parameter, then the Attribute will be multi-valued
    - if the value is a semi-colon-separated list of expressions, then the Attribute will be multi-valued
    - otherwise the Attribute will be a single real (double)

Setting Attributes

- Global Attributes are set with an `ATTRIBUTE` statement before the first Body is created
- Attributes can be set for a Body (and all newly-created Faces) with an `ATTRIBUTE` statement following the Branch that created the Body
- Attribute can be set on any entity(s) by putting an `ATTRIBUTE` statement following a `SELECT` statement
- Best practice is to set the Attributes as soon as the Body is created (for example via a primitive or grown Body command)

Attribute Example (1)

Whole configuration



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/attribute8a.csm" has been loaded
```

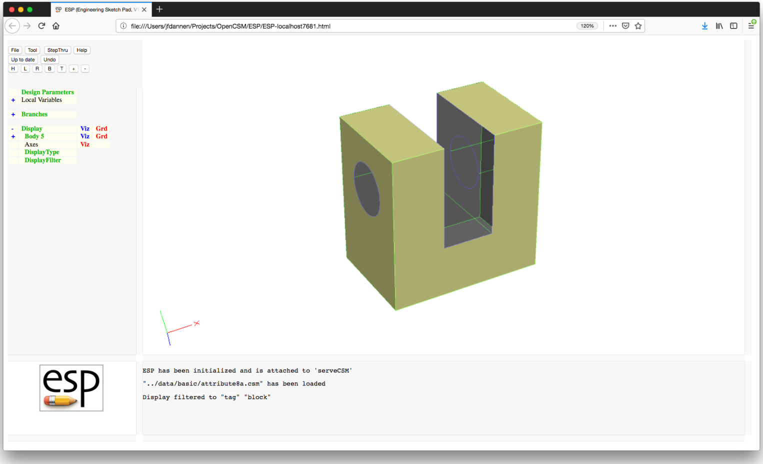
Attribute Example (2)

`.csm` file

```
ATTRIBUTE density  2710   # global attribute

BOX       0  0  0  3  3  2
ATTRIBUTE tag  $block

BOX       1  1  0  1  2  2
ATTRIBUTE tag  $slot
SUBTRACT

CYLINDER -1  2  1  4  2  1  1/2
ATTRIBUTE tag  $hole
SUBTRACT

END
```

Attribute Example (3)

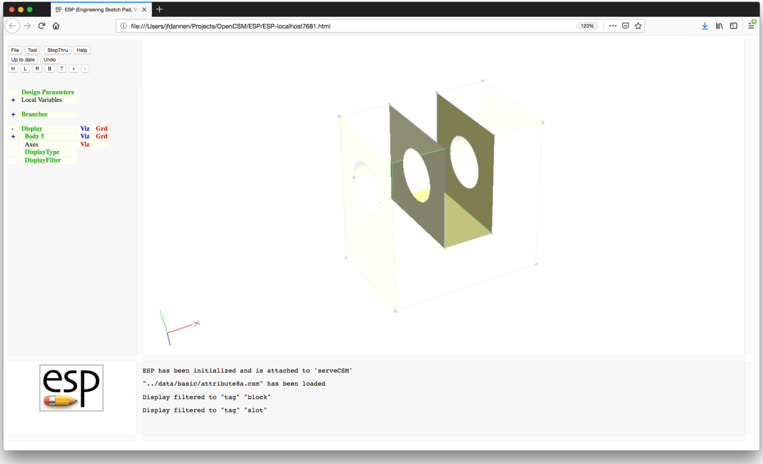
DisplayFilter to `tag block`



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/attribute8a.csm" has been loaded
Display filtered to "tag" "block"
```

Attribute Example (4)

