# SigFit

## Release Notes
Version 2007-R2

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Sigmadyne, Inc.
803 West Avenue
Rochester, NY 14611
www.sigmadyne.com

**Technical Support**

IMPORTANT: When contacting technical support please provide the following:

1. Your .sig file defining your SigFit analysis.
2. All files referenced by the .sig file. This includes FEA model files, FEA results files, OLOAD files, VECTOR files, etc.
3. The nature of the problem and the error you are seeing, if any.

<u>Licensing Issues</u>

Gregory Michels
(585) 235-6892
michels@sigmadyne.com

<u>Visual SigFit</u>

Gregory Michels
(585) 235-6892
michels@sigmadyne.com

<u>SigFit Engine</u>

Victor Genberg
(585) 235-7460
genberg@sigmadyne.com

Gregory Michels
(585) 235-6892
michels@sigmadyne.com

For more information about Sigmadyne visit our website at: www.sigmadyne.com.

The background theory used in SigFit is discussed in the following book & short courses:

Doyle, K., Genberg, V., Michels, G., **<u>Integrated Optomechanical Analysis</u>**, TT58, SPIE Press, October, 2002.

**<u>Integrated Optomechanical Analysis</u>** short course available from Sigmadyne, Inc.

**<u>SigFit</u>** short course available from Sigmadyne, Inc.

# 1 Summary

Version 2007-r2 includes the following new features: (see section 3)

1) New surface type = anamorphic
2) New output option = extra nodal output file
3) New output option = data csv file
4) New options for Off-Axis optics
5) Optional creation of ray visualization elements in OPD analyses
6) Revised subtraction of dRoC or Power
7) Auto-size of HITOUT output array
8) Improved calculation of surface RMS in harmonic/random analysis
9) Radial correction may be turned off by the user
10) Line-of-Sight (LOS) calculation for static, adaptive and dynamic response
11) Line-of-Sight equations may be written in Nastran bulk data format
12) Zernike MPC and DRESP for RMS & PV are under new ATYP=EQNGEN
13) Selection of ANSYS FEA Entities by Name
14) Support for ANSYS Workbench
15) Spaces allowed in filenames

Version 2007-r2 fixes some bugs in 2007-r1 (see section 4)

# 2 Installation and Upgrading:

Instructions for installing may be found in the SigFit-Ref-Man-v2007r2.pdf Section 1.

# 3 New Features

## 3.1 New Anaomorphic Surface Type

Surfaces in SigFit may now be defined as anamorphic with the following form:

$$Z(x,y)=\frac{c_x x^2 + c_y y^2}{1+\sqrt{1-(1+k_x)c_x^2 x^2-(1+k_y)c_y^2 y^2}}$$
$$+AR\{(1-AP)x^2+(1+AP)y^2\}^2+BR\{(1-BP)x^2+(1+BP)y^2\}^3$$
$$+CR\{(1-CP)x^2+(1+CP)y^2\}^4+DR\{(1-DP)x^2+(1+DP)y^2\}^5$$

The input data on the SURGEOM for STYP=ANAMOR and entry for $C_X$,$C_Y$,$K_X$,$K_Y$ are the same as a biconic surface. The coefficients for the additional polynomials are given on SURPOLY entries as follows:

| SURPOLY | SID | N | M | A | B |
|---|---|---|---|---|---|
| SURPOLY | SID | 2 | 0 | AR | AP |
| SURPOLY | SID | 3 | 0 | BR | BP |
| SURPOLY | SID | 4 | 0 | CR | CP |
| SURPOLY | SID | 5 | 0 | DR | DP |

## 3.2 New Output Option OUTNODX For Additional Nodal File Output

The standard **nod** file is unchanged and called by OUTNOD YES. The new OUTNODX option creates a **nodx** file by an entry of OUTNODX YES. The entries in this file are the residual surface disturbances after each polynomial term is removed. For the purposes of this file, A and B parts of Zernike polynomial terms (e.g., Coma-X and Coma-Y) are both subtracted to give a single column of residual disturbance after that term has been removed. Use the SigFit polynomial fit tables and the K numbering to identify terms. A new Patran template file “sigfit_nodx.res_tmpl” is provided.

## 3.3 New Output Option OUTDATA For CSV File Surface Data

The option to write an ASCII csv file containing the following data is turned on by OUTDATA entry.

| Node | Surface Position | | | Area | Disturbance data | | |
|---|---|---|---|---|---|---|---|
| Id | X | Y | Z | Wt | d1 | d2 | d3 |

where the data is common separated.

Id = node number from FE model
X,Y,Z = coordinates of node in the VCID system
Wt = area weight assigned to the node.
dj = translational surface displacement for load case j (in FE units)

The value of dj is either surface normal or surface sag depending on the choice ASAG on the SOL entry.
The the DTYP field selects what type of disturbance data to use and the MXCSV field selects the maximum number of columns in the file.

**OUTDATA** Selects the writing of surface disturbance and geometry data to .csv file.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| OUTDATA | DTYP | MXCSV | | | | | | |

| Field | Contents | |
|---|---|---|
| DTYP | Result type which will be written to the OUTDATA file. | |
| | NONE | No OUTDATA files will written. (Default) |
| | INPUT | Input as read from FEA before radial correction |
| | MOD | After radial correction and any subtractions. |
| | RSD | Residual surface after polynomial fitting. |
| | ADAPT | After adaptive control correction. |
| | OPD | Optical path difference for ATYP = DNDT, DNDS. |
| MXCSV | Maximum number of columns per .csv file. (Integer>0, Default = 200) | |

## 3.4 New Options For Off-Axis Optics

In previous releases, if the user specified an offset (using SUROFF), SigFit would use that offset to create a new “fitting” coordinate system (FCID). Fitted polynomials would be centered on the FCID and not on the vertex coordinate system (VCID). However, the FCID was always oriented parallel to the VCID with the FCID origin located on the optical surface.

