May 16, 2016

NASGRO v8.1 Release Notes

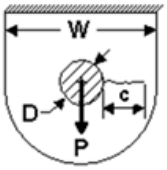
New Stress Intensity Factor Models:

- **New Lug Solutions:**
  - **TC27 - Through Crack at Hole in Lug (*replaces TC04*)**
  - **CC19 - Corner Crack at Hole in Lug (*replaces CC03*)**
  - **SC32 – Surface Crack at Hole in Lug (*replaces SC12*)**

Three completely new lug solutions are now available that have improved accuracy and wider geometry ranges. These SIF models employ univariant weight function (WF) solutions that utilize nonlinear stress distributions obtained from a large matrix of FEM analyses. These models consider a neat-fit pin/hole condition and the FEAs employed state-of-the-art contact algorithms to include the friction and contact between the pin and the lug. These WF models can also accommodate residual stresses.

These new SIF models were verified and validated against independent FEM/BEM analyses as well as against data contained in a USAF/Lockheed report (AFWAL-TR-84-3080).

TC27



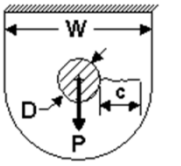
$S_B = P/Dt$

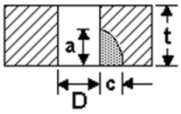
t = thickness

$1.25 \le W/D \le 10$

$0 \le c/(W-D) \le 0.4995$

CC19





$S_B = P/Dt$

$0.1 \le D/2t \le 10$

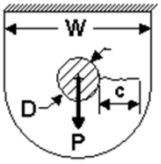
$1.25 \le W/D \le 10$

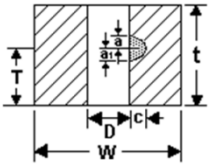
$0 \le c/(W-D) \le 0.45$

$a/c \ge 0.1$

$0 \le a/t \le 0.9$

SC32





$0 \le \mathrm{Max}\left(\frac{a}{T}, \frac{a}{t-T}\right) \le 0.9$

$0 \le c/(W-D) \le 0.4$

$0.5 \le a/c \le 10$

$0.25 \le D/t \le 2$

$1.25 \le W/D \le 10$

$0.1 \le T/t \le 0.9$

- **Revised CC16 Finite Width Correction Factors for Pin Loading**

The stress intensity factor solution CC16 combines solutions from the Fawaz-Anderson database of wide-plate solutions with finite-width and offset correction factors to compute K-values. These solutions apply to elliptical corner cracks at offset holes in finite-width plates under tension, out-of-plane bend, and pin loading. CC16 was first implemented in NASGRO version 7.1. It was discovered during the v8.0 development cycle that CC16 results for pin-loaded holes (and only pin-loaded holes) in narrow plates could be excessively non-conservative. Therefore, a modified finite-width correction factor for pin-loaded CC16 was developed based on the CC08 solution, which had been modified to accommodate pin-loading and to widen the geometry range significantly. This revised pin-loaded CC16 solution was implemented in v8.0f (and back-ported to v7.12) on an expedited basis.

However, further study of this revised solution indicated that, while accurate for narrow plates with centered holes, these values could be over-conservative for narrow plates with holes highly offset from the centerline. Therefore, a second CC16 revision focusing on the hole-offset correction factor has been developed, verified, and implemented in v8.1a. Once again, the revised CC16 solution only changes K-values under pin-loading – solutions for tension and out-of-plane bending have been unaffected.

The new correction factor routines are based on a look-up table of more than 44,000 solutions at various non-dimensional ratios, again based on the current CC08 solution. The look-up table was derived by comparing CC08 solutions for wide plates with CC08 solutions for narrow plates with offset holes. For a given geometry, the routines determine the appropriate correction factor by interpolating over the relevant solution space that includes both finite-width and hole-offset effects. These new correction factors provide improved CC16 solutions for pin-loading that are usually within 10% of benchmark stress intensity factor solutions, as evaluated by a matrix of 162 benchmark K-solutions from 3D finite element models with explicitly meshed crack fronts.

The user should be aware that these revised pin-loaded CC16 solutions in finite width plates will give different values in version 8.1 when compared to v7.1x, and earlier versions. *For analyses that are predominately pin loaded with "narrow" plates, predicted lives could be much less than obtained in previous versions of NASGRO.* Additional details on the development and verification of the CC16 finite width correction factor for pin loading are provided in Appendix C of the User's Manual.

- **New Pin Load Capability for CC08 and SC18:**

  Pin loads (bearing stresses) can now be accommodated for these univariant WF models for a corner crack and a surface crack at an offset hole in a plate.

- **Expanded Geometry Ranges for Selected Models:**

  - **CC08:** D/t and a/t ranges increased to be similar to CC16.

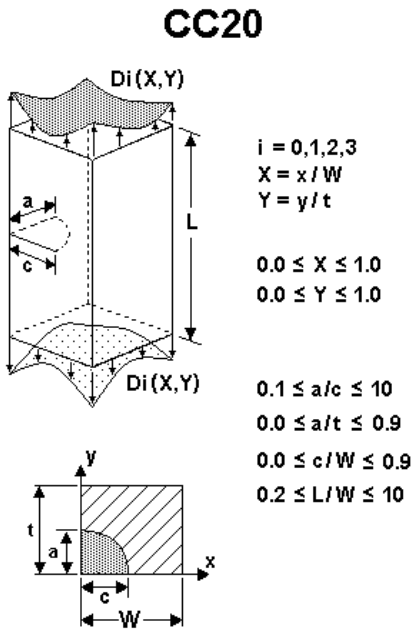
  - **EC05:** geometry limits expanded to be consistent with EC02.

  - **CC08 & TC13:** solution enhanced to permit crack to be on long ligament side of hole. A checkbox now appears on the geometry screen to allow the user to specify that the crack is located on the long ligament side of the hole. The crack located on the short ligament side is the default.

  - **TC13:** geometry limits expanded such that now:
    $0.01 \leq 2B/W \leq 1.0$
    $0.01 \leq D/2/B \leq 0.9$

- **CC20 – New Displacement-Controlled Corner Crack Solution**

  This displacement-controlled model was developed for inclusion in NASGRO by NLR under funding by ESA. The solutions were developed using a very large matrix of detailed finite element models. The model was verified using handbook solutions and independent finite element models.



