

DARWIN 6.0 Release Notes

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Summary of New Capabilities

The DARWIN 6.0 release includes the following new features:

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GUI Enhancements

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New Analysis Mode for Titanium Hard Alpha Anomalies

DARWIN 6.0 includes a number of features that address general inherent anomalies. However, these new features are not intended for use in the certification of components with titanium hard alpha anomalies. Therefore, a new Titanium Hard Alpha analysis mode has been created to ensure that you can select only those features that are appropriate for a hard alpha risk assessment. As shown in Figure 1, DARWIN automatically disables the features associated with general inherent anomalies when the Titanium Hard Alpha analysis mode is selected.

Figure 1: Titanium Hard Alpha analysis mode

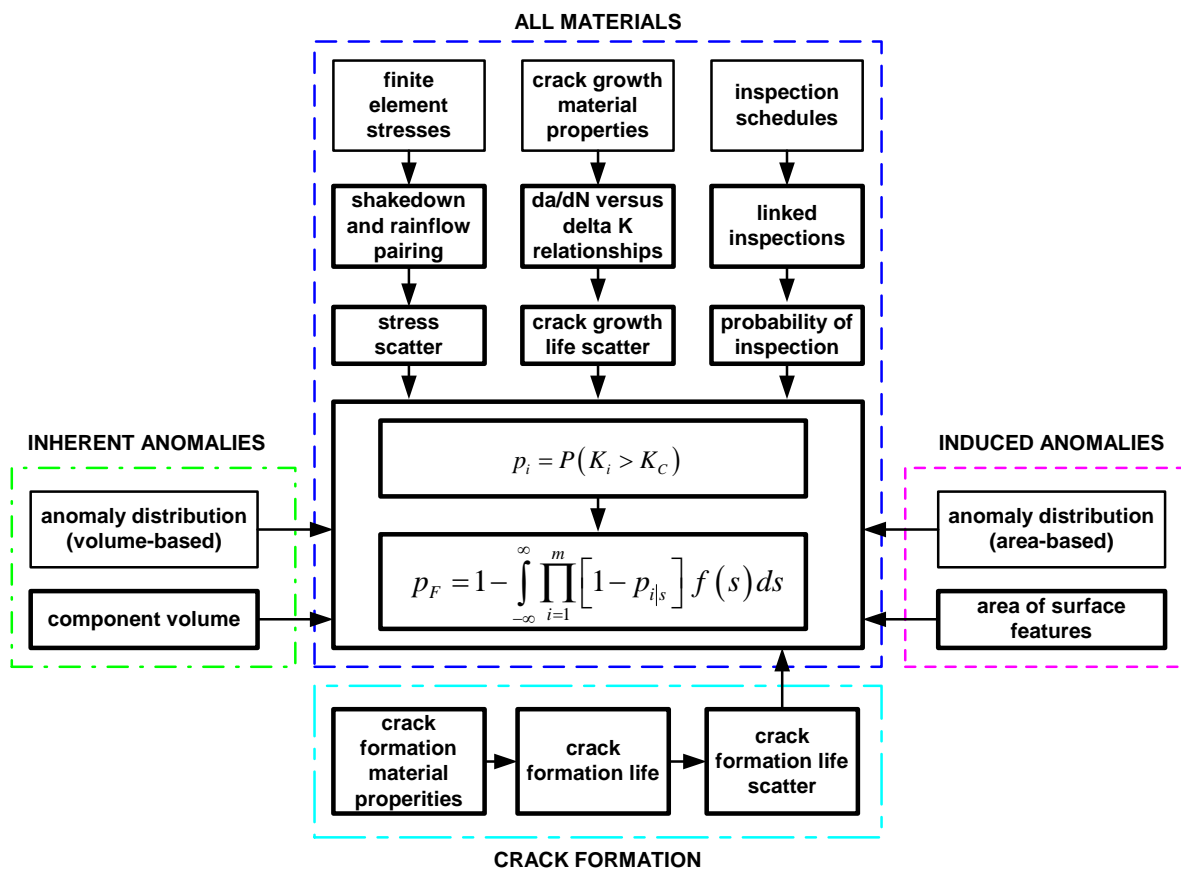
The screenshot displays the 'Project 1: Setup' dialog box. It is divided into several sections:

