DARWIN® 9.2 Release Notes

June 2019
Southwest Research Institute®

Summary of New Capabilities

DARWIN 9.2 includes the following new features:
- 2D/3D Surface Autozoning
- Dhondt Fatigue Crack Growth Model
- El Haddad Small Crack Model
- Life/Risk Contour Fracture Plates Visualization
- Location-Specific POD Curves
- Restart Using Intermediate Fracture Plates
- Autoplate Speed/Robustness Improvements
- GUI Node Selection Speed Improvement
- 3D GUI Visualization Enhancements
- Hot Corrosion Enhancements
- Shakedown Enhancement for 1D Geometry Mode
- Mission Scaling Enhancements
- Crack Size Termination Criterion Enhancement
- Bivariant Plate Enhancement
- Fleet Risk Module Enhancement
- 3D Anomalies Enhancements
- Production Inspections on Non-Hoop Planes
- Direct Import of ANSYS and ABAQUS Load Step Times
- GUI File Access Speed Enhancement
- New Treatment of Material Properties Interpolation

2D/3D Surface Autozoning

In previous versions of DARWIN, autozoning was not supported for risk assessment of surface damage anomalies. Manual zoning was the only option for this anomaly type. In DARWIN 9.2, the optimal autozoning framework that was previously developed for risk assessment of inherent anomalies was extended to support surface damage anomalies (Figure 1). It enables users to assign properties (e.g., anomaly distributions, materials, inspections) to finite element surfaces, and identifies the optimal placement of these surfaces into surface zones. Similar to the autozoning capability for inherent anomalies, this new feature provides life and risk contours as well as zone risk convergence values. This feature is available in both the "General" and "FAA circular hole feature" analysis modes for both 2D and 3D geometries. It supports the use of manufacturing process credits that may be used in FAA circular hole feature certification assessments.
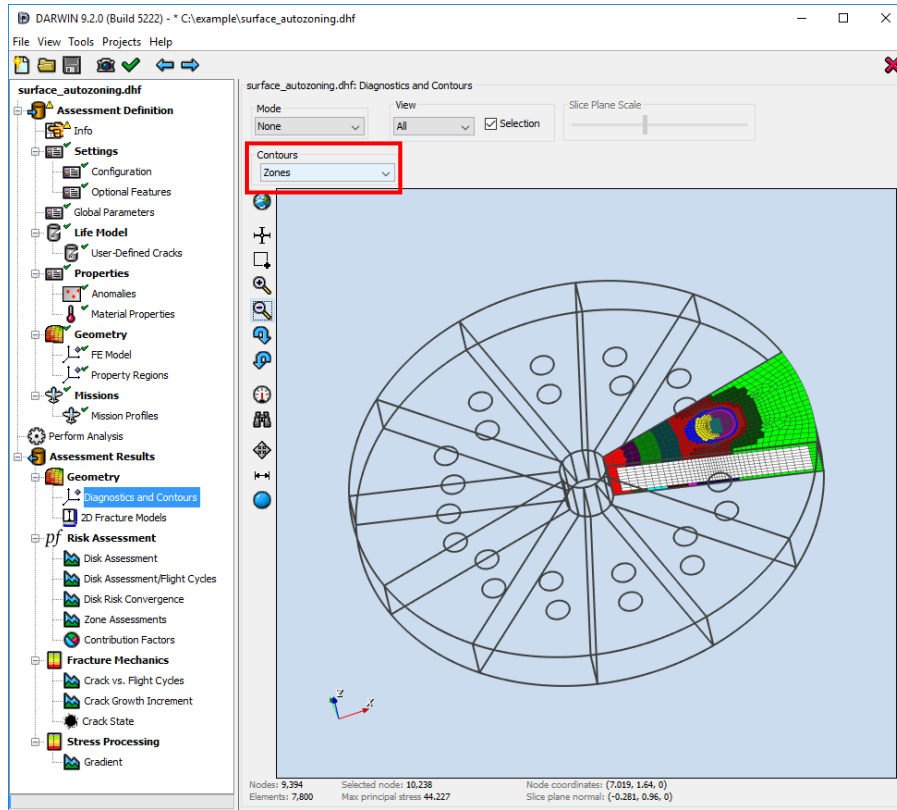
Figure 1: DARWIN 9.2 extends autozoning to support risk assessment of surface damage anomalies.

Dhondt Fatigue Crack Growth Model

DARWIN includes a number of different models for fatigue crack growth analysis that are available to the user. DARWIN 9.2 includes a new Dhondt cyclic crack growth model (a modified version of the DARWIN Walker crack growth model) that includes dependency of threshold on stress ratio. An example material properties file (*.mat) for this new crack growth model is shown in Figure 2. The GUI was enhanced to display Dhondt model parameters and to plot the associated crack growth rate curves as shown in Figure 3. Further details are provided in the DARWIN User's Guide.

```
DADN DATA
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~!
! dadN for air                                                            !
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~!
AIR
FCG_FORMAT              DHONDT
STRESS_RATIO_FORMAT     NONE
TEMPERATURE_INTERPOLATION_FORMAT CLOSEST

!dadN_ref DK_ref m     eps   delta  Kc     gp   wp   wn    a_scc  DK_th0  DK_th_i gamma  Temp
1.0e-7    20.0   3.0   10.0  10.0   100.0  1.2  0.5  0.24  1.0e-3 7.0     3.0     0.5     75.0
3.0e-7    18.0   3.1   12.0  15.0   90.0   1.9  0.4  0.28  5.0e-3 8.0     5.0     0.4    300.0
8.0e-7    15.0   3.3   15.0  8.0    80.0   1.8  0.3  0.30  8.0e-3 9.0     8.0     0.3    800.0
```

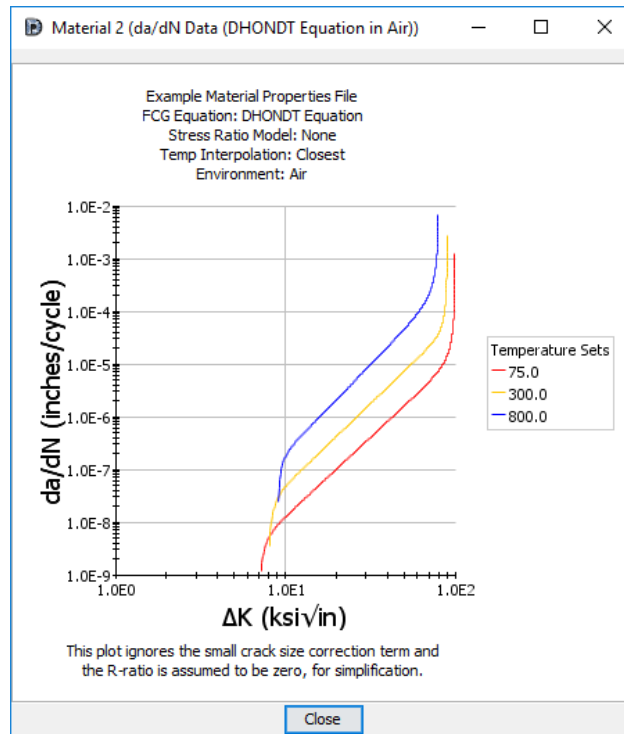**Figure 2: Example material properties file for the new Dhondt crack growth model.**

Figure 3: The DARWIN GUI was enhanced to plot crack growth rate curves associated with the Dhondt model.