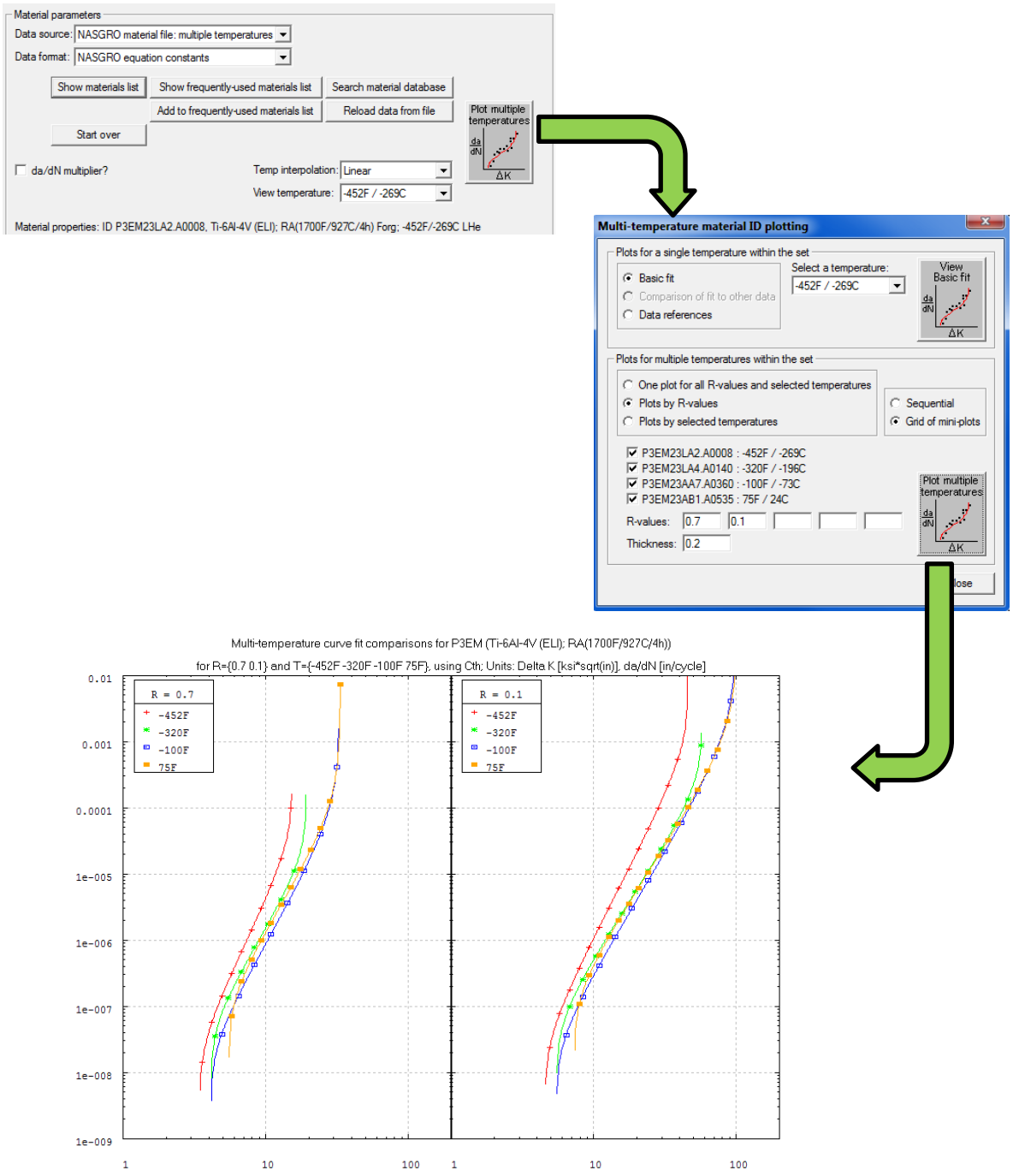
- **Superseded Models:**

  The following crack cases have been moved to the "superseded solutions" group:
  - SC17 – (use SC30 instead)
  - SC19 – (use SC31 instead)

  These models may still be used but are no longer recommended. They are being retained in the "superseded solutions" group for historical and comparative purposes.

Plotting of Multi-Temperature da/dN Equation Fits in NASFLA:

- It is now possible to plot NASGRO equation fits for entries in the NASGRO and User multiple temperature material files. For any one temperature within the chosen data set, you can compare the fit to its underlying test data or to other similar data. For more than one temperature within the set, it is now possible to compare the fits for the different temperatures at user-supplied R-values. A plotting tool is activated when clicking on the "Plot multiple temperatures" button on the material input page and provides three options for generating multi-temperature plots. An example is shown below for a case of four temperatures and two R values:



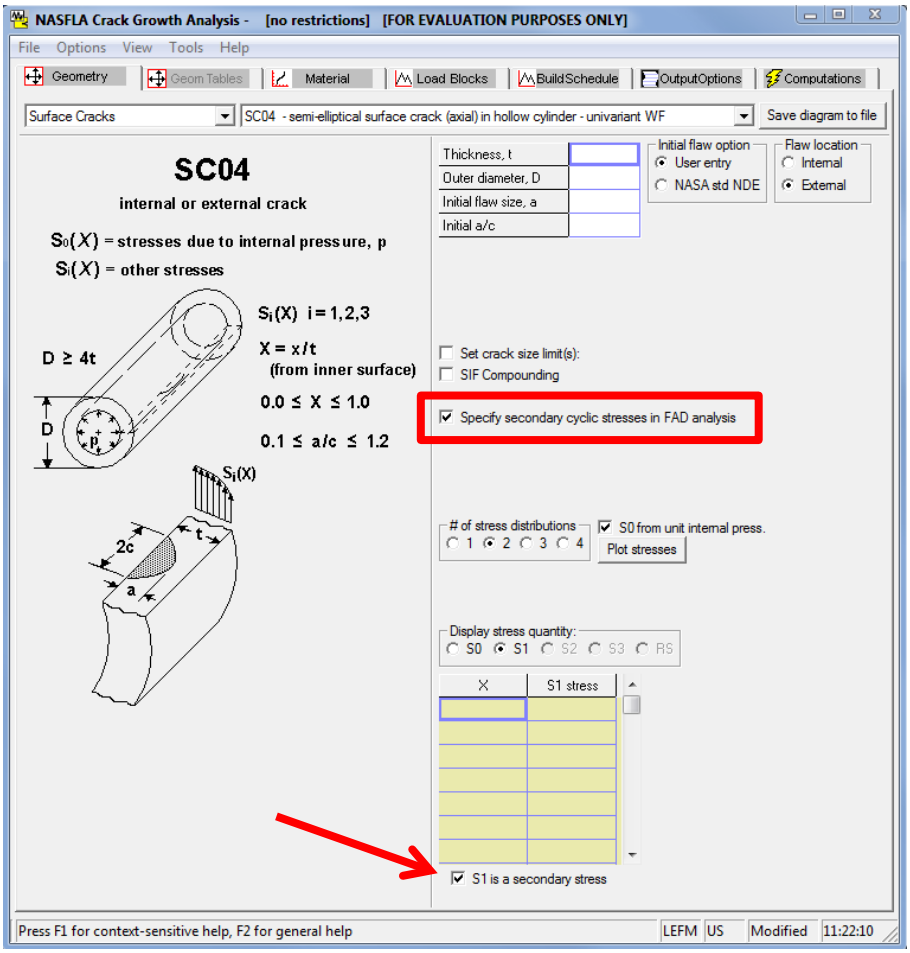
Failure Assessment Diagram (FAD) Improvements:

- Limit load solutions and FAD capability were added for the following SIF models:
  - TC07 - axial through crack in a cylinder
  - TC08 - circumferential through crack in a cylinder
  - SC06 - constant depth circumferential (internal or external) crack in cylinder
  - TC06 - through crack in a sphere

- The FAD diagram plotted by the NASFLA GUI can now accommodate crack transitions between models if they occur during the course of the analysis.

- Proper handling of secondary stresses in FADs has been implemented. For crack cases that are capable of producing a FAD, a checkbox appears on the geometry screen allowing the user to "Specify secondary cyclic stresses in FAD analysis" as shown below using SC04 as an example. In this example S0 would be the hoop stress from an internal pressure (primary stress) and S1 would be a secondary stress. Note that the check box below the S1 stress input grid has been checked to indicate that S1 is a secondary stress and the grid color for S1 has been changed to goldenrod signifying a secondary stress input.

- Appendix X has been updated to describe these FAD improvements.



New NASFLA Features and Improvements:

- The inverse calculation schemes in NASFLA have been overhauled for improved robustness (calculation of initial flaw size for a target life and calculation of a stress scale factor multiplier for a target life). The new scheme utilizes a two-stage bisection/Pegasus iteration procedure and does not require input of an estimated solution. These new methods are more robust and generally much faster than those used previously. The output format describing the results and the iteration process have also been improved.

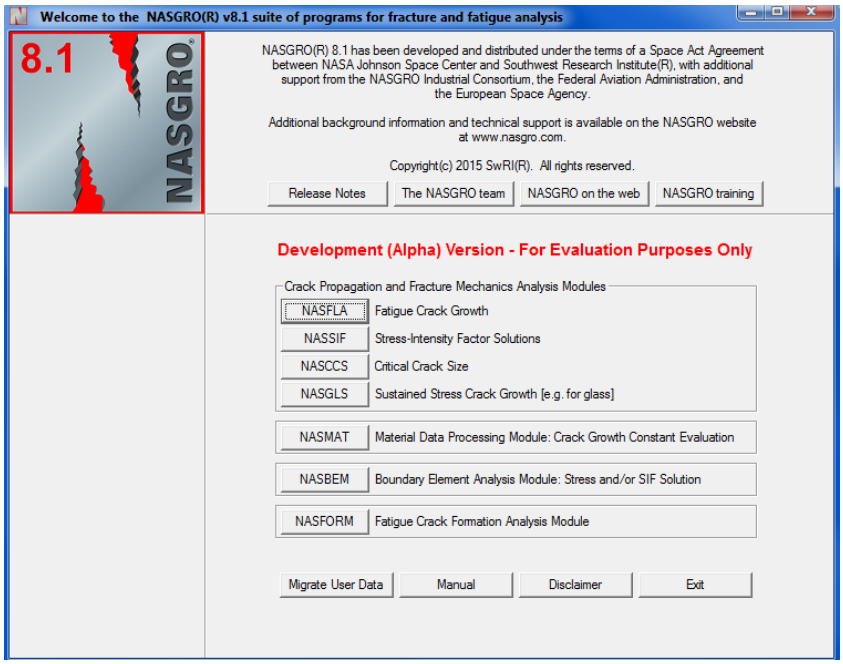
- Enhanced keyword searching capability for the new XML materials database enabling "and/or" choices using two keywords via the existing "Search material database" feature on the Material screen.

- It is now possible to compare NASFLA-supplied and User-supplied material data using the "Compare two IDs" button on the material screen. Previously, only two NASA database materials could be compared.

- The transition between CC10 to TC13 has been documented in the User's Manual (Appendix D). The bivariant stress variation that the user specifies for CC10 is converted to a univariant stress variation in the c-direction for TC13 using an integration (averaging) scheme over the net section.

- The alternate threshold model using Fth in NASFLA was updated to be consistent with NASMAT for R < -1.

- The functionality and layout of the main opening screen of NASGRO has been redesigned as shown below so that all buttons to access all GUIs are now accessible at once, removing the need for the user to first make radiobox selections before being able to access specific GUIs.:



- A number of new and/or modified pop-up notes have been added to the NASFLA and other GUIs to provide guidance and recommendations for users in regards to choices of crack cases. New pop-up notes were added for TC04, CC03 and SC12 recommending the use of TC27, CC19 and SC32 instead, respectively.

Additions (NASCCS):

- Stress intensity factor models TC27, CC16, CC19 and SC32 have been added to NASCCS.

- Negative pin load options have been added to all models in NASCCS that can accept pin loads (bearing stresses).