In this release, the user may choose the Z-axis of the internally created FCID to be parallel to the Z-axis of VCID (OFFAXZ=SAG) or parallel to the local surface normal (OFFAXZ=NORM). The X-axis will always lie in X-Z plane of the VCID. If the FCID is created by SigFit, the ID assigned to the system is –SID of the surface, so that the ID will not conflict with existing coordinate system IDs.

A third option is to specify the FCID as an existing rectangular coordinate system ID in the model file or a rectangular coordinate system defined in the .sig file using CORD2R entries. This allows total generality for fitting polynomials in any desired coordinate system.

If ASAG=SAG (on the SOL entry), polynomials will be fit to the surface deformation in the directrion of the Z-axis of the FCID. If ASAG=NORM, the local surface normal displacement component will be used.

The rigid-body motion calculation of an off-axis surface defaults to being expressed in the vertex coordinate system (VCID) as required by most optical analysis programs despite how the FCID is defined. If the user selects (RBCID=FCID), then rigid-body motion is calculated in the FCID system.

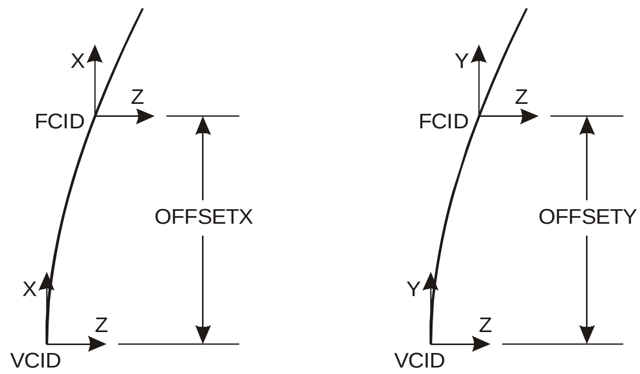
In all cases, the optical prescription (RoC, Conic constant, SURPOLY) is defined relative to the vertex coordinate system (VCID). The Z error is the optical prescription Z minus the nodal location Z. The surface normal is determined from the optical prescription.

Imlementation of this feature has been achived by modyfying the format of the SUROFF entry. Note that all prior SUROFF entries are backwards compatibale and will give the same behavior as in prior versions.

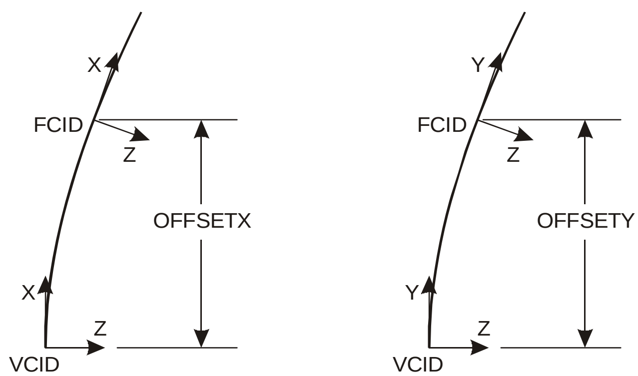
**SUROFF** Defines an offset from the vertex coordinate system for performing polynomial fitting in an off-axis coordinate system.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| SUROFF | SID | OFFSETX | OFFSETY | OFFAXZ | FCID | RBCID | | |

| Field | Contents | |
|---|---|---|
| SID | Surface ID. (Integer > 0, Required) | |
| OFFSETX | X offset of FCID with respect to VCID expressed in FE model units. (Real, Default = 0.0) | |
| OFFSETY | Y offset of FCID with respect to VCID expressed in FE model units. (Real, Default = 0.0) | |
| OFFAXZ | Orientation of FCID. | |
| | SAG | The Z axis of FCID will be oriented parallel to the optical axis of the surface. |
| | NORM | The Z axis of FCID will be oriented normal to the surface at the offset point. |
| FCID | Reference to a coordinate system definition defining FCID. See Remark 4. (Integer or Blank , Default = Blank) | |
| RBCID | Defines what coordinate system the rigid body motions will be expressed in. See Remark 5. | |
| | VCID | Rigid body motions will be expressed in the VCID. (Default) |
| | FCID | Rigid body motions will be expressed in the FCID. |




Definitions of VCID, FCID, OFFSETX, and OFFSETY with OFFAXZ = SAG and FCID = Blank.




Definitions of VCID, FCID, OFFSETX, and OFFSETY with OFFAXZ = NORM and FCID = Blank.

## 3.5 Optional Creation of Integration Ray Visualization Elements in OPD/BIR Analyses

For ATYP = DNDT, DNDS, and BIRE SigFit integrates through a lens to calculate the OPD or BIR effect. The integration ray paths used in SigFit can now be written to a file. This file can be read into a model file to visualize the integration ray paths on the model. This can be a useful feature in trying to understand OPD response. RAYVID must be chosen so generated node and element IDs do not conflict with the existing element IDs of the finite element model. This feature is currently limited to generating PLOTEL elements for Nastran.

**OUTRVIZ** Selects the writing of a model file of consisting of 1D elements representing the rays traced for any of the analyses of ATYP = DNDT, DNDS, or BIRE.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| OUTRVIZ | RVIZFLG | RAYVID | | | | | | |

| Field | Contents | |
|---|---|---|
| RVIZFLG | Defines if the file generation should be performed or suppressed. | |
| | NO | Output will be suppressed. (Default) |
| | YES | Output will be generated. |
| RAYVID | Starting ID of the elements written for rays. (Integer, Required) | |

## 3.6 Revised Subtraction of dRoC/Power

When subtracting dRoC/Power, the previous version of SigFit subtracted only that term. In v2007r2, SigFit now subtracts the associated dCoC/Bias (where CoC=center-of-curvature) when subtracting dRoC/Power. This is more representative of focus correction from an external source.