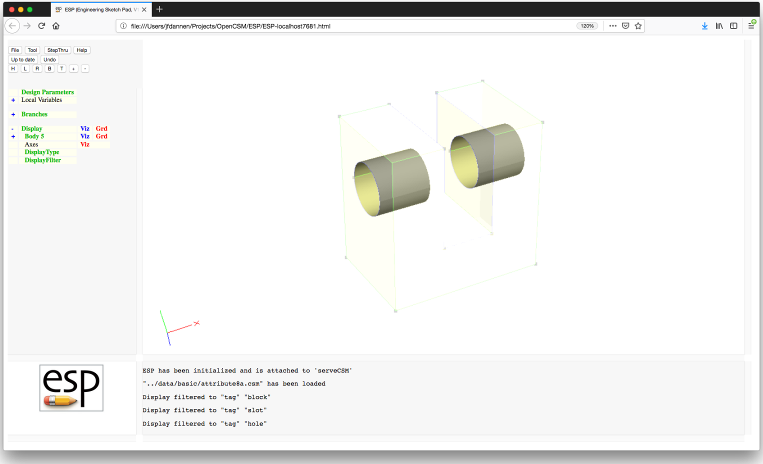
DisplayFilter to `tag slot`



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/attribute8a.csm" has been loaded
Display filtered to "tag" "block"
Display filtered to "tag" "slot"
```

Attribute Example (5)

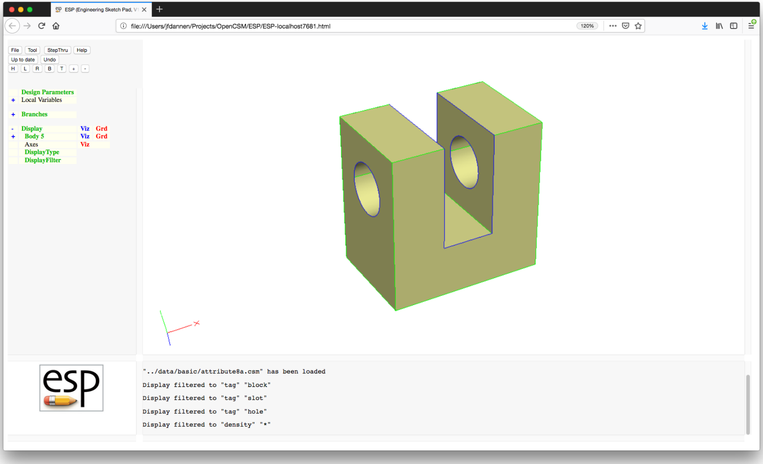
DisplayFilter to `tag` `hole`



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/attribute8a.csm" has been loaded
Display filtered to "tag" "block"
Display filtered to "tag" "slot"
Display filtered to "tag" "hole"
```

Attribute Example (6)

DisplayFilter to `density *`



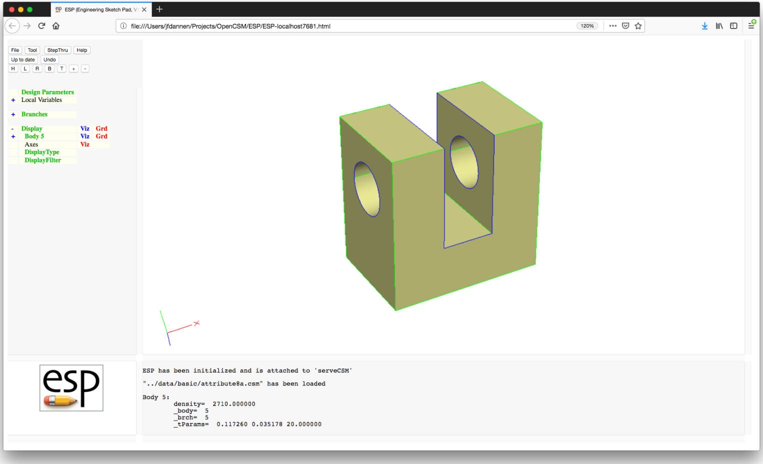
```
"../data/basic/attribute8a.csm" has been loaded
Display filtered to "tag" "block"
Display filtered to "tag" "slot"
Display filtered to "tag" "hole"
Display filtered to "density" "*"
```

Viewing Attributes

- Attributes can be viewed in `ESP` in three ways:
    - pressing the mouse in the Tree Window when cursor is over the Body name
    - pressing the $\wedge$ or **6** key when pointing to a Face, Edge, or Node in the Graphics Window
    - using the `Display Filter` option (at the bottom of the Tree Window)

Attribute Example (6)

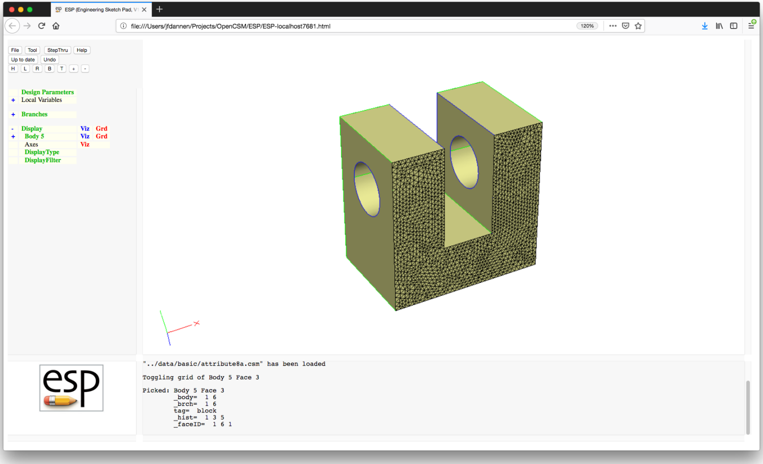
After pressing **Body 5** in TreeWindow



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

"../data/basic/attribute8a.csm" has been loaded

Body 5:
        density=  2710.000000
        _body=  5
        _brch=  5
        _tParams=  0.117260 0.035178 20.000000
```

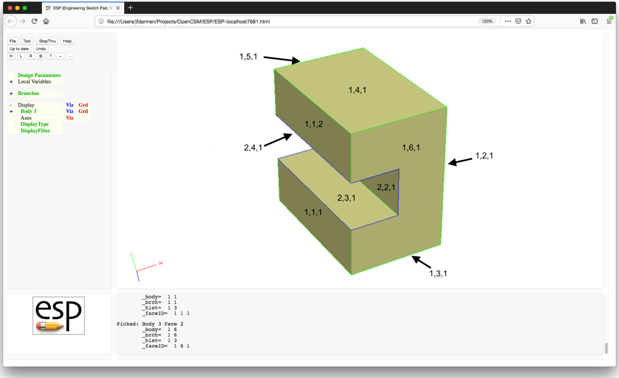
Attribute Example (6)

After pressing ∧ on Face with Grid