Additional New Items, Changes and Fixes by NASGRO Module for v8.1 Alpha

	Applicable NASGRO Module										
Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
New			X							X	Implemented transiton capabilities caused by local ligament failure for crack cases CC02, CC04, CC08, CC10, CC15, CC16, CC17, and HC01. Modified the capabilities for TC23. Documented the capabilities for these crack cases in Appendix D.
New			X	X	X	X					Crack cases CC03, CC19, SC12: Added informative popup messages.
New			X								Crack cases CC08, SC18: Added the "Negative Pin Load" option.
New			X								Crack cases SC06, TC06, TC07, TC08: Alternative Failure Criteria analysis options have been added.
New			X	X	X	X					Crack cases CC08, TC13: A new option "Crack in long ligament" has been added, allowing the user to select the initial flaw location to now be on either side of the hole.
New			X								When loading an input file, if the values for any material parameters differ in the input file from those stored in the material database, the message window that is displayed will now list those parameter names specifically, along with both their input and material database values.
New			X								Added the ability to obtain equivalent values of the threshold variables, DK1f, Fth & Fth- when user-determined values of DK1, Cth & Cth- are entered, and vice-versa.
New									X		Modified the NASFORM output file to now include total and plastic strain amplitudes calculated in a strain-life computation.
Change			X								Improved user-specified crack size limit capabilities to handle the situation where the user-specified crack size limit is larger than the solution limit for all the crack cases with transition capabilities.
Change			X								Modified code to print number of cycles in integer to the out1 file.
Change										X	Revised the formulas for pin load conversion in TC03-to-TC02 transition in Appendix D.
Change			X								Changed functioning of the "0 throughout" option, the default for threhold fanning exponent in the material tab, retaining the input cell value (either transferred from file or entered by user) of Cth- throughout the calculation instead of changing it to zero. This was done to avoid the slight elevation of threshold that occurred when the small positive value of Cth- (in the NASGRO database) was changed to zero.
Change			X				X				Extended the lower limit of the range of minimization for determining Fth- to Rp, the negative value of R corresponding to the peak (which the code transforms into a plateau) in the formula for the Cth- based threshold. Extending the limit was done to improve the correspondence between Cth- and Fth- based thresholds for values of R < -2, and Fth- values for all materials in the NASFLA database were modified to reflect this change.
Change										X	Added figures for TC27, CC19, CC20 & SC32, and updated Table 6a. Updated figures for TC13, CC08 and EC05.
Change										X	Appendix C: Added sections for crack cases TC27, CC19, CC20 & SC32. Also added sections (for previously introduced) crack cases SC30 & SC31, and paragraphs for SC17 & SC19.
Change										X	Appendix Q: Changed threshold values for the following material IDs: M2IFB1AB1, M2UA31AB1, Q3EA10AA14, Q3EA10AA18 & R3AB18AB1, reflecting materials files changes made to avoid negative values for the threshold fanning exponent.
Change			X							X	Made the following changes to the following NASA materials: Single temperature NASA material file: - M2IFB1AB1: changed DK1 from 1.1 to 1.0, Cth from -0.36 to 0.0, DK1f from 1.04 to 1.0, Fth from -0.24 to 0.0; - M2UA31AB1: changed DK1 from 1.02 to 0.8, Cth from -0.5 to 0.0, DK1f from 0.94 to 0.8, Fth from -0.33 to 0.0; - Q3EA10AA14: changed Cth from -0.02 to 0.0, Fth from -0.01 to 0.0; - Q3EA10AA18: changed Cth from -0.02 to 0.0, Fth from -0.01 to 0.0; - R3AB18AB1: changed Cth from -0.02 to 0.0, Fth from -0.01 to 0.0; Multi-temperature NASA material file: - M2IFB1AB1.C0535: changed DK1 from 1.1 to 1.0, Cth from -0.36 to 0.0, DK1f from 1.04 to 1.0, Fth from -0.24 to 0.0; - Q3EA10AA14.A1060: changed Cth from -0.02 to 0.0, Fth from -0.01 to 0.0; - Q3EA10AA18.A1460: changed Cth from -0.02 to 0.0, Fth from -0.01 to 0.0;
Change			X								Added error checking to prevent the selection of a long block file on the NASFLA GUI Load Blocks tab from being run if the file is empty. Previously, an empty file could be selected and run. Now, an existing file that is selecetd is also checked to see if it is empty, and if so, a GUI error is returned, properly preventing an analysis.

Additional New Items, Changes and Fixes by NASGRO Module for v8.1 Alpha

	Applicable NASGRO Module										
Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
Change			X	X							Crack cases: TC14, TC24: - Changed the grid labels on the Gemoetry tab for entering tabular displacement values from "S0, S1", etc. to "D0, D1", etc. to more clearly indicate that these are displacement values, not stress values. - Changed SIF Compounding grid labels on the Geom Tables tab from "c/D1" to "c/DD" for the normalizing parameter, and "CF for S0", "CF for S1", etc. to "CF for D0", CF for D1", etc. for the entered displacement values. - Updated all error message text to refer to "D0", etc., instead of "S0", etc.; and for the normalizing parameter: "DD" instead of "D1".
Change			X								Material database search results are now sorted in alphabetical order by material ID, for both single and multitemperature material searches. Previously, search results were presented in the order in which they were located in the material file, which is not guaranteed to be in ID order.
Change			X	X	X	X					Crack cases SC11, SC12: The displayed bitmap is now dynamic, based on the "# of flaws" selected.
Change						X					Changed the NASGLS GUI default title text from "NASGLS da/dt Analysis" to "NASGLS Sustained Stress Crack Growth Analysis".
Change			X	X	X	X					Added a new link to each GUI's "Help" menu, for accessing the SwRI/NASGRO training course website. This menu item can also be accessed by using the keyboard shortcut: "Ctrl + T".
Change			X	X	X	X					On startup, all GUIs will now begin with user-control set to the "Geometry Choices" dropdown box.
Change			X	X	X	X					Crack case CC08: Expanded the following solution requirements: - "0.25 <= D/2t <= 2" changed to "0.1 <= D/2t <= 10"; - "a/c >= 0.5" changed to "a/c >= 0.1".
Change			X	X	X	X					Crack case EC05: the geometry limits have been expanded to match those of crack case EC02.
Fix			X								Saving the input file after modifying either the stress scale factors or the limit stresses on the Load Blocks tab would revert the stress scale factors and limit stress values back to their previous values.
Fix							X				When plotting new data from the 'Enter da/dN Delta K' tab, data from one R-value would get overwritten onto another R-value, resulting in incorrect plots and corrupting the grid data.
Fix			X								Crack cases SC17, SC18, SC26, SC27, SC28, SC32: When using the parameter analysis grid and doing multiruns, the symmetry flag that is written to all runs' batchfiles was determined by the current configuration of the Geometry tab, which applies only to the first run. This was causing potential problems for runs 2 and higher, if those higher runs' symmetry status differed from that of the first run. The batchfile will now be written with the proper symmetry flag for each multirun by looking at the geometry values in the parameter analysis grid itself to determine symmetry, and not the Geometry tab.
Fix			X								When changing the data source to 'new data' on the Materials tab, previous values for Cth and Fth would be retained.
Fix			X								When selecting a custom user file on the Materials tab, the listing of available material IDs would not be updated and thus would only display materials in the default user file.
Fix			X								Crack case TC11: The FAD diagram would not plot when selecting 'Plot FAD' from the Computations tab.
Fix			X								Crack case TC12: The Kr(c) data was missing from the computation output and the FAD diagram would not plot when selecting 'Plot FAD' from the Computations tab.
Fix			X								Misleading crack tip description during transition from TC11 to TC12. Inconsistent crack tip description with the two crack tips of TC11 was found and corrected where a- and c-tips were used instead of c- and c1-tips as shown in GUI bitmap.
Fix			X								Disabling the Failure Criteria 'Net Section Stress' checkbox would not save properly to input file and would re-enable upon loading the input file, and the FAD checkbox values were not being saved to the input file when multi-temperature data was selected.
Fix				X							NASSIF did not validate the c or c1 values against the solutions's geometric limits, despite being able to derive those values from entered values of a/c and c, or c/c1 and c.
Fix			X								When viewing multi-temperature data in units differing from those stored in the material file, every time a temperature was selected the data would be treated as if it were unconverted and reconverted again.
Fix					X						Any data entered on the Output Options or Load Blocks tabs that triggered a GUI error message, such as non-numeric data in a numeric field, would prevent computation from succeeding even after the error was corrected or if a correct input file was loaded.
Fix			X								Fixed an error in calculation of stress intensity factors caused by limit stresses at a1-tip and c1-tip for crack case CC17.
Fix			X								Corrected a problem in load type setting for TC23-to-TC19 transition, which can result in incorrect fatigue life calculation after transition. Resumed c/c1 data printing in floating point format to the out2 file for TC23.

