Engineering Sketch Pad (ESP) Training Session 5: Using UDPs, UDFs, and UDCs

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Overview

- Difference between UDPs, UDFs, and UDCs
- Using user-defined primitives (UDPs)
  - list of UDPs shipped with ESP
  - calling a UDP
- Using user-defined functions (UDFs)
  - list of UDFs shipped with ESP
  - calling a UDF
- Using user-defined components (UDCs)
  - list of UDCs shipped with ESP
  - calling a UDC
- Writing a UDC
  - creating the interface
  - example UDC
- Hands-on exercises:
  - reflected cone
  - fuselage

Differences Between UDPs, UDFs, and UDCs (1)

- Users can add their own user-defined primitives (UDPs)
  - UDPs create a single solid
  - UDPs do not consume any Bodys from the stack
  - UDPs are written in C, C++, or FORTRAN and are compiled
  - UDPs can be written either top-down or bottom-up or both
  - UDPs have access to the entire suite of methods provided by `EGADS`
  - UDPs are coupled into `ESP` dynamically at run time
- Users can add their own user-defined functions (UDFs)
  - UDFs are the same as UDPs, except they consume one or more Bodys from the stack

Differences Between UDPs, UDFs, and UDCs (2)

- Users can add their own user-defined components (UDCs)
  - UDCs can be thought of as "macros"
  - UDCs consume zero or more Bodys from the stack
  - UDCs create zero or more Bodys (onto teh stack)
  - UDCs are written as `.csm`-type scripts

UDPs Shipped with ESP (1)

- `bezier` — generate a Bezier Wire, Sheet, or Solid Body from a input file
- `biconvex` — generate a biconvex airfoil
- `box` — generate a (rectangular) Wire, Sheet, or Solid Body centered at the origin (with possibly-rounded corners)
- `ellipse` — generate an ellipse centered at the origin
- `freeform` — generate a freeform Wire, Sheet, or Solid Body from an input file
- `import` — read a Body out of a `.step` file
- `kulfan` — generate a Kulfan airfoil segments

UDPs Shipped with ESP (2)

- `naca` — generate a NACA 4-series airfoil or camberline
- `naca456` — generate a NACA 4-, 5-, or 6-series airfoil
- `parsec` — generate a Parsec airfoil by either specifying Sobieski's parameters or spline parameters
- `pod` — generates a VSP-like pod
- tt sample — used as an example for users who want to create their own UDP
- `sew` — sew Faces in a `step` file into a Solid Body
- `supell` — generate a 4-quadrant super-ellipse
- `waffle` — generate a waffle by extruding a 2D group of segments

Calling a UDP

- UDPs are called with a `udprim` statement

```
udprim    $primtype $argName1 argValue1 \
                    $argName2 argValue2 \
                    $argName3 argValue3 \
                    $argName4 argValue4
```

- `$primtype` must start with a letter
- At most 4 name-value pair can be specified on the `udprim` statement
- More name-value pairs can be specified in any number of `udparg` statements that precede the `udprim` statement

```
updarg    $primtype $argName1 argValue1 \
                    $argName2 argValue2 \
                    $argName3 argValue3 \
                    $argName4 argValue4
```

- name-value pairs are processed in order (with possible over-writing)

UDCs Shipped with ESP

- `createBEM` — create a NASTRAN-type built-up-element (BEM) file from Body on Stack
- `createPoly` — create a AFLR `.poly` file between the two Bodys on the top of the Stack

- UDCs are called in exactly same way as UDPs are called

UDCs Shipped with ESP

- `biconvex` — generate a biconvex airfoil
- `boxudc` — similar to the box UDP
- `diamond` — generate a double-diamond airfoil
- `flapz` — cut a (deflected) flap in a Body
- `gen_rot` — general rotation with two fixed points
- `popupz` — pop up a part of the configuration
- `spoilerz` — pop up a spoiler
- `duct` — generate a duct
- `fuselage` — generate a fuselage
- `strut` — generate a strut (between a duct and wing)
- `wing` — generate a wing

Calling a UDC

- UDCs are called with a `udprim` statement
- `$primtype` must start with a slash (`/`) or dollar-slash (`$/`)
  - if `/`, then the UDC file is in the current working directory
  - if `$/`, then the UDC file is in the same directory as the `.csm` file
- The `udprim` statement can be preceded by one or more `udparg` statements
- name-value pairs are processed in order (with possible over-writing)

