

# **MASSOUD Manual**

**Multidisciplinary Aerodynamic-Structural  
Shape Optimization Using Deformation**

**AIAA-2000-4911**

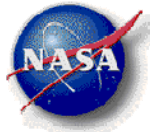
**Jamshid A. Samareh**

jamshid.a.samareh@nasa.gov

**NASA Langley Research Center**

# Outline

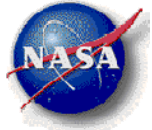
---



- Detailed Document
- Overall Process
- Compile
- Design Location File
- Create Parameterized Model
- Deform Grid
- Visualize
- User-Defined Design Variables

# Detailed Document

---



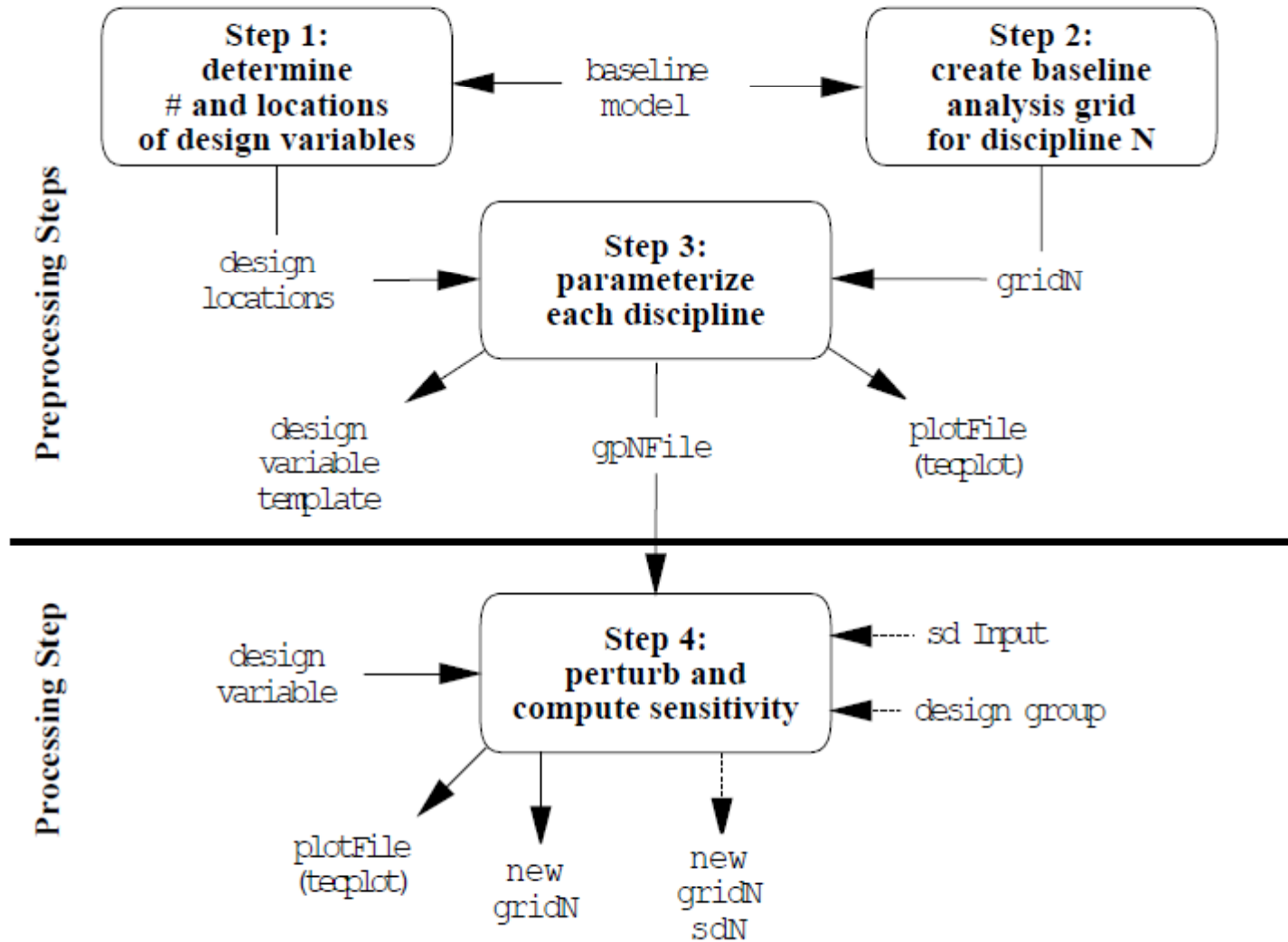
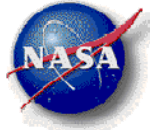
**TM-1999-pending**  
**MASSOUD User's Manual (Ver. 2.0)**