El Haddad Small Crack Model

In previous versions of DARWIN, treatment of small cracks was limited to the NASGRO fatigue crack growth model. The NASGRO model uses a small crack correction parameter to account for small crack effects on the driving force of fatigue crack growth analyses.

DARWIN 9.2 includes a new El Haddad small crack correction parameter to account for small crack effects. It can be applied to all DARWIN fatigue crack growth models (except the NASGRO model which already provides treatment for small cracks). This is an optional feature that is dependent on environment (air/vacuum) but independent of temperature or stress ratio. An example material properties file (*.mat) for this new feature is illustrated in Figure 4.

```
DADN DATA

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~!
! dadN for air.                                                          !
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~!
AIR
FCG_FORMAT              PARIS
STRESS_RATIO_FORMAT     NONE
TEMPERATURE_INTERPOLATION_FORMAT CLOSEST
!C n Exp delta Kth Kc Temp
9.689e-10 3.107 3.0 58.0 75.0
5.882e-10 3.224 3.0 58.0 300.0
1.99e-09 2.852 3.0 58.0 600.0

EL_HADDAD        0.002
```

Figure 4: Example material properties file illustrating the new El Haddad small crack correction parameter.

Life/Risk Contour Fracture Plates Visualization

The life contours and autozoning features in DARWIN use the autoplate algorithm to predict fatigue crack growth life and fracture risk results at all of the nodes (or selected regions) in a finite element model. In previous versions of DARWIN, the fracture plates associated with life and risk contours created by the Autoplate algorithm were discarded after the analysis was completed and were not available for viewing by the user.

DARWIN 9.2 has been enhanced to enable users to access the Autoplate-generated fracture plate results associated with crack growth life contour and autozoning analyses. The fracture plate data are provided as optional analysis output. When this option is enabled, the DARWIN risk assessment code (RAC) records detailed information regarding the size, orientation, and initial crack type associated with the fracture plates at each node in an FE model. The RAC outputs this information to a table in the DARWIN output (*.dhf) file. This file stores the results in HDF5 format enabling them to be copied directly into spreadsheet tools such as Microsoft Excel. This optional fracture plate output is enabled by activating the "Export Intermediate Nodal Results" option in the GUI preferences menu as highlighted in Figure 5.
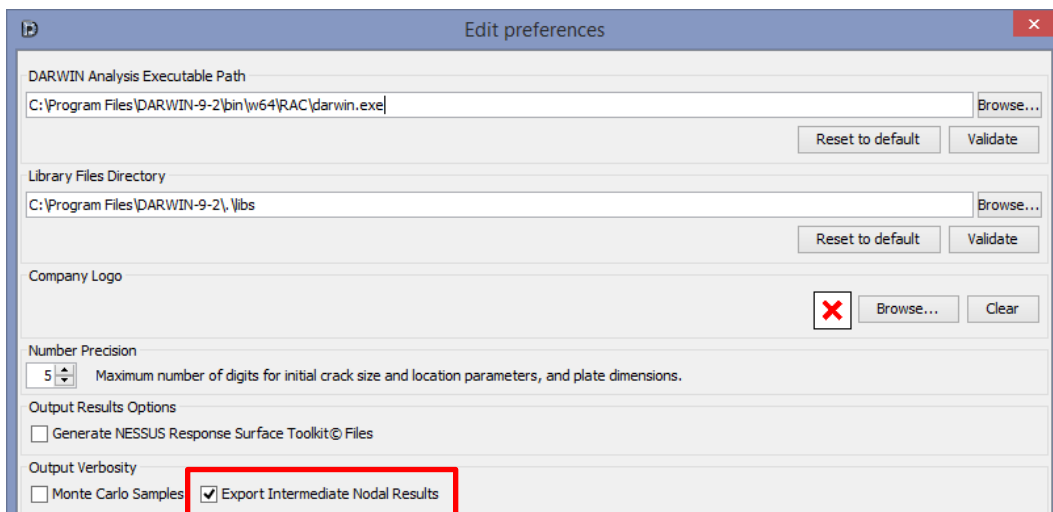

Figure 5: Activation of optional fracture plate output in the GUI preferences menu.
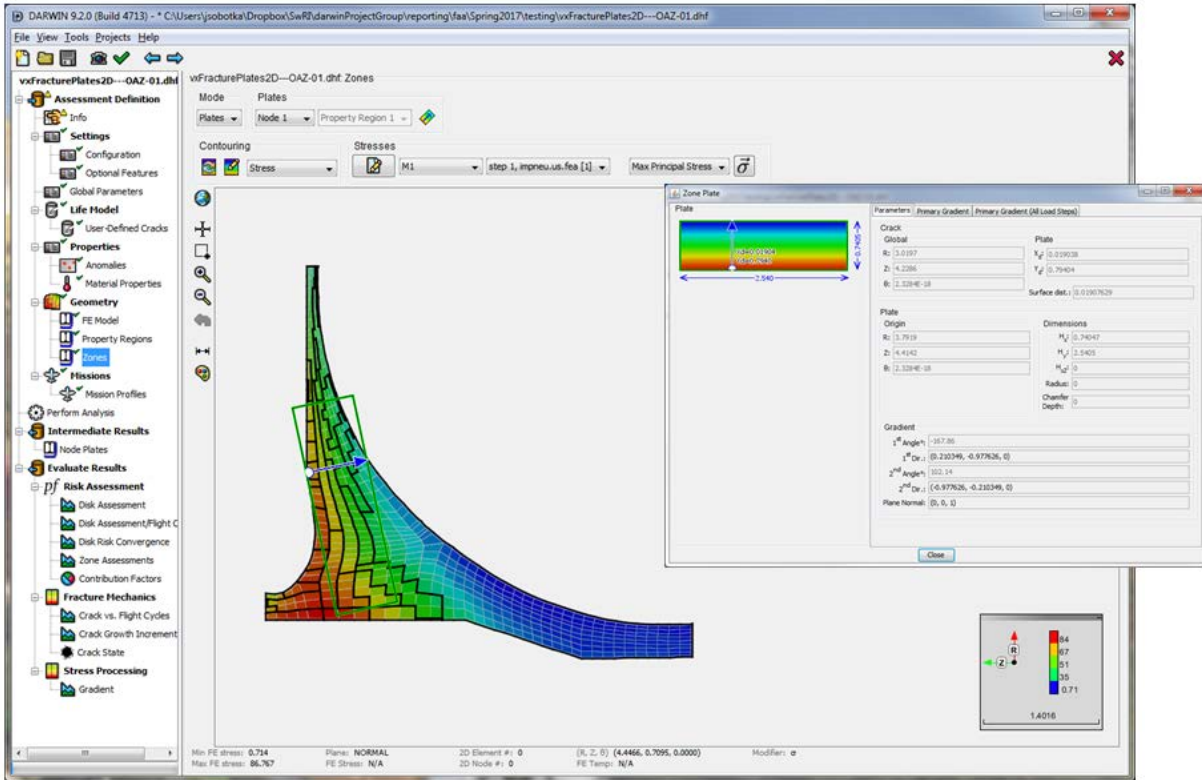
Figure 6: Users may view fracture plates associated with life and risk contours directly in the DARWIN GUI as illustrated for an example 2D finite element model.