- Title:** A text input field.
- Description:** A text input field.
- Global factors:** A group box containing:
 - % not inspected (service inspections):
 - Fracture toughness factor:
 - Stress multiplying factor: Median COV
- Service life:** A group box containing:
 - Beginning flight:
 - Ending flight:
 - Flights per increment:
- Analysis mode:** A group box with three radio buttons:
 - Titanium Hard Alpha
 - General Inherent
 - Surface Damage
- Geometry mode:** A group box with three radio buttons:
 - 1D User-defined stress profiles
 - 2D Axisymmetric Model
 - 3D Model
- Units:** A group box with two radio buttons and a button:
 - US Customary
 - SI
 -

Probabilistic Treatment of Materials with Multiple Anomalies

Risk computations in previous versions of DARWIN are based on the assumption that a disk has only one significant anomaly. If the anomaly occurrence rate is relatively small, the total risk for the disk is the sum of the risks of the zones. However, this approach is not valid for materials that exhibit a higher frequency of anomalies. Modifications to the risk computations have been implemented to account for multiple (i.e., unlimited) significant anomalies in a disk for both the Monte Carlo and Importance Sampling probabilistic methods (and associated confidence bounds). These modifications apply to both inherent and induced anomalies, and the framework is shown in Figure 2. Further details regarding the probabilistic treatment of multiple anomalies are presented in the DARWIN Theory Guide (Volume II) in the Probabilistic Life Prediction of Multiple Anomaly Materials section of the Probabilistic Methods chapter.

Figure 2: Overview of the probabilistic framework for materials with multiple anomalies

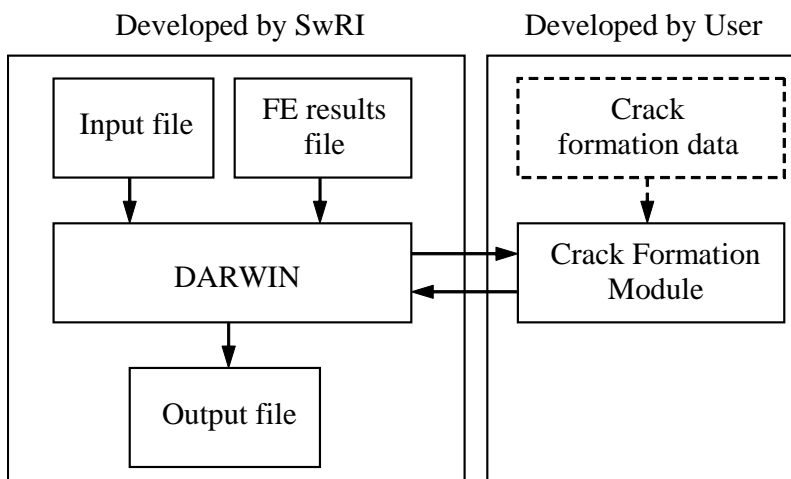


Crack Formation Module

Hard alpha anomalies in titanium alloys generally exhibit negligible crack formation lives because fatigue cracks can begin propagating almost immediately. However, in other materials, the crack formation life may be non-negligible and should be considered in the risk computation. A Crack Formation Module is introduced in DARWIN 6.0 that allows you to link DARWIN with user-supplied crack formation algorithms, as shown in Figure 3, for the prediction of crack formation life. During run time, DARWIN communicates with the Crack Formation Module to obtain the crack formation life associated with an anomaly with specified temperature and applied stress values.

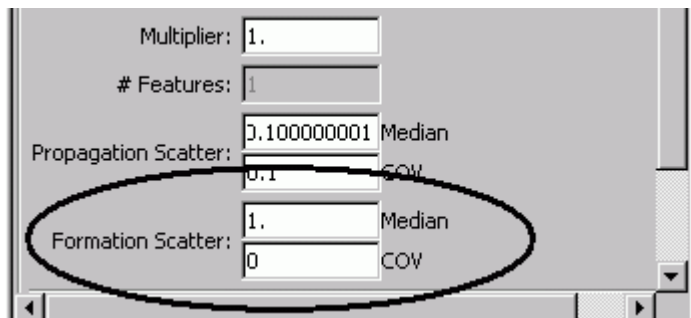
A new Formation API allows you to develop and compile the Crack Formation Module as an independent program. Details regarding creation and execution of the Crack Formation Module are provided in the DARWIN User's Guide.

