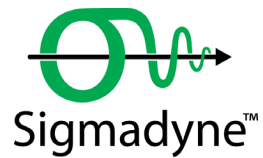

SigFit

Release Notes Version 2020R1



May 20, 2020

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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.

Licensing Issues

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

Doyle, K., Genberg, V., Michels, G., **Integrated Optomechanical Analysis 2nd Ed.**, SPIE Press, 2012.

Integrated Optomechanical Analysis short course available from Sigmadyne, Inc.

SigFit short course available from Sigmadyne, Inc.

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1 Installation and Upgrading:

Instructions for installing may be found in the Install-Instructions-v2020R1.pdf found at <http://www.sigmadyne.com/download>.

SigFit V2020R1 has been tested on the following operating systems and platforms:

Microsoft Windows 10 on Intel x86_64

ATTENTION: SigFit V2020R1 uses a new version of the license server software. Please be sure to upgrade your license server software according to the installation instructions. You do NOT need a new license file.

2 New Features

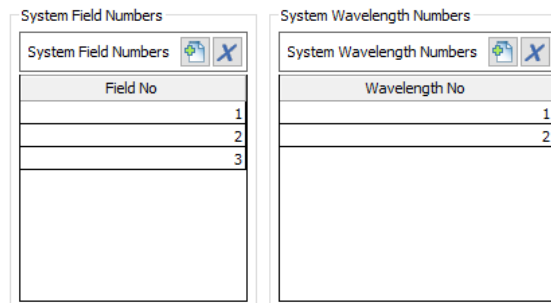
2.1 Wavefront Error Prediction Via Optical Analysis Linear Optical Model Improvements

2.1.1 Support for Use With Code V

The current feature that allows users to compute wavefront error by linking to an optical analysis model or previously generated linear optical model file has been extended to include use with Code V versions 10.6 or later. Characterization of surface error by normal or axial sag deformation directions are both supported. Surface types are currently limited to conic surfaces without asphere terms. Linking to .len or .seq files is supported. See Section 5.20.3 of the SigFit Reference Manual or Tutorial Example 3 for more details.

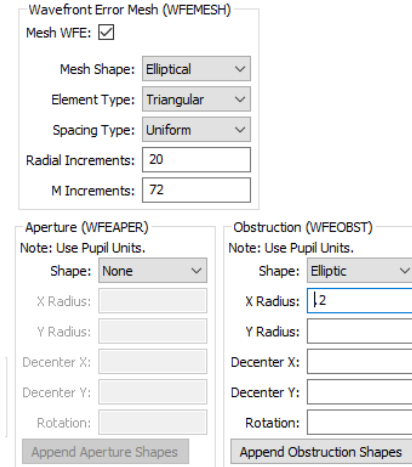
2.1.2 Support for Fields and Wavelengths

The current feature that allows users to compute wavefront error by linking to an optical analysis model or previously generated linear optical model file now supports multiple fields and wavelengths. Field and wavelength numbers are specified in SigFit as shown below. A linear optical model will be generated using the link to the optical analysis for each combination of field and wavelength and will be used to generate wavefront predictions for each.



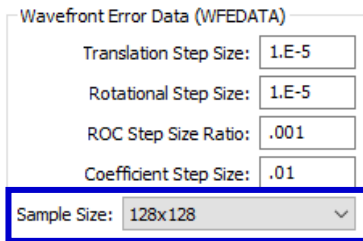
2.1.3 Support for Pupil Apertures and Obstructions

Support to apply apertures and obstructions in pupil space has been added through the combination of mesh, aperture, and obstruction features similar to those allowed for surfaces. The user specifies a mesh to be applied to the pupil over which the wavefront is computed. This mesh is populated by evaluation of the polynomial representation of the wavefront. Apertures or obstructions expressed in normalized pupil coordinates may be defined.



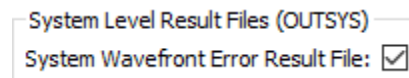
2.1.4 Support for Sample Size

The ray sampling density may now be specified. The default value is 128x128.



2.1.5 Added Output Option to Write Wavefront Error Results to CSV File

Results for wavefront analysis are already written to the .fit file. Results for polynomial fitting and active control analyses may also be written to a CSV file with a selection in the System Level Result Files section of the Output Module.