Users may also view the intermediate fracture plate results in the DARWIN GUI. The GUI displays the fracture plates superimposed onto the component geometry as illustrated in Figure 6. The GUI displays the fracture plate dimensions and orientation as well as the stress gradient at specified nodes. Users may specify nodes by clicking on them in the component geometry or by selecting a node ID from a provided drop-down menu.

Location-Specific POD Curves

Previous DARWIN versions provide the capability for users to assign individual POD (i.e., inspection probability of detection) curves to selected regions of 2D and 3D models. The POD curves are stored in ASCII-formatted text files (*.pod) that contain a single POD curve in each file.

DARWIN 9.2 has been enhanced to support location-specific POD curves for application to fracture risk assessments. These POD curves are stored in files with a new format entitled LPOD (*.lpod) that contain a POD curve at every node in a finite element model. The LPOD file format is a hybrid of the POD curve and HSIESTA file formats. The file is generated using third-party NDE simulation software (it can also be constructed manually). When imported into DARWIN, the POD curves in the LPOD file are automatically assigned to their respective nodes in the FE model. The POD contour for a specified flaw size can be viewed directly on the FE model as shown in Figure 7. Users can also view the POD curve at specified nodal locations on the FE model (also shown in Figure 7). This feature is available for 2D and 3D anomalies in both 2D and 3D FE models.
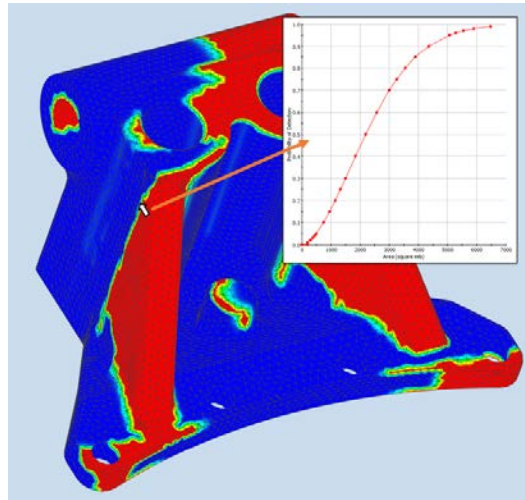
Figure 7: DARWIN 9.2 includes a new capability to import and view location-specific POD curves for application to fracture risk assessments.

Restart Using Intermediate Fracture Plates

When the user enables the previously mentioned "Export Intermediate Nodal Results" option, fracture plate data are stored in the DARWIN output file and are accessible for GUI visualization. These data can also be applied to life and risk assessment analyses where they can significantly reduce the associated computation times. To use the previously computed fracture plate results, select the ''Utilize existing intermediate results'' option (Figure 8).
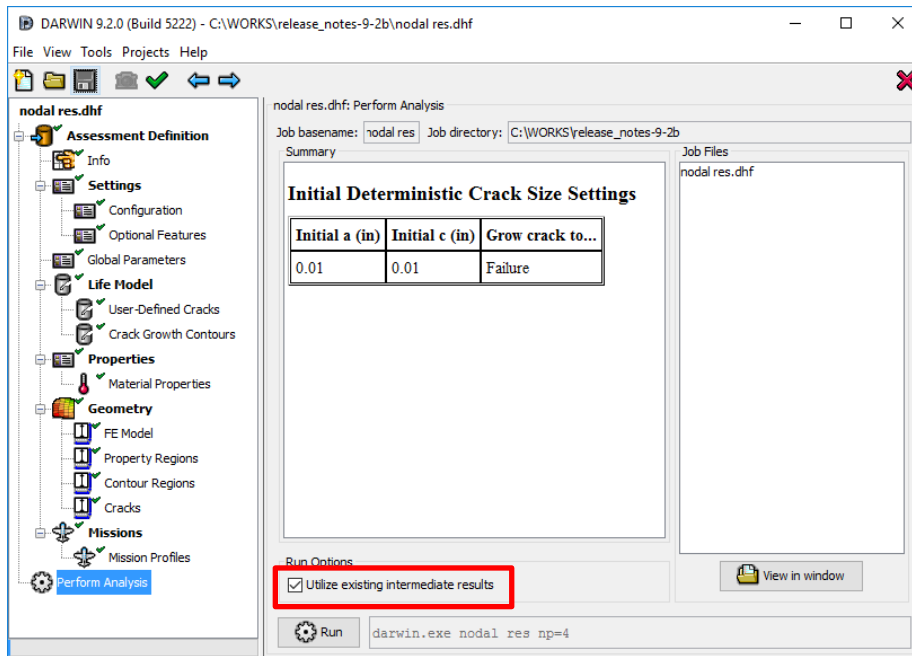

Figure 8: DARWIN 9.2 includes a new restart capability that uses previously computed fracture plate data. It is enabled via the 'Utilize existing intermediate results' option.

Autoplate Speed/Robustness Improvements

The computational efficiency of many DARWIN analyses is directly related to the efficiency of the DARWIN autoplate algorithm. In previous versions of DARWIN, the autoplate algorithm was limited to use on a single computer processor even when multiple processors were available.

In Version 9.2, DARWIN was enhanced to perform autoplate computations in parallel utilizing multiple processors. The autoplate algorithm was further restructured for improved computational performance. Initial results (Figure 9) indicate that the DARWIN 9.2 autoplate algorithm runs 10-20 times faster than the previous 9.1 version when life computations are executed in parallel mode using 4 processors.

The robustness of the autoplate algorithm is also of critical importance. In previous versions of DARWIN, the analysis was terminated if the fatigue crack growth (FCG) computation could not be completed at all of the nodes in an FE model. In other words, the autoplate algorithm was required to build a valid plate at every node in the entire model, or the analysis would terminate.

DARWIN 9.2 was enhanced to skip nodes of the finite element model at which FCG computations cannot be completed. The enhancement enables users to view nodes that were skipped (if any) after the analysis is complete, and substantially improves the robustness of the computation.
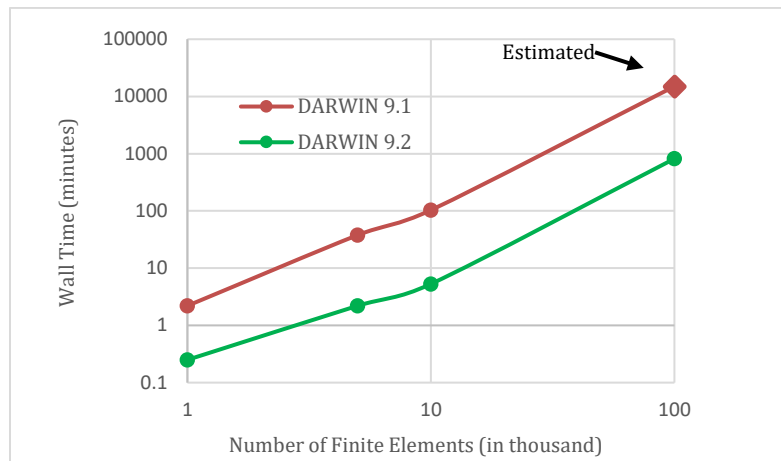

Figure 9: Initial results indicate that the DARWIN 9.2 autoplate algorithm runs 10-20 times faster than the previous version when executed in parallel mode using 4 processors.