Jamshid A. Samareh  
*Multidisciplinary Optimization Branch*  
*NASA Langley Research Center*  
*Hampton, VA 23681*

MASSOUD

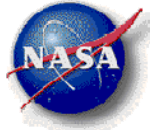
Multidisciplinary  
Aerodynamic-Structural  
Shape Optimization  
Using Deformation

# Overall Process



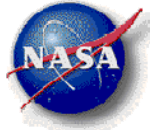
# Compile

---

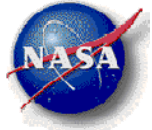


- Unzip and make
  - unzip MASSOUD\_Src.zip
  - cd MASSOUD\_Src
  - make
  - Copy “massoud.exe” and “massoudDesignDriver.exe” to your working directory
- Makefile uses “gcc” compiler. If you would like to use a different compiler, change Makefile accordingly

# Design Location File

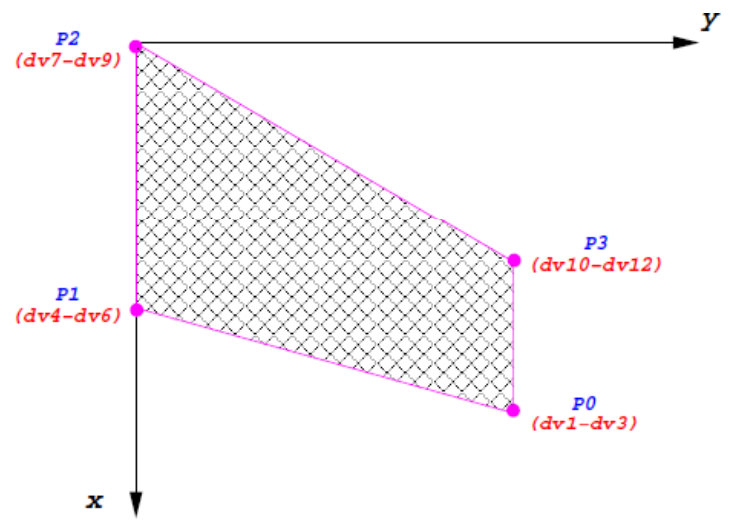
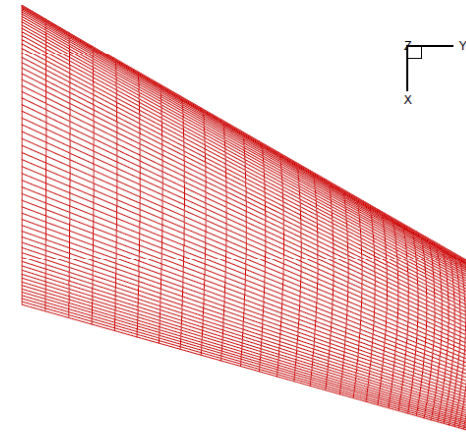
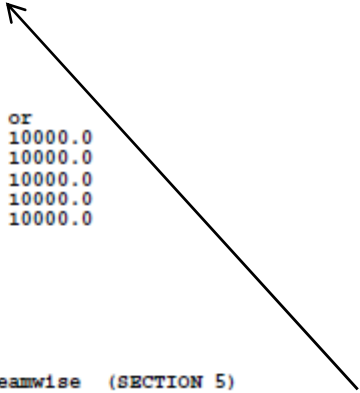


```
m6 Shape Optimization (designLocations) (SECTION 1)
np      ne      ntwist  ncmax  x      y      z
4       1       5       20    0      1      2
Pt      x      y      z (SECTION 2)
0       9.8000503e-01  1.0500000e+00  0.0000000e+00
1       6.8757999e-01  0.0000000e+00  0.0000000e+00
2       -9.9999998e-03  0.0000000e+00  0.0000000e+00
3       5.9375000e-01  1.0500000e+00  0.0000000e+00
0 1 2 3
#Twist curves (SECTION 3)
#Ax      Ay      Az
0.0      1.0      0.0
# x      y      z      ir      or
6.9531375e-01  1.0500000e+00  0.0000000e+00  1000.0  10000.0
5.6383407e-01  7.8749996e-01  0.0000000e+00  1000.0  10000.0
4.3235439e-01  5.2499998e-01  0.0000000e+00  1000.0  10000.0
3.0087471e-01  2.6249999e-01  0.0000000e+00  1000.0  10000.0
1.6939500e-01  0.0000000e+00  0.0000000e+00  1000.0  10000.0
#le/te definitions (SECTION 4)
2
0.0000000e+00  0.0000000e+00  0.0000000e+00
6.0374999e-01  1.0500000e+00  0.0000000e+00
2
6.7758000e-01  0.0000000e+00  0.0000000e+00
9.7000498e-01  1.0500000e+00  0.0000000e+00
5      2      #number of ncp, degx for thickness streamwise (SECTION 5)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for thickness spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
5      2      #number of ncp, degx for camber streamwise (SECTION 6)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for camber spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
```