2.2 Support for Code V Extended Zernike Fringe Including Offset Apertures

In Code V version 11.3 a new surface type was introduced called an Extended Fringe Zernike. Among other features not discussed here, this surface allows for an offset between the base conic and the Zernike polynomial prescriptions. This now allows users to use axial sag deformation in SigFit analyses sending results to Code V surfaces having an offset aperture. See Tutorial Example 2 for more details on support of this surface in SigFit. Please see the Code V documentation for more about the SPS ZFE surface and its other features.

While a regular Fringe Zernike set is generally not advised to represent surface error due to the lack of important terms, the terms included in this Code V Extended Fringe Zernike surface are generally excellent for representing most deformations because the surface formulation includes hexafoil ($\cos(6\theta)$ and $\sin(6\theta)$) terms. In addition, use of a residual interpolation may augment any polynomial fit lacking desired surface error.

2.3 Support for Latest APIs

Support for the following APIs to finite element analysis software have been updated.

Finite Element Analysis Software	Latest Version Supported
All NASTRAN and ANSYS	No API Required
SIMULIA Abaqus	2020

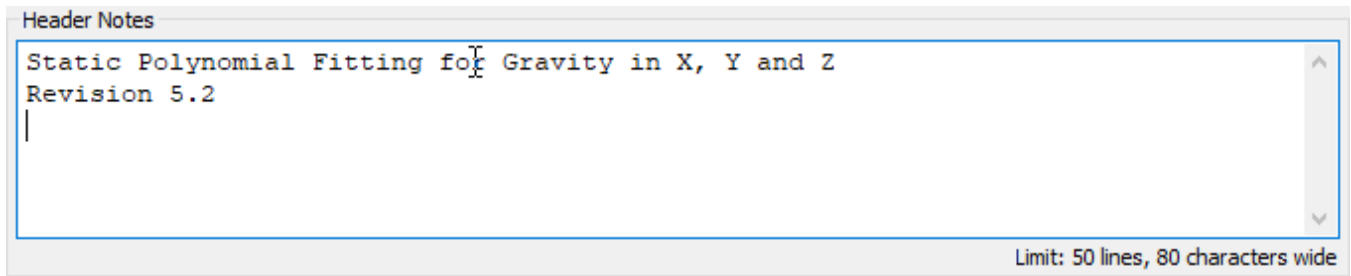
SolidWorks Simulation	2020SP2
-----------------------	---------

Support for the following APIs to optical analysis software have been updated.

Optical Analysis Software	Latest Version Supported
Code V	11.4
Zemax OpticStudio	2020.1.3

2.4 User Defined Header

A user defined header may be specified through a simple text editor in the Solution module of VSigFit. The user is limited to 50 lines of 80 columns each. If more than 80 columns are used the editor will wrap lines automatically. This header text will be printed on nearly every output file SigFit writes, where allowed by the format specifications of that file, using comment characters where required for macro files.

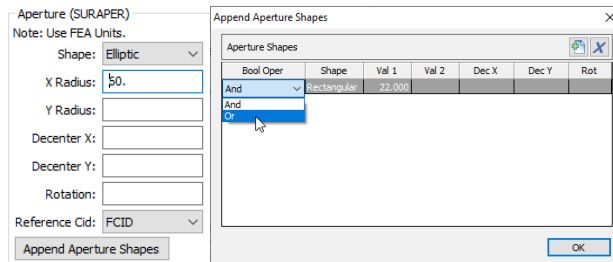


2.5 Increased Precision Augment Interpolation Files for GRD INT Format

The precision with which a GRD INT file is written is limited by the precision of a signed 2 byte integer according to the format of the file. This results in about four decimal significant figures, which may not be suitable for all applications. Generation of GRD INT files now will result in two files per interpolation with the second GRD INT file representing the original data minus what was represented in the first GRD INT file. This results in about eight decimal digits of precision. The second GRD INT file will use a suffix of x2.int. The corresponding macro files that call the INT files will call both GRD INT files onto the same surface using unique labels as required. No user action is required to enable this feature.

2.6 VSigFit Support of Appended Aperture and Obstruction Definitions

Appended aperture and obstruction definitions have been released in SigFit for a few versions but have not been supported by VSigFit until now. Appended apertures and obstructions allow the user to specify and locate additional shapes along with a boolean as to how they should be used.