GUI Node Selection Speed Improvement

Previous versions of DARWIN did not provide adequate response times for GUI node selection operations in large complex finite element (FE) models. The time required to reposition a crack center from one node to another within the model could be measured in tens of seconds or more.

DARWIN 9.2 was enhanced to provide improved responsiveness for GUI node selection operations. Initial benchmark test results for a large 3D FE model (Figure 10) indicate that DARWIN 9.2 GUI response times are significantly faster than previous versions. Testing is underway to assess performance on additional FE models.
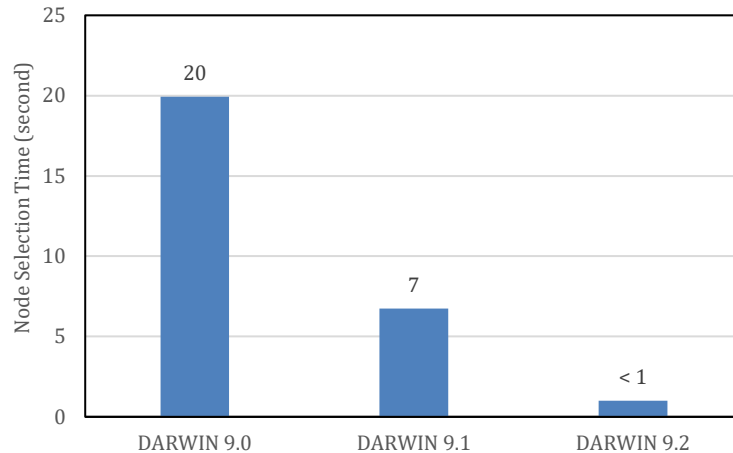
Figure 10: Comparison of GUI node selection response times for a large finite element model in several DARWIN versions.

3D GUI Visualization Enhancements

DARWIN provides the capability for users to assign material properties to FE models by selecting groups of finite elements called property regions. A number of tools are provided for selecting elements in 2D FE models including individual elements, contours, and bounding boxes. For 3D FE models, however, selection of elements in previous versions of DARWIN was limited to selection of all surface elements, all interior elements, or all (surface and interior) elements.

DARWIN provides the capability to view life and fracture risk results displayed as color contours on FE models. For 2D models, the results are viewable in all elements. For 3D models, life and risk contours can be viewed in all elements on the exterior surfaces. However, life and risk contours inside 3D FE models were difficult to view in previous versions of DARWIN.

DARWIN 9.2 provides new capabilities for selecting elements and viewing results in 3D FE models. Groups of finite elements can now be defined as "utility regions" that can be used both to assign input properties to elements and to view life and risk results in selected regions of the model.

The following additional options are now provided for definition of utility regions in 3D models:

- Select elements by contour. Users enable the 'Select unassigned elements by contour' feature and click on an element in the FE model. DARWIN selects all elements that have the same contour value. This feature is illustrated in Figure 11a for the display of elements with identical temperature values.

- Select elements by contour range. Users enable the 'Select unassigned elements by contour range' feature and specify a minimum and maximum value for the displayed contour. DARWIN selects all elements having contour values within the specified contour range. This feature is illustrated in Figure 11b for the display of elements with maximum principal stress above a specified value.

- Select elements by bounding box. Users enable the 'Select unassigned elements (including hidden elements) within a rectangle' feature and draw a rectangle on the 3D FE model via mouse clicks. DARWIN selects all elements within and behind the rectangle defined by the user.

DARWIN 9.2 includes additional capabilities to create utility regions by applying set operators to previously created utility regions. The following set operators are available:

- AND (Intersection): Contains elements that are in both utility regions and excludes elements that are only in one utility region.

- OR (Union): Contains elements that are in both utility regions.

- XOR (Symmetric Difference): Contains elements that are in one utility region and excludes elements that are in both utility regions.

- NOT (Set Difference): Contains elements that are in a selected utility region and excludes elements that are in another utility region.

The set operators are particularly useful for viewing results in the interior of 3D FE models. As an example, Figure 12c shows fracture risk contours in the interior of a 3D FE model that are based on the intersection of previously defined utility regions shown in Figures 12a&b.
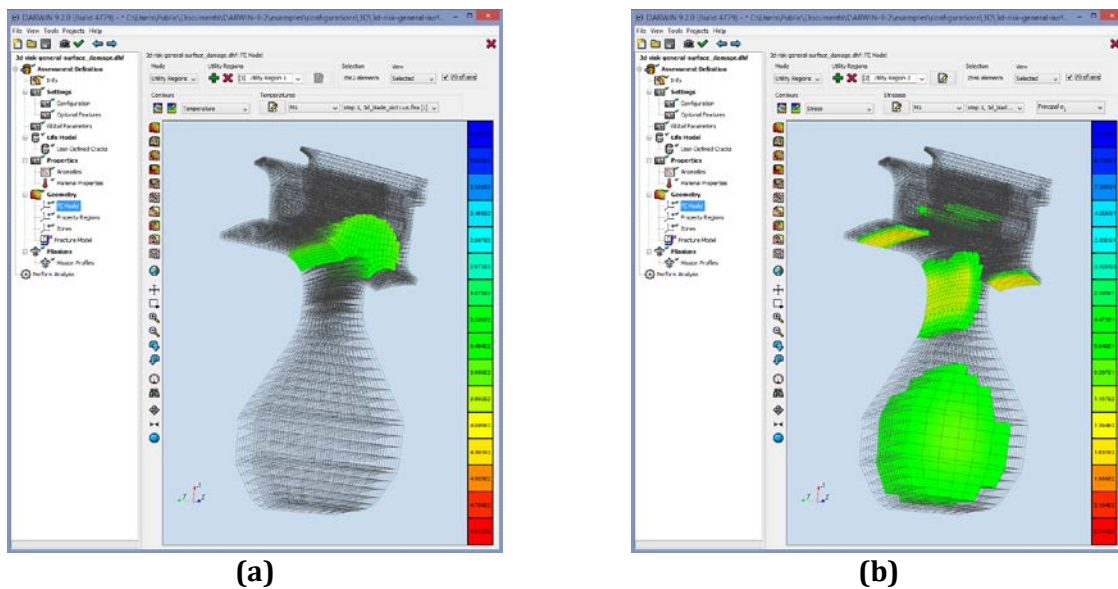