In version v2004, dRoC is calculated with the CoC restricted to be ON the VCID X axis. In version 2007r1, dRoC was generalized to CoC allowed to move anywhere in 3D space. Now in v2007r2, both calculations are performed. In the fit file, the ON-Axis calculation is listed as dRoC(1D), and the full 3D CoC is listed as dRoC(3D). If subtracting dRoC, the user may select either form. User selection of the form of dRoC to subtract is made by new options for the SUBTPOW field on the SUBT entry. See the Dictionary for details.

## 3.7 Auto-size of HITOUT Array

If the fields for HOX1, HOX2, HOY1, HOY2 on the HITOUT entry are left blank, SigFit will use RMAX of the surface as the bounds of the array. For HOFRMT = GRDINT, ZDAT, ZGARR

| | |
|---|---|
| HOX1 = -Rmax | HOX2 = +Rmax |
| HOY1 = +Rmax | HOY2 = -Rmax |

For HOFRMT = OASIS

| | |
|---|---|
| HOX1 = -Rmax | HOX2 = +Rmax |
| HOY1 = -Rmax | HOY2 = +Rmax |

## 3.8 Improved Surface RMS Calculation in Harmonic/Random Analysis

In harmonic/random response each node on an optical surface may vibrate with its own phase angle. To find the maximum net surface RMS over the full response cycle (0-360 degrees) at any frequency, SigFit has a new calculation of the response angle at which the maximum surface RMS over the 360 degree cycle ocurrs. The previous calculation was conservative and slightly over-estimated the surface RMS by assuming that all nodes vibrate at exactly the same phase for each forcing frequency. This same technique is used throughout SigFit to combine all vector data with phase angles.

## 3.9 Radial Correction May Be Turned Off

There are special cases where the user may want to turn off radial correction, which may be accomplished with ARCORR=NONE on the SOL entry. This is **NOT** recommended, and may lead to incorrect results. When using this option the user must verify his or her own results.

## 3.10 Line-of-Sight (LoS) Calculation

In SigFit, the definition of LoS is the decenter of the “Chief Ray” away from it’s nominal design position caused by the “average” rigid-body motions of the optical surfaces.

To calculate LoS, the user must specify the full optical system because SigFit uses a classical ray trace algorithm to trace the “chief ray” through the system. Thus ALL optical surfaces must be specified, even if they are not modeled in the finite element model. Note that surfaces may be specified by “NONE” on SURFACE meaning no FE nodes represented on the surface. Thus, if the FE model represents only a portion of the optical system, the remaining optical surfaces should be specified with proper optical prescription, but represented as “NONE” on the SURFACE entry. In some cases, a surface may be represented by a single node to account for rigid-body motion of an optic. Even though this ray travels along the optical axis, it will still reflect off a primary mirror with a hole in the center, because the system is represented by the optical prescription, not the FE model.

The surface numbering (SID) must be in the order in which the ray traverses the system. SID need not start at 1, nor be consecutive, but the numerical order is significant. The highest numbered optical surface specified is assumed to be the focal plane. LoS will be calculated in the VCID system of the focal plane.

Both refractive and reflective surfaces are considered in the LoS calculation. For refractive surfaces, the index of refraction must be specified for the material following each surface. This requires that material entry (MID) on the SURFACE must point to MAT entry for material definition. A value of 0 for MID implies a vacuum with index of 1.0 follows the surface. A reflective surfaces is indicated by MID value of –1 on SURFACE. The reflected ray will use the same index of refraction as the in-coming ray.

The optical prescription specified on SURGEOM and SURPOLY is used to calculate the ray path. All surface types in SigFit are supported. As a data check on geometry input, the intersection point of the nominal chief ray is output in the fit file. Normally this should intersect the vertex (0, 0) of each surface. The user may specify an off-axis ray if desired on LOSRAY.

The LoS coefficient for each surface is calculated by a finite difference step which the user may control on LOSDATA. For each perturbed motion of a surface, the coefficient is calculated from the displaced ray on the focal plane. SigFit creates coefficients for LoS in the image space (motion on the focal plane) in FE units, and in the object space (apparent angular motion) in radians. The object space coefficients are found by dividing the image space coefficients by the previously calculated focal length.

As a data check on the LoS equations, a rigid-body error check is automatically performed and results presented in fit file. Rigid body translations should cause NO LoS motion. Rigid-Body rotations should cause LoS motion equal to focal length.

### 3.10.1 LoS Results (ATYP=FIT, ADAPT, RAND, HARM, TRAN)

LoS error can now be computed for the optical system represented by all of the the surface definitions in a SigFit analysis. Supported analysis types are ATYP = FIT, ADAPT, RAND, HARM, and TRAN. The calculation of LoS errors is performed through the use of linear functions of all surface motions. These linear functions are generated by a forward difference sensitivity analysis using a real ray trace of a single ray to all defined surfaces sequenced in order of the surfaces' SIDs. The LoS error is calculated from the lateral deviations of the ray on the final surface, which is considered to be the image plane. These lateral deviations in image space are then used to compute angular LoS error coefficients in object space by dividing the image space coefficients by the previously calculated focal length.

LoS results appear at the bottom of the fit file. In dynamics, LoS results are also sent to the response files (OUTDYN YES). In random response, the percent contribution of each mode to LoS is presented in the fit file, for identification of problem modes. If the user requests OUTLOS YES, then an additional file (outname_los_01.csv) is written giving the contribution to LoS from each surface individually. This may be used to understand (and fix) LoS problems. See the Examples Manual section on Telescope for an example.