2.7 Enhancements to Import of Surfaces From Optical Analysis

2.7.1 Import of Aperture Offsets

Specified aperture offsets are now imported from both Code V and Zemax Optic Studio models. These offsets will be imported into the surface offset attributes to the corresponding SigFit surface definition. The apertures definitions themselves will not be imported.

2.7.2 Improved Precision for VSigFit Import of Code V Surfaces Using Global Coordinates

Generation of the surface vertex coordinate system definitions for surfaces defined in global coordinates in a Code V model and imported into VSigFit are now expressed with greater precision. This improvement eliminates small but sometimes noticeable errors in nominal surface position to which disturbances would be added during a SigFit analysis. Surfaces expressed in Code V using local coordinates are not affected.

2.7.3 Support for Code V Image Surface Thickness

When importing surface definitions from a Code V model the thickness on the image surface was being ignored in prior versions but is now used to locate the image surface.

2.8 Specification of λ_{TK} in Sellmeier dn/dT Properties Now Expressed in Microns in VSigFit

SigFit has two entries to describe Sellmeier dn/dT properties: SELLM and SELLM1. While SELLM expresses λ_{TK} in microns, SELLM1 expresses λ_{TK} in nanometers. For the most recent versions VSigFit has favored the SELLM1 entry and prompted the user for λ_{TK} in nanometers. However, in order to avoid confusion VSigFit will now require λ_{TK} to be specified in microns as shown below since λ_{TK} is generally given in the glass catalogs in microns.

DNDT Sellmeier Definitions

DNDT Sellmeier (SELLM)

DNDT Sellmeier Id: 1

D0: 3.8E-6

D1: 1.41E-8

D2: 2.28E-11

E0: 6.44E-7

E1: 8.03E-11

Lambda TK (um, NOT nm): .108

It is very important for the user to understand that VSigFit has always stored λ_{TK} using the entry that corresponds to the requested units as displayed in the Sellmeier definition in VSigFit. Therefore, prior analysis definitions using the SELLM1 definitions will import properly and be converted to the SELLM entry without any user action.

2.9 New Dynamics Output Files

Two new files associated with dynamics analysis may be requested as discussed below.

Dynamics Files (OUTDYN)

Harmonic Response Peak Mag Files: All

Harmonic Response Cmplx File: All

Harmonic Response Cmplx File Format: Mag/Pha

Random Response File: All

% Modal Rand Resp Contrib: None

2.9.1 Harmonic Response Complex File

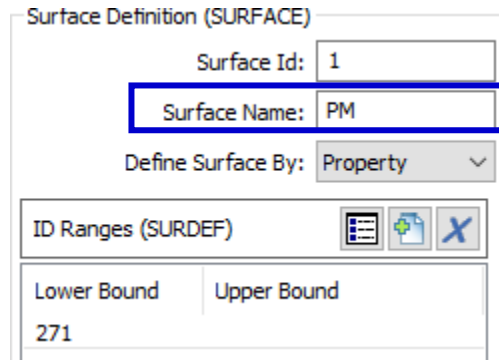
The harmonic responses of surfaces and system predictions are now available in their complex form in addition to the exiting peak magnitude output. The complex form of the harmonic response data may be selected to be in the form of magnitude and phase or real and imaginary values. The file is formatted in CSV format similar to the peak magnitude form.

2.9.2 Percent Modal Random Response Contribution

Percent random response contributions have been printed to the .fit file for many versions. They may now be requested to be printed to CSV format.

2.10 Name Lengths Extended to 16 Characters

Names of SigFit entities such as surfaces, lenses, materials, and Monte Carlo variables may now be 16 characters.



Note that in the previous version there was a formatting issue with these names if more than 8 characters were used. This would result in being unable to open the file requiring making manual edits to the .sig file. This error has been corrected as noted in Section 3.

Note this change has no relation to the functions of referring to Named Selections in an ANSYS model or surface names in a Code V model.