(a)   **(b)**

Figure 11: Illustration of new finite element selection capabilities in DARWIN 9.2. (a) element selection "by contour" for elements containing a temperature contour value of 350 degrees F, and (b) element selection "by contour range" for elements with maximum principal stress values greater than 50 Ksi.
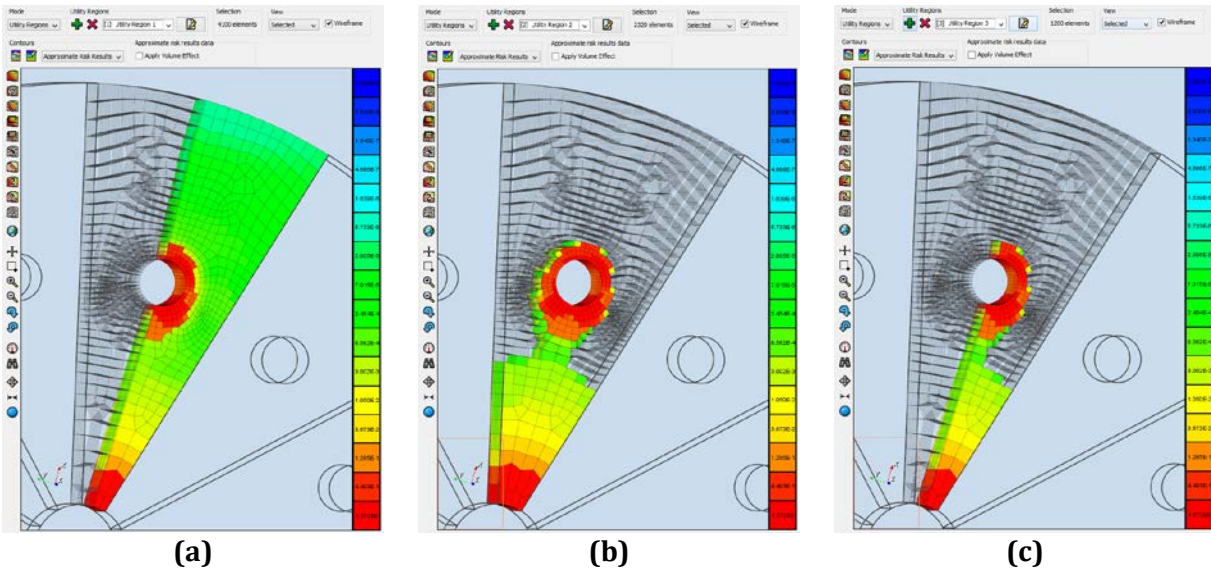
Figure 12: Example fracture risk results contours: (a) utility region 1 ('by box'), (b) utility region 2 ('by contour range'), and (c) intersection of utility regions 1 and 2.

Hot Corrosion Enhancements

Hot corrosion is a major concern for gas turbine engine components when fuels with high salt contaminants are used. Hot corrosion may become more prevalent when low-grade fuels or biomass-derived fuels with relatively high sodium, sulfur, vanadium, and chloride contents are utilized. Hot corrosion can also be more severe in aircraft engines that are used in coastal areas, over deserts, and volcanic regions where high chloride bearing salts and fine sulfate bearing sands can be ingested in the engines, pass through hot gas paths, and result in salt deposits on vanes, blades, and disks. Recent advances in gas turbine engine designs have led to higher service temperatures in the airfoils and disks which, in turn, increase the susceptibility to and potential for hot corrosion damages in these components.

In previous versions of DARWIN, hot corrosion life and risk assessments were based on time-dependent corrosion pit growth sizes that were provided by the user. In DARWIN 9.2, a new hot corrosion crack formation life model has been implemented that computes time-dependent corrosion pit growth sizes that previously were provided by the user (Figure 13). New physics-based models are used to predict the pit incubation and initiation stages. Once a pit has initiated, the DARWIN Flight_life module is used to predict the fatigue crack growth portion of total life. As an alternative option, users may link their own proprietary hot corrosion crack formation life model with DARWIN via a new hot corrosion user module that is included with this feature.
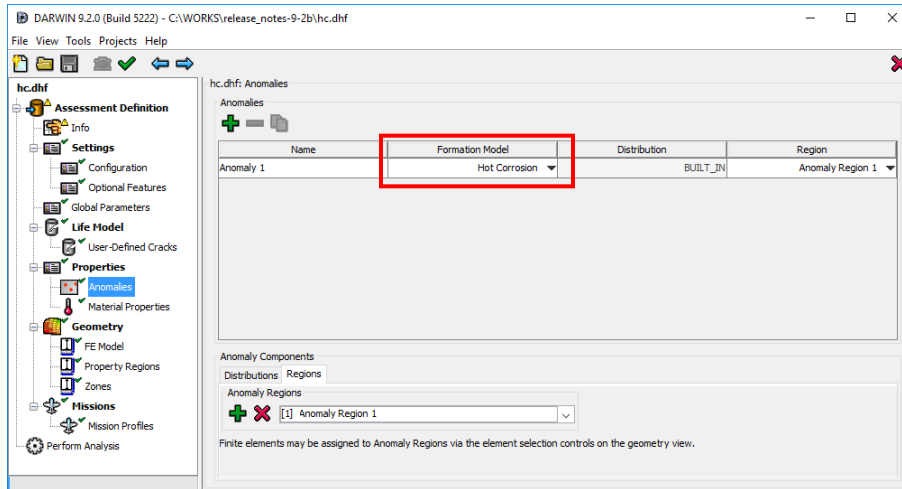
Figure 13: DARWIN 9.2 provides new physics-based models to simulate the hot corrosion process.

Shakedown Enhancement for 1D Geometry Mode

The DARWIN Shakedown module provides treatment for stress values that are above the yield strength of the material for use in fatigue crack growth computations. The shakedown algorithm computes the Von Mises stress based on stress components in three orthogonal directions. These stresses are readily available in the 2D and 3D geometry modes where they are extracted from 2D axisymmetric and 3D finite element models, respectively. However, only one component of stress is available in the 1D geometry mode (users provide stress profiles in a single direction only). In current versions of DARWIN, a plane stress condition is used to perform shakedown in the 1D geometry mode in which stress values that are orthogonal to the user-defined input stress profiles are set to near-zero values. This approach is valid for the plane stress condition, but may be anti-conservative for the plane strain stress state.
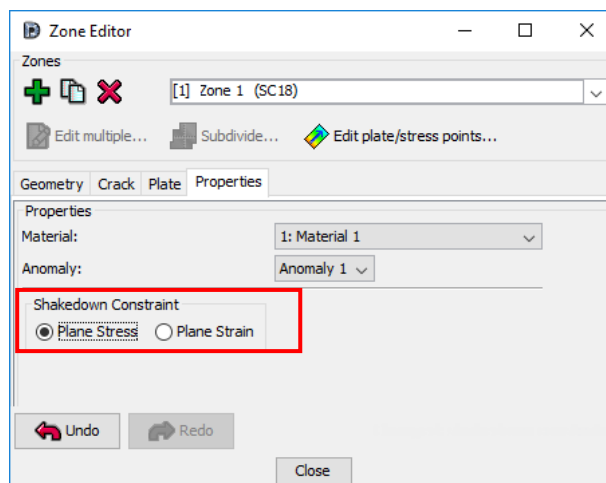

Figure 14: DARWIN 9.2 enables users to specify the stress state (plane stress or plane strain) when using shakedown in the 1D geometry mode.

DARWIN 9.2 has been enhanced to provide treatment for both plane stress and plane strain conditions when using shakedown in the 1D geometry mode. The GUI enables users to select either plane stress or plane strain when using shakedown in the 1D mode (Figure 14). When plane stress is selected, stress values that are orthogonal to the user-defined input stress profiles are set to near-zero values. When plane strain is selected, the stress in one orthogonal direction is set to a near-zero value, and the stress value in the other orthogonal direction is set to the user-defined stress profile values multiplied by a constant (Poisson's ratio).

Mission Scaling Enhancements

DARWIN provides two options for the user to adjust stress and temperature values that are extracted from finite element models during stress processing. The first option multiplies all stress and temperature values by a user-specified value. The second option replaces values extracted at the initial crack center with a user-specified value (stress values within each zone are scaled based on the ratio of the user-provided value and the extracted value). In previous versions of DARWIN, the user was required to use the same option for both stress and temperature scaling for a given load step.