Additional New Items, Changes and Fixes by NASGRO Module for v8.1 Alpha

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Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
Fix			X								Loading an input file with a custom user file which cannot be found at that location or by that name causes NASFLA to crash.
Fix			X								Corrected an error in passing user's crack size for computing the number of cycles specified for the original crack model to the post-transition model in CC10-to-TC13 transition.
Fix			X								Fixed an error in handling flat load steps (with zero amplitude) in load spectrum, which can result in incorrect fatigue life if the load spectrum contains flat load steps.
Fix			X	X	X					X	Enhanced net section stress calculation for SC05 internal crack to handle large crack with the angle of crack front arc larger than 90 degrees. Updated Appendix B accordingly.
Fix			X								Crack cases CC08, SC18: When tension, bend is selected along with 'Automatic' shakedown, an incorrect value for residual stress is written to the batchfile causing computation to terminate with a DLL error.
Fix				X							Crack cases TC13, CC08, SC18: When residual stress is selected, switching from 'tension, bend, pinload' to 'user input' and then back will erroneously uncheck the residual stress checkbox and hide the residual stress grid.
Fix			X								When plotting FAD data and saving it to text file, the text file values are incorrect
Fix							X				When performing a Walker or Spline fit, NASMAT will erroneously generate an error message about the alpha and Smax/Sig0 values.
Fix						X					Crack case TC11 would not complete analysis due to errors in both the generated batchfile and the DLL parsing of the batchfile.

NASGRO v8.1 Beta Release Notes

- **Revised CC16 and CC17 Finite Width Correction Factors for Pin Loading:**

NASGRO Version 8.0f included a significant revision to the finite width correction factors for crack case CC16 (corner crack at a hole) under pin loading. It had been discovered that the original finite width correction factors for pin loading could give stress intensity factor (SIF) values that were too low under some conditions. NASGRO Version 8.1 Alpha included a second revision to these CC16 correction factors that reduced some unnecessary over-conservatism for holes that were significantly off-center in the plate. (Refer back to page 2 of these notes.)

Note that changes to CC16 also affect the HC01 hybrid crack case (corner crack and through crack at offset hole). HC01 performs internal calls to CC16. Therefore, computations involving HC01 in 8.1 Alpha and 8.1 Beta may give different results from computations in 8.0f and earlier, depending on the specific geometry.

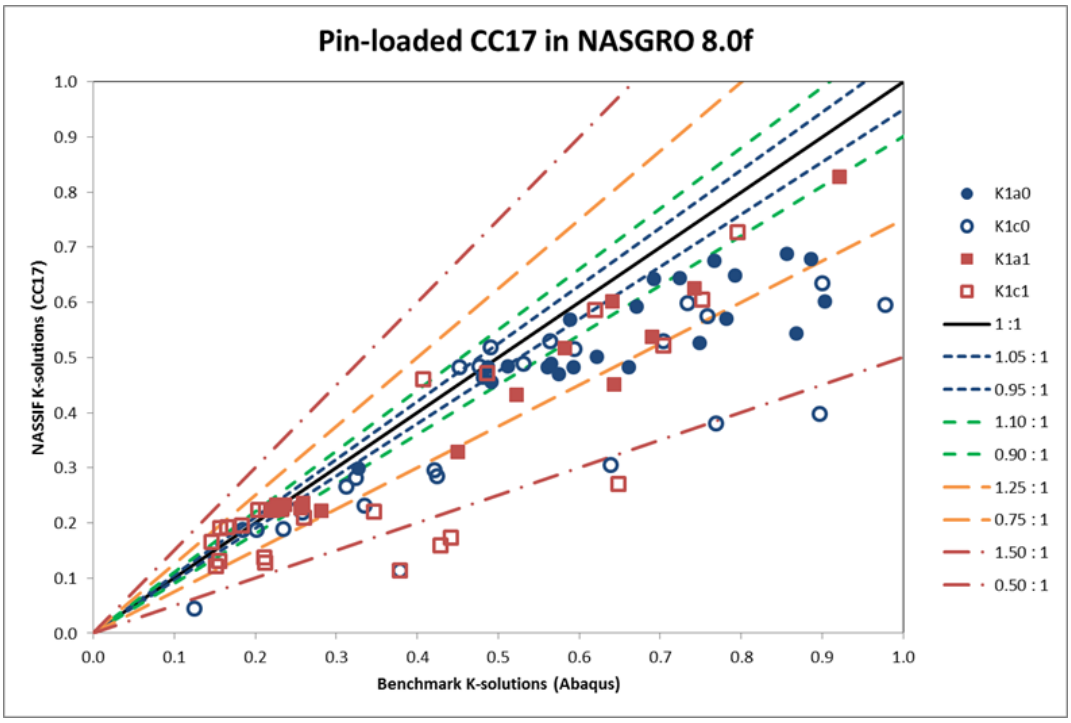
Study of the finite width correction factors for crack case CC17 (two unequal corner cracks at a hole) under pin loading found related problems. Again, the SIFs could be too low under some conditions. However, since the CC17 crack case is much more complex and employs a much larger database of solutions than the CC16 crack case, resolution of these issues required extensive additional investigation.