Writing a UDC

- Define the interface
  - input variables (with default values)
  - output variables (with default values)
  - dimensioned variables (which all default to 0)
- Add assertions to ensure valid inputs
- Make sure all "output" variables are assigned values

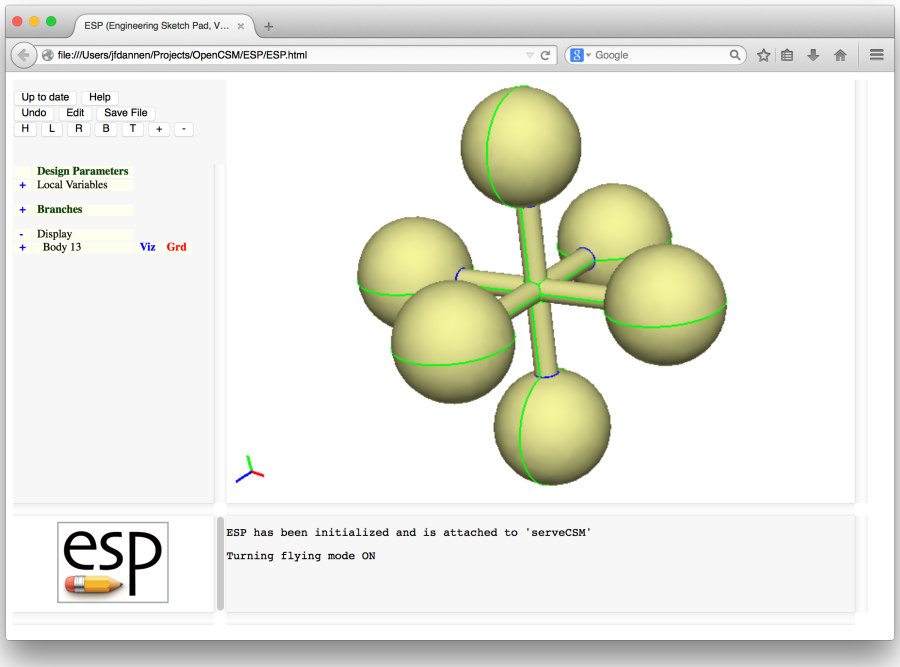
Example UDC — `dumbbell.udc`

```
# dumbbell

interface Lbar     in  0    # length of bar
interface Dbar     in  0    # diameter of bar
interface Dball    in  0    # diameter of balls
interface vol      out 0    # volume

assert    ifpos(Lbar,1,0)   1
assert    ifpos(Dbar,1,0)   1
assert    ifpos(Dball,1,0)  1
set       Lhalf    "Lbar / 2"

cylinder  -Lhalf  0  0  +Lhalf  0  0  Dbar
sphere    -Lhalf  0  0   Dball
union
sphere    +Lhalf  0  0   Dball
union

set       vol    @volume

end
```

Example UDC — jack.csm

```
# jack

udparg  $/dumbbell  Lbar   5.0
udparg  $/dumbbell  Dball  1.0
udprim  $/dumbbell  Dbar   0.2
set     foo @@vol
store   dumbbell 0 1

restore dumbbell
rotatey 90  0  0
union

restore dumbbell
rotatez 90  0  0
union

# show that vol was a local variable in .udc
assert  ifnan(vol,1,0)  1
end
```