DARWIN 9.2 was enhanced to provide independent scaling options for stress and temperature at each load step (Figure 15). For example, stress values can be multiplied by a user-specified value, and temperature values can be replaced by a user-specified value within the same load step.

An additional enhancement enables users to add or subtract user-specified values from the stress and temperature values that are extracted from finite element models. This additional feature can be used in conjunction with the option to multiply extracted stress values by user-specified values.
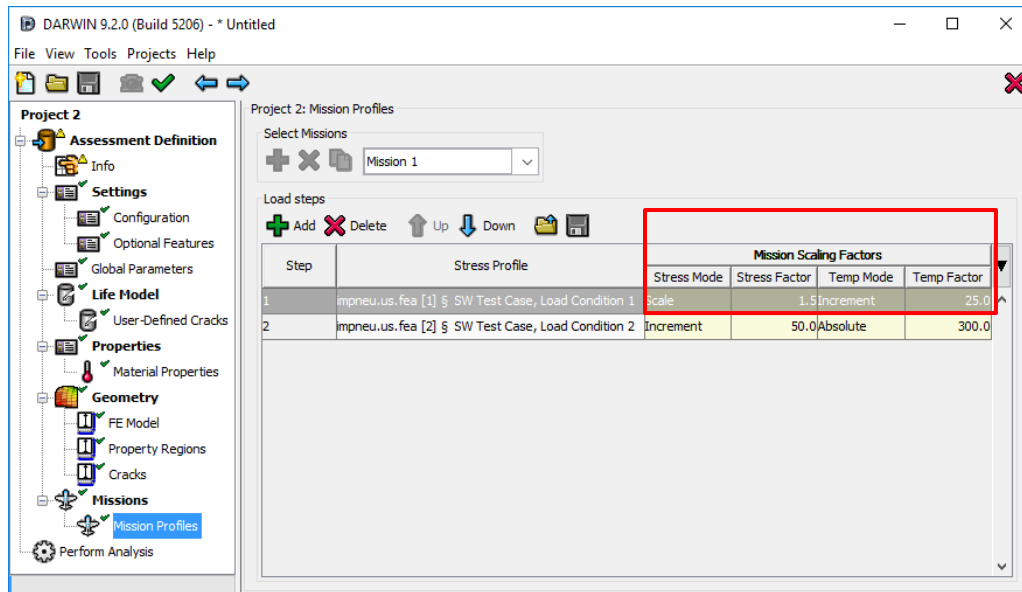

Figure 15: DARWIN 9.2 was enhanced to provide independent scaling options for stress and temperature at each load step within a mission.

Crack Size Termination Criterion Enhancement

DARWIN enables users to specify fatigue crack growth termination criterion in terms of failure (i.e., stress intensity factor exceeds fracture toughness), user-specified life, or user-specified length or area. In previous versions of DARWIN, the user could specify only a single length value for both the a and c dimensions of a crack. DARWIN would terminate when either a or c exceeded the single user-specified length.

In DARWIN 9.2, the crack size termination option was enhanced to enable the user to specify separate termination lengths for crack a and c dimensions (Figure 16). The crack growth termination message was enhanced to report which crack dimension (i.e., a or c) has reached the termination length.

Figure 16: The crack size termination option was enhanced in DARWIN 9.2 to enable the user to specify separate termination lengths for both crack *a* and *c* dimensions.

Bivariant Plate Enhancement

Previous versions of DARWIN support stress intensity factor solutions defined using bivariant plates (i.e., plates with stress gradients in two directions). These plates required stresses at every point in the plate, and the geometry of the finite element model needed to completely enclose the plate. This restriction introduced several situations that could be accommodated by univariant plate solutions but not by bivariant plate solutions. Figure 17 shows three geometries that were not previously supported for bivariant plates: (a) tolerance issues on the edge, (b) plates with far-field missing material, and (c) plates with holes.

DARWIN 9.2 was enhanced to support bivariant plates in finite element models with tolerance issues, far-field missing material, and internal holes (Figure 17). This enables users to define and view bivariant plates for these geometries such as extension of plate boundaries beyond the finite element model as shown in Figure 17b. These enhanced definitions are an optional feature in DARWIN 9.2 and are disabled by default. When this option is enabled, the GUI performs a check to determine if an enhanced definition is needed for each bivariant plate (this operation is invisible to the user and happens in the background). The check is accomplished by assessing the stress values at selected points within the plate (the GUI places points on a 100 X 100 grid within the plate). The enhanced definition is not needed if stress values are available at all points within the grid. However, if stress values are not available at one or more of the grid points, these points are marked by the GUI as "disabled nodes" and then grouped into one of the three geometries shown in Figure 17. For geometries with tolerance issues and far-field missing material (Figures 17a & b), the GUI proceeds
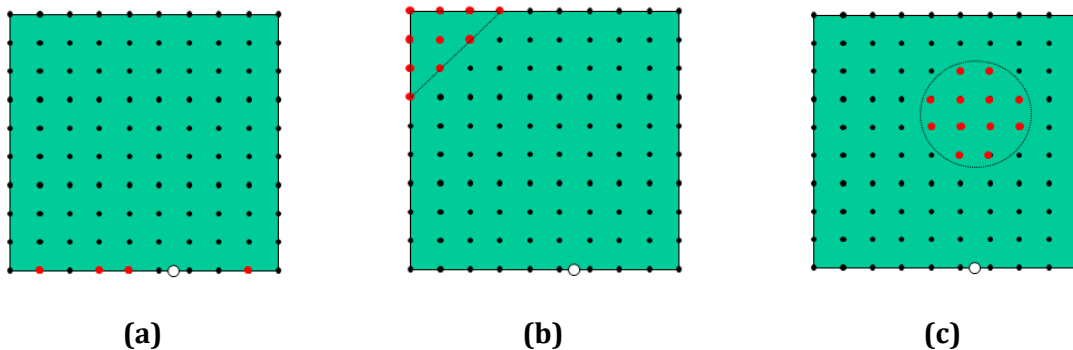
(a)   **(b)**   **(c)**

Figure 17: DARWIN 9.2 was enhanced to support bivariant plates in finite element models with: (a) tolerance issues, (b) far-field missing material, and (c) internal holes.

without any further checks. However, the GUI prevents the construction of plates with holes (Figure 17c) if the shakedown feature is activated. The GUI also prevents the construction of plates with convex crack surfaces. This geometry type is not supported at this time and requires further investigation. The GUI has also been updated to display stresses in the zone plate visualization screen.

Once the disabled nodes have been identified via the GUI, they are passed to the stress processing module for further processing. If the user has enabled shakedown, a new enhanced shakedown method for bivariant plates with missing material (described in the DARWIN User's Guide) is used to compute the relaxed stresses. The result is then passed to Flight_life where it is treated as a complete rectangular bivariant plate with zero stresses at the disabled nodes. Verification of this feature is underway and is scheduled for completion in October 2017.

Fleet Risk Module Enhancement

The DARWIN Fleet Assessment Module (FAM) assesses the risk of one or more fleets of aircraft based on disk risk results associated with individual DARWIN project files (*.dhf). It is provided as a separate module that the user can access via the DARWIN tools menu. The initial version was released in DARWIN 7.1. It was subsequently enhanced to enable component replacement following a simulated inspection (replacement of the same component type in Version 8.1, and replacement of a different type of component in Version 8.2). In all previous versions, inspections could only be applied to individual DARWIN project files, and could not be applied across an entire fleet.