Three new data entries are required. The SYSLOS entry turns on the calculation of LoS error.

**SYSLOS** Selects system analysis calculations to be performed.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| SYSLOS | LOSCALC | | | | | | | |

| Field | Contents | |
|---|---|---|
| LOSCALC | Selects the calculation of system line-of-sight. | |
| | NO | No equation generation will be performed. (Default) |
| | YES | Equation generation will be performed. |

The LOSDATA entry specifies the index of refraction before the first surface (INITN) and the finite difference step sizes (DELT and DELR) used to determine the LoS sensitivities of each surface.

**LOSDATA** Specifies data for line-of-sight calculation.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| LOSDATA | INITN | DELT | DELR | | | | | |

| Field | Contents |
|---|---|
| INITN | Index of refraction prior to the first surface. (Real, Default = 1.0) |
| DELT | Translational finite difference step size in FE units. (Real, Default = 1.0E-6) |
| DELR | Rotatational finite difference step size in FE units. (Real, Default = 1.0E-6) |

The LOSRAY entry specifies the starting position and direction of the ray which should be used to compute LoS error.

**LOSRAY** Defines starting ray position and orientation for line-of-sight calculations.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| LOSRAY | LOSCID | X0 | Y0 | Z0 | VECX | VECY | VECZ | |

| Field | Contents |
|---|---|
| LOSCID | Coordinate system ID for starting ray data ID. (Integer $\geq$ 0, Default = VCID of 1$^{st}$ surface) |
| X0,Y0,Z0 | Starting ray location in LOSCID expressed in FE units. (Real, Default = 0.0, 0.0, 0.0) |
| VECi | Vector components of starting ray expressed in LOSCID (Real, Default = 0.0, 0.0, 1.0) |

The OUTLOS entry is an optional entry selecting the output of LoS error results sorted by each surface's contribution to the total system level LoS error.

**OUTLOS** Selects the writing of a .csv file of line-of-sight results sorted by surface contribution.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| OUTLOS | LOSFLG | | | | | | | |

| Field | Contents |
|---|---|
| LOSFLG | Defines if the file generation should be performed or suppressed.<br>NO Output will be suppressed. (Default)<br>YES Output will be generated. |

If LOSCALC=YES on the SYSLOS entry, then SigFit will write a table of calculated LoS coefficients for each surface in the fit file. For each loadcase in ATYP=FIT SigFit will write the resulting LoS in X, Y, V and R (where V = vector sum of X and Y and R = V/FocalLenth = angular LoS error). The LoS X,Y,V will be in FE model units, R in radians. In ATYP=ADAPT, the LoS calculation will be performed on the corrected surfaces.

In ATYP=HARM, RAND, TRAN the LoS will be calculated on each mode shape as well as each response frequency/time step. The LoS response tables are written to the standard dynamic response files after the individual surface data is written, if OUTDYN=YES

If LOSFLG=YES, then a csv file will be written which give the total LoS of each loadcase (or mode shape) as well as the contribution of each surface to the total. This can be useful in understanding the behavior in any given loadcase or modeshape.

### 3.10.2 LoS Equation Generation (ATYP=EQNGEN)

Equations of LoS can be generated for the optical system represented by the surface definitions in the SigFit analysis. Equations are generated as linear functions of all surface motions and are computed as is done for LoS post-processing. No displacement results will be read. Coefficients may be written in Nastran MPC format and included in the FE model. As part of the output, RBE3 elements are written with proper area weighting for the average surface rigid-body motion. The advantage of this approach is that the coefficients are written in the correct units, coordinate systems, sign convention, and FE model node numbering. See Examples Manual section on Telescope for an example.

The above data entries of LOSDATAand LOSRAYare input to this calculation. The entry which turns on LOS Equation generation is:

**EQNLOS** Requests generation of equations for use in finite element analyses to compute the system line-of-sight errors.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| EQNLOS | LOSGEN | EQNID | STRTDIGS | | | | | |

| Field | Contents |
|---|---|
| LOSGEN | Selects the calculation of system line-of-sight errors.<br>NO No equation generation will be performed. (Default)<br>YES Internal equation generation will be performed. |
| EQNID | Equation ID. See Remark 2. (Integer, Default = 1) |
| STRTDIGS | Starting digits used to number the responses or equations for system line-of-sight. See Remark 2. (1 ≤ Integer ≤ 99, Default = 9) |

## 3.11 MPC Equations for Zernike Polynomial Coefficients and Surface RMS & PV

Previous analysis types used for writing Nastran MPC equations of Zernike polynomial coefficients and MSC.Nastran DRESPi/DEQATN entries for surface RMS and surface P-V have been rehoused under a single equation generation analysis type. This reoganization of the equation generation capability was done to simplify the interface and prepare SigFit's equation writing interface for more advanced equation writing features in the future. The new analysis type is selected with ATYP=EQNGEN on the SOL entry. Prior SigFit analysis definitions using ATYP=MPC and ATYP=DRESP2 are no longer allowed.