```
"../data/basic/attribute8a.csm" has been loaded

Toggling grid of Body 5 Face 3

Picked: Body 5 Face 3
        _body=  1 6
        _brch=  1 6
        tag=  block
        _hist=  1 3 5
        _faceID=  1 6 1
```

`ibody/iford` Refresher



```
         _body=  1 1
         _brch=  1 1
         _hist=  1 3
         _faceID=  1 1 1

Picked: Body 3 Face 2
         _body=  1 6
         _brch=  1 6
         _hist=  1 3
         _faceID=  1 6 1
```

```
BOX       0  0  0  2  3  3
BOX      -1  1 -1  2  1  5
SUBTRACT
```

- FaceID is generated by the Body in which the Face first exists
- EdgeID is generated based upon the `ibody/iford` of its two adjoining Faces
    - Edge on bottom of front Face has EdgeID 1, 3, 1, 6, 1
    - Edge at bottom of slot & front Face has EdgeID 1, 6, 2, 3, 1

SELECT Statement

- The `SELECT` statement stores its values in:
  - `@seltype`
    - -1 if only a Body is selected
    - 0 if one or more Nodes are selected
    - 1 if one or more Edges are selected
    - 2 if one or more Faces are selected
  - `@selbody` contains the number of the Body selected
  - `@sellist` contains the list of the Nodes, or Edges, or Faces selected within `@selbody`

Selecting a Body

- `SELECT BODY` — selects last Body created
- `SELECT BODY ibody` — selects Body `ibody`
- `SELECT BODY -n` – selects the nth Body from the top of the Stack
- `SELECT BODY $attrName1 attrValue1 ...` — selects the last Body that matches all the given Attributes

Selecting Face(s)

- `SELECT FACE` — selects all Faces in selected Body
- `SELECT FACE iface` — selects Face `iface` in selected Body
  - using this is considered a bad practice since Face numbering may change depending on the version of `OpenCASCADE` that is being used
- `SELECT FACE ibody1 iford1 iseq=1` — selects the Face that has the indicated `ibody1/iford1`
  - as each Face is created, it is marked with the Body in which it was created and the face-order in that Body. This is the preferred technique.
- `SELECT FACE xmin xmax ymin ymax zmin zmax` — selects the Faces with the specified bounding box
- `SELECT FACE $attrName1 attrValue1 ...` – selects the Faces that matches all the given Attributes

Selecting Edge(s)

- `SELECT EDGE` — selects all Edges in selected Body
- `SELECT EDGE iedge` — selects Edge `iedge` in selected Body
  - using this is considered a bad practice since Edge numbering may change depending on the version of `OpenCASCADE` that is being used
- `SELECT EDGE ibody1 iford1 ibody2 iford2 iseq=1` — selects the Edge that has the indicated `ibody1/iford1`
  - as each Edge is created, it is marked with the `ibody/iford` of the Faces that adjoin it. This is the preferred technique.
- `SELECT EDGE xmin xmax ymin ymax zmin zmax` — selects the Edges with the specified bounding box
- `SELECT EDGE xmid ymid zmid` — selects the Edge whose midpoint is closest to the given coordinates
- `SELECT EDGE $attrName1 attrValue1 ...` – selects the Edges that matches all the given Attributes

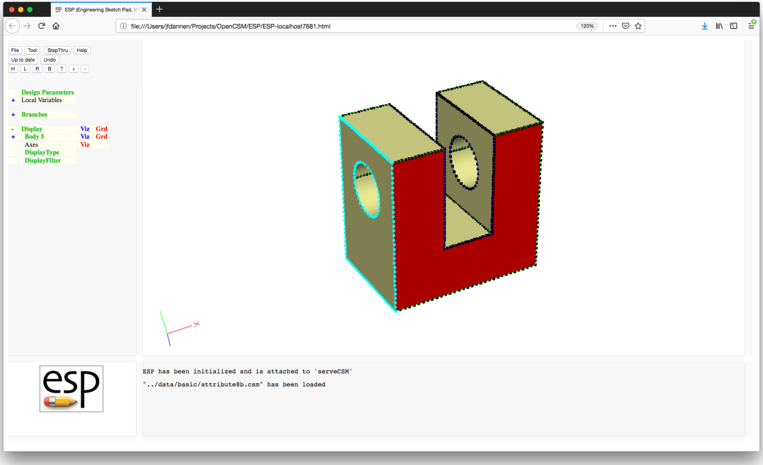
Selecting Node(s)

- `SELECT NODE` — selects all Nodes in selected Body
- `SELECT NODE inode` — selects Node `inode` in selected Body
    - using this is considered a bad practice since Node numbering may change depending on the version of `OpenCASCADE` that is being used
- `SELECT NODE x y z` — selects the Nodes closest to the given coordinates
- `SELECT NODE $attrName1 attrValue1 ...` – selects the Nodes that matches all the given Attributes

Selection Example (1)

