Engineering Sketch Pad (ESP)

Training Session 1
ESP Overview & Getting Started

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updated for v1.22

Overview (1)

- ESP Overview
  - Background and Objectives
  - ESP Architecture
  - Distinguishing Features
- Starting `serveESP`
- User Interface
  - Screen Layout
  - Image Manipulation
  - View Manipulation
- Getting Info
- StepThru Mode

Overview (2)

- Journals & Exporting
- Tool Interface Modules (TIMs)
  - Erep Editor
  - Plugs
  - Pyscript
  - Plotter (via Pyscript)
- Collaboration mode

Background (1)

- Over the past 40 years, there have been an increasingly-complex (complicated) series of “CAD” systems to support the geometry needs of the manufacturers of mechanical devices
    - CAD = “computer aided drafting”
    - CAD = “computer-aided drawing”
    - CAD = “computer-aided design”
    - CAD = “computer-aided development”
- “CAD” has sometimes been erroneously equated with geometry

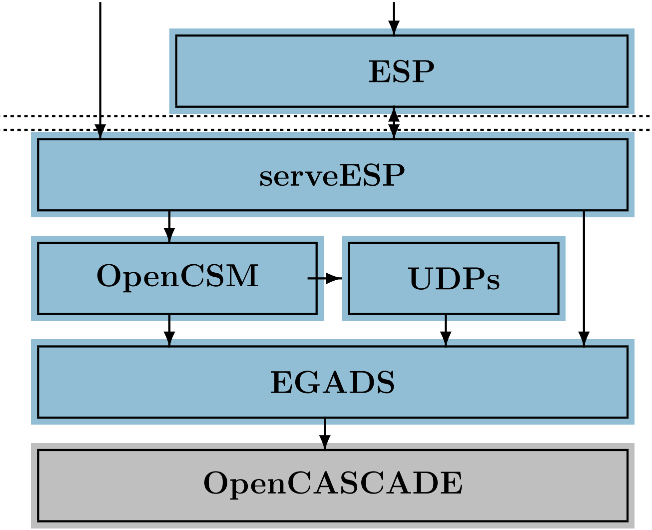
Background (2)

- These systems are built around the notion that the developer of a geometric model should construct the model to be consistent with the manufacturing process (**mCAD**)
- The analytical designer of a system wants to think about the function and performance of the device being generated, often leading to the generation of a separate **aCAD** model
- The modeling techniques supported by **aCAD** and **mCAD** are often so dissimilar that model transfer between them is done by limited translators or by “starting over”
- This one-way path from **aCAD** to **mCAD** leads to a “broken process”

Objective

- ESP is:
  - a geometry creation and manipulation system designed specifically to support the analysis and design of aerospace vehicles
  - can be run stand-alone for the development of models
  - can be embedded into other analysis and design systems to support their geometry needs
- ESP is not:
  - a full-featured computer-aided design (CAD) system designed specifically to support the mechanical design and manufacturing of any complex system
  - a system to be used for creating "drawings"

ESP Architecture



user interactions

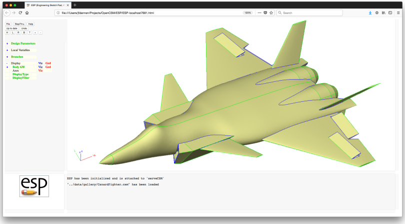
system driver
create graphic objects

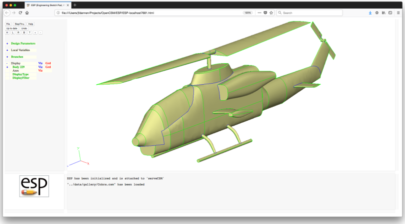
design parameters
feature tree
user-defined primitives
sensitivities

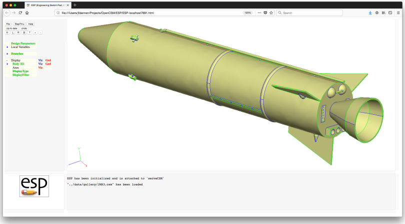
top-down & bottom-up
persistent attribution
watertight tessellation

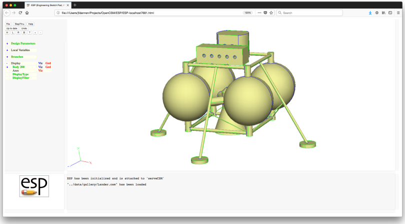
geometry primitives
boundary representations

Gallery of ESP Configurations









Distinguishing Features — Solid Modeller

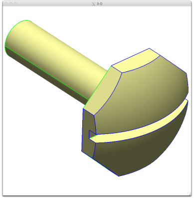
- Construction process guarantees that models are realizable solids
    - watertight representation needed for grid generators
    - sheets and wires are supported when needed
- Parametric models are defined in terms of:
    - Feature Tree
        - "recipe" for how to construct the configuration
    - Design Parameters
        - "values" that describe any particular instance of the configuration

Distinguishing Features — Feature-based

- Configurations start with the generation of primitives
  - standard primitives: point, box, sphere, cone, cylinder, torus
  - grown primitives (from sketches): extrude, rule, blend, revolve, sweep, loft
  - user-defined primitives (UDPs)
- Bodys can be modified
  - transformations: translate, rotate, scale, mirror
  - applications: fillet, chamfer, hollow
- Bodys can be combined
  - Booleans: intersect, subtract, union
  - other: join, connect, extract, combine

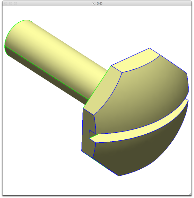
Construction Process (1)

```
     # bolt example

     # design parameters
 1:  DESPMTR   Thead     1.00   # thickness of head
 2:  DESPMTR   Whead     3.00   # width     of head
 3:  DESPMTR   Fhead     0.50   # fraction  of head that is flat

 4:  DESPMTR   Dslot     0.75   # depth of slot
 5:  DESPMTR   Wslot     0.25   # width of slot

 6:  DESPMTR   Lshaft    4.00   # length   of shaft
 7:  DESPMTR   Dshaft    1.00   # diameter of shaft

 8:  DESPMTR   sfact     0.50   # overall scale factor

     # head
 9:  BOX       0      -Whead/2  -Whead/2  Thead   Whead     Whead
10:  ROTATEX   90  0  0
11:  BOX       0      -Whead/2  -Whead/2  Thead   Whead     Whead
12:  ROTATEX   45  0  0
13:  INTERSECT

...
```

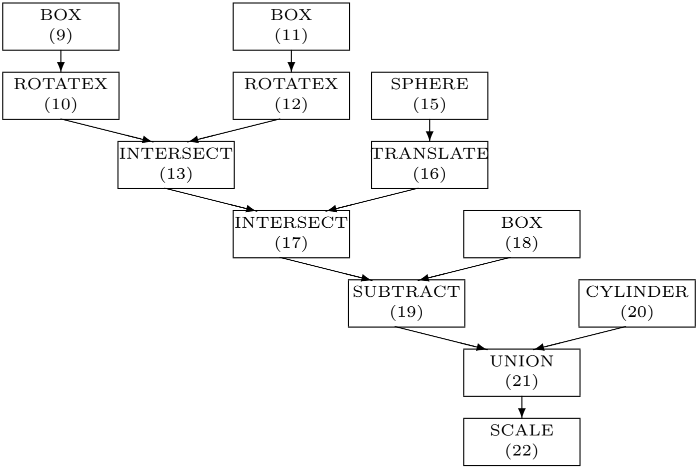


Construction Process (2)

```
...

14:   SET       Rhead   (Whead^2/4+(1-Fhead)^2*Thead^2)/(2*Thead*(1-Fhead))

15:   SPHERE    0            0   0    Rhead
16:   TRANSLATE Thead-Rhead  0   0
17:   INTERSECT

      # slot
18:   BOX       Thead-Dslot  -Wslot/2   -Whead   2*Thead   Wslot    2*Whead
19:   SUBTRACT

      # shaft
20:   CYLINDER  -Lshaft   0   0   0   0   0   Dshaft/2
21:   UNION

22:   SCALE     sfact

23:   END
```