Previously ATYP=MPC allowed the writing of Zernike polynomials as a Nastran MPC equation. This analysis type is now incorporated under the more generalized equation writing analysis type selected with ATYP=EQNGEN. The associated data entry is:

**EQNPOL** Requests generation of equations for use in finite element analyses to compute best fit polynomial coefficients to surface deformations.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| EQNPOL | POLGEN | EQNID | STRTDIGS | | | | | |

| Field | Contents | |
|---|---|---|
| POLGEN | Selects the generation of polynomial coefficient equations. | |
| | NO | No equation generation will be performed. (Default) |
| | YES | Internal equation generation will be performed. |
| EQNID | Equation ID. See Remark 2. (Integer, Default = 1) | |
| STRTDIGS | Starting digits used to number entities used in equations. See Remark 2. (Integer, Default = 9) | |

Previously ATYP=DRESP2 allowed the writing of DRESP2 entries for RMS & PV for use in Nastran SOL 200 for optimization. This analysis type is now incorporated under the more generalized equation writing analysis type selected with ATYP=EQNGEN. The associated data entry is:

**EQNRES** Requests generation of equations for use in finite element analyses to compute the residual surface error after all polynomials are subtracted.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| EQNRES | RESGEN | EQNID | STRTDIGS | GIDINC | RESTYP | | | |

| Field | Contents | |
|---|---|---|
| RESGEN | Selects the generation of residual surface equations. | |
| | NO | No equation generation will be performed. (Default) |
| | YES | Internal equation generation will be performed. |
| EQNID | Equation ID. See Remark 2. (Integer, Default = 1) | |
| STRTDIGS | Starting digits used to number the responses or equations for residual surface RMS and residual surface P-V. See Remark 2. (Integer, Default = 9) | |
| GIDINC | Grid increment used to number residual displacement grids and their responses or equations. See Remark 2. (Integer, Default = 100,000) | |
| RESTYP | Residual surface error type. | |
| | BOTH | Surface RMS and surface peak-to-valley. (Default) |
| | RMS | Surface RMS. |
| | PV | Peak-to-valley. |

In most applications of optimization, the user may include both EQNPOL and EQNRES to obtain surface RMS after Power is removed. In the Nastran Examples Folder, **"tele_sig_eqngen_all.sig"** uses EQNLOS, EQNPOL, and EQNRES in the same execution. The created **"tele_sig_eqngen_all_mpc.bdf"** includes all 3 sets of equation output. See the examples manual **"SigFit-Exp-Man-v2007r2.pdf"** Section 8 for the telescope example.

## 3.12 Selection of ANSYS FEA Entities by Name

A feature allowing the user to reference the finite element entities associated with surfaces and lenses by name has been added. This feature allows the user to reference nodes, surface elements, and solid elements by the names of Components in ANSYS Classic or by Named Selections in ANSYS Workbench. New entries are the SURDEF1 and the LENDEF1. Note that while a SURDEF1 entry must reference a Component or Named Selection of nodes or surface elements only, a LENDEF1 entry must reference a Component or Named Selection of nodes or solid elements only. These new entries are as follows:

**SURDEF1** Defines the finite element model surface definition data in terms of a name.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| SURDEF | SID | | | | | | | |
| % | Name | | | | | | | |

| Field | Contents |
|---|---|
| SID | Surface ID. (Integer > 0, Required) |
| Name | Name. (Character, Required) |

**LENDEF1** Defines the finite element model lens definition data in terms of a name.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| LENDEF1 | LENID | | | | | | | |
| % | Name | | | | | | | |

| Field | Contents |
|---|---|
| LENID | Lens ID. (Integer > 0, Required) |
| Name | Name. (Character, Required) |

When using ANSYS Classic Components may be constructed of either all of the nodes on the surface or lens or all of the elements making up the surface for lens. However, a Component defining elements of a surface must be comprised of surface elements. Solid elements cannot be used to define the finite element entities making up a surface. Likewise, a Component defining elements of a lens must be comprised of solid elements.

## 3.13 Support for ANSYS Workbench

The addition of the feature to select FEA entities by name in ANSYS gives the user the ability to use SigFit in conjunction with ANSYS Workbench. For a detailed tutorial on using ANSYS Workbench with SigFit, see the charts in C:\Program Files\Sigmadyne\SigFit\2007R2\Examples\ansys\WorkbenchExample\Lens-Example.ppt.

### 3.14 Spaces Allowed in Filenames

In prior versions spaces were not allowed in the specification of filenames. Spaces are now allowed in the specifications of filenames.

## 4 Bug Fixes

### 4.1 Birefringence: Missing CAO visualization file

In stress birefringence, the viz file for CAO overwrote the BIR viz file
Fix: each file is now given a unique name

### 4.2 Reading Nastran Damping Matrix

If reading a Nastran damping matrix and using a subset of modes, there was an array overflow (fatal error).
Fix: array sizes are now allocated correctly in this case

### 4.3 RoC Calculation With Symmetry Sub-Model

In a symmetric sub-model, the calculation of ΔRoC could be incorrect for certain anti-symmetric boundary condition combinations.
Fix: ΔRoC is now correct for all symmetric model boundary conditions

### 4.4 Missing HITOUT RSD Array

In a fitting analysis, the HITOUT array on RSD (residual after all polynomials subtracted) was not written
Fix: the HITOUT array for RSD is now written, if requested

### 4.5 ANSYS ASIG Read Error

When reading Ansys ASIG file, it was possible to get a reading error if data extended beyond column 132.
Fix: 150 columns in ASIG are now read

### 4.6 HITOUT NoData

When writing a HITOUT array based on a surface in which some nodes had NO DATA, it was possible for the HITMAP to return a zero rather than a NO DATA value. Typically, this would only occur if the specified model was a HitMap visualization array, rather than a true FE model.
Fix: NO DATA value is now written where appropriate.

### 4.7 HITOUT HOSAG

When writing HITOUT surface data, the SAG displacement was always used, even if the user requested NORM.
Fix: SigFit correctly writes either SAG or NORM components to output hitmaps as specified by the user on the HITOUT entry.