```
ATTRIBUTE density  2710                     # global attribute

BOX        0  0  0  3  3  2
ATTRIBUTE tag  $block

BOX        1  1  0  1  2  2
ATTRIBUTE tag  $slot
SUBTRACT

CYLINDER -1  2  1  4  2  1  1/2
ATTRIBUTE tag  $hole
SUBTRACT

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

SELECT    FACE   1 6 1                      # select by FaceID
ATTRIBUTE _color $red

SELECT    EDGE   -.1 0.1  -.1 3.1  -.1 2.1  # select by bbox
ATTRIBUTE _color  $cyan
ATTRIBUTE _gcolor $cyan
```

Selection Example (2)



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/attribute8b.csm" has been loaded
```

Modifying the Selection List

- Use `SELECT ADD ...` to add Faces, Edges, or Nodes to the selection list
- Use `SELECT SUB ...` to remove Faces, Edges, or Nodes from the selection List
- Both of these option use the selection type from the previous selection

- Use `SELECT SORT $key` to sort `@sellist` based upon `$xmin`, `$ymin`, `$zmin`, `$xmax`, `$ymax`, `$zmax`, `$xcg`, `$ycg`, `$zcg`, `$length` (if Edges), or `$area` (if Faces)

Attributes Automatically Set to Bodys

`_body`	`Body index (bias-1)`
`_brch`	`Branch index (bias-1)`
`_tParams`	`specified tessellation parameters: maximum side length, maximum specified sag, maximum angle`
`_csys_*`	`arguments when CSYSTEM was defined`
`<any>`	`all global attributes`
`<any>`	`all attributes associated with Branch that created Body`
`<any>`	`all attributes associated with "select $body" statement`

Attributes Automatically Set to Faces (1)

```
_body        non-unique 2-tuple associated with first Face creation
    [0]      Body index in which Face first existed (bias-1)
    [1]      face-order associated with creation (see above)

_brch        non-unique even-numbered list associated with Branches
                that are active when the Face is created (most
                recent Branch is listed first)
    [2*i  ] Branch index (bias-1)
    [2*i+1] (see below)

             Branches that contribute to brch attribute are
                primitive  (for which brch[2*i+1] is face-order)
                udprim.udc (for which brch[2*i+1] is 1)
                grown      (for which brch[2*i+1] is face-order)
                applied    (for which brch[2*i+1] is face-order)
                sketch     (for which brch[2*i+1] is Sketch primitive if
                            making WIRE)
                patbeg     (for which brch[2*i+1] is pattern index)
                recall     (for which brch[2*i+1] is 1)
                restore    (for which brch[2*i+1] is Body number stored)
```

Attributes Automatically Set to Faces (2)

```
_faceID      unique 3-tuple that is assigned automatically
      [0]    body[0]
      [1]    body[1]
      [2]    sequence number

             if multiple Faces have same _faceID[0] and _faceID[1],
                then the sequence number is defined based upon the
                first rule that applies:
                * Face with smaller xcg  has lower sequence number
                * Face with smaller ycg  has lower sequence number
                * Face with smaller zcg  has lower sequence number
                * Face with smaller area has lower sequence number

_hist        list of Bodys that contained this Face (oldest to newest)

_tParams     specified tessellation parameters: maximum side length,
                maximum specified sag, maximum angle

<any>        all attributes associated with Branch that first created Face

<any>        all attributes associated with "SELECT $face" statement
```

Attributes Automatically Set to Edges (1)

```
_body         non-unique 2-tuple associated with first Edge creation
    [0]       Body index in which Edge first existed (bias-1)
    [1]       100 * min(body[1][ileft],body[1][irite])
                  + max(body[1][ileft],body[1][irite])
              (or -3 if non-manifold)

_edgeID       unique 5-tuple that is assigned automatically
      [0]     _faceID[0] of Face 1 (or 0 if non-manifold)
      [1]     _faceID[1] of Face 1 (or 0 if non-manifold)
      [2]     _faceID[0] of Face 2 (or 0 if non-manifold)
      [3]     _faceID[1] of Face 2 (or 0 if non-manifold)
      [4]     sequence number

...
```