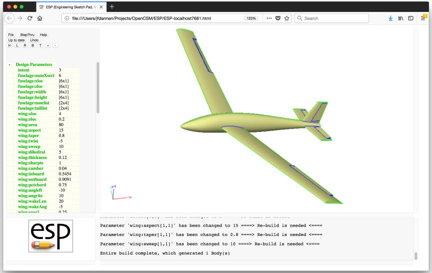
Review of Construction Process (3)



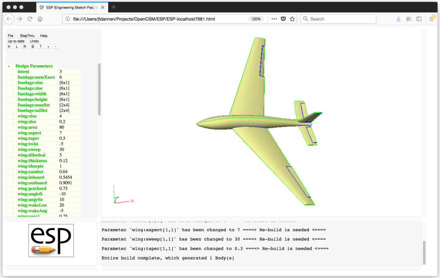
Distinguishing Features — Parametric

- ESP models typically contain one or more Design Parameters
- Design Parameters can be single-valued, 1D vectors, or 2D arrays of numbers
- Each Design Parameter has a current value, upper- and lower-bounds, and a current "velocity" (which is used to define sensitivities)
- Design Parameters can be "set" and "get"
  - through ESP's tree window
  - externally via calls to the Application Programming Interface (API)
- Arguments of all operations can be written as "expressions" that reference Design Parameters

Parameter Changes for Glider



$$\text{aspect} = 15$$
$$\text{sweep} = 10$$
$$\text{taper} = 0.8$$

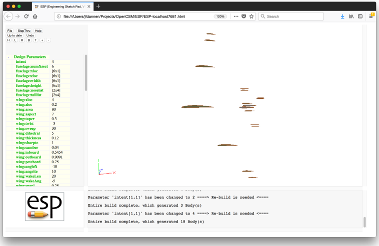


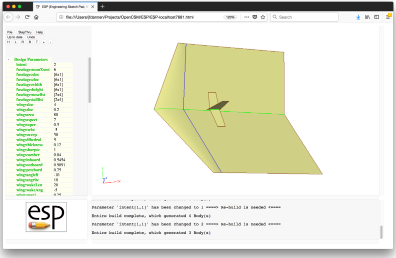
$$\text{aspect} = 7$$
$$\text{sweep} = 30$$
$$\text{taper} = 0.3$$

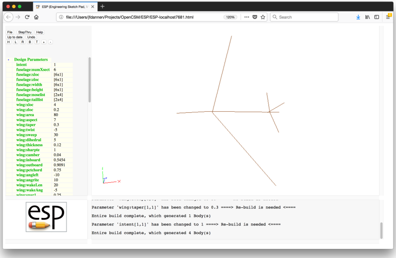
Distinguishing Features — Associative

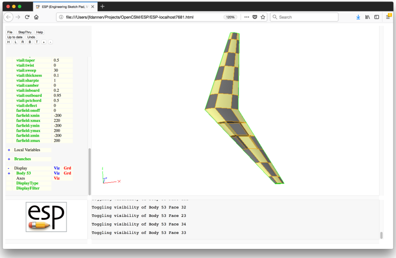
- ESP maintains a set of global and local attributes on a configuration that are persistent through rebuilds
- Supports the generation of multi-fidelity models
  - attributes can be used to associate conceptually-similar parts in the various models
- Supports the generation of multi-disciplinary models
  - attributes can be used to associate surface groups which share common loads and displacements
- Supports the "marking" of Faces and Edges with attributes such as nominal grid spacings, material properties, ...

Multiple Models for Glider





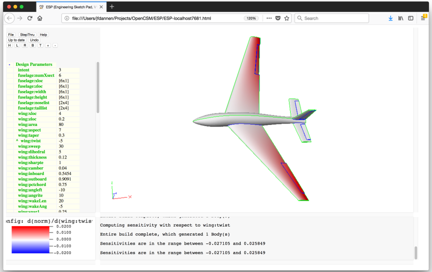




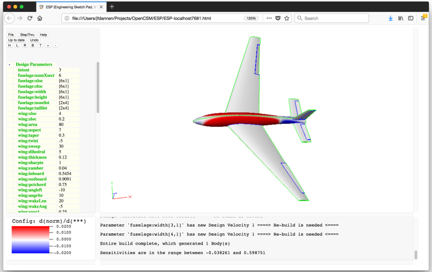
Distinguishing Features — Differentiated

- ESP allows a user to compute the sensitivity of any part of a configuration with respect to any Design Parameter
- Many of OpenCSM's commands have been analytically "differentiated"
  - efficient, since there is no need to re-generate the configuration
  - accurate, since there is no truncation error associated with "differencing"
- Other commands (currently) require the use of finite-differenced sensitivities
  - robust, due to new mapping technique
  - less efficient, since it requires the generation of a "perturbed" configuration
  - less accurate, since one needs to carefully select a "perturbation step" that is a balance between truncation and round-off errors

Sensitivities for Glider



twist



fuselage width

Distinguishing Features — Extensible

- Users can add their own user-defined primitives (UDPs)
  - create a single primitive solid
  - are written in C, C++, or FORTRAN and are compiled
  - can be written either top-down or bottom-up
  - have access to the entire suite of methods provided by `EGADS`
  - are coupled into `ESP` dynamically at run time
- Users can add their own user-defined functions (UDFs)
  - consume one or more Bodys from stack
  - are otherwise similar to UDPs
- Users can add their own user-defined components (UDCs)
  - can be thought of as “macros”
  - create zero or more Bodys
  - are written as `.csm`-type scripts

Distinguishing Features — Deployable

- `ESP`'s back-end (server) runs on a wide variety of modern compute platforms
  - LINUX
  - OSX
  - Windows
- `ESP`'s user-interface (client) runs in most modern web browsers
  - FireFox
  - Google Chrome
  - Safari
  - Edge (chromium-based versions)
- `ESP` can be distributed anywhere in the computer environment
  - open-source project (using the LGPL 2.1 license) that is distributed as source

Distinguishing Features — Embeddable

- Models are defined in `.csm` files
  - human readable ASCII
  - stack-like language that is consistent with Feature Tree traversal
  - contains looping via "patterns"
  - contains logical (if/then) constructs
  - contains error recovery via thrown/caught signals
- `OpenCSM` modeling system is defined by an Application Programming Interface (API) that allows it to be embedded into other applications
  - load a Master Model
  - interrogate and/or edit the Master Model
  - execute the Feature Tree and create BRep(s)
  - interrogate the BRep(s)
  - "set" and "get" sensitivities

Launching `serveESP` (1)

- Double-clicking `runESP122` icon on desktop
  - Automatically starts server and brings up browser
  - User can select **File→Open** to use existing `.csm` file
  - Closing the browser automatically stops the server
  - No command-line options can be used
- Double-clicking on `ESP122` icon on desktop
  - Brings up a terminal window in which all the `ESP` environment variables are set
  - Allows user to launch `serveESP` multiple times, with filenames and/or command-line options
  - Terminal window remains open until the user closes it

Launching serveESP (2)