A new FAM enhancement was implemented in DARWIN 9.2 that enables the user to perform an inspection-based corrective action across an entire fleet of aircraft in accordance with AC 39-8. An overview of the inspection-based corrective actions enhancement is shown in Figure 18. The user defines an inspection-based corrective action by following five basic steps as shown in Figure 18. In step 1, the user enables a new inspections feature in the FAM. In step 2, the user opens an inspection timetable definition menu (similar to the menu that is used to define inspections for individual DARWIN runs). In step 3, the user defines one or more inspection timetables. An inspection timetable is a set of inspection times characterized by a probability distribution. Inspection times are specified in terms of the times that fleets enter service (expressed in months). Several distributions (e.g.,

normal, tabular, Weibull, deterministic) are available in the fleet assessment module for defining inspection timetables. In the fourth step, the user assigns an inspection timetable to one or more disks.

In the final step, the user executes the fleet risk analysis. During this process, the FAM transfers the month-based inspection timetable definitions to the cycle-based DARWIN project files for each disk associated with an inspection timetable. The month-based inspection times are converted to cycles and adjusted based upon the disk set usage rate and number of accumulated cycles that are defined by the user. After all DARWIN project files have been updated with the fleet-wide inspection times, they are automatically executed to obtain the new disk risk curves via the DARWIN risk assessment code. Note that inspection timetables are only applicable to DARWIN projects that are configured to support the inspection-based corrective actions.

Upon completion of the DARWIN disk risk analyses, the fleet risk plots are automatically updated in the FAM to include the effects of inspection-based corrective actions. Example results for the FAM inspection-based corrective actions enhancement are shown in Figure 19.
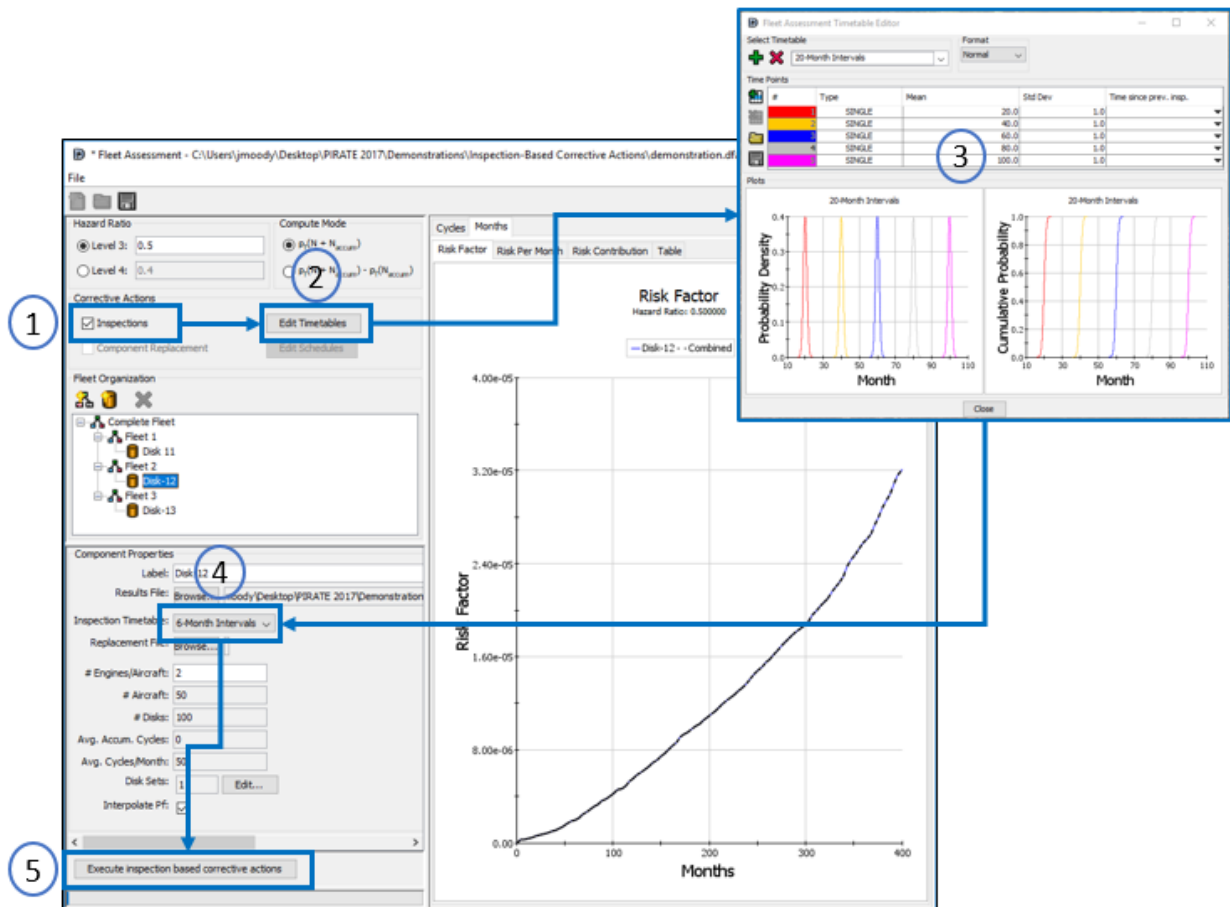

Figure 18: Overview of the inspection-based corrective actions enhancement to the Fleet Assessment Module in DARWIN 9.2.

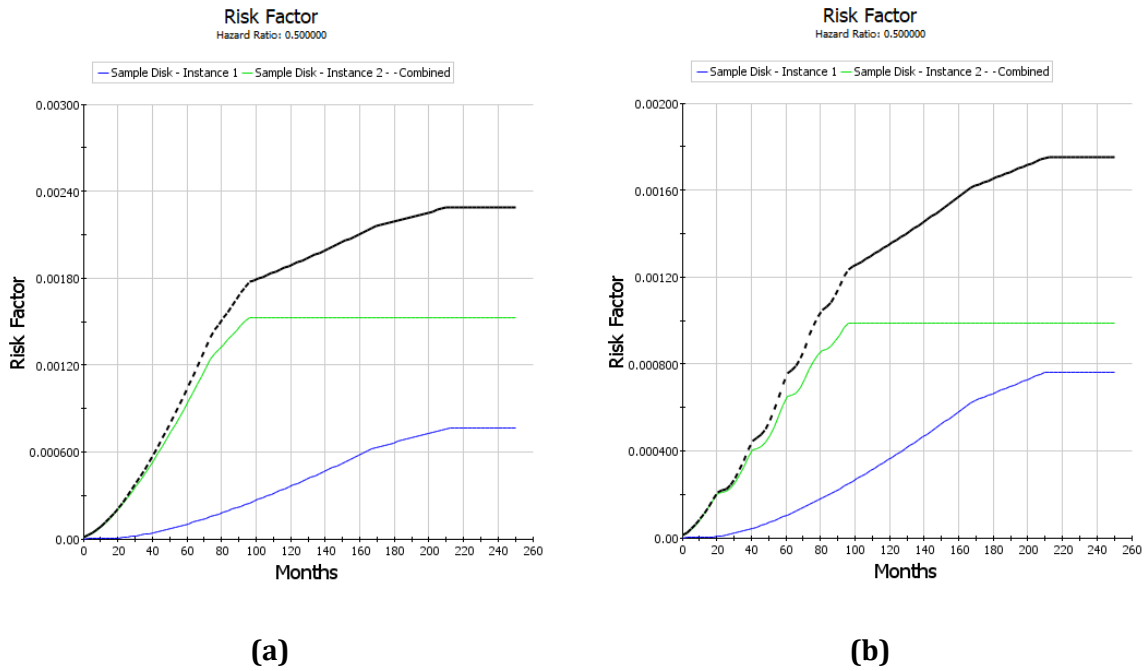**(a)**   **(b)**

Figure 19: Example fleet risk results for the DARWIN Fleet Assessment Module inspection-based corrective actions enhancement:(a) without inspection, and (b) with inspection. Note that different scales are shown in Figures (a) and (b).