Attributes Automatically Set to Edges (2)

```
...
            _edgeID[0]/[1] swapped with edge[2]/[3]
               100*_edgeID[0]+_edgeID[1] > 100*_edgeID[2]+_edgeID[3]
            if multiple Edges have same _edgeID[0], _edgeID[1],
               _edgeID[2], and _edgeID[3], then the sequence number
               is defined based upon the first rule that applies:
               * Edge with smaller xcg    has lower sequence number
               * Edge with smaller ycg    has lower sequence number
               * Edge with smaller zcg    has lower sequence number
               * Edge with smaller length has lower sequence number

_nface      number of incident Faces

_tParams    specified tessellation parameters: maximum side length,
               maximum specified sag, maximum angle

<any>       all attributes associated with "select $edge" statement
```

Attributes Automatically Set to Nodes

`_nodeID`	`unique integer`
`_nedge`	`number of incident Edges`
`<any>`	`all attributes associated with "select $node" statement`

Special User-defined Attributes for Bodys

`_makeQuads`	`to make quads on all Faces in Body`
`_name`	`string used in ESP interface for a Body`
`_stlColor`	`color to use for all Faces in an .stl file`

Special User-defined Attributes for Faces

`_color`	`color of front of Face in ESP either R,G,B in three 0-1 reals or $red, $green, $blue, $yellow, $magenta, $cyan, $white, or $black`
`_bcolor`	`color of back of Face in ESP (see _color)`
`_gcolor`	`color of grid of Face in ESP (see _color)`
`_makeQuds`	`to make quads for this Face`
`_stlColor`	`color to use for this Face in an .stl file`

Special User-defined Attributes for Edges

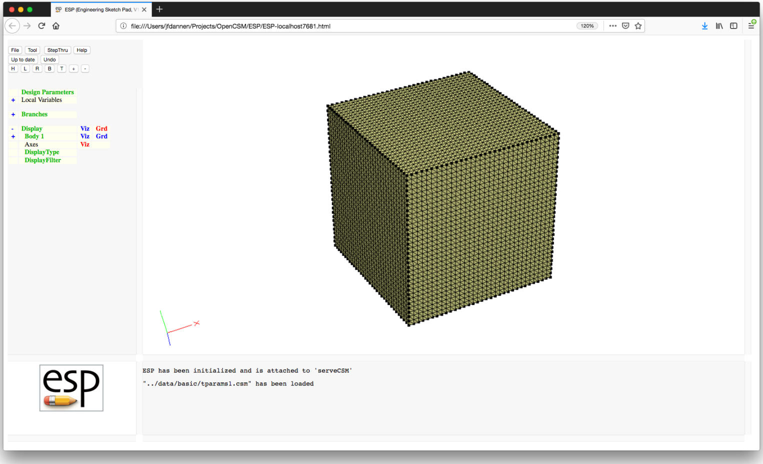
`_color`	`color of front of Edge in ESP either R,G,B in three 0-1 reals or $red, $green, $blue, $yellow, $magenta, $cyan, $white, or $black`
`_gcolor`	`color of grid of Edge in ESP (see _color)`

Special User-defined Attributes for Nodes

`_color`	`color of Node in ESP`
	`either R,G,B in three 0-1 reals`
	`or $red, $green, $blue, $yellow, $magenta,`
	`$cyan, $white, or $black`

Tessellation Parameters (1)

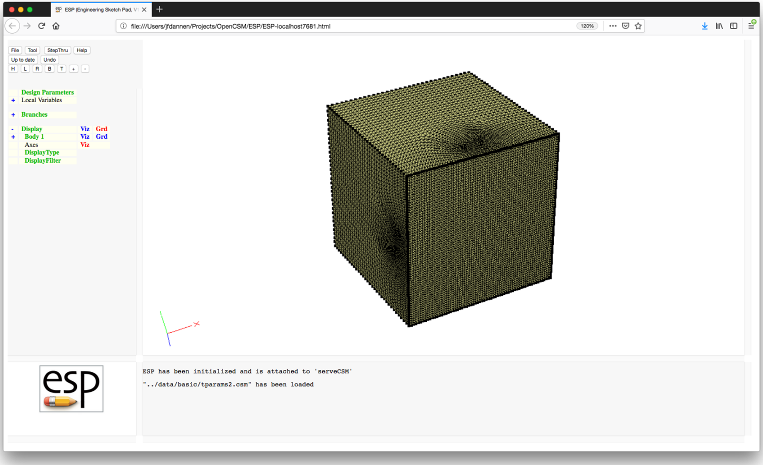
Default tessellation has `_tParams` = 0.043; 0.013; 20



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/tparams1.csm" has been loaded
```

Tessellation Parameters (2)

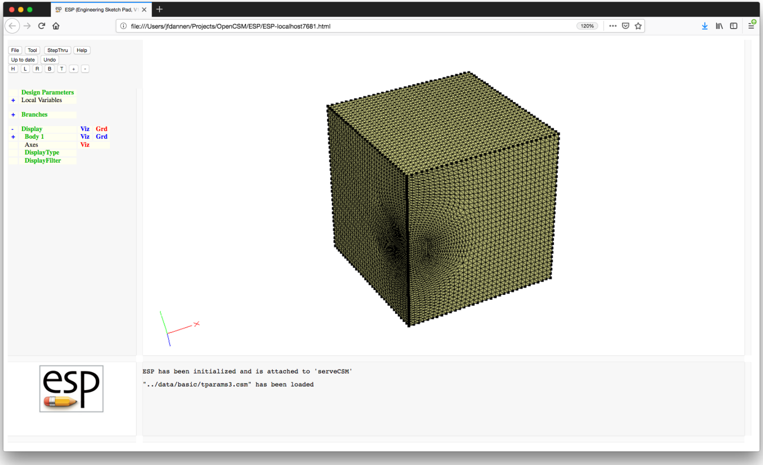
```
SELECT     FACE  1  6
ATTRIBUTE .tParams "0.02; 0.013; 20"
```



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/tparams2.csm" has been loaded
```