- If starting from terminal window:
  - Technique 1: start browser automatically:

    ```
    setenv ESP_START "open -a /Applications/Firefox.app ...
                              ... $ESP_ROOT/ESP/ESP.html"
    ```

    or

    ```
    export ESP_START="open -a /Applications/Firefox.app ...
                              ... $ESP_ROOT/ESP/ESP.html"
    ```

    or

    ```
    set ESP_START="open -a /Applications/Firefox.app ...
                           ... $ESP_ROOT$/ESP/ESP.html"
    ```

    and then

    ```
    serveESP $ESP_ROOT/data/tutorial1
    ```

  - Technique 2: start browser separately:

    ```
    serveESP $ESP_ROOT/data/tutorial1
    ```

    and then open a browser on `ESP.html`

serveESP Command Line (1)

- To start serveESP

  `serveESP [filename[.csm]] [options...]`

  where `filename` can be given in the following forms:
  - (blank) starts without any input files (**File→Open** is then typically used within ESP)
  - `name.csm` reads the given `.csm` file
  - `name.cpc` reads the given `.cpc` file, which is a `.csm` file with all the UDCs inline
  - `name.stp` or `name.step` or `name.STP` or `name.STEP` creates and reads `autoStep.csm` (which loads the given STEP file)
  - `name.igs` or `name.iges` or `name.IGS` or `name.IGES` creates and reads `autoIges.csm` (which loads the given IGES file)
  - ...

serveESP Command Line (2)

- To start serveESP

  `serveESP [filename[.csm]] [options...]`

  where `filename` can be given in the following forms:

  - ...
  - `name.egads` or `name.EGADS` creates and reads `autoEgads.csm` (which loads the given EGADS file)
  - `name.py` to start with a Pyscript (and without a Brep)
  - otherwise a `.csm` extension is added and the file is read

`serveESP` Command Line (3)

- Frequently used `[options...]` include:
  - `-batch` runs the case but does not attach to a browser
  - `-help` or `-h` prints listing of acceptable options
  - `-jrnl jrnlname` can be used to replay a previous session
    - current session is stored in file `portXXXX.jrnl`
    - file must be renamed to be used for next session
  - `-skipBuild` to skip initial build
  - `-skipTess` to skip tessellation at end (and automatically select `-batch`)
  - `--version` or `-version` or `-v` to return version information
  - ...

serveESP Command Line (4)

- Other [options...] include:
  - -despmtrs despname to update the Design Parameters from the despname file
  - -dict dictname loads Constant Parameters from the dictname file
  - -dumpEgads to dump EGADS file in form Body_XXXXXX.egads after each Body is built
  - -loadEgads to load Body_XXXXXX.egads file if it exists in current directory
  - -onormal to plot in (nearly) orthonormal (not perspective)
  - -outLevel n selects the output level (1 is the default)
  - -port portnum selects the port for communication with the browser (7681 is the default)
  - -printStack to print the contents of the stack after every command is executed (useful for debugging)

`serveESP` Command Line (5)

- Other `[options...]` include:
  - `-plot plotfile` to plot additional information or provide input for the `-histDist` option
  - `-plotBDF filename` superimposes BDF information in GraphicsWindow
  - `-plotCP` to plot Bspline control points
  - `-histDist dist` to generate histograms of the distances from the points in the `plotfile` from the configuration. Points that are further than `dist` are added to a new `plotfile` called `bad.points`

serveESP Command Line (6)

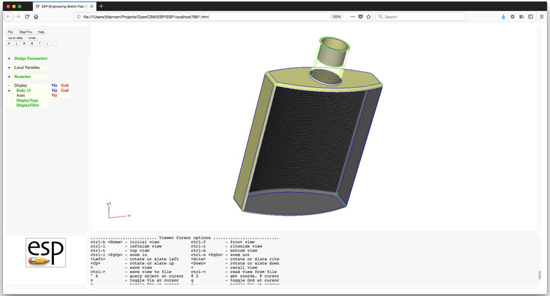
- Still other (less frequently used) [options...] include:
  - -verify to execute ASSERT statements that contain verify=1
  - -addVerify creates verification files (for automatic regression testing)
  - -egg eggname uses an external grid generator
  - -tess tessfile to specify the name of an input tessellation file (to be used instead of the EGADS tessellation)

serveESP Command Line (7)

- Other (for development) `[options...]` include:
  - `-ptrb ptrbname` to generate information with which the sensitivities are debugged
  - `-allVels` to compute Node/Edge/Face velocities
  - `-dxdd despmtr` to create a `.sens` file that contains the geometric sensitivities with respect to `despmtr` (automatically selects `-batch`)
  - `-egads egadsfile` to start from an `.egads` file

ESP Screen Layout

- GraphicsWindow
  - 3D image
  - 2D sketcher
  - forms
- TreeWindow
  - Design Parameters
  - Local Variables
  - Branches
  - Display
- KeyWindow
  - color key
- MessageWindow



GraphicsWindow Default Colors

- Faces
  - yellow — front of Face (for SolidBody)
  - pink — front of Face (for SheetBody)
  - grey — back of Face
  - black — grid
- Edges
  - green — manifold Edge that was first created as part of a primitive (such as the Edges in a `BOX`)
  - blue — manifold Edge that was first created as part of a Boolean or Applied Branch
  - brown — non-manifold Edge that supports only one Face
  - orange — non-manifold Edge that supports more than two Faces
  - black — grid
- Nodes
  - black

Image Manipulation via the Mouse

- Translation
  - press and drag any mouse button
- Rotation
  - hold down **Ctrl** and drag any mouse button
  - hold down **Alt** and drag any mouse button
- Zoom
  - hold down **Shift** and drag any mouse button
  - scrolling the middle mouse button also scrolls in/out
- Flying mode
  - press **!** in GraphicsWindow to toggle mode
  - image continues moving image until mouse is released
- Note: the mouse mappings are defined in `ESP.js`

Image Manipulation via Key Presses

"flying-mode" is off by default

Key-press	"flying-mode" off	"flying-mode" on
$\leftarrow$	rotate left 30°	translate left
$\rightarrow$	rotate right 30°	translate right
$\uparrow$	rotate up 30°	translate up
$\downarrow$	rotate down 30°	translate down
+	zoom in	zoom in
-	zoom out	zoom out
PgUp	zoom in	zoom in
PgDn	zoom out	zoom out
Home	home view	home view

Note: holding **Shift** reduces the increment

Image Manipulation via Buttons

Button press	orientation	note
H	home view	y vs x
L	left side view	y vs z
R	right side view	y vs $-z$
B	bottom view	z vs x
T	top view	$-z$ vs x
+	zoom in	
-	zoom out	

Buttons are near top of TreeWindow

Saving Viewing Orientation

key press	action
>	save view (in memory)
<	restore view (from memory)
Ctrl->	save view (in a file)
.	save view (in a file)
Ctrl-<	restore view (from a file)
,	restore view (from a file)

Image Manipulation via the TreeWindow

- In the TreeWindow, **Display** contains an entry for each Body
- If the **Body** is expanded (the + on the left is pressed), then entries appear for **Faces**, **Edges**, **Nodes**, and **Csystems**
- If the **Faces**, **Edges**, **Nodes**, or **Csystems** are expanded, the names of all entities in the "group" are listed
- **Viz** toggles the visibility of the associated Body(s), Face(s), Edge(s), Node(s), or Csystem(s)
- **Grd** toggles the visibility of the grid of the associated Body(s), Face(s), or Edge(s)
- **Trn** toggles the pseudo-transparency of the associated Face(s)
- **Ori** toggles the orientation vectors of the associated Edge(s)
- Toggling at a "group" level effects the setting of its children
- Pressing **Display** gives the user the option of turning on/off the display of all Nodes, Edges, or Faces in all Bodys