Figure 3: Crack formation computations are performed via a user-supplied crack formation module



A crack formation life scatter variable is introduced to address the variability associated with crack formation life, and is specified in the Zone Editor as shown in Figure 4.

Figure 4: Specification of Crack Formation Scatter Variable in the Zone Editor



3-Dimensional Anomaly Modeling

The anomaly distribution in previous versions of DARWIN was based on a single degree of freedom defect distribution for rare anomalies associated with titanium materials (described in AC 33.14-1) and surface damage (currently under development by RISC). For multiple anomaly materials, additional parameters have been introduced to provide three-dimensional modeling using six degrees of freedom. Two aspect ratios are used to define the width and depth of an anomaly. Three angles are used to define the orientation of an anomaly with respect to the global axis of the disk. The data format of the anomaly distribution file has been modified to provide for 3D anomalies. In addition, a capability has been added for deterministic modeling of 3D anomalies as shown in Figure 5.

Figure 5: Definition of deterministic 3D anomalies

The screenshot shows a software dialog box titled "prob_analysis_inherent1-6-0.ddb: Life Model". It is divided into three main sections:

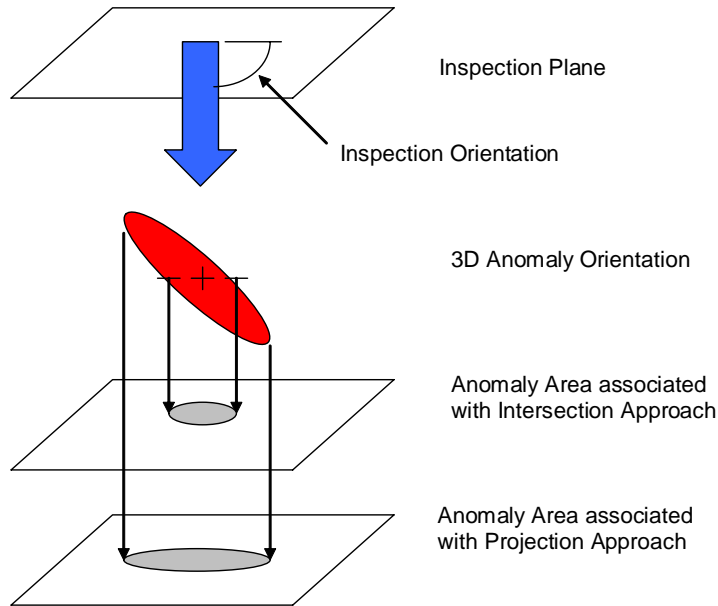
- Life Options:** Contains two checkboxes: "Formation Module" (unchecked) and "Enable Crack Propagation" (checked).
- Crack Propagation Options:** Includes a "Solution Method" dropdown menu set to "Flight...", a "Tabular Input" text field, and a "Browse..." button.
- Initial Deterministic Anomaly Size:** Features two radio buttons: "2D Anomaly" (unchecked) and "3D Anomaly" (checked). Below them is a table with five columns: "Length (in)", "Width Aspect", "Height Aspect", "Angle 1 (rad)", and "Angle 2 (rad)". The table contains one row of values: 0.01, 1.0, 1.0, 0.0, and 0.0. A horizontal scrollbar is located below the table.

A note at the bottom of the dialog reads: "Note: initial crack size applies only to deterministic crack growth (not risk)."

Length (in)	Width Aspect	Height Aspect	Angle 1 (rad)	Angle 2 (rad)
0.01	1.0	1.0	0.0	0.0

For general inherent anomalies with non-spherical shapes, the cross sectional area is dependent on the orientation of the anomaly relative to the crack growth/inspection planes as well as the associated footprint of the anomaly in these planes. As shown in Figure 6, two configurations are available in DARWIN to model the anomaly footprint: (1) intersection, and (2) projection. For the intersection approach, the footprint is defined as the area of the intersection of the anomaly and a plane that passes through the center of the anomaly. For the projection approach, the footprint is based on the projection of the exterior anomaly surface on the crack growth/inspection planes. This capability is currently limited to the hoop stress plane, but will be expanded to include the axial and radial planes in the near future. Further details on this capability are provided in the DARWIN User's Guide.