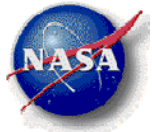


# Design Location File

```
m6 Shape Optimization (designLocations) (SECTION 1)
np      ne      ntwist  ncmax  x      y      z
4       1       5       20     0      1      2
Pt      x      y      z (SECTION 2)
0       9.8000503e-01  1.0500000e+00  0.0000000e+00
1       6.8757999e-01  0.0000000e+00  0.0000000e+00
2       -9.9999998e-03  0.0000000e+00  0.0000000e+00
3       5.9375000e-01  1.0500000e+00  0.0000000e+00
0 1 2 3
#Twist curves (SECTION 3)
#Ax      Ay      Az
0.0      1.0      0.0
# x      y      z      ir      or
6.9531375e-01  1.0500000e+00  0.0000000e+00  1000.0  10000.0
5.6383407e-01  7.8749996e-01  0.0000000e+00  1000.0  10000.0
4.3235439e-01  5.2499998e-01  0.0000000e+00  1000.0  10000.0
3.0087471e-01  2.6249999e-01  0.0000000e+00  1000.0  10000.0
1.6939500e-01  0.0000000e+00  0.0000000e+00  1000.0  10000.0
#le/te definitions (SECTION 4)
2
0.0000000e+00  0.0000000e+00  0.0000000e+00
6.0374999e-01  1.0500000e+00  0.0000000e+00
2
6.7758000e-01  0.0000000e+00  0.0000000e+00
9.7000498e-01  1.0500000e+00  0.0000000e+00
5      2      #number of ncpX, degX for thickness streamwise (SECTION 5)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpY, degY for thickness spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
5      2      #number of ncpX, degX for camber streamwise (SECTION 6)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpY, degY for camber spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
```