Image Inquiry

- Re-center the image at the current location and set a new "rotation center"
  - ***** or **8**
- Find the approximate location of the cursor (in 3D space) and report it in the MessageWindow
  - **@** or **2**
  - little red square shows location
  - distance to last inquiry is also reported
  - red square is turned off if distance from last inquiry is zero
- Identify the object (Edge or Face) and list all its attributes in the MessageWindow
  - $\wedge$ or **6**
- List the key-press options in the MessageWindow
  - **?**

Image Orientation

- Orientation of image in GraphicsWindow
  - red axis in x-direction
  - green axis in y-direction
  - blue axis in z-direction
- Visibility of Axes is also sometimes useful

Image Manipulation

- Turn off the visibility of the Node, Edge, or Face at cursor
  - **v**
- Toggle the grid on the Edge or Face at cursor
  - **g**
- Toggle the transparency of the Face at cursor
  - **t**
- Toggle the orientation vectors of the Edge at cursor
  - **o**

StepThru Mode

- Show step-by-step build process
  - **StepThru** button (near top of TreeWindow)
- Next step in build process
  - **NextStep** button (near top of TreeWindow) or **n** key in GraphicsWindow
- Previous step in build process
  - **p** key in GraphicsWindow
- First step in build process
  - **f** key in GraphicsWindow
- Last step in build process
  - **l** key (letter "l") in GraphicsWindow
- Exit StepThru mode
  - **CancelStepThru** at bottom of Display listing in TreeWindow

- Method:
  - start ESP: `serveESP`
  - add Design Parameter by pressing **DesignParameters**
  - add Branch by pressing **Branch**
- Advantages:
  - most similar to other CAD packages
  - can use interactive sketcher
- Disadvantages:
  - generally slow
  - cannot add comments, indentation, etc.
  - harder to debug

Creating a Script (2)

Using an External Text Editor

- Method:
  - use any text editor to create `myFile.csm`
  - run ESP: `serveESP -loadEgads -dumpEgads myFile`
- Advantages;
  - can use any editor with which you are familiar
  - easy to add comments, spacing, indentation, . . .
- Disadvantages:
  - do not get help in writing `.csm` file
  - cannot use interactive sketcher (except via a UDC)
  - requires many `ESP` restarts

Creating a Script (3)

Using the Integrated Code Editor

- Method:
  - start ESP: `serveESP`
  - **File→Edit** and then **Save**
- Advantages:
  - context-sensitive editor with hints
  - easy to add comments, spacing, indentation, ...
- Disadvantages:
  - slightly different key mappings
  - cannot use interactive sketcher (except via a UDC)

Using the jrnl (1)

- Every time that you execute `ESP`, a new `.jrnl` file is generated (which overwrites any existing file)
  - default name if `port7681.jrnl` (unless you used the `-port` command line option)
- The `.jrnl` file remembers all the interactions that you had with the `ESP` interface (example on next page)
- Each user action is a separate line in the `.jrnl` file

Using the jrnl (2)

Example `port7681.jrnl`

```
setPmtr|H|1|1|3|
build|0|
clrVels|
setVel|D|1|1|1|
build|0|
```

Using the jrnl (3)

- To use a `.jrnl` file, follow these steps:
  - when `ESP` completes, rename the `.jrnl` file, with a command such as

    ```
    mv port7681.jrnl my.jrnl
    ```

    or

    ```
    ren port7681.jrnl my.jrnl
    ```

    (this is needed so that the `.jrnl` is not overwritten below)
  - edit the `.jrnl` file to remove the offending command (which is usually the last line)
  - restart `ESP` with the command

    ```
    serveESP -jrnl my.jrnl my.csm
    ```

    (assuming that the name of your `.csm` file is `my.csm`)

Saving vs. Exporting (1)

- ESP has two ways of saving your work:
  - **File→Edit→Save**
    - Save an exact copy of information in the code editor
    - Remembers comments, indentation, line-splitting, spacing, etc.
    - Is preferred method of saving your work, unless you make changes in the ESP TreeWindow (for example, add/edit/remove a Branch or change a Design Parameter)
  - **File→Export FeatureTree**
    - Makes an output file by reading the current feature tree
    - Forgets comments, indentation, line-splitting, spacing, etc.
    - Is only useful if you have made edits via the TreeWindow

Saving vs. Exporting (2)

Original .csm file

```
# example program
# written by John Dannenhoffer

# define parameters for the box
DESPMTR   L   3.0   # length (ft)
DESPMTR   H   2.0   # height (ft)
DESPMTR   D   1.0   # depth  (ft)

# create the box (centered at the origin)
BOX      -L/2  -H/2  -D/2 \
          L     H     D

# put _name attributes on the Faces
PATBEG       iface  6
   SELECT    FACE   iface
   ATTRIBUTE _name  $face_+iface
PATEND

END
```

Saving vs. Exporting (3)

.csm file generated by Export FeatureTree

```
# example_out.csm written by ocsmSave (v1.22)

# Constant, Design, and Output Parameters:
despmtr   L       3.00000
despmtr   H       2.00000
despmtr   D       1.00000

# Global Attributes:

# Branches:
box       -L/2   -H/2   -D/2   L   H   D
patbeg    iface   6
   select    FACE   iface
attribute _name   $face_+iface
patend

end
```

CSM Commands

Primitives

POINT	`xloc yloc zloc`
BOX	`xbase ybase zbase dx dy dz`
SPHERE	`xcent ycent zcent radius`
CYLINDER	`xbeg ybeg zbeg xend yend zend radius`
CONE	`xvrtx yvrtx zvrtx xbase ybase zbase radius`
TORUS	`xcent ycent zcent dxaxis dyaxis dzaxis ...`
	`... majorRad minorRad`
IMPORT	`$filename bodynumber=1`
UDPRIM	`$primtype $argName1 argValue1 ...argValue4`
	`name → UDP/UDF`
	`/name → path($pwd)/name.udc`
	`$/name → path($csm)/name.udc`
	`$$/name → path($root)/udc/name.udc`
RESTORE	`$name index=0`

Grown

EXTRUDE	`dx dy dz`
RULE	`reorder=0`
BLEND	`begList=0 endList=0 reorder=0 oneFace=0`
REVOLVE	`xorig yorig zorig dxaxis dyaxis dzaxis angDeg`
SWEEP	
LOFT*	`smooth`

Applied

FILLET	`radius edgeList=0 listStyle=0`
CHAMFER	`radius edgeList=0 listStyle=0`
HOLLOW	`thick=0 entList=0 listStyle=0`

Booleans

INTERSECT	`$order=none index=1 maxtol=0`
SUBTRACT	`$order=none index=1 maxtol=0`
UNION	`toMark=0 trimList=0 maxtol=0`
JOIN	`toler=0 toMark=0`
CONNECT	`faceList1 faceList2 edgeList1=0 edgeList2=0`
EXTRACT	`entList`
COMBINE	`toler=0`

Transforms

TRANSLATE	`dx dy dz`
ROTATEX	`angDeg yaxis zaxis`
ROTATEY	`angDeg zaxis xaxis`
ROTATEZ	`angDeg xaxis yaxis`
SCALE	`fact xcent=0 ycent=0 zcent=0`
MIRROR	`nx ny nz dist=0`
APPLYCSYS	`$csysName ibody=0`
REORDER	`ishift iflip=0`