Tessellation Parameters (1)

```
SELECT     EDGE  1  1  1  6
ATTRIBUTE .tParams "0.02; 0.013; 20"
```



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/tparams3.csm" has been loaded
```

Csystem rules (1)

- Csystems (coordinate systems) are generated by the `CSYSTEM` statement and are applied to the Body on the top of the Stack
- Csystems are treated in many ways like Attributes
    - Csystem names must not be the same as an Attribute name
    - Csystems are found in `ESP` in same place as Attributes
- Csystems are transformed along with any transformations that are applied to their Body

Csystem rules (2)

- Format of the `CSYSTEM` statement is:
  - If argument to `CSYSTEM` contains 9 entries:

    ```
    {x0, y0, z0, dx1, dy1, dz1, dx2, dy2, dz2}
    origin is at (x0,y0,q0)
    dirn1  is in (dx1,dy1,dz1) direction
    dirn2  is in (dx2,dy2,dz2) direction
    ```

  - If argument to `CSYSTEM` contains 5 entries and first is positive:

    ```
    {+iface, ubar0, vbar0, du2, dv2}
    origin is at normalized (ubar0,vbar0) in iface
    dirn1  is normal to Face
    dirn2  is in (du2,dv2) direction
    ```

Csystem rules (3)

- Format of the `CSYSTEM` statement is:
  - If argument to `CSYSTEM` contains 5 entries and first is negative:

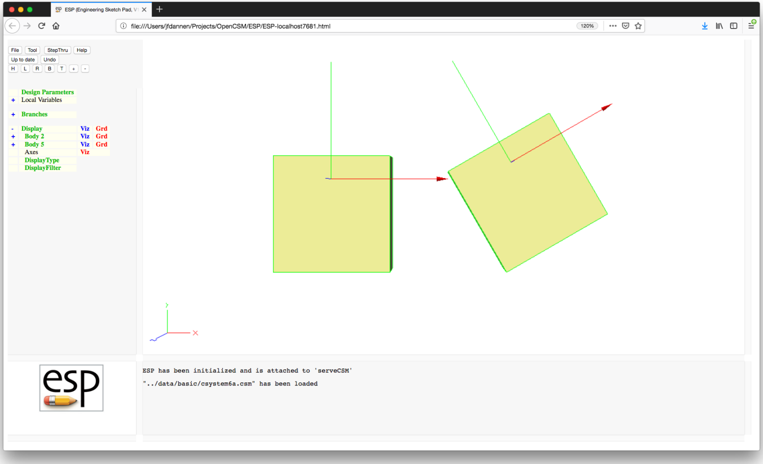
    ```
    {-iedge, tbar, dx2, dy2, dz2}
    origin is at normalized (tbar) in iedge
    dirn1  is tangent to Edge
    dirn2  is part of (dx2,dy2,dz2) that is
                orthogonal to dirn1
    ```

  - If argument to `CSYSTEM` contains 7 entries:

    ```
    {inode, dx1, dy1, dz1, dx2, dy2, dz2}
    origin is at Node inode
    dirn1  is in (dx1,dy1,dz1) direction
    dirn2  is part of (dx1,dy2,dz2) that is
                orthogonal to dirn1
    ```

Csystem Defined with respect to Body

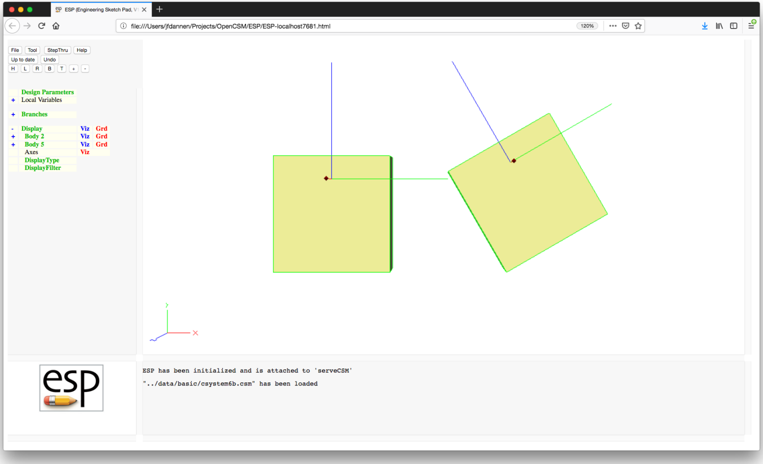
```
CSYSTEM cs1 "0.5; 0.8; 1.1;   1;0;0;   0;1;0"
```



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/csystem6a.csm" has been loaded
```

