Using GSA and GSC to control Gullwing Surfaces

GSA and GSC Optimization Operands

GSA and GSC are SYNOPSYS™ optimization operands for lens construction parameter aberrations (see User Manual 10.3.3 for more details)

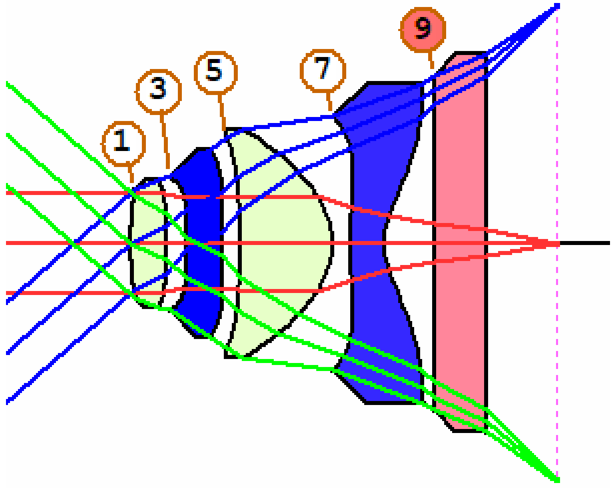
These operands are intended for when you are designing molded glass aspheric lenses and you want to avoid the "gull-wing" shape. Consider the lens below.

The shape of surface 7 might cause a problem in molding if the process involves pressing a heated glass globule into an aspheric mold. The center of the surface is convex, and then it becomes concave partway out to the edge. This geometry can cause air to become trapped between the glass and the mold, since it has nowhere to go once the center and edge of the mold are in contact with the glass. Then the lens will not match the mold in that area. In brief, the sag of the shape has a stationary point (SP) between the axis and margin, which must be avoided. The same issue is seen at surface 3.

One way to deal with the problem is to try to move the SP either to the axis or to the edge of the lens, and that is the function of these operands. GSA returns the fractional aperture of the SP measured from the axis. GSC returns the fractional distance from the CAO of the surface. If the return goes to zero, then the surface does not have a gull-wing shape anymore.

In this example, it is unlikely one can move the SP to the edge of either surface, since the slope there wants to be quite large. So the GSA version would likely work better in this instance.

This issue does not arise with molded plastic lenses, since the process is very different.



GSA and GSC Optimization Operands

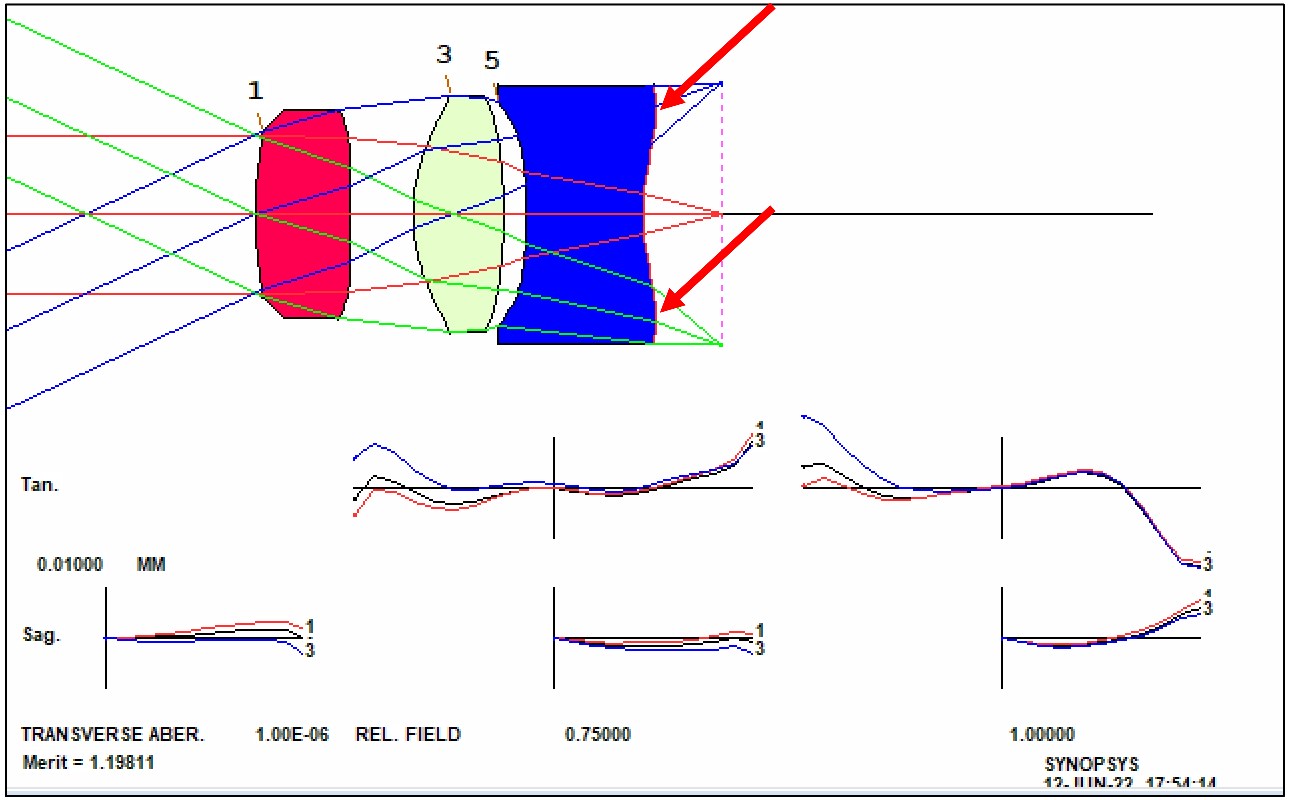
General Syntax:
M *tar wt* A GSA *nb*
M *tar wt* A GSC *nb*