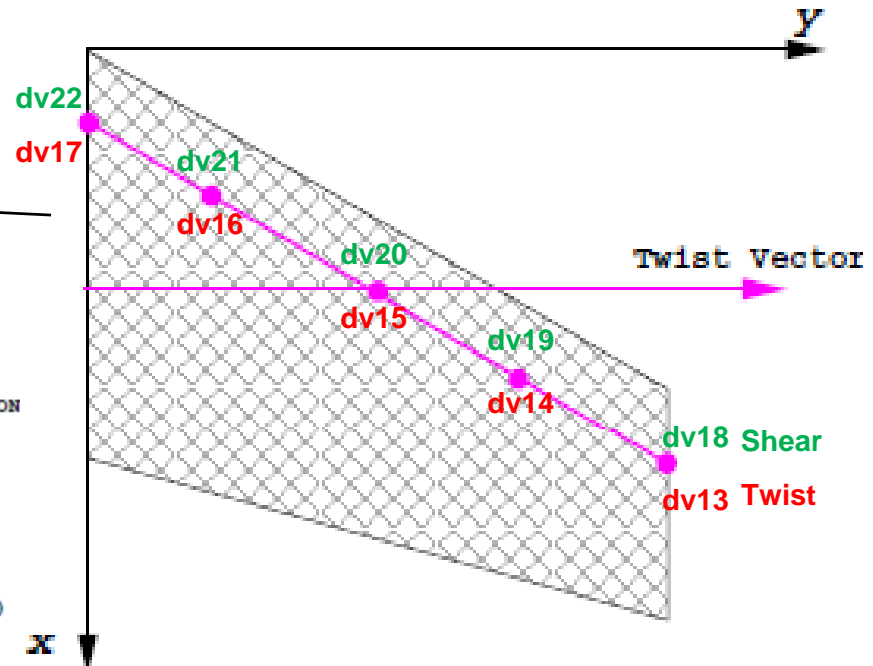


# Design Location File, Cont.



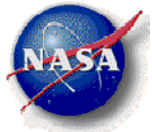
```

m6 Shape Optimization (designLocations) (SECTION 1)
np      ne      ntwist  ncmx   x      y      z
4       1       5       20     0      1      2
Pt
0       x      y      z (SECTION 2)
0       9.8000503e-01  1.0500000e+00  0.0000000e+00
1       6.8757999e-01  0.0000000e+00  0.0000000e+00
2       -9.9999998e-03  0.0000000e+00  0.0000000e+00
3       5.9375000e-01  1.0500000e+00  0.0000000e+00
0 1 2 3
#Twist curves (SECTION 3)
#Ax      Ay      Az
0.0      1.0      0.0
# x      y      z      ir      or
6.9531375e-01  1.0500000e+00  0.0000000e+00  1000.0  10000.0
5.6383407e-01  7.8749996e-01  0.0000000e+00  1000.0  10000.0
4.3235439e-01  5.2499998e-01  0.0000000e+00  1000.0  10000.0
3.0087471e-01  2.6249999e-01  0.0000000e+00  1000.0  10000.0
1.6939500e-01  0.0000000e+00  0.0000000e+00  1000.0  10000.0
#le/te definitions (SECTION 4)
2
0.0000000e+00  0.0000000e+00  0.0000000e+00
6.0374999e-01  1.0500000e+00  0.0000000e+00
2
6.7758000e-01  0.0000000e+00  0.0000000e+00
9.7000498e-01  1.0500000e+00  0.0000000e+00
5      2      #number of ncp, degx for thickness streamwise (SECTION
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for thickness spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
5      2      #number of ncp, degx for camber streamwise (SECTION 6)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for camber spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
    
```



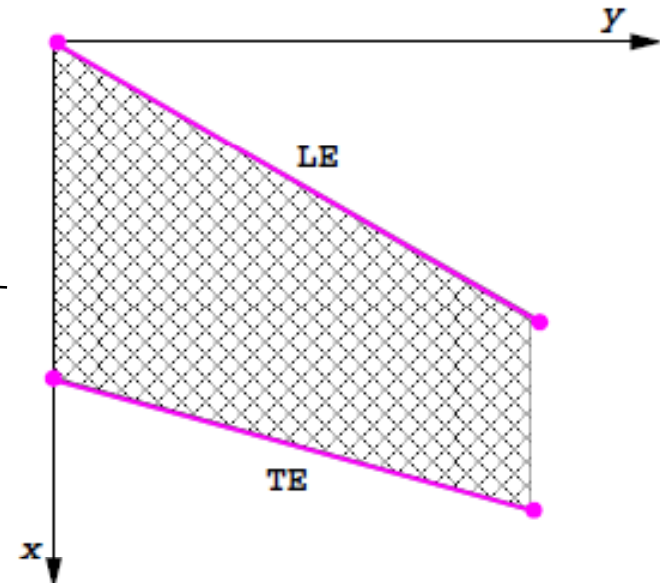


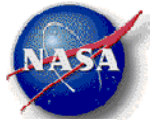
# Design Location File, Cont.



```

m6 Shape Optimization (designLocations) (SECTION 1)
np      ne      ntwist  ncmax  x      y      z
4       1       5       20     0      1      2
Pt      x      y      z (SECTION 2)
0       9.8000503e-01  1.0500000e+00  0.0000000e+00
1       6.8757999e-01  0.0000000e+00  0.0000000e+00
2       -9.9999998e-03  0.0000000e+00  0.0000000e+00
3       5.9375000e-01  1.0500000e+00  0.0000000e+00
0 1 2 3
#Twist curves (SECTION 3)
#Ax      Ay      Az
0.0      1.0      0.0
# x      y      z      ir      or
6.9531375e-01  1.0500000e+00  0.0000000e+00  1000.0  10000.0
5.6383407e-01  7.8749996e-01  0.0000000e+00  1000.0  10000.0
4.3235439e-01  5.2499998e-01  0.0000000e+00  1000.0  10000.0
3.0087471e-01  2.6249999e-01  0.0000000e+00  1000.0  10000.0
1.6939500e-01  0.0000000e+00  0.0000000e+00  1000.0  10000.0
#le/te definitions (SECTION 4)
2
0.0000000e+00  0.0000000e+00  0.0000000e+00
6.0374999e-01  1.0500000e+00  0.0000000e+00
2
6.7758000e-01  0.0000000e+00  0.0000000e+00
9.7000498e-01  1.0500000e+00  0.0000000e+00
5      2      #number of ncp, degx for thickness streamwise (SECTION 5)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for thickness spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
5      2      #number of ncp, degx for camber streamwise (SECTION 6)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for camber spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
    
```