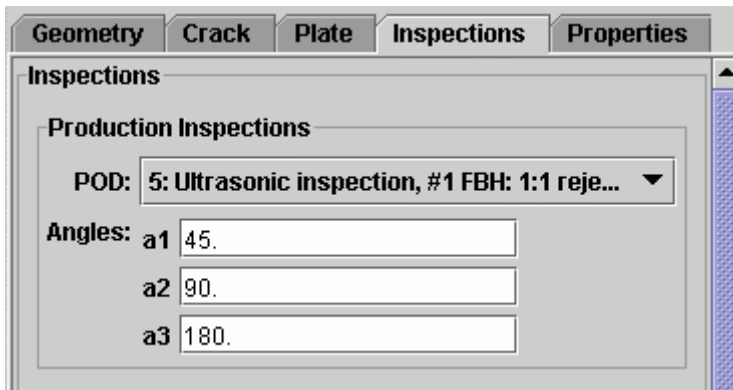
Figure 6: Two configurations are available in DARWIN to model the area of a general inherent anomaly in the crack growth/ inspection planes: (1) intersection, and (2) projection.



Production Inspection Capability

The anomaly distributions published in the Advisory Circular (AC 33.14-1) quantify the number of anomalies present following a specific production inspection. A capability has been added to DARWIN allowing you to specify the parameters of the anomaly distribution independent of the production inspection. As shown in Figure 7, you can specify a POD for the production inspection for anomaly distributions that do not have a pre-specified production inspection.

Figure 7: Specification of Production Inspections



Bivariant Stress Intensity Factor Solution for Corner Crack at Hole (CC10)

A bivariant weight function formulation was developed for a corner crack at an offset hole. It is based on reference solutions that were numerically generated using FADD3D fracture mechanics software. A capability is provided to visualize the bivariant stress field in three-dimensional space. CC10 is currently limited to univariant and bivariant stress fields using the weight function solution approach. Further details regarding CC10 are provided in the Selecting a Bivariant Crack Solution section in the Preprocessing chapter of the DARWIN User Guide.