Sketch

SKBEG	`x y z relative=0`
SKVAR	`$type valList`
SKCON	`$type index1 index2=-1 $value=0`
LINSEG	`x y z`
CIRARC	`xon yon zon xend yend zend`
ARC	`xend yend zend dist $plane=xy`
SPLINE	`x y z`
SSLOPE	`dx dy dz`
BEZIER	`x y z`
SKEND	`wireonly=0`

Solver

SOLBEG	`$varList`
SOLCON	`$expr`
SOLEND	

Stack

MARK	
STORE	`$name index=0 keep=0`
GROUP	`nbody=0`

Logic

IFTHEN	`val1 $op1 val2 $op2=and val3 $op3 val4`
ELSEIF	`val1 $op1 val2 $op2=and val3 $op3 val4`
ELSE	
ENDIF	

Looping

PATBEG	`$pmtrName ncopy`
PATBREAK	`expr`
PATEND	

Error handling

CATBEG	`sigCode`
CATEND	
THROW	`sigCode`

Declarations

DIMENSION	`$pmtrName nrow ncol despmtr=0`
CFGPMTR	`$pmtrName values`
DESPMTR	`$pmtrName values`
CONPMTR	`$pmtrName value`
OUTPMTR	`$pmtrName`
LBOUND	`$pmtrName bounds`
UBOUND	`$pmtrName bounds`

Attribution

ATTRIBUTE	`$attrName attrValue`
CSYSTEM	`$csysName csysList`
GETATTR	`$pmtrName attrID global=0`

User-defined components

INTERFACE	`$argName $argType default=0`
END	

Miscellaneous

SET	`$pmtrName exprs`
UDPARG	`$primtype $argName1 argValue1 ...`
SELECT	`$type arg1 ...`
ASSERT	`arg1 arg2 toler=0 verify=0`
DUMP	`$filename remove=0 toMark=0`
EVALUATE	`$type arg1 ...`
NAME	`$branchName`
PROJECT	`x y z dx dy dz useEdges=0`

User-defined Primitives/Functions

bezier	`$filename debug imax jmax cp[]`
biconvex	`thick camber`
box	`dx dy dz rad @area @volume`
csm	`$filename $pmtrname pmtrvalue @volume`
createBEM	`$filename space imin imax nocrod`
createPoly	`$filename hole[]`
droop	`xle thetale xye thetate`
editAttr	`$attrname $input $output overwrite`
	`$filename verbose @nchange`
ellipse	`rx ry rz nedge thbeg`
fitcurve	`$filename ncp ordered periodic xform[] xyz[] @npnt @rms`
flend	`fraca fracb toler plot`
freeform	`$filename imax jmax kmax xyz[]`
ganged	`$op toler`
guide	`nxsect origin axis`
hex	`corners[] uknots[] vknots[] wknots[] @area @volume`
import	`$filename bodynumber @numbodies`
kulfan	`class[] ztail[] aupper[] alower[]`
naca	`series thickness camber maxloc offset sharpte`
naca456	`thkcode toc xmaxt leindex camcode cmax xmaxc cl a`
nurbbody	`$filename`
parsec	`yte poly[] param[] meanline`
pod	`length fineness @volume`
poly	`points[]`
printBbox	
printBrep	

(continued on other side)

ESP Quick Reference 1 Version 1.18

Recovering from an Error

- If the MessageWindow turns yellow
  - `OpenCSM` has detected an error
  - Double-clicking in the MessageWindow will automatically open the code editor to the appropriate line
- If the MessageWindow turns pink
  - `ESP` has lost its connection to `serveESP` and the session must be restarted
  - Consider using the `-jrnl` option to get you (almost) back to the situation that caused the connection to be lost

Tool Interface Modules (TIMs)

- Access to tools that support the preparation and use of models
    - Erep Editor
    - Plugs
    - Pyscript
    - CAPS (not described here)
    - Plotter (called from Pyscript)
    - Viewer (called from Pyscript/CAPS)
    - Flowchart (called from Pyscript/CAPS)
- Most are launched via the **Tool** button

Erep Editor (1)

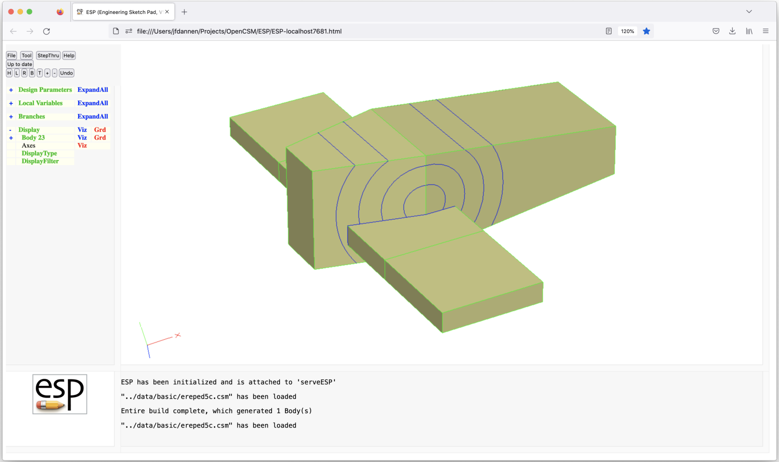
- An Erep is an effective topology the may be used in a down-stream analysis (such as `CAPS`)
- Ereps share geometry with a supporting Brep (which is comprised of Nodes, Edges, and Faces)
- ENodes in an Erep are a subset of the Brep's Nodes
- EEdges in an Erep are combinations of the Brep's Edges
  - the EEdges are the concatenation of one or more contiguous Edges
  - note: not all Edges are associated with an EEdge (that is, some Edges may be interior to an EFace)
- EFaces are combinations of one or more of the Brep's Faces
  - note: every Face is associated with an EFace

Erep Editor (2)

- Ereps are specified via attributes on the Brep
- Nodes that have a `.Keep` Attribute are forced to be ENodes
- Edges that have a `.Keep` Attribute are forced to be part of an EEdge
- Attributes on the Faces define which ones are to be combined into an EFace
  - The Attribute name is user-selected (for example `_erep`)
  - All Brep Faces that have a `_erep` Attribute with the same integer value are candidates to be combined into an EFace
    - the Faces must be contiguous
    - the dihedral angle between adjacent Faces must not exceed a user-specified tolerance (typically 5 degrees)
  - The Erep Editor uses “colors” to specify the Attribute values

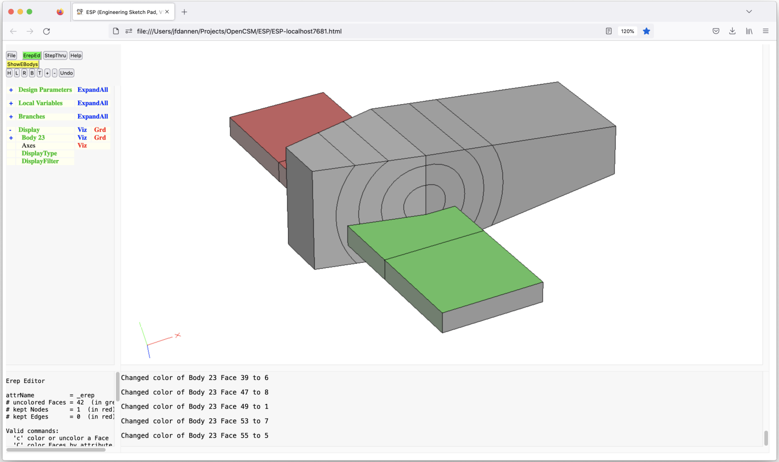
Erep Editor (3)