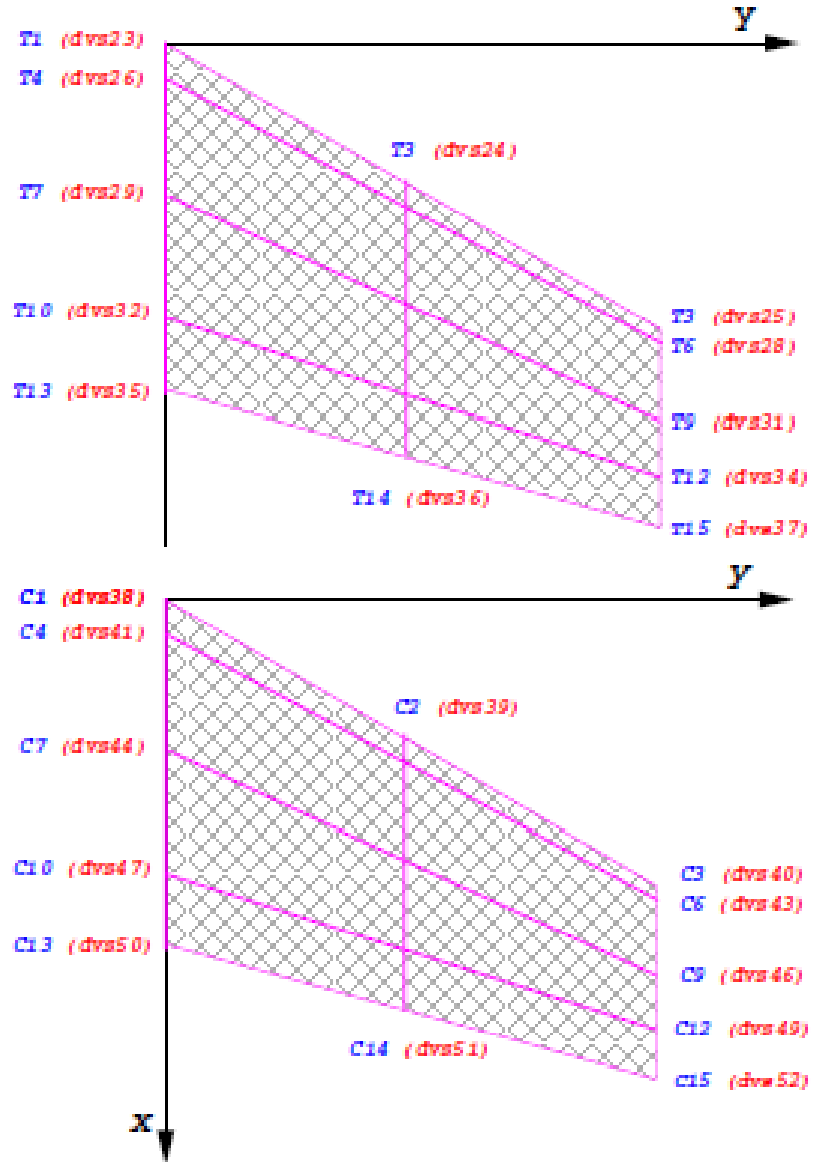


# Design Location File, Cont.

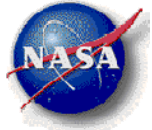
```

m6 Shape Optimization (designLocations) (SECTION 1)
np      ne      ntwist  ncmx   x      y      z
4       1       5       20     0      1      2
Pt      x      y      z (SECTION 2)
0       9.8000503e-01 1.0500000e+00 0.0000000e+00
1       6.8757999e-01 0.0000000e+00 0.0000000e+00
2       -9.9999998e-03 0.0000000e+00 0.0000000e+00
3       5.9375000e-01 1.0500000e+00 0.0000000e+00
0 1 2 3
#Twist curves (SECTION 3)
#Ax      Ay      Az
0.0      1.0     0.0
# x      y      z      ir      or
6.9531375e-01 1.0500000e+00 0.0000000e+00 1000.0 10000.0
5.6383407e-01 7.8749996e-01 0.0000000e+00 1000.0 10000.0
4.3235439e-01 5.2499998e-01 0.0000000e+00 1000.0 10000.0
3.0087471e-01 2.6249999e-01 0.0000000e+00 1000.0 10000.0
1.6939500e-01 0.0000000e+00 0.0000000e+00 1000.0 10000.0
#le/te definitions (SECTION 4)
2
0.0000000e+00 0.0000000e+00 0.0000000e+00
6.0374999e-01 1.0500000e+00 0.0000000e+00
2
6.7758000e-01 0.0000000e+00 0.0000000e+00
9.7000498e-01 1.0500000e+00 0.0000000e+00
5      2      #number of ncp, degx for thickness streamwise (SECTION 5)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for thickness spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00
5      2      #number of ncp, degx for camber streamwise (SECTION 6)
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for camber spanwise
0.0000000e+00
0.5000000e+00
1.0500000e+00