2.11 NASTRAN Modal Damping Matrix Data Enhancements

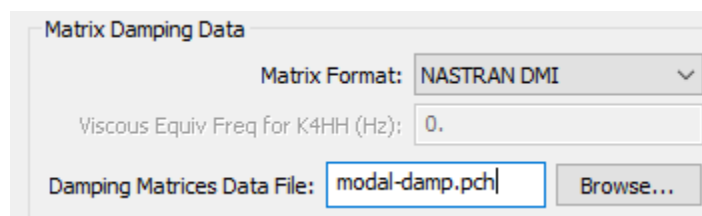
2.11.1 New DMAP Alter for MSCNastran 2018 and Later

A new DMAP alter is required for versions of MSCNastran 2018 and later for obtaining a modal damping matrix file.

```
$ Alter for SOL 111 in Nastran v2018 to output damping
COMPILE GAMMX SOUIN=MSCSOU,NOLIST,NOREF
ALTER 'CALL ASSEMGMA'
DIAGONAL MHH/VMDIAG/$
MATPCH VMDIAG/ $
DIAGONAL KHH/VKDIAG/$
MATPCH VKDIAG/ $
MATPCH BHH/ $
MATPCH RSK4SHH/ $
$ exit is optional - if want to quit after damping
EXIT
```

A modal damping matrix file is used to define a modal damping matrix that is not otherwise definable in SigFit due to the use of discrete or nonuniform modal damping as might occur with dashpots or material damping.

The new DMAP may be found in C:\Program Files\Sigmadyne\SigFit\2020r1\MSCNASTRAN_Support\DMAP-Alter-for-damping-v2018.bdf. Such damping is specified in the Matrix Damping Data section as shown below.



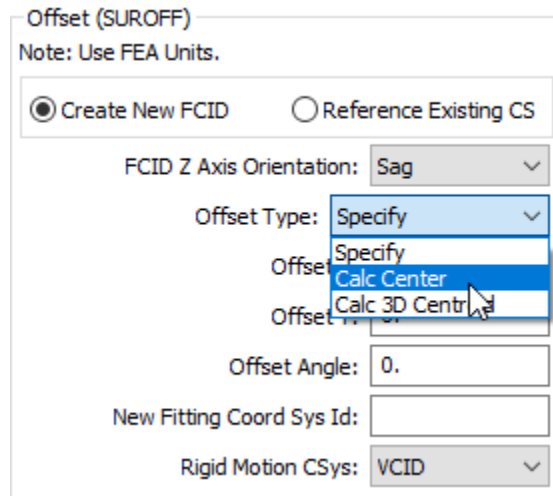
2.11.2 Enhanced Output For Improved Checking

An enhancement to the NASTRAN modal damping matrix file is the inclusion of the generalized mass and stiffness matrices so that Sigfit can verify that the generalized mass is unity (required in SigFit) and that the generalized stiffness corresponds to the eigenvalues specified in the modal disturbance file of eigenvectors. These enhancements have been made to all versions of the DMAP provided in the MSCNASTRAN_Support folder.

2.12 Enhanced Settings for Surface Offset

The offset type has been enhanced with a change in behavior and an added option. In prior versions the choice Calc Center would find the centroid of the surface nodes using their area weighting and place the fitting coordinate system at this centroid computed in *three dimensions*. It was intended that this choice would be used for racking analysis.

In the current version there is a change of behavior in which Calc Center will find the centroid in X and Y of the vertex coordinate system but place the fitting coordinate system on the surface using the supplied prescription. A new choice as shown below, Calc 3D Centroid, will perform the previous centroid location in three dimensions. This three dimensional centroid location is generally intended for racking analysis and not for surface error analysis, while Calc Center can serve as a simple way to locate the fitting coordinate system for surface error analysis.



Note that the default value for the offset type is Specify, which allows the user to specify the X and Y offsets of the fitting coordinate system expressed in the vertex coordinate system, and this behavior is unchanged. With this default offset type SigFit will place the fitting coordinate system on the surface at the specified X and Y location using the provided prescription. The fitting coordinate system is the coordinate system in which the polynomial fit of surface data is centered. It is important to use this offset to keep the fitting coordinate system near the center of the data to be fit with polynomials in order to obtain a well posed polynomial fit.

2.13 Improved Surface Node Extent Summary Expressed in Fitting Coordinate System

The surface nodes extent summary near the start of output in the .fit file has been improved. The section for each surface summarizing the node extents in the fitting coordinate system now displays extents in the X and Y directions as has been displayed in the vertex coordinate system.