### 4.8 Selection of Surf Def Calculation Other Than Linear Would Grey The Widget

Selection of Nonlinear, Nonlin & Pscr Sag, or Nonlin & FEM Sag for Surf Def Calculation on the Solution pane in VsigFit would grey the Surf Def Calculation preventing the user from changing it. The intent was to grey Surf Def Direction when anything but Linear was chosen for Surf Def Calculation.
Fix: The proper greying rule was implemented for the Surf Def Calculation widget on the Solution pane of VsigFit.

### 4.9 Browsing a Filname Specification With a Space Would Hang VSigFit

After specifying a filename path containing spaces for attributes such as FE Model Filename or FEA Disturbances Filename using the Browse utility VsigFit would hang.

Fix: Spaces are now allowed in the specification of filenames and VSigFit does not hang no matter how the specifications are made.

## 4.10 Unexpected Ordering of Disturbance Cases During Command Execution

A sorting error could result in unexpected ordering of various results such as distrubance cases if the user (1) submitted a SigFit analysis via the command line instead of executing the analysis through VSigFit and (2) constructed the analysis definition file with objects in a non-sequential order. Although analysis results of disturbances cases and surfaces may have been ordered in an unexpected manner, the labeling of results and surfaces was correct.
Fix: The sorting error was corrected and analysis results objects are presented in the expected order no matter how the analysis definition file is ordered or how the analysis is submitted.

## 4.11 Error When Using PSD Table File

When specifying a power spectral density with a TABFILE in random response analysis, SigFit fails with a run-time error.
Fix: The error preventing the use of  use of a power spectral density with a TABFILE has been corrected.

# 5 Example of LoS calculation in Random response

```
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
OUTNAME%tele_sig_random_los
SOL     RAND    23.622-6SAG     LIN
FEAPROG MSCNAST IN      PATRAN
OPTPROG CODEV   IN
MODFILE%tele_nas_model_all.bdf
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SURFACE 2       PM      PROP    1000    2       NEG     -1
SURDEF  2       1001
SURGEOM 2       CONIC   -101.533-1.0023
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SURFACE 3       SM      PROP    2000    3       POS     -1
SURDEF  3       2001
SURGEOM 3       CONIC   -12.489 -1.4949
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SURFACE 5       FP      PROP    3000    5       NEG     1
SURDEF  5       3001
SURGEOM 5       FLAT
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SUBT    2       ALL     NONE
SUBT    3       ALL     NONE
SUBT    5       ALL     NONE
MAT     1       AIR     ISO
MATN1   1       1.0
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
$       DISCOMB DISFEA  DISVEC  DISPOL  DISHI   DISZYG
DISTYP  NO      RANGES  NONE    NONE    NONE
DFCASE  4       100      1.00000
DFFILE% tele_nas_run_modes.pch
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
HARMTYP 1       DATA    1       DATA    CONST           1.0
FREQ    20.     180.    2.0
FREQ4   3
PSDTYP  DATA    LOGLOG  3
$FORCE
VECTOR  1       60000   3.8600+80.0     0.0     0.0     0.0     0.0
$PSD
TABLE   3       20.     2.0-8
TABLE   3       60.     2.0-6
TABLE   3       140.    2.0-6
TABLE   3       180.    2.0-8
DMPTYP  DATA    CONST           0.01
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SYSLOS  YES
LOSRAY          0.0     0.0     -1.0    0.0     0.0     1.0
LOSDATA 1.0     1.d-6   1.d-6
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
OUTLOS  YES
OUTDYN  YES
DIAGPRT STD
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
```

**Surfaces must include optical index or -1 for reflective**

**New Data**

**Selected output from fit file:**

```
-----------------------------------------------------------------------------
  Calculation of LoS Coefficients - Beta Release

    Starting Ray in Coord Sys =    1000
    Position xo=  0.00000E+00  0.00000E+00 -1.00000E+00
    Dir Cos  qo=  0.00000E+00  0.00000E+00  1.00000E+00
    Index    no=  1.00000E+00
    Step size  =  1.00000E-06  1.00000E-06

    Initial Ray intersection with each Surface
    X,Y,Z = intersection in VCID coord sys
    N = index of refraction after surface
    R = -1 => reflection,  R = +1 => refraction
    If intersection is NOT (0,0,0), check geometry
             SID            X            Y            Z            N    R
               1  0.00000E+00  0.00000E+00  0.00000E+00  1.00000E+00   -1
               2  0.00000E+00  0.00000E+00  0.00000E+00  1.00000E+00   -1
               3  0.00000E+00  0.00000E+00  0.00000E+00  1.00000E+00    1

    LoS Coefficients, Units= FEA units= in/in & in/rad
    SID = surface Id
    DOF = surface RB component in VCID system
    LoS = measured in focal plane VCID system
    Note: angles are in Radians and Right-Hand rule
             SID          DOF        LoS-X        LoS-Y
               2            1      10.4338       0.0000
               2            2       0.0000      10.4338
               2            3       0.0000       0.0000
               2            4       0.0000    1059.3753
               2            5   -1059.3753       0.0000
               2            6       0.0000       0.0000

               3            1      -9.4339       0.0000
               3            2       0.0000      -9.4339
               3            3       0.0000       0.0000
               3            4       0.0000    -117.8200
               3            5     117.8200       0.0000
               3            6       0.0000       0.0000

               5            1      -1.0000       0.0000
               5            2       0.0000      -1.0000
               5            3       0.0000       0.0000
               5            4       0.0000       0.0000
               5            5       0.0000       0.0000
               5            6       0.0000       0.0000

    Estimated Focal Length  =     529.6877
```