```



# Design Location File, Cont.



- GridTool Family Name

- “planform”
- “twistv” twistv
- “twist” twist distribution
- “le” leading edge
- “te” trailing edge
- “tx”, thickness locations
- “ty”, thickness locations
- “cx”, camber locations
- “cy” camber locations

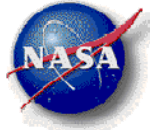
```

m6 Shape Optimization (designLocations) (SECTION 1)
np      ne      ntwist  ncmx     x      Y      Z
4       1       5       20       0      1      2
Pt      X      Y      Z (SECTION 2)
0       9.8000503e-01  1.0500000e+00  0.0000000e+00
1       6.8757999e-01  0.0000000e+00  0.0000000e+00
2       -9.9999999e-03  0.0000000e+00  0.0000000e+00
3       5.9375000e-01  1.0500000e+00  0.0000000e+00
0 1 2 3
#Twist curves (SECTION 3)
#Ax     Ay     Az
0.0     1.0     0.0
# x      Y      Z      ir
6.9531375e-01  1.0500000e+00  0.0000000e+00  1000.0
5.6383407e-01  7.8749996e-01  0.0000000e+00  1000.0
4.3235439e-01  5.2499998e-01  0.0000000e+00  1000.0
3.0087471e-01  2.6249999e-01  0.0000000e+00  1000.0
1.6939500e-01  0.0000000e+00  0.0000000e+00  1000.0
#le/te definitions (SECTION 4)
2
0.0000000e+00  0.0000000e+00  0.0000000e+00
6.0374999e-01  1.0500000e+00  0.0000000e+00
2
6.7758000e-01  0.0000000e+00  0.0000000e+00
9.7000498e-01  1.0500000e+00  0.0000000e+00
5      2      #number of ncp, degx for thickness st:
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for thickness sp:
0.0000000e+00
0.5000000e+00
1.0500000e+00
5      2      #number of ncp, degx for camber strea:
0.0
0.1
0.5
0.75
1.0
3      2      #number of ncpy, degy for camber spanw:
0.0000000e+00
0.5000000e+00
1.0500000e+00
    
```

To Read design location file into GridTool:  
**GridTool -pf M6.p3d -massoud M6.designLocation**

# Create Parameterized Model

---



```
massoudDesignDriver -inputOption inputGrid \  
designLocations outputFile.gp
```

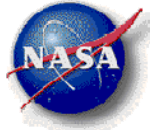
- inputOptions: NASTRAN (-n), NASTRAN large field (-n16), fast (-f), plot3d (-p), tecplot (-t), panels (-c), APAS(-a), and GridTool curves (-gtc)

- Example:

```
massoudDesignDriver.exe -p M6.p3d M6.designLocation M6.gp
```

# Create Parameterized Model, Cont.

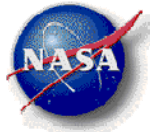
---



The run will produce 6 Files:

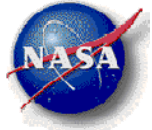
- M6.gp (parameterized file)
- designVariableTemplate
- designTemplate.usd
- designVariableTemplateName
- baselineShape.plt
- GP\_Log

# Deform Grid



## massoud M6.input

```
#MASSOUD INPUT FILE
# runOption (0 analysis), (> 0 sd user's dvs ) (-1, sd using massoud's dvs)
-1
# core (0 incore solution)(1 out of core solution)
0
# input parameterized file
M6.gp
# design variable input file
M6.Mdesign
# input sensitivity file (used for runOption > 0
M6.usd
# output file grid file
M6New.plt
# output tecplot file for viewing
M6New.plt
# file containing the design variables group
designVariableGroups
# user design files
```