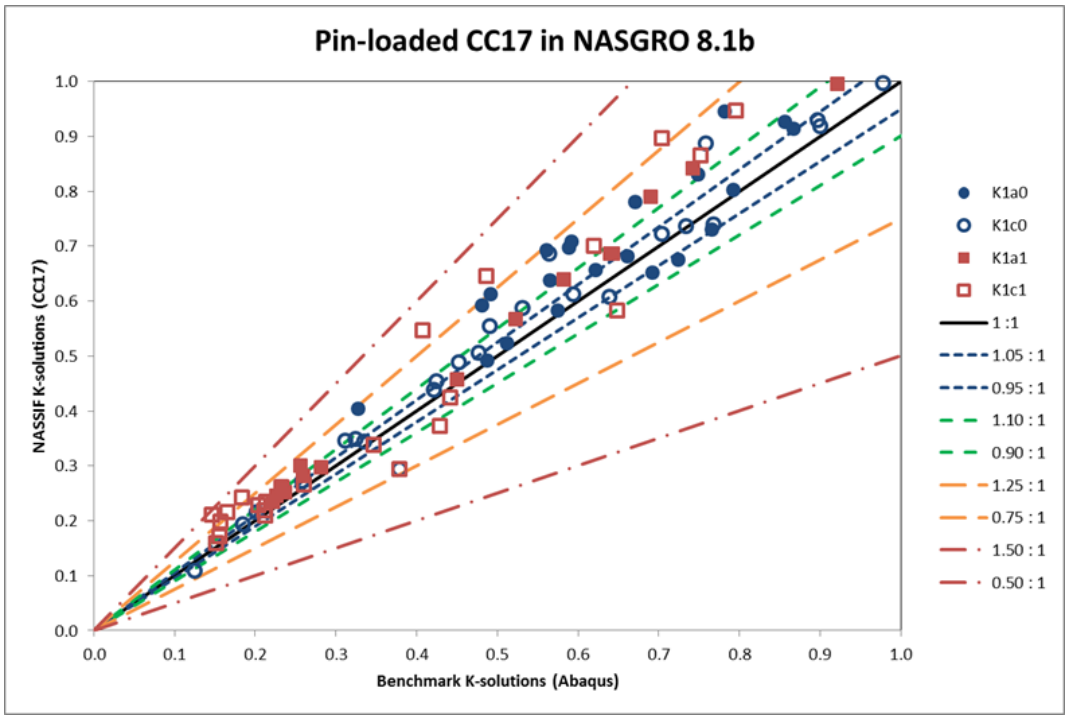
During the process of these CC17 investigations, a minor bug was found in the second revision (8.1a) to the CC16 correction factors. This bug only affected cracks on the long ligament side of plates with offset holes. Fixing this bug further improved the accuracy of the CC16 finite width correction factor for pin loading. This bug fix is being released in NASGRO Version 8.1 Beta.

An improved finite width correction factor for CC17 under pin loading has now been developed, and this new correction factor is being released for the first time in Version 8.1b. The new correction factor appears to provide excellent accuracy for a wide range of geometries, generally better than 10-15%. Errors can be slightly larger for some extreme geometries, including very large cracks, or very small cracks in very thick plates (very small D/t ratios). The inaccuracies (when they occur) are generally conservative (predicted SIFs slightly too high). Further details are available in Appendix C.

Comparisons of the CC17 solutions in Versions 8.0f and 8.1b against benchmark 3D finite element analyses are provided in the graphs below. Shown are the SIF solutions for both corner cracks (subscripts 0 and 1) at both the “a” and “c” tips. It must be emphasized that many of the verification geometries were intentionally selected to be extreme cases. Both the old and new CC17 solutions give excellent results for many configurations with wider plates and smaller cracks. Nevertheless, there was clearly a need for an improved correction factor, and so we have taken the unusual step of releasing this significant change in a Beta version to ensure that it reaches our users as soon as possible.

It should also be emphasized that these revisions affect ONLY CC16, HC01, and CC17 solutions for pin loading (not solutions for remote tension or bend loading) and only involve the finite width correction factors. *However, for models that are predominantly pin loaded with “narrow” plates, predicted lives in 8.1b using CC17 could be significantly lower than those obtained in previous versions of NASGRO.*


Pin-loaded CC17 in NASGRO 8.0f
NASSIF K-solutions (CC17)
Benchmark K-solutions (Abaqus)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
K1a0
K1c0
K1a1
K1c1
1 :1
1.05 : 1
0.95 : 1
1.10 : 1
0.90 : 1
1.25 : 1
0.75 : 1
1.50 : 1
0.50 : 1


Pin-loaded CC17 in NASGRO 8.1b
NASSIF K-solutions (CC17)
Benchmark K-solutions (Abaqus)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
K1a0
K1c0
K1a1
K1c1
1 :1
1.05 : 1
0.95 : 1
1.10 : 1
0.90 : 1
1.25 : 1
0.75 : 1
1.50 : 1
0.50 : 1

- **New Pin Load Capability for CC08 (revised from 8.1 Alpha):**

A new capability for pin loading was added to crack case CC08 (corner crack in plate) in NASGRO Version 8.1 Alpha. Previously, CC08 only supported remote tensile loading, remote bending, or user-provided crack plane stresses. The original verification of CC08 with pin-loading showed these new stress intensity factor solutions were consistently higher than benchmark finite element solutions. Improved agreement between CC08 and benchmark values was obtained by reducing the stresses input to the CC08 weight function by 5%, i.e., multiplying pin-loaded stresses for CC08 by a factor of 0.95. It was originally intended to implement CC08 with this small correction factor, but it was accidentally not included in NASGRO Version 8.1 Alpha. This correction factor has been added to NASGRO Version 8.1 Beta. It reduces the magnitude of pin-loaded CC08 stress intensity factors by 5% compared to NASGRO 8.1a and improves the overall accuracy of the solution.

- **New Features Added to NASCCS:**

In the past, the critical crack size module (NASCCS) has been missing several features that are routinely available in the NASFLA and NASSIF modules for weight function (WF) solutions. In NASGRO 8.1b, many of these missing features have been added to NASCCS for a selection of the most commonly used weight function solutions. The new capabilities now available in NASCCS include the following:

- The user can input stress distributions from files for univariant WF solutions (this capability was already available in NASCCS for bivariant WF crack cases)
- The user can input and use a residual stress distribution (which will be superimposed with the fatigue stress distribution), either via file, or via the tabular grid in the GUI
- The user can invoke and use optimum point spacing (OPS) for stress distributions
- The user can generate plots of the stress distributions in the GUI via the usual "plot stresses" button

The crack cases thus enhanced are SC18, SC30, SC31, SC32, EC04, EC05, CC08, CC09, CC10, CC11, CC12, CC19, TC11, TC12, TC13, and TC27.