Example UDC — Jack



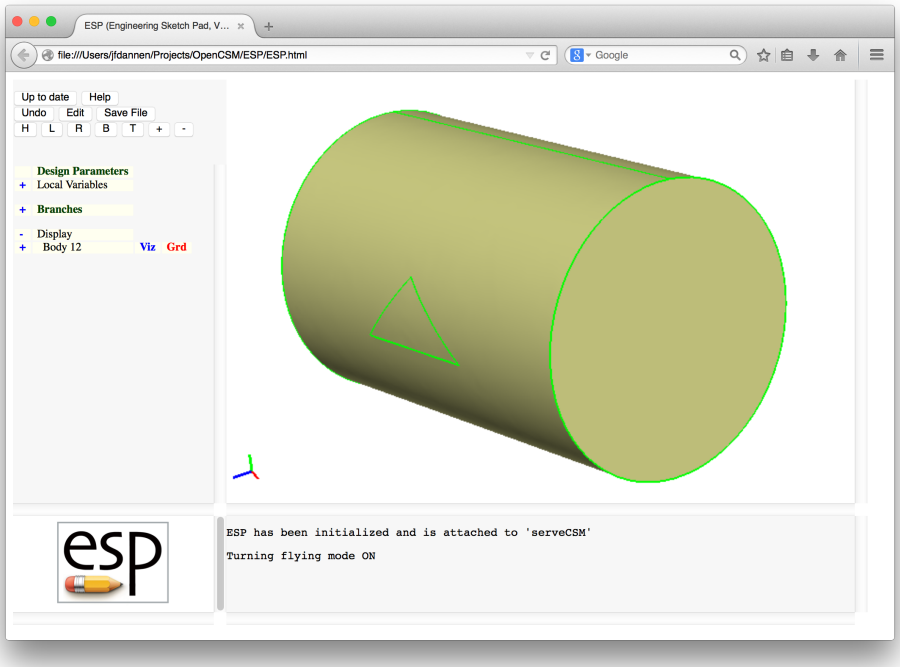
Example UDC — cutter.udc

```
# cutter

interface xx    in  0
interface yy    in  0
interface zbeg  in  0
interface zend  in  0

assert    ifpos(xx.size-2,1,0)  1
assert    ifzero(xx.size-yy.size,1,0)  1

skbeg         xx[1]    yy[1]    zbeg
   patbeg i xx.size-1
      linseg  xx[i+1]  yy[i+1]  zbeg
   patend
   linseg     xx[1]    yy[1]    zbeg
skend  1

extrude   0  0  zend-zbeg

end
```


Example UDC — scribeCyl.csm

```
# scribeCyl

dimension xpoints   1  3
dimension ypoints   1  3

set       xpoints  "-1.;  1.;  .0;"
set       ypoints  "-.5; -.5; +.5;"

cylinder  -3  0  0  +3  0  0  2
rotatex   90  0  0

udparg    $/cutter  xx    xpoints
udparg    $/cutter  yy    ypoints
udparg    $/cutter  zbeg  0
udprim    $/cutter  zend  3
subtract

end
```

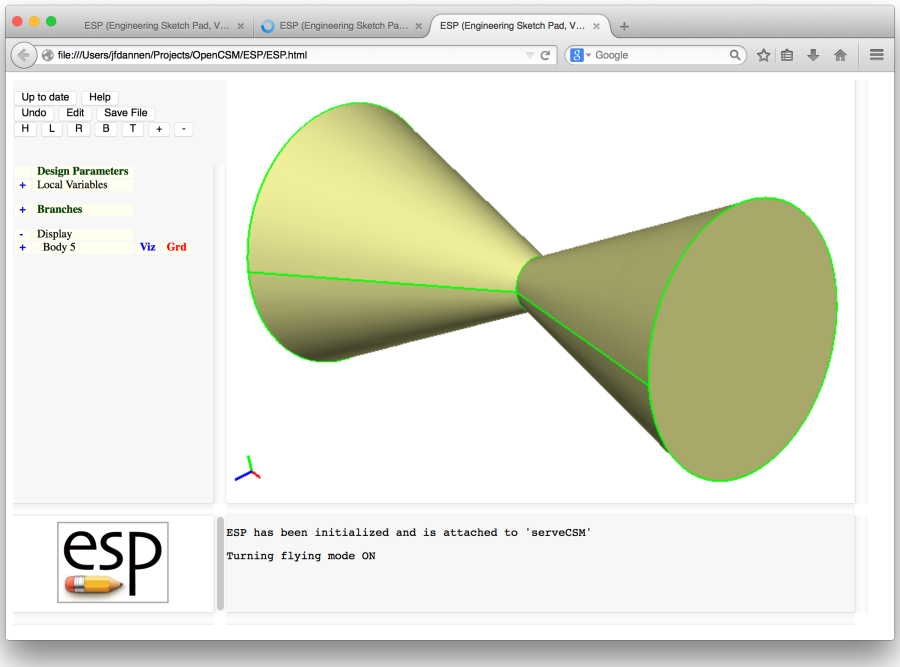
Example UDC — Scribed Cylinder



Hands-on Exercises

- Write `mirrorDup.udc` to
  - store a copy of the Body on the top of the stack
  - mirror the Body across a plane whose normal vector and distance from the origin are given
  - union the original and mirrored Bodys
- Apply `mirrorDup.udc` to a cone whose vertex is at the origin
- Write `fuselage.udc` to create a fuselage by blending a series of super-ellipses, where the dimensions of the cross-sections are provided in arrays

Reflected Cone



Muddy Cards

- Any questions?
- Any suggestions?
- Were the examples useful?