# Deform Grid, Cont.

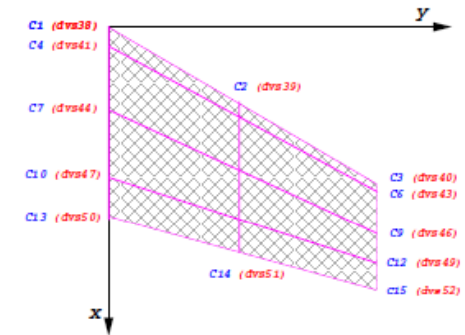
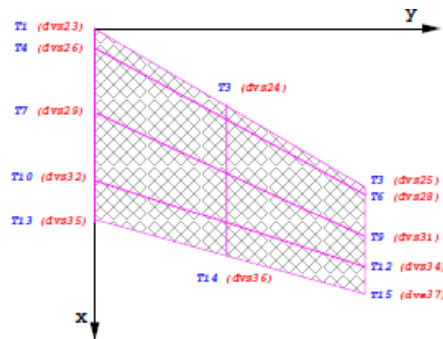
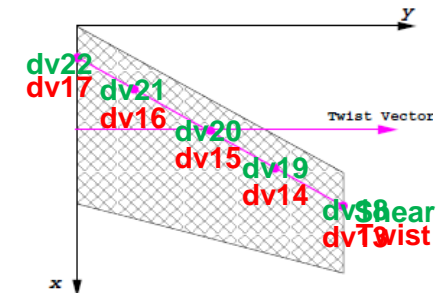
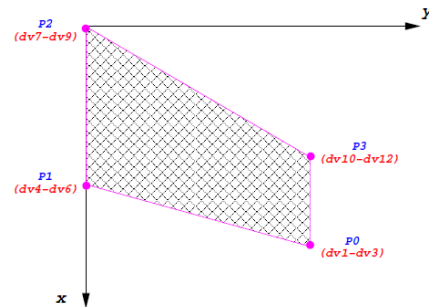
## M6.Mdesign

Similar to designVariableTemplate

```

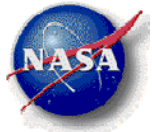
#MASSOUD Design Variables
#Planform dvs (1 - 12)
4
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
#Twist dvs (13 - 17)
5
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
#Shear dvs (18 - 22)
5
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
#Thickness(do x, do y) dvs (23 - 37)
5 3
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
#Camber (do x, do y) dvs (38 - 52)
5 3
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00

```



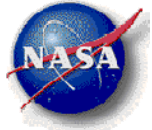
# Visualize: Two approaches

---



- Use tecplot:
  - `tecplot M6New.plt.sd1`
  - The tecplot file contains the derivatives of surface grid with respect to design variables (e.g., XD19, YD19, ZD19)
- Use GridTool
  - `GridTool -d M6New.plt.sd1`





# User-Defined Design Variables

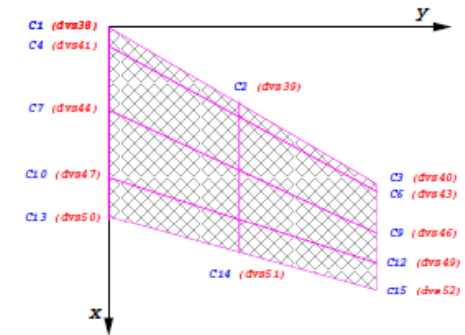
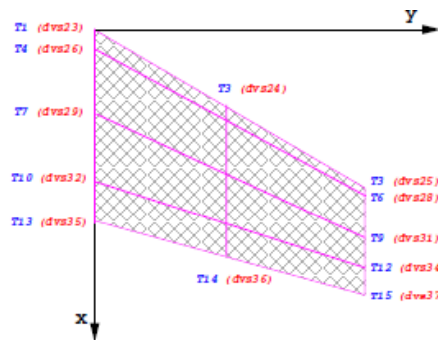
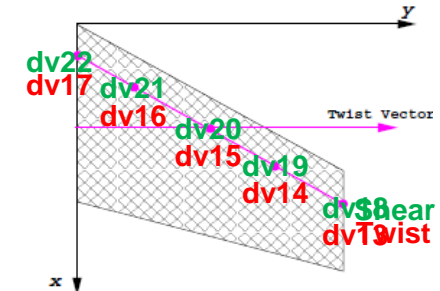
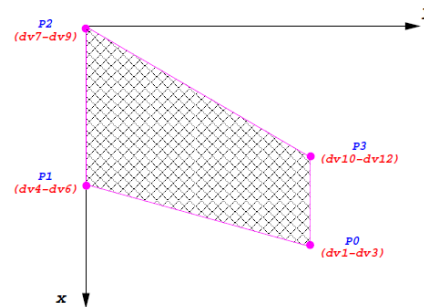
```

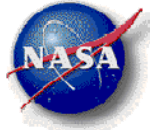
#MASSOUD Design Variables
#Planform dvs (1 - 12)
4
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
#Twist dvs (13 - 17)
5
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
#Shear dvs (18 - 22)
5
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
0.000000e+00
#Thickness(do x, do y) dvs (23 - 37)
5 3
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
#Camber (do x, do y) dvs (38 - 52)
5 3
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00
0.000000e+00 0.000000e+00 0.000000e+00