- **Modification to Generalized Willenborg Model (Calculation of ΔK_{th}):**

The applied stress ratio is now used directly in the computation of ΔK_{th} within the Generalized Willenborg model eliminating an error present in the previous iterative scheme and bringing the model more nearly in line with the original intentions of the developers of the Generalized Willenborg model. In earlier versions of NASGRO, ΔK_{th}, itself being a function of R, had been obtained using an iterative predictor-corrector procedure used to obtain R_{eff} . This iterative procedure has now been removed in v8.1. A description was added in Section 2.1.7.1 of the user manual. The net effect of these changes on calculated life was found to be about a five percent reduction in life in some cases. In other cases little or no difference in life was noted; however, the difference will be spectrum dependent.

Additional New Items, Changes and Fixes by NASGRO Module for v8.1 Beta

	Applicable NASGRO Module										
Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
New					X						Crack Cases SC18, SC30, SC31, SC32, EC04, EC05, CC08, CC09, CC10, CC11, CC12, CC19, TC11, TC12,TC13,TC27 now support residual stress, stress input from files, OPS, and can plot the selected stresses.
New						X					Crack case SC30 has been added to NASGLS and is implemented for symmetric loadings only since NASGLS is unable to support 3DOF cracks.
Change			X								The current method of comparing input file and database material parameter values when a NASFLA input file is loaded has been improved. Previously, the comparison used the literal string values for the comparison, such that, in the popup message that allows the user to select either input file values or material database values to be used in the analysis, every difference was listed, including numerically identical entries (e.g. "0" and "0.0") which aren't actual differences. Now, the numeric values are compared, so that only actual differences will be listed. Additionally, a tolerance range of + or - 0.01% is used, so extremely close values won't be listed (but will still be loaded if the user selects "use input file values"), and any differences in the Threhsold Fanning Exponent set that is not used in the analysis will not be listed: If "Cth" is chosen, any differences in the parameters DK1f, Fth, Fthm would not be listed; and if "Fth" is selected, any differences in DK1, Cth, Cthm would also not be listed.
Change						X					Crack case SC17: The asymmetrical case will now be disallowed in NASGLS due to the inability of NASGLS to support 3DOF or 4DOF cracks.
Change						X					Crack case SC19: This crack case has been removed from NASGLS due to the inability of NASGLS to support 3DOF or 4DOF cracks.
Change						X					Crack case EC02: This crack case has been removed from NASGLS due to the unavailability of the solution. As this was the only crack case previously available in the category "Embedded Cracks", the entire crack category has been removed from NASGLS.
Change			X							X	Subroutines implementing a recursive iterative scheme to calculate Reff in the generalized Willenborg and Strip Yield models involving the factor phi were annulled, eliminationg a small error, and bringing the models more nearly in line with the original intentions of the authors. A description was added in Section 2.1.7.1 of the user manual.
Change										X	Added a description (to Appendix C) of the multiplier used to modify stress-intensity factor range to indirectly modify growth rate for crack cases like TC01 in the combined presence of sign-dependent stress quantitities like S0 and sign-independent stress quantities like S1.
Change										X	Appendix G: Note on abbreviations VAR and VIM were added to Table G3
Change										X	Appendix Q: Constants for M7TF12AB1 were changed, reflective of changes made in v7.1
Fix							X				Formatting error in legend for Walker model plots.
Fix			X								On the Materials tab with the Generalized Willenborg load interaction model selected, it was not possible to plot the da/Dn data via the "View Basic Fit" button.
Fix				X	X						Incorrect out-of-bound error message for offset SC19 cracks. The GUI correctly identifies the error and stops further computation. However, when users compute SIFs using NASGRO DLL in batch mode, the DLL issues a misleading error message when encountering out-of-solution bounds. The same fix has been applied to SC31 crack model.
Fix			X	X	X						Error from different point spacing along y-direction with adjacent x-coordinates need to be identified in DLL. Up to v8.1a, DLL allows the bivariant stress field with such inconsistency to proceed. A check has been implemented to terminate the analysis if this scenario is encountered.
Fix			X	X	X						Crack cases SC19, SC31: When attempting computation with the OPS checkbox enabled, the GUI generated an erroenous error message stating that the stress points were not equally spaced, blocking computation.
Fix						X					SC17 NASGLS analysis with unsymmetric geometry gives DLL error. Both 3D and 4D crack configurations are not supported in NASGLS analysis. The fix provides a clear error message to terminate the computation.
Fix						X					CC08 NASGLS with user input stress not working. The error was from mismatching data lines in GLSBAT batch files as a result of new short/long ligament feature introduced in v8.1a NASFLA and NASSIF. The fix excludes the switch for the short/long ligament in the batch file.
Fix						X					CC08 NASGLS subjected to tension, bending and pin loading not working. Simiar to bug report #1998, the error was from mismatching data lines in GLSBAT batch files. The fix excludes the switch for the short/long ligament in the batcfh file.
Fix						X					Crack cases SC17, SC19: When selecting either SC17 or SC19, a pop-up would generate erroneously referring the user to crack cases SC30 and SC31 which did not exist in NASGLS.
Fix						X					EC02 NASGLS subjected to remote tension and bend resulting in run-time error. The computational engine with 4DOFs of a EC02 crack was not implemented for NASGLS analysis. The fix provides a clear error message to terminate the computation.
Fix						X					TC13 NASGLS subjected to user-specified stress gradients does not produce any result. The error was from mismatching data lines in GLSBAT batch files as a result of new short/long ligament feature introduced in v8.1a. The fix excludes the switch for the short/long ligament in the batch file.