- Where the first parameter specifies that we want to Minimize the difference between the *tar* and the real values (fractional distance of the Stationary Point from the axis (for GSA) or from the clear aperture (GSC)
- *tar* is the target for the optimization. For the GSA or GSC operands, you want to set *tar* = 0
- *Wt* is the weight for the control
- *nb* is the number of the surface that you want to control

See next slides for an example on how to utilize these operands.

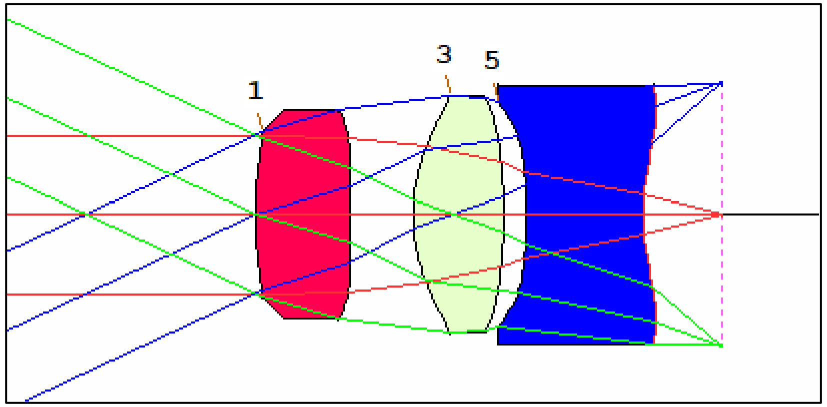
Simple Example

Consider this simple 3 element aspheric system (see Appendix A for the SYNOPSYS Lens Data File that defines this system). A quick examination of the system layout reveals that surface 6 has stationary points (SP) near the edges of the aperture. Because the SPs are close to the aperture edge, we will use GSC to move it to the aperture edge for correction.



Gullwing Surface Control Using GSC

System before optimization:



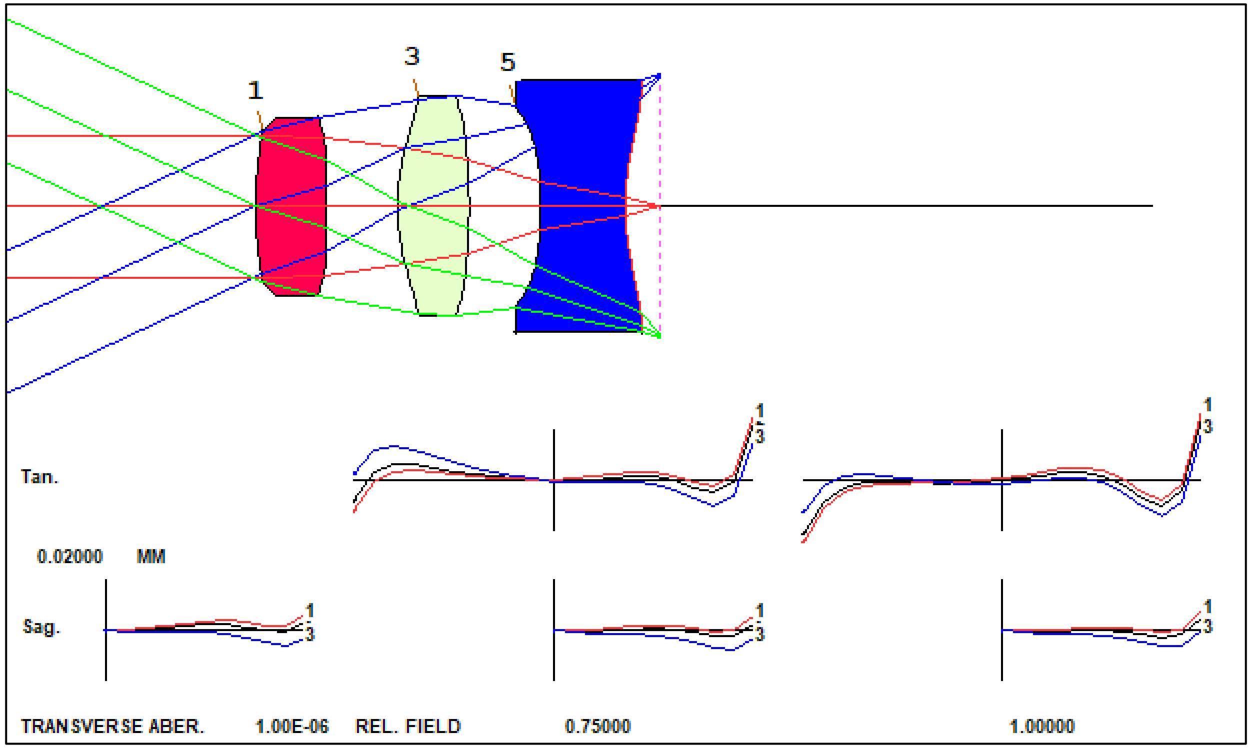
To correct the gullwing shape of surface 6, we add the GSC control in the standard aberration control block.
Syntax: **M *tar wt* A GSC *nb***