```

## M6.Mdesign

Similar to designVariableTemplate





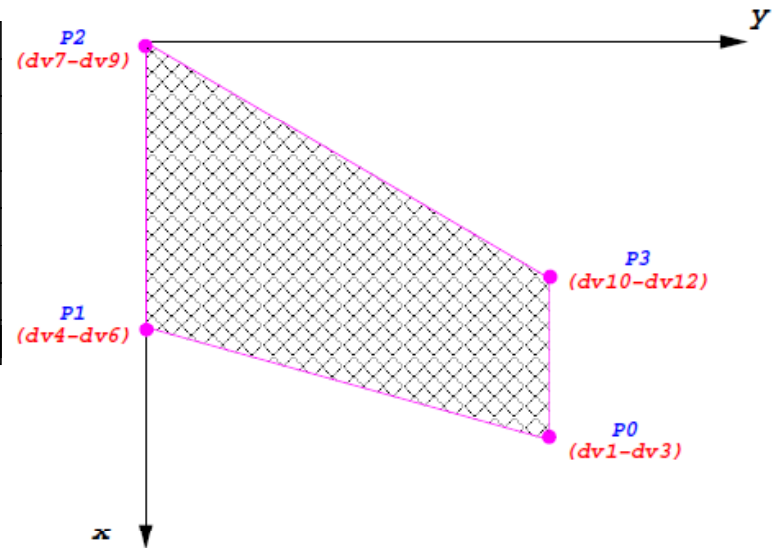
# User-Defined Design Variables

$$\frac{\partial \bar{R}}{\partial V_j} = \frac{\partial \bar{R}}{\partial P_i} \frac{\partial P_i}{\partial V_j}$$

$V_j$  MASSOUD Design Variables

$P_i$  User - Defined Design Variables

$$\begin{bmatrix} \frac{\partial P_1}{\partial V_1} & \frac{\partial P_2}{\partial V_1} & \dots & \frac{\partial P_{i_{\max}}}{\partial V_1} \\ \frac{\partial P_1}{\partial V_2} & \frac{\partial P_2}{\partial V_2} & \dots & \frac{\partial P_{i_{\max}}}{\partial V_2} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial P_1}{\partial V_{j_{\max}}} & \frac{\partial P_2}{\partial V_{j_{\max}}} & \dots & \frac{\partial P_{i_{\max}}}{\partial V_{j_{\max}}} \end{bmatrix}$$



$$P_1 = V_{10} - V_1 \quad (\text{Chord})$$

$$P_2 = (V_{10} + V_1) / 2 \quad (\text{Mid - Chord Location})$$

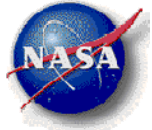
$$P_3 = V_2 = V_{11}$$

	$P_1$	$P_2$	$P_3$
$V_1$	-1	0.5	0
$V_2$	0	0	1
$V_{10}$	1	0.5	0
$V_{11}$	0	0	1



```
# this is input sd file for MASSOUD
# number of row == number dvs within MASSOUD
# number of col == final number dvs
#(row) (col) (#of nonzero rows)
52 3 4
d 1d 2d 3d
1 -1 0.5 0
2 0 0 1
10 1 0.5 0
11 0 0 1
```

# Deform Grid



## massoud M6.input

```
#MASSOUD INPUT FILE
# runOption (0 analysis), (> 0 sd user's dvs ) (-1, sd using massoud's dvs)
-1
# core (0 incore solution)(1 out of core solution)
0
# input parameterized file
M6.gp
# design variable input file
M6.Mdesign
# input sensitivity file (used for runOption > 0)
M6.usd
# output file grid file
M6New.plt
# output tecplot file for viewing
M6New.plt
# file containing the design variables group
designVariableGroups
# user design files
```