Original Brep configuration



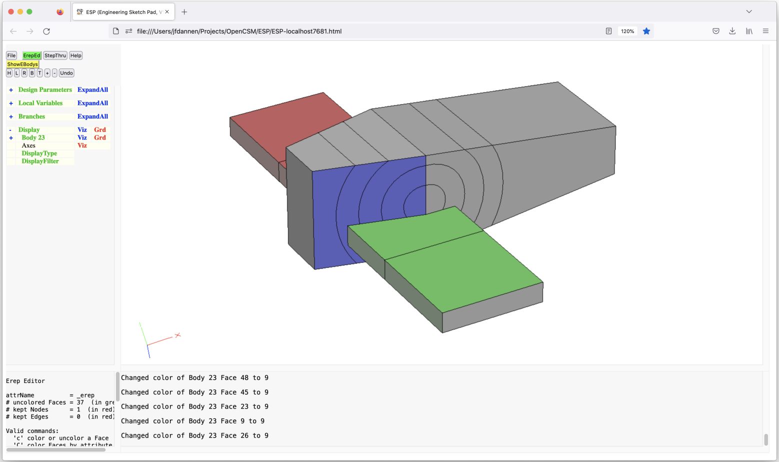
Erep Editor (4)

Wing Faces colored into 8 groups (using the “C” option)



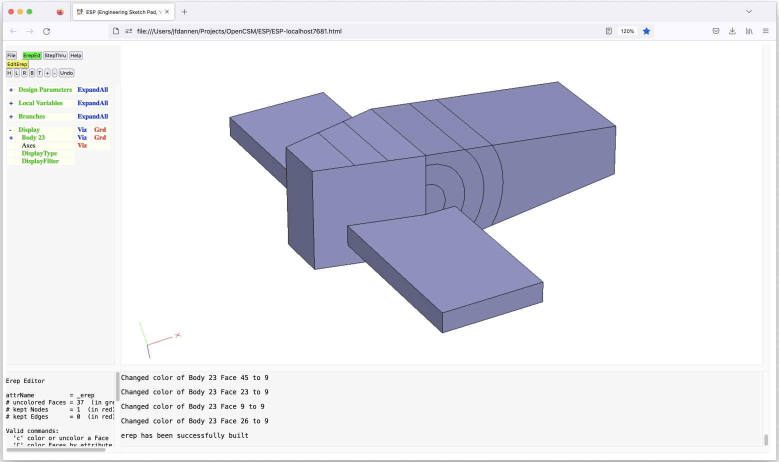
Erep Editor (5)

Fuselage side colored into one group (using the “c” option five times)



Erep Editor (6)

Associated Erep



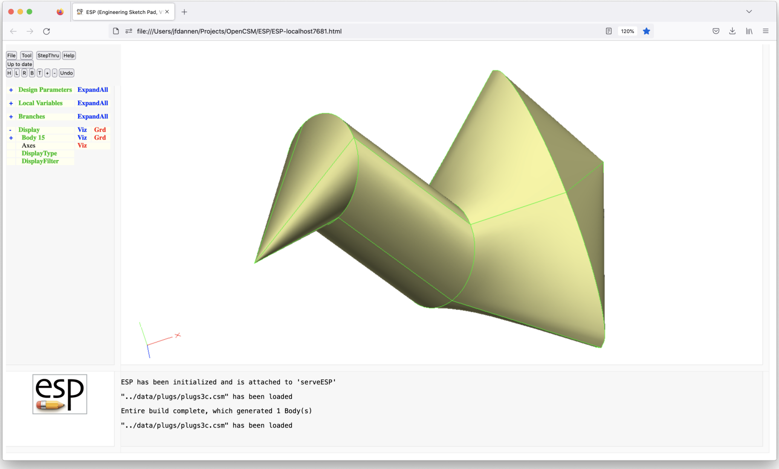
Plugs (1)

- `Plugs` is a tool for finding the Design Parameter values such that a Body matches a cloud of points
- Inputs:
  - a single parameterized Body
  - a cloud of (unclassified) points
- Outputs:
  - Design Parameter values
- Executed via **Tool** $\rightarrow$ **Plugs**
- Algorithm is described in Jia, P, and Dannenhoffer, J.F., "Generation of Parametric Aircraft Models from a Cloud of Points", AIAA-2016-1926, presented at AIAA SciTech 2016, January 2016.

Plugs (2)

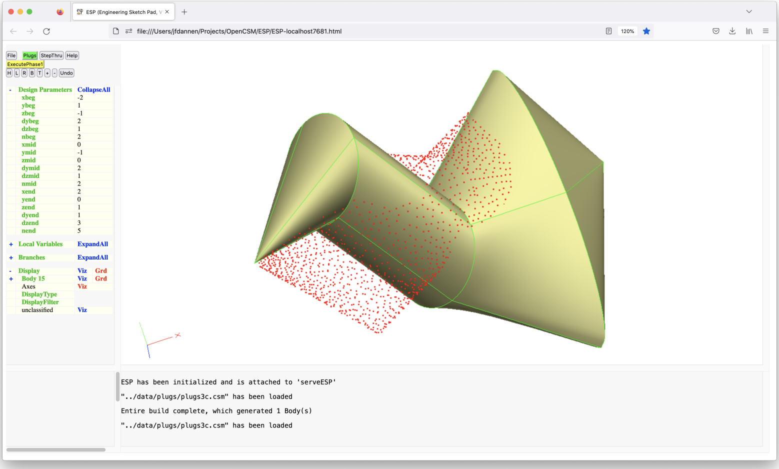
- Phase 1
  - Take up to 50 Levenberg-Marquardt optimization steps to vary the Design Parameters to match the bounding box of the point cloud
  - Unclassify all points in the cloud
- Phase 2
  - In a sequence of passes
    - classify each point in the cloud by determining the most likely Face to associated it with; if there is no obvious Face, leave the point unclassified
    - if all points are classified and the point classifications are the same as in the previous pass, exit
    - perform up to 50 steps of the Levenberg-Marquardt optimizer

Initial Body with user-guessed Design Parameters

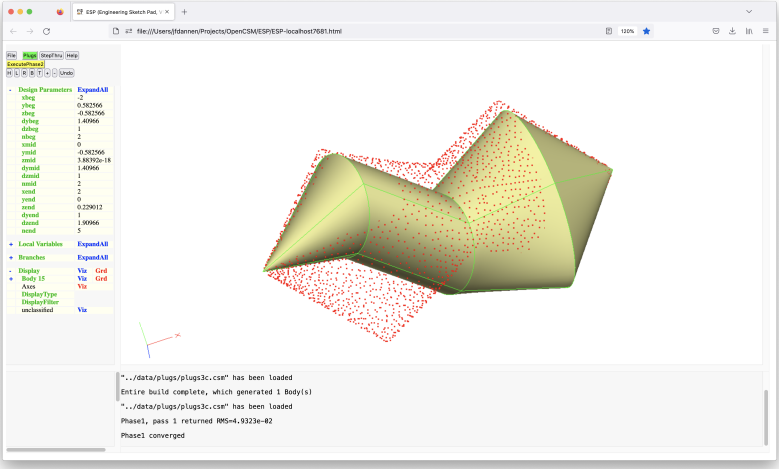


Plugs (4)

Initial Body with cloud of points (red points are unclassified)