**Chief Ray Input Data**

**Intersection at each surface as data check**

**Each Surface's LoS coefficients**

**Focal Length**

```
  Rigid Body Error check on LoS
  Unit Rigid Body motions given in CID=    1000
  RB Translation(1 FE unit) should give LoS = 0.0
  RB Rotation(1 Radian) should give LoS = Focal Length
         Input          DOF         LoS-X        LoS-Y
         RB-TX            1       -0.0001       0.0000
         RB-TY            2        0.0000      -0.0001
         RB-TZ            3        0.0000       0.0000
         RB-RX            4        0.0000     529.6877
         RB-RY            5     -529.6877       0.0000
         RB-RZ            6        0.0000       0.0000
```

**Rigid-Body Error Check**

```
--------------------------------------------------------------------------
Line-of-Sight error in FE units =in
   LoS-X,Y Image Space = in focal plane VCID system
   LoS-V   Image Space = vector sum in XY plane
   LoS-R  Object Space = angular(radians)= Los-V/FL
   LoS of mode shape vectors

   Mode#        LoS-X        LoS-Y        LoS-V        LoS-R
       4   6.3250E-09  -2.1199E-11   6.3251E-09   1.1941E-11
       5  -1.7076E+01  -2.7594E+01   3.2450E+01   6.1263E-02
       6  -2.7594E+01   1.7076E+01   3.2450E+01   6.1263E-02
       7   3.5114E+00   2.7090E+01   2.7317E+01   5.1571E-02
       8   2.7090E+01  -3.5114E+00   2.7317E+01   5.1571E-02
       9  -2.9541E-11  -4.7907E-10   4.7998E-10   9.0615E-13
      10   2.0502E-09  -6.1848E-11   2.0512E-09   3.8724E-12
      11  -5.3361E-01   1.3689E+00   1.4692E+00   2.7737E-03
      12   1.3689E+00   5.3361E-01   1.4692E+00   2.7737E-03
Truncated..
```

**LOS in Each Mode Shape**

```
--------------------------------------------------------------------------

Each modes % contribution to LoS PSD
Mode       Freq  LoS-X  LoS-Y  LoS-V  LoS-R
   4      70.07  0.000  0.000  0.000  0.000
   5      73.77  3.143 46.068  9.635  9.635
   6      73.77 21.433 46.068 25.158 25.158
   7      79.29  0.012  3.926  0.604  0.604
   8      79.29 41.636  3.926 35.933 35.933
   9      82.11  0.000  0.000  0.000  0.000
  10      82.92  0.000  0.000  0.000  0.000
  11      85.29  0.000  0.000  0.000  0.000
  12      85.29  0.000  0.000  0.000  0.000
  13      90.31  0.001  0.002  0.001  0.001
  14      90.31  0.000  0.002  0.001  0.001
  15      96.81  0.000  0.000  0.000  0.000
  16      96.81  0.000  0.000  0.000  0.000
  17     109.64  0.000  0.000  0.000  0.000
  18     109.64  0.000  0.000  0.000  0.000
  19     113.57  0.000  0.000  0.000  0.000
Truncated..
```

**Each Modes Contribution to Total LOS**

```
LoS Random Analysis Results:
   1-sigma => contains peaks 68.3% time
   3-sigma => contains peaks 99.7% time [multiply 1-sigma results by 3]
   Zero-Xs => number zero crossings/unit time
```

**LoS Random Response**

```
    FP Surface Coordinate System used for X Y
    LoS-X,Y => Image Space Translations (FE units)
    LoS-V   => Image Space Vector sum in XY plane
    LoS-R   => Object Space Los-V/FL=angular(radians)

                          <---Displacement--->     <Velocity>    <Accel>
      SID     Item          1-sigma      Zero-Xs     1-sigma      1-sigma
    Total     LoS-X       3.1496E-03   1.0206E+02   2.0200E+00   1.5809E+03
    Total     LoS-Y       4.1581E-11   7.6224E+01   1.9923E-08   9.6870E-06
    Total     LoS-V       3.1496E-03   1.0206E+02   2.0200E+00   1.5809E+03
    Total     LoS-R       5.9462E-06   1.0206E+02   3.8137E-03   2.9845E+00

 End Harmonic/Random Analysis
```

**<u>Selected output from los.csv file (OUTLOS=YES)</u>**

**Total LoS of each Mode**

**Each Surface contribution to LoS**

```
$ sig_tele_random_los_los_01.csv
$ 22-AUG-07  15:22:25
$ los
     Mode#,  Total-LoS-X,  Total-LoS-Y,       2LoS-X,       2LoS-Y,
         4,  6.32503E-09, -2.11990E-11, -7.83469E-10,  9.44372E-13,
         5, -1.70761E+01, -2.75939E+01,  1.78505E+00,  2.88453E+00,
         6, -2.75939E+01,  1.70761E+01,  2.88453E+00, -1.78505E+00,
         7,  3.51144E+00,  2.70901E+01,  4.81860E+00,  3.71746E+01,
         8,  2.70901E+01, -3.51144E+00,  3.71746E+01, -4.81859E+00,
         9, -2.95406E-11, -4.79066E-10, -1.62577E-10, -2.28377E-10,
      Truncated.. other modes and other surfaces
```