Additional New Items, Changes and Fixes by NASGRO Module for v8.1 Beta

	Applicable NASGRO Module										
Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
Fix						X					Remote tension, bend and pin-loaded TC13 NASGLS analysis does not produce any result. The error was from mismatching data lines in GLSBAT batch files. The fix excludes the switch for the short/long ligament in the batcfh file.
Fix			X								An incorrect conversion formula for the Walker material parameter "C", which caused a problem when converting from US to Metric units in the NASFLA GUI for Walker materials, has been corrected.
Fix				X	X						Large crack size in NASSIF resulting in crack transition message printed in SCREEN.OUT files. The update disables invoking any crack transtion in NASSIF analysis mode.
Fix			X								The material B6CB10AB1 would not plot via the "View Fit" button on the Material tab.
Fix						X					Resolved the problem which caused the program to crash when running NASGLS for crack cases DT01, DT02, and DT03.
Fix						X					Corrected the typo in printing crack size labels in the out1 file for crack cases TC11 and BE02 in NASGLS module.
Fix						X					Modified code to print the final results, which were missing in the previous versions, to the out1 file for crack case SC06 when crack size reached the crack size limit.
Fix						X					Skipped net section yield (NSY) check and environment crack growth threshould (Keac) check in NASGLS module since these checks are irrelevent.
Fix						X					Crack case SC07 would generate a Fortran error when attempting computation.
Fix			X	X	X						CC16 NASSIF GUI issues pop-up Fortran error indicating two few data for interpolation. Error was found in the interpolation routine for the determination of correction factors for CC16. The new update fixes such an error.
Fix			X								When using the Generalized Willenborg load interaction model on the Material tab, the value of "DK1" would not update properly when switching between material IDs, nor would it properly reload from file.
Fix										X	Updated Appendix C for crack case HC01: 1) changed the lower limit of c/c1 from 0.1 to 0.01; 2) updated the three verification figures to include the additional verification done after v7.1 Beta for very low c/c1 values (from 0.1 down to 0.01) and for very large (R+c1)/B1 value (0.95).
Fix			X	X							Corrected a typo in printing the lower c/c1 limit in the final results for crack case HC01, changing it from 0.1 to 0.01.
Fix			X	X	X	X					Set crack size limit to 0.85t for crack case SC06.
Fix				X							Crack case HC01 would erroneously fail run-time geometry checking, generating a pop-up message claiming "a" or "c" was outside the geometric limits of the problem.
Fix			X	X	X						Divergent EC05 SIF behavior when crack length approaches to a tiny value. A numerical accuracy issue was identified in some of the analytical forms derived for pre-integration that might diverge as the crack length approaches zero. These analytical forms were re-formulated to circumvent such an erroneous behavior.
Fix			X	X	X						Recent FEA verification resulting an update for correction factor routines used by pin-loaded CC16 SIF solutions.
Fix			X	X	X						Pin-loading stresses for CC08 need to have a 0.95 factor applied to them to improve accuracy. This factor is only for CC08 stresses and only for pin-loading. Reduction applied to cracks on both long and short ligaments. This factor was inadvertently omitted from 8.1a.
Fix			X	X							A new finite width correction factor for CC17 under pin loading has now been developed and implemented. This improves upon the solution in v8.1alpha (and earlier), particularly for narrow plates.
Fix					X						Crack cases SC19, SC31: NASCCS was not performing a check to ensure all geometric information had been entered and was numeric prior to computation.

Additional New Items, Changes and Fixes by NASGRO Module for v8.1 Final

	Applicable NASGRO Module										
Category	**NASGRO Main**	**Config Control**	**NASFLA**	**NASSIF**	**NASCCS**	**NASGLS**	**NASMAT**	**NASBEM**	**NASFORM**	**Users Manual**	**Description**
New						X					Aluminum Oxynitride (ALON) material properties added to NASGLS material files.
New	X		X	X	X	X	X	X	X		New license file and license security scheme now uses Flexnet.
New			X	X	X						Crack cases TC27, CC19: Added capability for two equal, symmetric cracks in a straight lug.
Change						X					Crack cases SC08, SC09, SC10, SC12, SC13, SC14, SC15, SC17, BE02, BE03, CC03, CC05, CC07,and TC04 were removed from NASGLS
Change			X								The capability to run inverse mode calculations in combination with parametric analyses was disabled pending further review of the appropriateness of this combination of options.
Fix			X								NASFLA would erroneously issue a "material selection incomplete" run-time error when switching between unit types with a material already selected.
Fix			X								Pasting data into the block spectrum grids would generate an erroneous run-time error stating some grid cells were empty.
Fix			X	X	X						Unknown issue resulting in software crash when NASGRO static library linked within client's software environment. It was found the pointer size used by the API functions was inconsistent for Linux 64 bit environment. This bug only affected the Linux 64-bit version of NASGRO release.
Fix			X								NASFLA was not properly validating multi-temperature data sets to ensure the number of temperatures and R-values fell within the program limits. NASFLA will now inform the user when a temperature set contains too many temperatures or R-values.
Fix			X								The input boxes for "Smax/Flow" and "alpha" on the material tab no longer display default values when selecting "new data".
Fix			X								Crack case CC08: The batchfile created when using an existing full tensor stress file was not being generated correctly, blocking computation.
Fix			X								CC19 NASFLA computation with computing cycles to specific crack sizes was not working. The error was fixed in the routine that handled displaying cycles where transition scenario from CC19 to TC27 was not correctly addressed.
Fix			X								CC19 NASFLA analysis was not working with Chang-Willenborg load interaction model. A fix was deployed to include CC19 crack model in the routine to compute plastic zone size used by Chang-Willenborg load interaction model.
Fix			X								CC19 NASFLA computation involving usage of strip yield model terminates with an error. The error was rectified by providing the definition of reference thickness for CC19 utilized by the strip yield interactive model.
Fix						X					Enabled and improved printing of transition messages to the output file for all the crack cases in NASGLS module with transition capabilities implemented.
Fix						X					Crack Case: SS05: The geometry check for "3W < L < 6W" was incorrectly displaying "3W < S < 6W" when triggered.
Fix			X								Crack Case CC11: NASFLA was not properly writing the flags for primary and secondary stresses to the batchfile in cases were tension/compression was selected, blocking computation.
Fix					X						NASCCS analysis for CC19 was not working. An erroneous statement used to exclude certain crack models for NASCCS analysis was identified, which ended in terminating the computation. The typo was corrected.
Fix			X	X	X						NASFLA analysis for SC31 crack model subjected to bivariant stress and with enabled OPS throws error on screen while not indicated in SCREEN.OUT. The termination of computation was found because of exceeding the preset maximum number of OPS contour lines. The update inceases this preset number and it is the same preset defined in the OPS routines provided to GUI.
Fix				X	X						Crack Case SC04: The tabular stress table was plotting incorrectly when the Stress S0 box was unchecked, due to a malformed batchfile.
Fix			X								Switching beween crack cases was incorrectly hiding the "Similitude model" radiobox on the Materials tab when Strip Yield was selected.
Fix			X	X	X						Strange SC30 SIF results for nearly stepwise stress gradient at the crack initiation site. The erroneous behavior was identified as a result of very small point spacing. This led to numerical accuracy problems. Revising the pre-integration formulation resolved the issue.