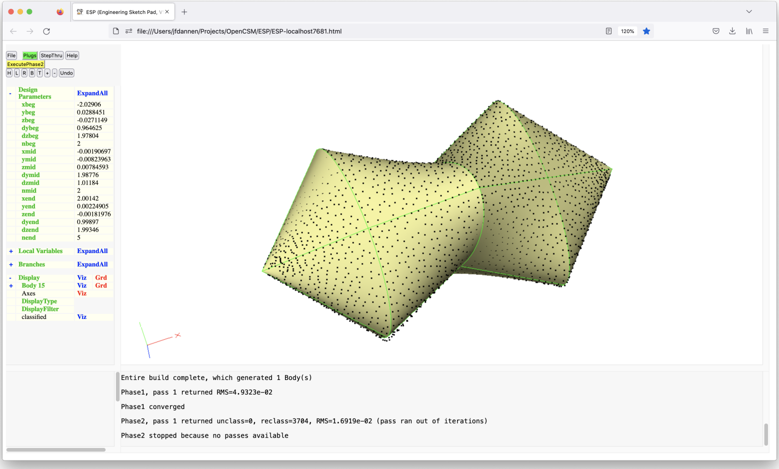


After Phase 1 — bounding boxes of Body and point cloud match



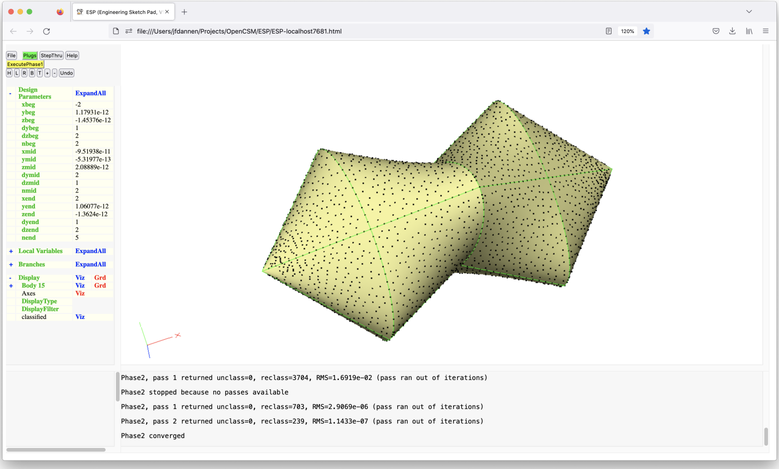
Plugs (6)

After Pass 1 of Phase 2 (black points are classified)



Plugs (7)

After Pass 4 of Phase 2 (converged)

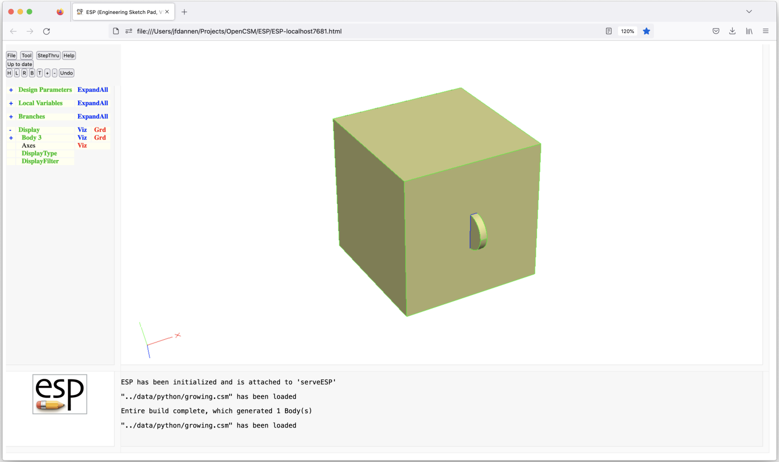


Pyscript (1)

- Embedded Python interpeter
- Has access to `OpenCSM` via `pyOCSM`
- Has access to `EGADS` via `pyEGADS`
- Context-sensitive editor
- Reports Python's output in MessageWindow
- Reports Python's errors in a pop-up dialog and turns the MessageWindow yellow
  - double-clicking in yellow MessageWindow opens Pyscript editor to the offending line
- Can be launched either directly from the `serveESP` command line or by choosing **Tool→Pyscript**

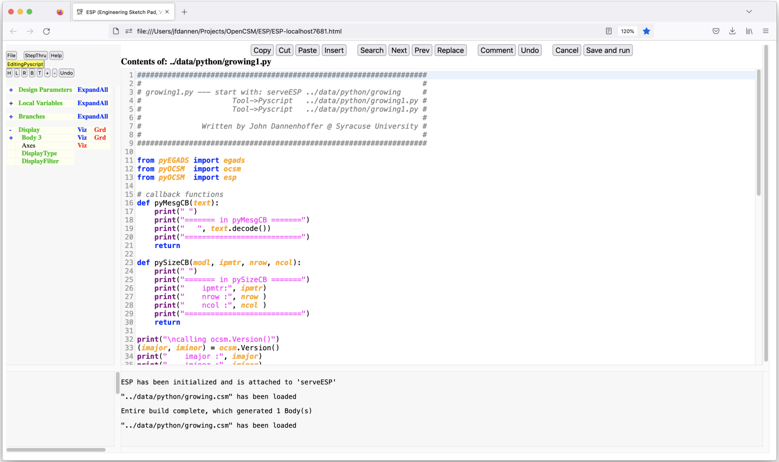
Pyscript (2)

Body before Pyscript starts



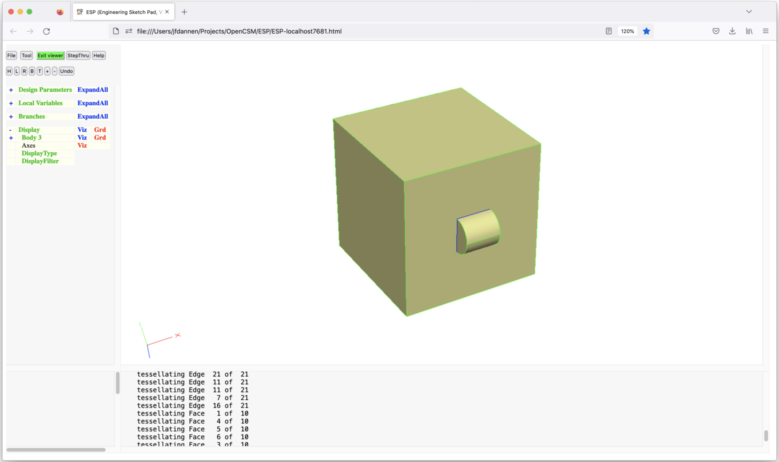
Pyscript (3)

Python script to modify the Model

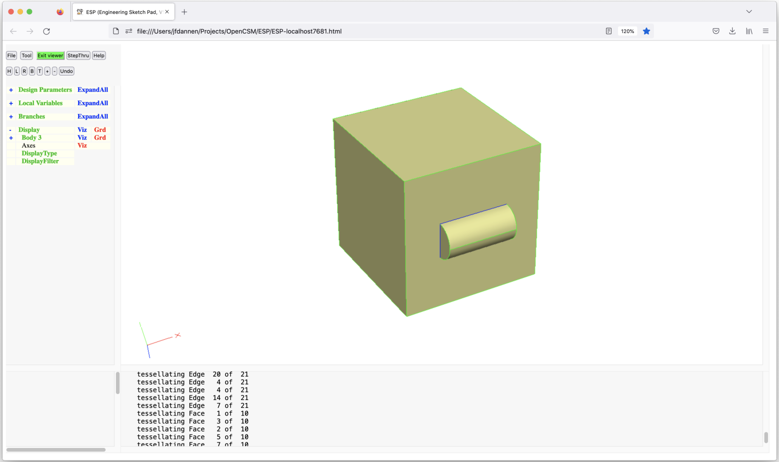


Pyscript (4)