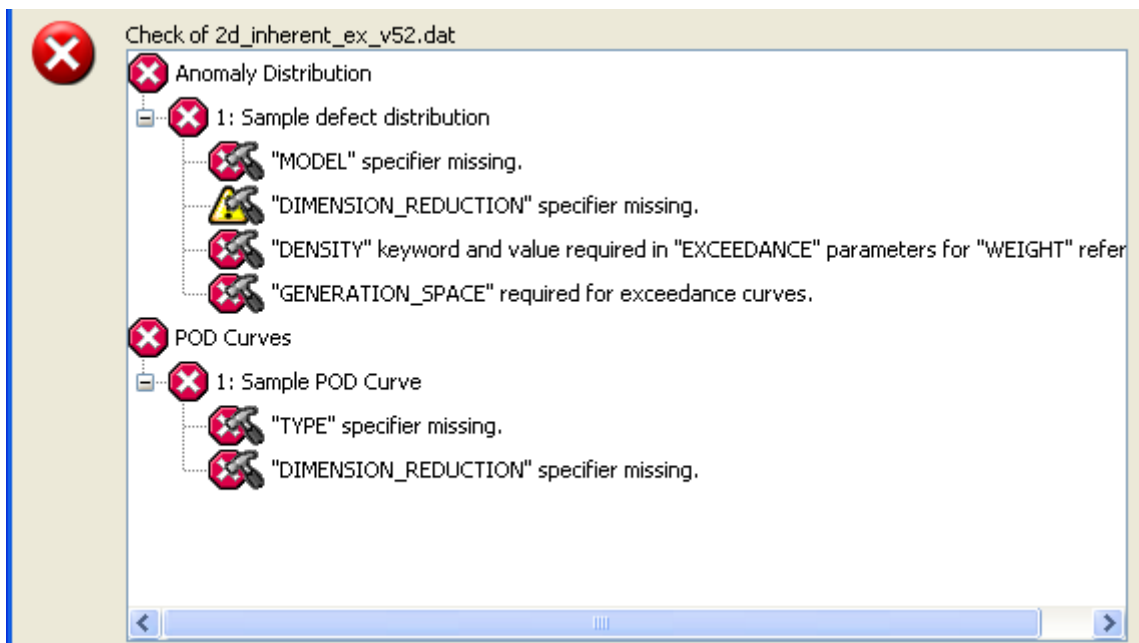
Comprehensive Verification Checks

A number of new verification checks were added to the GUI and risk assessment code to ensure that anomaly distributions and POD curves are correctly applied to the crack types and analysis modes that are available in DARWIN. To enforce these checks, a number of new keywords have been created for the DARWIN anomaly distribution and POD curve files and are required for successful execution. The primary library file converter window is shown in Figure 8.

A library conversion capability has been introduced that steps you through invalid keywords present in library files created in DARWIN version 5.2.

Once a file from version 5.2 has been loaded into version 6.0, a comprehensive verification check compares the old file to the new format and displays warnings and errors that need to be addressed in order to successfully run the file in version 6.0. An example of the converter dialog is shown and more detailed instructions are included in the Keyword Conversion Editor section in the Advanced Tools chapter.

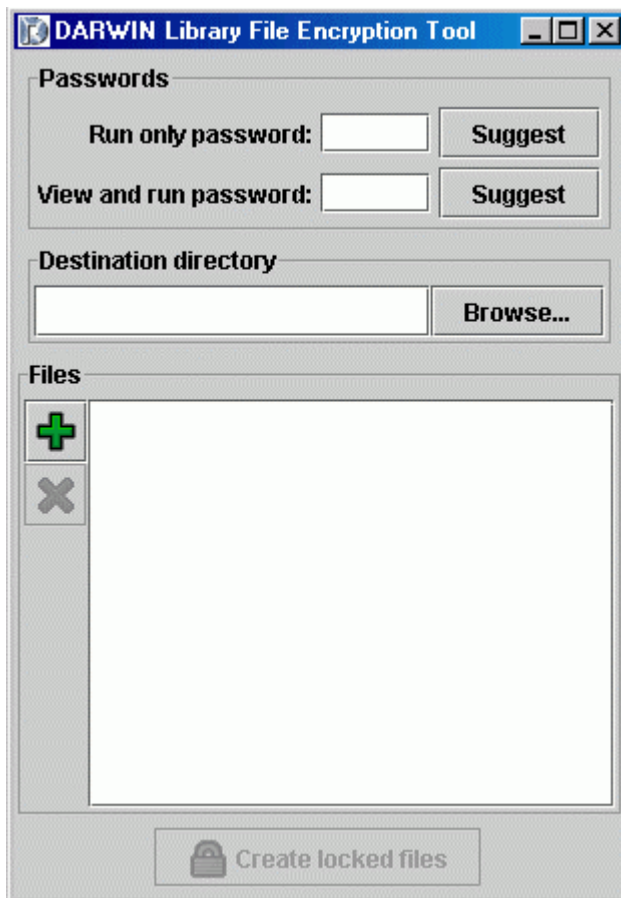
Figure 8: Keyword Conversion



Encryption Capability

Many of the DARWIN input variables are defined in data files that you create. The data files are in ASCII format and can be shared among users. Because data files may include proprietary data, it is desirable to protect them from unauthorized use. DARWIN includes a new encryption capability that allows you to encrypt data files. The interface is shown in Figure 9. Once a file is encrypted, other users can apply it to DARWIN only with a valid password. This capability currently supports material properties data files and will be expanded to other file types in the future.