**<u>Selected output from dyn.csv file  (OUTDYN=YES)</u>**

After all individual surface transfer and PSD response functions, The LOS transfer and PSD response transfer functions are listed

```
$ LoS Transfer Function - Sine Sweep Results
$ FP Surface Coordinate System used for X Y
$ LoS-X,Y => Translations (FE units)
$ LoS-V   => Vector sum in XY plane
$ LoS-R   => LoS-V/FL angular error(radians)
    Freq,     LoS-X,     LoS-Y,     LoS-V,     LoS-R
   20.00, 2.052E-02, 3.865E-10, 2.052E-02, 3.874E-05
   22.00, 2.055E-02, 1.169E-10, 2.055E-02, 3.879E-05
   24.00, 2.058E-02, 8.499E-10, 2.058E-02, 3.885E-05
   26.00, 2.060E-02, 4.224E-10, 2.060E-02, 3.890E-05
   28.00, 2.063E-02, 8.014E-11, 2.063E-02, 3.895E-05
   30.00, 2.065E-02, 2.827E-10, 2.065E-02, 3.899E-05
   32.00, 2.066E-02, 1.323E-09, 2.066E-02, 3.901E-05
   34.00, 2.067E-02, 5.681E-10, 2.067E-02, 3.902E-05
 Truncated..

 Maximum,     LoS-X,     LoS-Y,     LoS-V,     LoS-R
  Peak  , 1.024E+00, 1.314E-08, 1.024E+00, 1.933E-03
  Freq  , 1.510E+02, 7.303E+01, 1.510E+02, 1.510E+02
```

```
$ LoS PSD Response Function
$ FP Surface Coordinate System used for X Y
$ LoS-X,Y => Translations (FE units)
$ LoS-V   => Vector sum in XY plane
$ LoS-R   => LoS-V/FL angular error(radians)
    Freq,      LoS-X,      LoS-Y,      LoS-V,      LoS-R
   20.00, 8.421E-12, 2.988E-27, 8.421E-12, 3.002E-17
   22.00, 1.259E-11, 4.076E-28, 1.259E-11, 4.488E-17
   24.00, 1.819E-11, 3.103E-26, 1.819E-11, 6.482E-17
   26.00, 2.550E-11, 1.072E-26, 2.550E-11, 9.090E-17
   28.00, 3.488E-11, 5.263E-28, 3.488E-11, 1.243E-16
   30.00, 4.667E-11, 8.744E-27, 4.667E-11, 1.663E-16
   32.00, 6.125E-11, 2.512E-25, 6.125E-11, 2.183E-16
 Truncated..

 Maximum,      LoS-X,      LoS-Y,      LoS-V,      LoS-R
  Peak   , 1.475E-06, 3.451E-22, 1.475E-06, 5.259E-12
  Freq   , 7.400E+01, 7.303E+01, 7.400E+01, 7.400E+01

$ Spectral Moments of PSD
  Moment,      LoS-X,      LoS-Y,      LoS-V,      LoS-R,
  SpecM0, 9.920E-06, 1.729E-21, 9.920E-06, 3.536E-11
  SpecM1, 9.604E-04, 1.314E-19, 9.604E-04, 3.423E-09
  SpecM2, 1.033E-01, 1.005E-17, 1.033E-01, 3.683E-07
  SpecM4, 1.602E+03, 6.012E-14, 1.602E+03, 5.710E-03
```

## 6 Example of writing LOS MPC equations

```
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
OUTNAME%sig_tele_eqngen_los
SOL     EQNGEN  23.622-6NORM    LIN
FEAPROG MSCNAST IN      PATRAN
MODFILE%tele_nas_model_all.bdf
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SURFACE 2       PM      PROP    1000    2       NEG     -1
SURDEF  2       1001
SURGEOM 2       CONIC   -101.533-1.0023
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SURFACE 3       SM      PROP    2000    3       POS     -1
SURDEF  3       2001
SURGEOM 3       CONIC   -12.489 -1.4949
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
SURFACE 5       FP      PROP    3000    5       NEG     1
SURDEF  5       3001
SURGEOM 5       FLAT
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8
MAT     1       AIR     ISO
MATN1   1       1.0
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
EQNLOS  YES
LOSRAY          0.0     0.0     -1.0    0.0     0.0     1.0
LOSDATA 1.0     1.d-6   1.d-6
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
DIAGPRT STD
```

**New Analysis Type**

**Surfaces must include optical index or -1 for reflective**

**New Data**

**LoS equations in Nastran bulk data format**

**<u>Selected output from los_mpc.bdf file</u>**

```
$
$ MPCs for LoS, Units= FEA units= in/in & in/rad
GRID     9999000    3000     0.0     0.0     0.0    3000      36
$
$ Image Space LoS-X = Grid id = 9999000 Component = 1
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
mpc            1 9999000       1 -1.00000 9002000      1 1.0434+1
+                9002000       5 -1.059+3 9003000      1 -9.43390
+                9003000       5 1.1782+2 9005000      1 -1.00000
$
$ Image Space LoS-Y = Grid id = 9999000 Component = 2
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
mpc            1 9999000       2 -1.00000 9002000      2 1.0434+1
+                9002000       4 1.0594+3 9003000      2 -9.43390
+                9003000       4 -1.178+2 9005000      2 -1.00000
$
$ Object Space LoS-RX = Grid id = 9999000 Component = 4
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
mpc            1 9999000       4 -1.00000 9999000      2 -1.888-3
$
$ Object Space LoS-RY = Grid id = 9999000 Component = 5
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
mpc            1 9999000       5 -1.00000 9999000      1 1.8879-3
$ End LoS MPC
```

**RBE3's are also written for average rigid-body motion of each surface**

```
$ RBE3 to calc average surface motion     Surf#=  1     Optic-Id=  2
$--1---><--2---><--3---><--4---><--5---><--6---><--7---><--8---><--9--->
grid     9002000    1000     0.0     0.0     0.0    1000
rbe3     9002000         9002000  123456 0.16588     123   11001
+        0.54193     123   11002   11009   11016   11023   11030   11037
+        0.85639     123   11003   11010   11017   11024   11031   11038
+        1.16940     123   11004   11011   11018   11025   11032   11039
+        1.48041     123   11005   11012   11019   11026   11033   11040
..truncated
```