Body after first modification

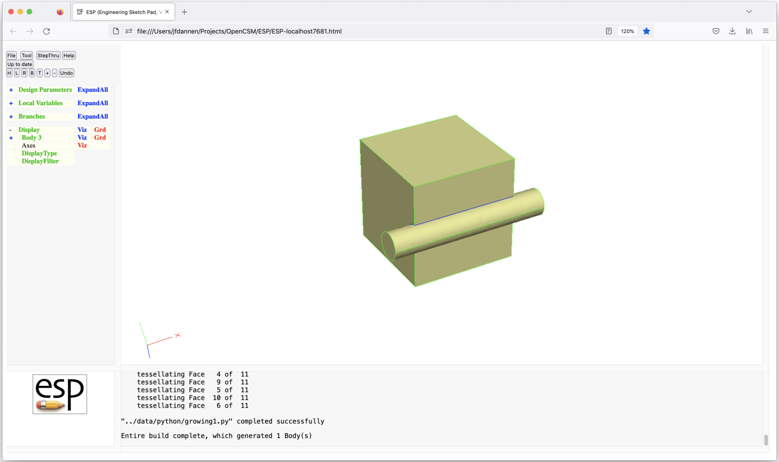


Body after second modification



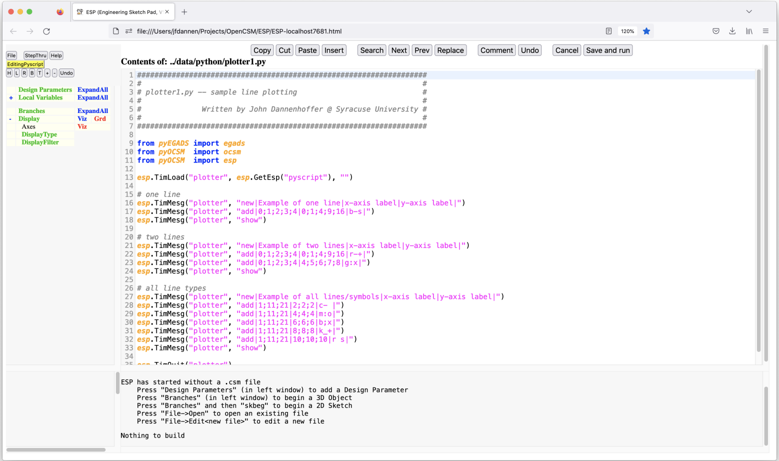
Pyscript (6)

Body after final modification



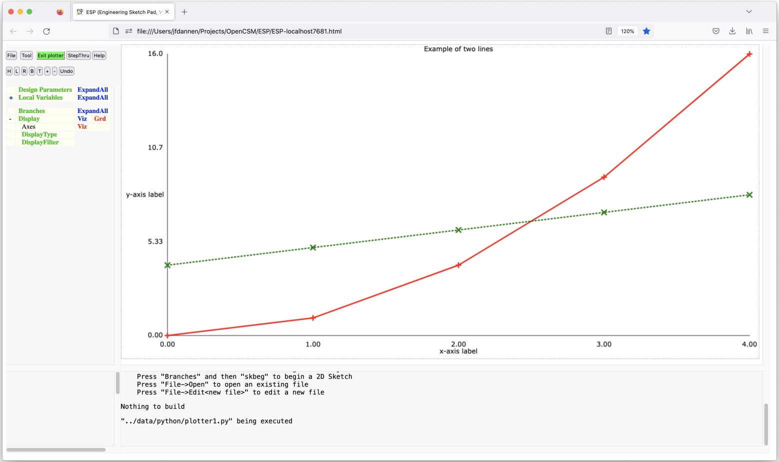
Pyscript (7)

Python script to launch the line plotter TIM



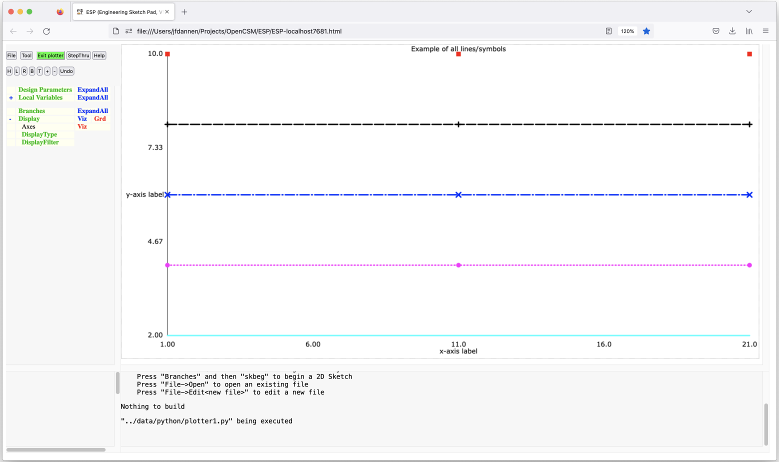
Pyscript (8)

Second plot produced by the line plotter TIM



Pyscript (9)

Third plot produced (showing available line and symbol types)



Collaboration Mode (1)

- Inspired by Pair Programming* paradigm
  - Driver: writes programs, detail-level, tactical decisions
  - Navigator: overlooks, feedback, high-level strategic choices
- ESP uses a browser-based, client-server architecture
- Interface is similar for single as well as multiple users
- Interchangeable role of Driver and Navigator by “Passing the Ball”
- Interface can be coupled with voice and/or other visual tools to enhance experience

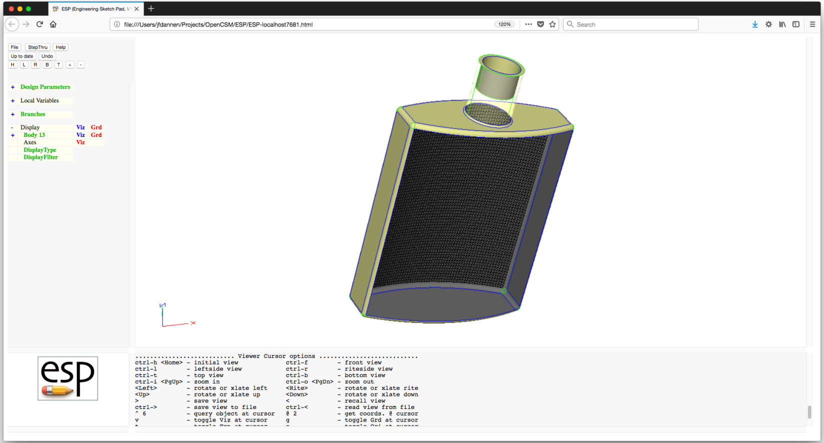
Collaboration Mode (2)

- New collaborative environment in ESP has several benefits:
  - shared ownership of the model
  - tendency to take fewer short-cuts
  - low error rate
  - reduced labor is more apparent while performing complex tasks

Homework exercise

1. Start `serveESP` using the file
   `$ESP_ROOT/training/ESP/data/session01/bottle2.csm`
   or
   `../training/ESP/data/session01/bottle2.csm`
   - Note that on Windows, you will need to use backslash (\) instead of the forward slash (/)
2. Explore the various image manipulation tools
3. See if you can get the image on the next page
4. Use StepThru to see how the bottle was created

bottle After Image Manipulations



Muddy Cards

- Opportunity to provide immediate “feedback”
- Any questions about presentation material, critique of sample problems, ...
- Mail questions to `jfdannen@syr.edu`
- Questions will be answered at next session