Figure 9: Encryption capability to protect proprietary data

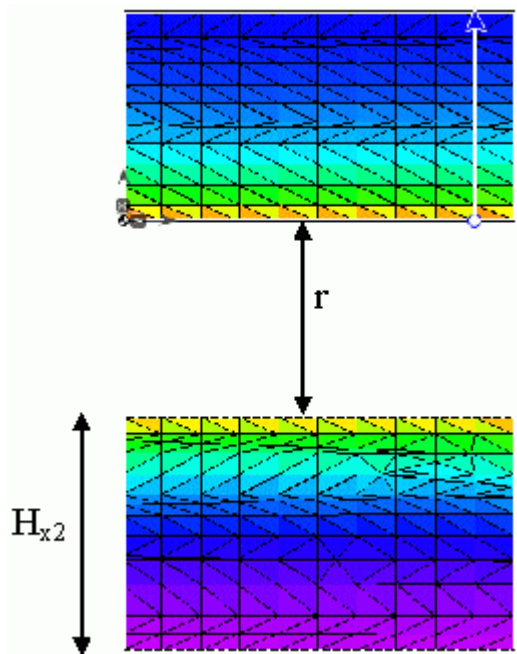


Extract Fracture Mechanics Plate Dimensions Directly From FEM

A capability has been developed to extract dimensions of the fracture mechanics plate directly from the finite element model for components with induced anomalies. A representation of this process is shown in Figure 10. These parameters are extracted during the plate creation stage of the zone definition process, and can be manually adjusted by the analyst.

Figure 10: Extracted fracture mechanics plate dimensions

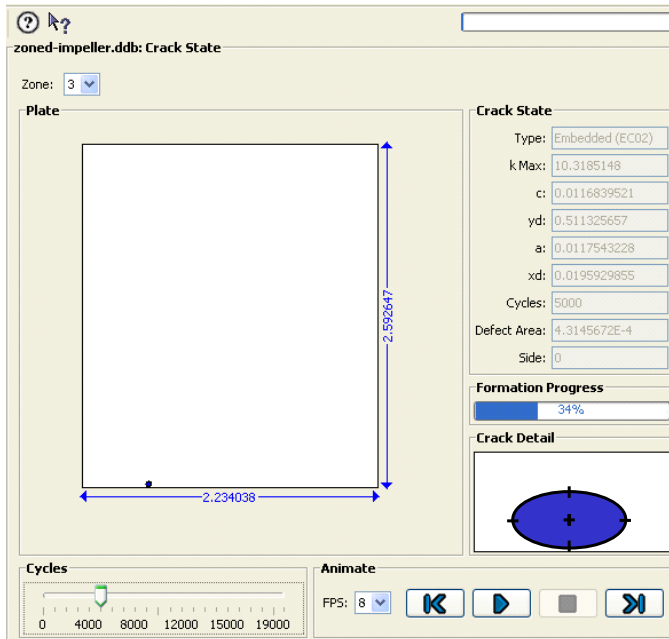
Geometry	Crack	Plate	Inspections	Properties
Plate				
Create plate Delete plate				
Origin		Dimensions		
X:	5.5950907357	H _w :	1.6038387598	
Y:	-0.295027421	H _y :	2.0001439253	
Z:	-2	H _{x2} :	3.8985126624	
		r:	0.4999176437	
Gradient				
1 st Angle°:	90.0000000002			
1 st Dir.:	(-0.844909, -0.53491, 0)			
2 nd Angle°:	0			
2 nd Dir.:	(0, 0, 0)			
Plane Normal:	(-0.534871, 0.844848, -0.011996)			



Crack Animation Enhancement

The crack animation feature has been enhanced to support multiple anomalies. A new field was added to provide status on the crack formation process shown in Figure 11. An additional field was added for enlarged display of the growing crack.

Figure 11: Crack animation enhancement



Report Generation Enhancement

Previous versions of DARWIN included a capability to provide a summary report in HTML format. This format allowed you to view the report directly in a web browser. However, the report consisted of a number of individual HTML files that were difficult to manage and print. A new capability has been developed that allows you to create a report in PDF file format, improving the overall portability and printing options associated with automated report generation.

General GUI Enhancements

Previously, the graphics display for 3D surface damage analysis was limited to nVidia graphics display hardware. The DARWIN GUI has been enhanced to support a wide range of commonly used graphics display hardware. This enhancement has been verified on the Windows, Linux, MacOS X, and Solaris platforms.

Other improvements for the 3D surface damage analysis mode include: (1) simultaneous display of all defined cracks on 3D models, (2) rotation of 3D models about the center of the screen (rather than center of the model), and (3) improved view controls (3D center on and zoom, disable wireframe and reference axis).

A Zone Editor Undo/Redo capability has been added, and the display of fracture mechanics results has been improved (you can now select plot results by individual crack type).