The complete optimization macro can be found in Appendix B

```
PANT
VLIST RAD ALL
VLIST TH ALL
VLIST GLM ALL
;
;
;

END


AANT P
M 0.5 1 A CONST 1.0 / DIV FNUM
LLL .5 1 .5 A BACK
;
;
;
GSR .5 10 7 M 0
GNR .5 2 7 M .2
GNR .5 1 7 M .4
GNR .5 2 7 M .6
GNR .5 1 7 M .7
GNR .5 2 7 M .9
GNR .5 1 7 M 1

M 0 5 A GSC 6

END

SNAP   1
DAMP    1.00000

SYNO 20
```

Gullwing Surface Control Using GSC

After optimization, the surface shape of surface 6 is improved. The Lens Data File (.rle) for this system can be found in Appendix C.



This is a simple example to demonstrate how to use the GSC command to correct the gullwing structure on surface 6. In this optimization, we only include the surface conic constants and the 4th order aspheric coefficients (G3) in our optimization variables specification, without using the higher order aspheric terms (see Appendix B). One can expand the set of optimization variables by including the higher order terms to further improve the system performance.

Appendix A Lens Data for the Starting System

```
 RLE
ID DSEARCH ASPHERIC CAMERA LENS ! ident      4
ID1 DSEARCH CASE WAS 00000000000000000000000010      2
 FNAME 'F2_3ELE_S2_A.RLE                                 '
 MERIT    1.19811
 LOG        4
 WAVL .6562700 .5875600 .4861300
 APS               1
 UNITS MM
 OBB  0.0000000  25.0000000    1.0000000   0.00000000000       0.0000000   0.0000000   1.0000000
   0 AIR
   1 RAD      3.7752145361326   TH      1.18858273
   1 CC     -4.24742841
   1 GLM      1.501000000             77.455384620
   1 DC1  0.000000000E+00 -2.926886880E-02  1.417867900E-04 -7.567864990E-03  0.000000000E+00
   1 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   1 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   1 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   2 RAD      7.7670734817796   TH      0.81221968 AIR
   2 CC   -100.00000000
   2 DC1  0.000000000E+00 -5.201678260E-02 -1.196160590E-02  1.160215090E-03  0.000000000E+00
   2 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   2 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   2 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   3 RAD      2.1049399636044   TH      1.14474988
   3 CC     -1.60964542
   3 GLM      1.519000000             56.358700300
   3 DC1  0.000000000E+00  4.546630500E-03 -1.944300390E-03 -1.293591700E-03  0.000000000E+00
   3 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   3 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   3 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   3 PLASTIC
```

To be continued in the next slide

Appendix A Lens Data for the Starting System, continued

```
  4 RAD     -6.7210113909274   TH      0.27864494 AIR
  4 CC     11.11883801
  4 DC1  0.000000000E+00  5.565316950E-03 -3.354912810E-03 -6.228226290E-04  0.000000000E+00
  4 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  4 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  4 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  5 RAD    -26.4944916859722   TH      1.48367543
  5 CC    -99.99999584
  5 GLM      1.650000000             21.845468590
  5 DC1  0.000000000E+00 -9.365261820E-02  4.439376650E-03  1.803237900E-03  0.000000000E+00
  5 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  5 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  5 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  5 PLASTIC
  6 RAD      2.3592097012973   TH      0.99802406 AIR
  6 CC     -8.82836849
  6 DC1  0.000000000E+00 -2.465294380E-02 -2.622097520E-03  7.850903740E-05  0.000000000E+00
  6 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  6 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  6 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  6 TH       0.99802406
  6 YMT      0.00000000
  7 CV      0.0000000000000   TH      0.00000000 AIR
 END
```