Csystem Defined with respect to Face 6

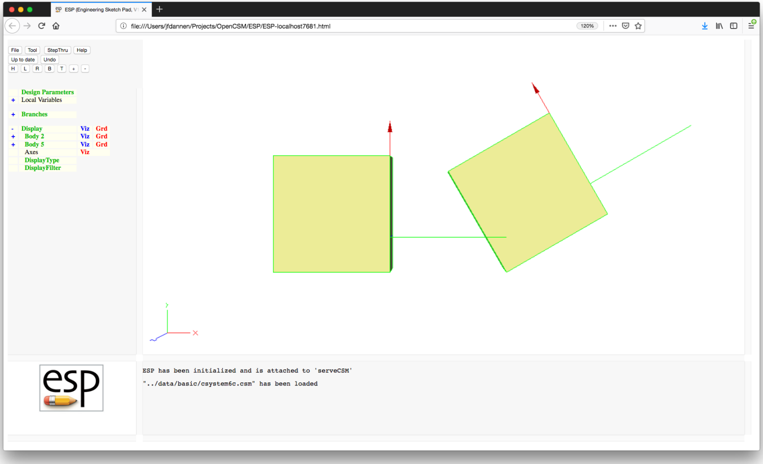
```
CSYSTEM cs1 "+6;   0.5; 0.8;   1;0"
```



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/csystem6b.csm" has been loaded
```

Csystem Defined with respect to Edge 6

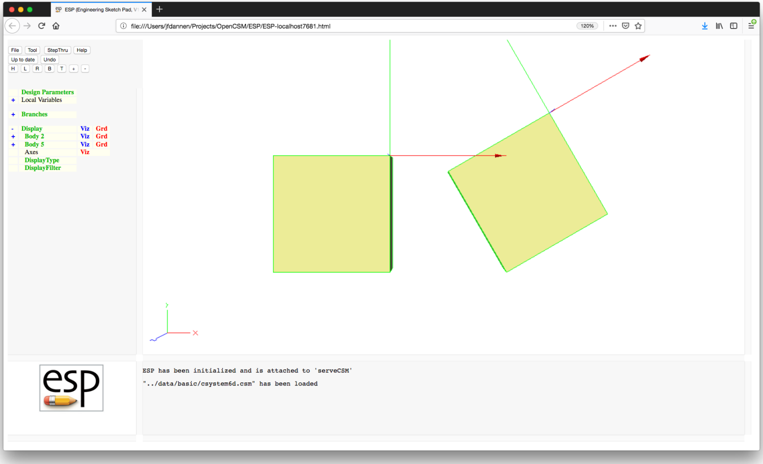
```
CSYSTEM cs1 "-6;   0.3;   1;0;0"
```



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/csystem6c.csm" has been loaded
```

Csystem Defined with respect to Node 7

```
CSYSTEM cs1 "7;   1;0;0;   0;1;0"
```



```
ESP has been initialized and is attached to 'serveCSM'
"../data/basic/csystem6d.csm" has been loaded
```

Attribute Editor (1)

- Best practice is to set Attributes when entity is first created
- If not possible, the `editAttr` UDF is available to set Attributes based upon the Attributes of an entity's neighbors

Attribute Editor (2)

- Statements in the attribute editor can be one of:
  - `NODE   <selector> <attrName1=attrValue1> ...`
  - `EDGE   <selector> <attrName1=attrValue1> ...`
  - `FACE   <selector> <attrName1=attrValue1> ...`
  - `AND    <selector> <attrName1=attrValue1> ...`
  - `ANDNOT <selector> <attrName1=attrValue1> ...`
  - `SET               <attrName1=attrValue1> ...`
- Keywords can either be specified in lowercase or UPPERCASE
- `<selector>` can be one of `HAS`, `ADJ2NODE`, `ADJ2EDGE` or `ADJ2FACE`

Attribute Editor (3)

- Typical block of code looks like:

```
NODE ADJ2FACE tagType=spar tagIndex=1
AND  ADJ2FACE tagType=lower
AND  ADJ2EDGE tagType=root
SET           capsConstraint=pointConstraint1
```

- Patterns can be used with `PATBEG` and `PATEND`

EditAttr Example (1)

```
# SolidBody
BOX       0 -1 -1  3  2  2
ATTRIBUTE type  $OML

SELECT    FACE  @nbody  1
ATTRIBUTE face  $xmin
SELECT    FACE  @nbody  2
ATTRIBUTE face  $xmax
SELECT    FACE  @nbody  3
ATTRIBUTE face  $ymin
SELECT    FACE  @nbody  4
ATTRIBUTE face  $ymax
SELECT    FACE  @nbody  5
ATTRIBUTE face  $zmin
SELECT    FACE  @nbody  6
ATTRIBUTE face  $zmax
STORE     SolidBody
```