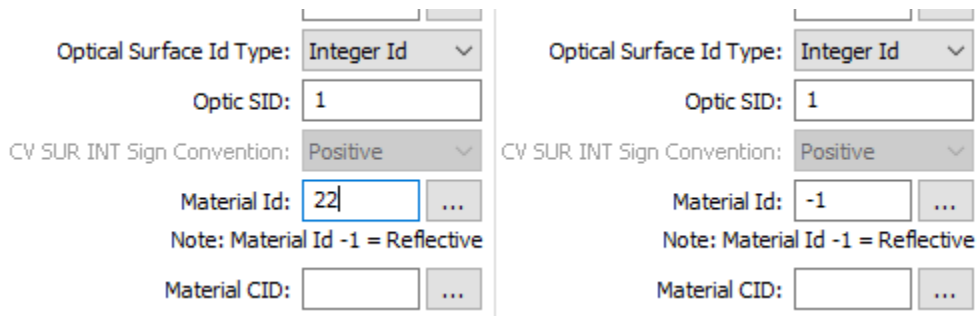
```

Fitting Coord: FCID =      1000      # Fit =      1008      Fit Ar= 6.0695E+02
Node R (FCID): Rmax = 1.4000E+01  Rmin = 1.5000E+00  Ravg = 9.4301E+00
Node T (FCID): Tmax = 1.8000E+02  Tmin = -1.8000E+02  Tavg = 1.0766E+00
Node X (FCID): Xmax = 1.4000E+01  Xmin = -1.4000E+01  Xavg = -1.4225E-16
Node Y (FCID): Ymax = 1.4000E+01  Ymin = -1.4000E+01  Yavg = 2.4590E-16
Node Z (FCID): Zmax = -1.1100E-02  Zmin = -9.6620E-01  Zavg = -4.8895E-01
Aperture      : Rmax = 1.4000E+01  Based on Max Node Position
Poly Fitting  : Norm = 1.4000E+01  Based on Rmax
    
```

Best Sphere : CBFS =-9.8120E-03 Curvature thru Vertex and Edge
 Best Sphere : SRoC =-1.0192E+02 Based on FE model footprint

2.14 Use of Reflective Material ID -1 Substitutes Thermo-optic Properties of Prior Surface's Material

In thermo-optic analysis the material ID reference on the surface definition can refer to a defined material or to -1, a reflective surface. In cases where the reflection exists inside a transmissive optic the user would need to specify the material reference to a defined material as shown in the figure on the left. If the analysis definition was created from a prior surface error analysis in which line of sight error may have been performed then this material ID would have been -1 as shown in the figure on the right. (Note that the refractive index properties of the prior surface would carry over to the reflective surface in line of sight error analysis.) In order to perform thermo-optic analysis in prior version the user would have had to change the -1 reference to a material reference providing thermo-optic material property data. In the current version the -1 will cause the thermo-optic properties of the prior surface to be used. Multiple reflective surfaces may be defined sequentially.

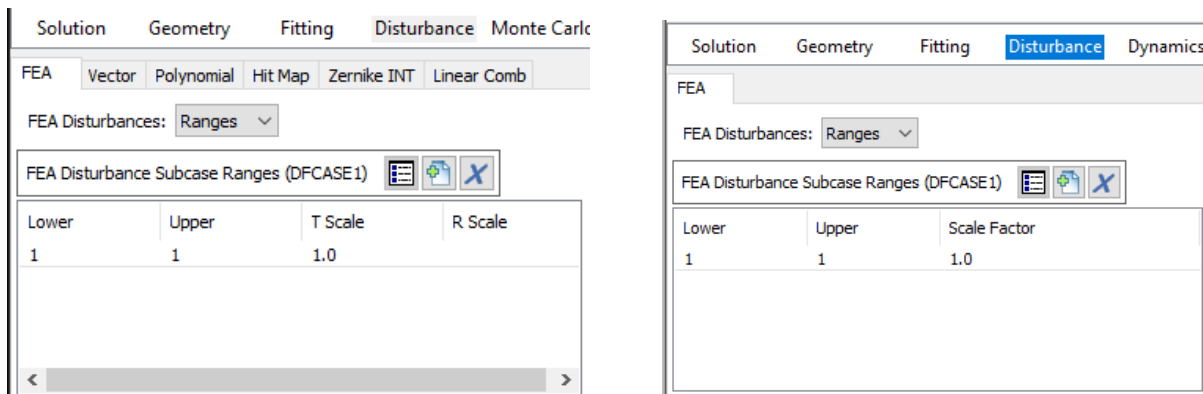


2.15 Multiple Lenses Supported in Aero-Optic Analysis

The aero-optic analysis has been limited to a single aero-optic refractive region, presumably present in front of an optical system moving through the atmosphere. The application of the aero-optic feature to the study of turbulence effects on ground based astronomical systems has required the need for multiple aeroelastic regions. Multiple regions are now supported.