3D Anomalies Enhancements

DARWIN includes a capability to characterize inherent anomalies as 3D ellipsoids having 6 degrees of freedom (3D anomalies). For 2D crack growth analysis, crack growth dimensions are based on the intersection or projection of the 3D anomaly with or on the fracture plane. In previous versions of DARWIN, the fracture plane was limited to the hoop plane. 3D anomalies also were not supported by autozoning.

In DARWIN 9.2, 3D anomalies are no longer limited to the hoop plane.   This new capability enables users to select non-hoop planes (e.g., axial, radial, maximum principal stress) for life and risk assessments (see Figure 20). DARWIN 9.2 was also enhanced to provide autozoning support for 3D anomalies (see Figure 21).
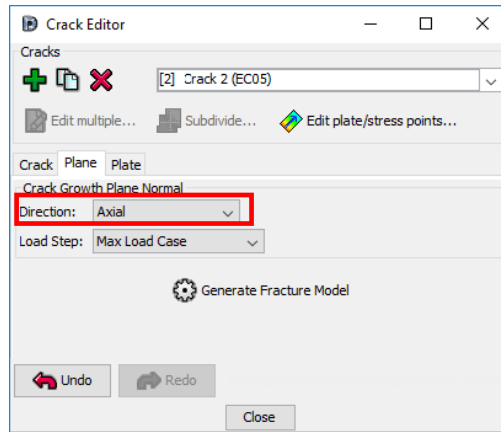
Figure 20: DARWIN 9.2 was enhanced to enable users to specify non-hoop crack growth planes for 3D anomalies.
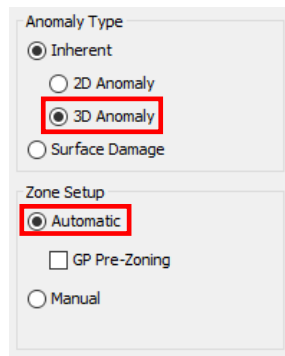

Figure 21: DARWIN 9.2 was enhanced to provide autozoning support for 3D anomalies.

Production Inspections on Non-Hoop Planes

DARWIN contains a capability to simulate the effect of production inspections that occur prior to service for both 2D and 3D anomalies. In previous versions of DARWIN, this capability was limited to the hoop direction. DARWIN 9.2 includes a new capability to specify production inspections on non-hoop planes (e.g., axial, radial, hoop, or user-defined; see Figure 22).
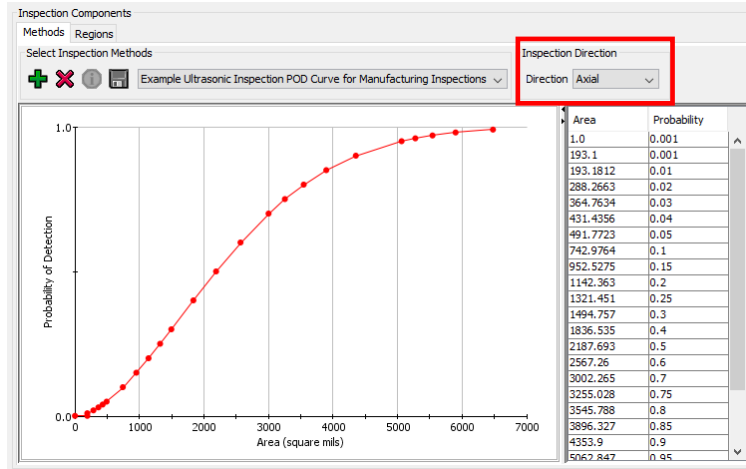
Figure 22: DARWIN 9.2 enables users to specify production inspections in non-hoop directions.

Direct Import of ANSYS and ABAQUS Load Step Times

In previous versions of DARWIN, load step times associated with imported ANSYS or ABAQUS FE results files were defined manually by the user. DARWIN 9.2 includes an enhancement to directly import load step time values contained in ANSYS and ABAQUS FE results files into DARWIN projects. When an FE results file containing load step times is imported into a time-dependent DARWIN project, the load step time input fields are automatically populated (see Figure 23).
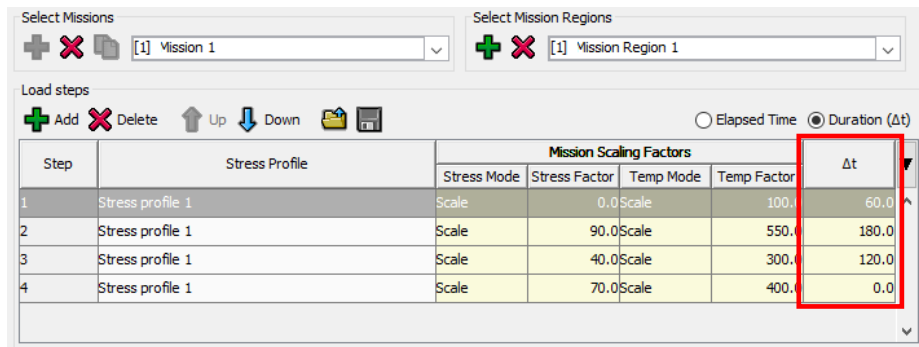

Figure 23: In DARWIN 9.2, load step times contained in ANSYS and ABAQUS results files are automatically incorporated into time-dependent projects.

GUI File Access Speed Enhancement

In previous versions of DARWIN, the Graphical User Interface (GUI) used a legacy XML file format for internal computations. An internal converter was used to translate the HDF5-based DARWIN project files into the XML format, and the resulting translation time could be extensive for large files.

In DARWIN 9.2, the GUI was enhanced to perform internal computations directly using the HDF5 file format. This enhancement significantly improves GUI speed for large project files.

New Treatment of Material Properties Interpolation

DARWIN fracture mechanics analyses use temperature-dependent fatigue properties that are defined in the user-provided material properties file (*.mat). During analyses, fatigue properties associated with each service temperature are computed via interpolation. Special treatment is required for service temperatures that fall outside the range of temperatures provides in the *.mat file. In previous versions of DARWIN, a warning was issued if the service temperature was above or below the temperature range in the *.mat file, and fatigue properties were based on values at the nearest temperature. Use of fatigue properties at the nearest temperature may lead to non-conservative fatigue crack growth lives, particularly when the service temperature is significantly higher than the highest temperature in the *.mat file. To mitigate this issue, DARWIN 9.2 has been enhanced to terminate and issue an error whenever the service temperature is outside the range of temperatures in the *.mat file.