EditAttr Example (2)

```
# 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     .
```

EditAttr Example (3)

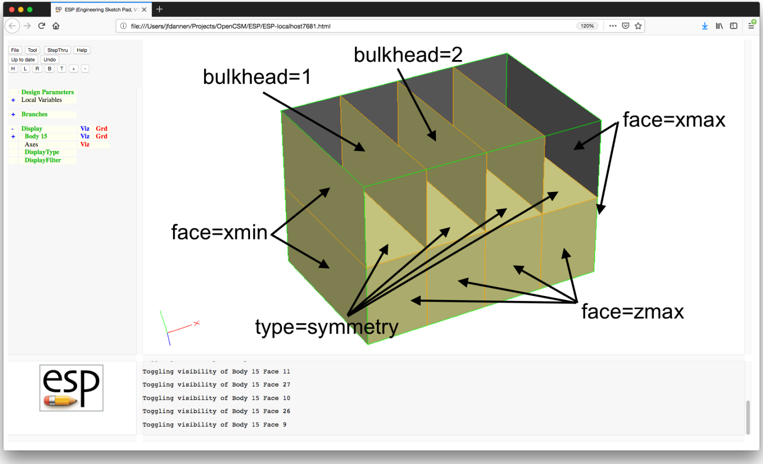
```
# Waffle (centered on SolidBody)
UDPRIM    waffle   filename <<   depth zmax-zmin+2
   POINT  A AT  xmin-1  (ymin+ymax)/2
   POINT  B AT  xmax+1  (ymin+ymax)/2
   LINE   AB  A  B  type=symmetry

   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  bulkhead=!val2str(i,0)
   PATEND
>>
TRANSLATE 0  0  zmin-1
STORE     Waffle
```

EditAttr 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
UNION
```

EditAttr Example (5)

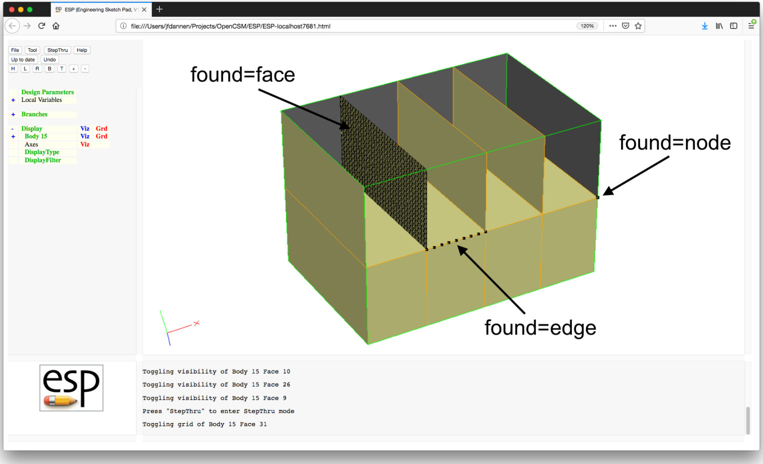
Some Faces not shown for clarity



```
Toggling visibility of Body 15 Face 11
Toggling visibility of Body 15 Face 27
Toggling visibility of Body 15 Face 10
Toggling visibility of Body 15 Face 26
Toggling visibility of Body 15 Face 9
```

EditAttr Example (6)

Attributes that we want to define



```
Toggling visibility of Body 15 Face 10
Toggling visibility of Body 15 Face 26
Toggling visibility of Body 15 Face 9
Press "StepThru" to enter StepThru mode
Toggling grid of Body 15 Face 31
```

EditAttr Example (7)

```
# select Face on bulkhead=1 but top half
UDPRIM    editAttr  filename  <<
   FACE   HAS       bulkhead=1
   AND    ADJ2FACE  face=ymax
   SET              found=face
>>
```

EditAttr Example (8)

```
# select Edge on OML seam between bulkheads 1 and 2
UDPRIM    editAttr  filename  <<
   NODE   ADJ2FACE  bulkhead=1
   SET              bulkhead=1
   NODE   ADJ2FACE  bulkhead=2
   SET              bulkhead=2
   EDGE   ADJ2FACE  face=zmax
   AND    ADJ2FACE  type=symmetry
   AND    ADJ2NODE  bulkhead=1
   AND    ADJ2NODE  bulkhead=2
   SET              found=edge
>>
```

EditAttr Example (9)

```
# select Node on OML seam at the outlet
UDPRIM    editAttr  filename  <<
   NODE   ADJ2FACE  face=xmax
   AND    ADJ2FACE  face=zmax
   AND    ADJ2FACE  type=symmetry
   SET              found=node
>>
```

Homework Exercise

- Using `$ESP_ROOT/training/ESP/data/session08/wingStruct.csm`
  - 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
  - for the skin panels on the rite wing that are between the first and second rib, make their color red and their grid white
  - make the Edges blue that are between two red panels