2.16 Scale Factor on Rotations When Specifying Ranges of Disturbances Has Been Eliminated

Prior versions of SigFit supported scaling of the FEA rotational displacements (R Scale) independent from the scaling of the translational displacements (T Scale) as shown in the figure on the left. The default for this scaling was blank which would use the value of the scale factor for the translation displacements. The scaling of the rotational displacements caused user confusion and result labeling complexity for a feature likely never used and non-physical. The independent scale factor on nodal rotations has been removed and a single scale factor remains as shown in the figure on the right.



3 Error Fixes

3.1 Fixed Use of Negative Orders for Phase Change Analysis of Diffractive Optics

The use of negative orders on surfaces on which diffractive properties were assigned would generate unbounded results for diffractive phase change analysis. This issue has been corrected.

This issue did NOT affect line of sight analysis using diffractive surfaces and also did not affect phase change analysis of diffractive optics for positive orders. Simply negating the cut plane normal direction and using a positive order was a workaround to obtain results for negative orders. This workaround is no longer required.

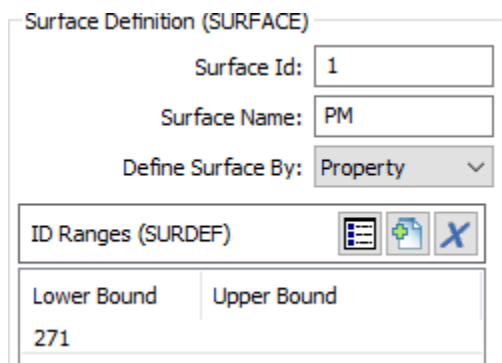
3.2 Fixed Phase Change of Diffractive Optics Output to WFR INT Files When Order Not Equal to 1

When performing phase change analysis of diffractive optics described by Zernike WFR INT files (Zernike polynomial fitting of phase data for Code V) would use an order of 1 irrespective of the order specified for the diffractive surface. The WFR INT files of phase change of diffractive surfaces now correctly uses the specified order.

Note that the use of Zernike polynomials to represent phase changes in Code V is not ideal because a WFR INT file is not truly phase but is wavefront change. This means that the characterization of phase change is only valid as a single wavelength as documented in Section 5.18.1.1 of the SigFit Reference Manual. A better choice of representing phase change is to use XY polynomials, which will use a diffractive optical element surface in Code V for true phase representation.

3.3 Fixed Lack of Error Checking When Exceeding 8 Character Limit on Names

In the prior version if more than 8 characters were used for an entity name such as a surface or lens name there was no error trap to enforce an 8 character field and the write of the entry did not correctly support more than 9 characters. The result was a failure to find nodes/elements on the surface or lens with warnings in the .fit file and a .sig file that could not be reopened in VSigFit without some manual editing of the file. This issue has been fixed and these names may be up to 16 characters with an enforcement to prevent more than 16 characters.



3.4 Fixed Optical File Write for Monte Carlo Analysis

In recent versions the writing of macro files output for all realizations of a Monte Carlo analysis has been inoperable when requested. Files are now generated to a directory as documented.

3.5 Replaced Warning With Fatal Error for Master Datum With No Nodes Found

In prior versions failure to find nodes associated with a datum would issue a warning to the fit file but continue analysis. This message has now been elevated to a fatal error forcing the user to address the issue.

3.6 Fixed Issue With Reading ANSYS MCF File With 25-50 Modes When Importing Modal Response Functions

If dynamics analysis was performed by importing modal response functions from ANSYS with between 25 and 50 modes then the modal response functions would be not found and the analysis would end with an error indicating such. The read of the .mcf file for any number of modes has now been corrected.

3.7 Fixed Incorrect Attribute Calls in Validation Methods of Some Objects in Data Module

Some objects in the Data module would generate errors when performing validation by calling non-existing subroutines or attributes. These errors have been corrected.