Appendix B Optimization Macro

Surface conics constants

4th order aspheric terms

Z =	G(1) R**2	+ G(2) Y	+ G(3) R**4	+ G(4) R**2Y	+ G(5) Y**2
	+ G(6) R**6	+ G(7) R**4Y	+ G(8) R**2Y**2	+ G(9) Y**3	+ G(10) R**8
	+ G(11) X	+ G(12) R**2X	+ G(13) R**4X	+ G(14) X**3	+ G(15) XY
	+ G(16) R**10	+ G(17)	+ G(18) R**12	+ G(19) R**14	+ G(20) R**16
	+ G(21) R**18	+ G(22) R**20			

See the page, 'Power-series Aspheric', in the Help Manual for more details

```
PANT
VLIST RAD ALL
VLIST TH ALL
VLIST GLM ALL

VY 1 CC
VY 2 CC
VY 3 CC
VY 4 CC
VY 5 CC
VY 6 CC

VY     1 G    3
VY     2 G    3
VY     3 G    3
VY     4 G    3
VY     5 G    3
VY     6 G    3
END

AANT P
M 0.5 1 A CONST 1.0 / DIV FNUM
LLL .5 1 .5 A BACK
LUL 5 1 1 A TOTL

AGE .5 1 1
AAE 0.1 1 1
ACC
GSR .5 5 7 M 0
GNR .5 3 7 M .2
GNR .5 3 7 M .4
GNR .5 3 7 M .6
GNR .5 3 7 M .7
GNR .5 3 7 M .9
GNR .5 3 7 M 1

M 0 5 A GSC 6
END

SNAP   10
DAMP    1.00000

SYNO 20
```

Appendix C Lens Data for the Improved System

```
 RLE
ID DSEARCH ASPHERIC CAMERA LENS ! ident      1
ID1 DSEARCH CASE WAS 0000000000000000000000010      2
 FNAME 'F2_3ELE_GSC.RLE                                    '
 MERIT   0.396805
 LOG        1
 WAVL .6562700 .5875600 .4861300
 APS               1
 UNITS MM
 OBB  0.0000000  25.0000000    1.0000000   0.00000000000       0.0000000   0.0000000   1.0000000
   0 AIR
   1 RAD      3.9108881962892   TH      1.00000000
   1 CC     -4.55299177
   1 GLM      1.501000000             77.455384615
   1 DC1  0.000000000E+00 -1.754052555E-02  1.417867900E-04 -7.567864990E-03  0.000000000E+00
   1 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   1 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   1 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   2 RAD    160.8256995218425   TH      1.00000000 AIR
   2 CC    -99.79290778
   2 DC1  0.000000000E+00 -3.468120721E-02 -1.196160590E-02  1.160215090E-03  0.000000000E+00
   2 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   2 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   2 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   3 RAD      2.9438522542746   TH      1.00000000
   3 CC     -1.55386591
   3 GLM      1.519000000             56.358700300
   3 DC1  0.000000000E+00 -5.579862745E-03 -1.944300390E-03 -1.293591700E-03  0.000000000E+00
   3 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   3 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
   3 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
   3 PLASTIC
```

To be continued in the next slide

Appendix A Lens Data for the Improved System, continued

```
  4 RAD     -9.8989464131885   TH      1.00000000 AIR
  4 CC     11.13345572
  4 DC1  0.000000000E+00 -4.001537984E-04 -3.354912810E-03 -6.228226290E-04  0.000000000E+00
  4 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  4 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  4 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  5 RAD     -9.5083502755252   TH      1.19170906
  5 CC    -99.97516975
  5 GLM      1.650000000             21.845468591
  5 DC1  0.000000000E+00 -8.475658988E-02  4.439376650E-03  1.803237900E-03  0.000000000E+00
  5 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  5 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  5 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  5 PLASTIC
  6 RAD      3.0254290449667   TH      0.48206758 AIR
  6 CC     -8.86286115
  6 DC1  0.000000000E+00 -5.440809833E-03 -2.622097520E-03  7.850903740E-05  0.000000000E+00
  6 DC2  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  6 DC3  0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
  6 DC4  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00  0.000000000E+00
  6 TH       0.48206758
  6 YMT      0.00000000
  7 CV      0.0000000000000   TH      0.00000000 AIR
END
```