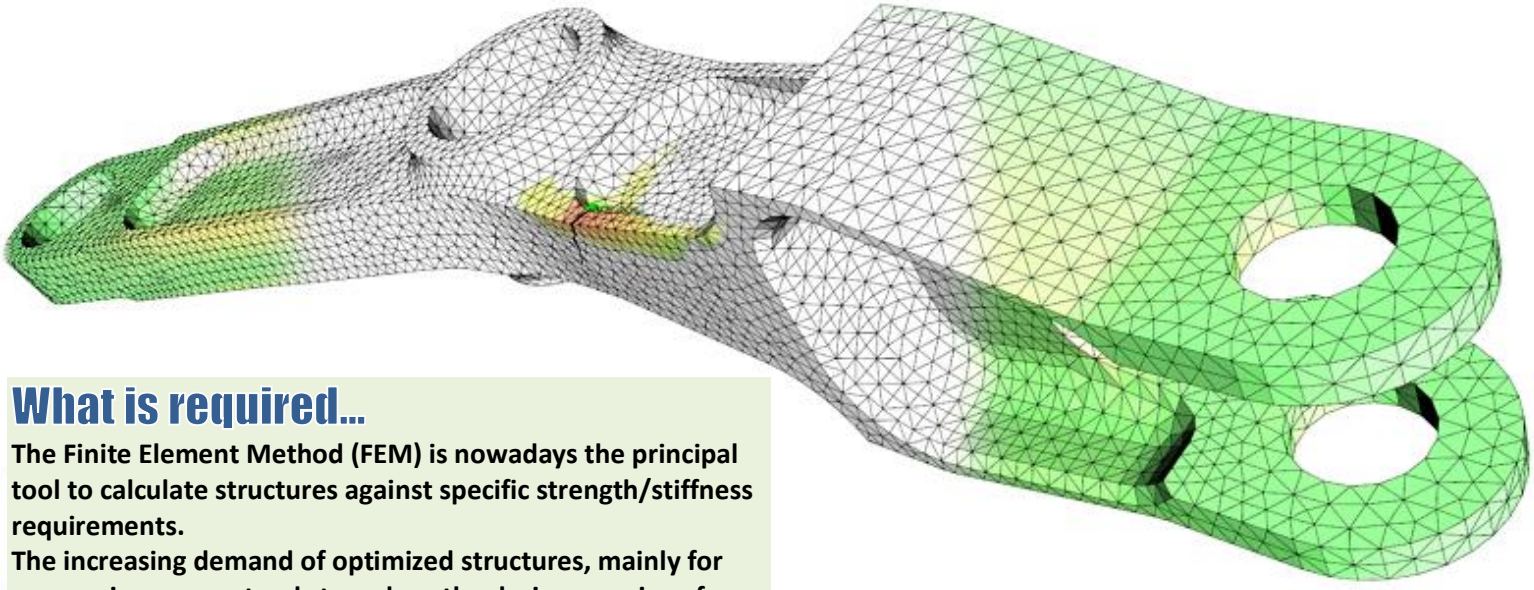
LIFING

Fatigue and Damage Tolerance Analysis Software



What is required...

The Finite Element Method (FEM) is nowadays the principal tool to calculate structures against specific strength/stiffness requirements.
The increasing demand of optimized structures, mainly for economic reasons, tends to reduce the design margins of safety, or reserve factors. In such conditions, the durability requirement plays a fundamental role: lightweight structures, such as an airframe, have to be designed such to fulfil strength/stiffness requirements, but also such to survive a defined number of loading cycles. Generally the tighter the safety margins are, the more prone the structure is to fatigue failure.
Fatigue and Damage Tolerance (i.e. understanding how an intact structure gets cracked during its operative life due to loads which are well below the static allowables, and understanding how the cracks develop over the life once initiated) are more and more topics that must be considered by the structural engineers with special care.
Additionally, key element for a reliable FDT assessment, is the application of real loads experienced by the structure, which are not sometimes well defined in many applications.

Key Benefits

- **LIFING** reduces design costs, permitting the designers to analytically identify and improve fatigue critical locations.
- It handles NASTRAN, ABAQUS, ANSYS Finite Element Models.
- It Implements multithreading technology (fast analysis of big FEMs).
- It includes the module **QUICK2DFEM**, to generate automatically and solve 2D and 3D meshes with functionality to calculate Stress Intensity Factors with J-Integral and M-Integral.
- It includes a tool for the **Load Construction** based on sensor measurements from test campaign (such a feature is handled by specific commercial software, however **LIFING** has an integrated tool).
- **LIFING** stores all data in a SQLITE database whose data can be accessed anytime, also without **LIFING.**
- It is distributed with floating licenses such to allow, with a single license, multiple engineers to use it.

...our Solution

LIFING is a fatigue solver, with its own post-processor. Based on FEM, it copes with all aspects which are involved in a fatigue assessment:

- crack initiation (handled by the module Life),
- crack growth (handled by the module Growth),
- operative loads derivation.

What differentiate LIFING from other similar commercially available software are the following characteristics:

LIFING has been developed by engineers, with solid background on fatigue, fracture mechanics, stress and FEM, mainly active in the aerospace domain.

As a result of such a technical background, **LIFING** has the following characteristics:

- It is based on a simple and intuitive workflow process. Both the user interface and the post-processor are designed with the target to define, in few steps, all the parameters to run the fatigue analysis quickly and easily.
- It provides to the fatigue engineer the vast majority of methods which are required for a fatigue or damage tolerance assessment (strain-life, stress-life, crack growth methods).
- It provides all analysis details, such to allow the analyst to trace the calculation, step-by-step.
- Annotations and attachments (any kind of file like pdf, bmp, stl, ...) can be stored in the database, enhancing the reporting activity.
- It is modular: ad-hoc methods and be easily coded and integrated.

Fatigue assessments have never been so easy so far.
The implemented methods library can be easily extended to embody additional specific analysis methods.

LIFING website: www.lifing-fdt.com
Mail to: support@lifing-fdt.com

FATIGUE - CRACK INITIATION

Fatigue Life, i.e. crack initiation, is calculated throughout the entire FEM or at user defined locations. Life, critical location (where initial crack will nucleate) and crack orientation are calculated.

If solid element FEM is used, stresses are automatically surface resolved, then, based on given fatigue material properties and gives spectrum of loads, fatigue life is calculated.

Multiaxial Fatigue Strain based approaches are implemented:

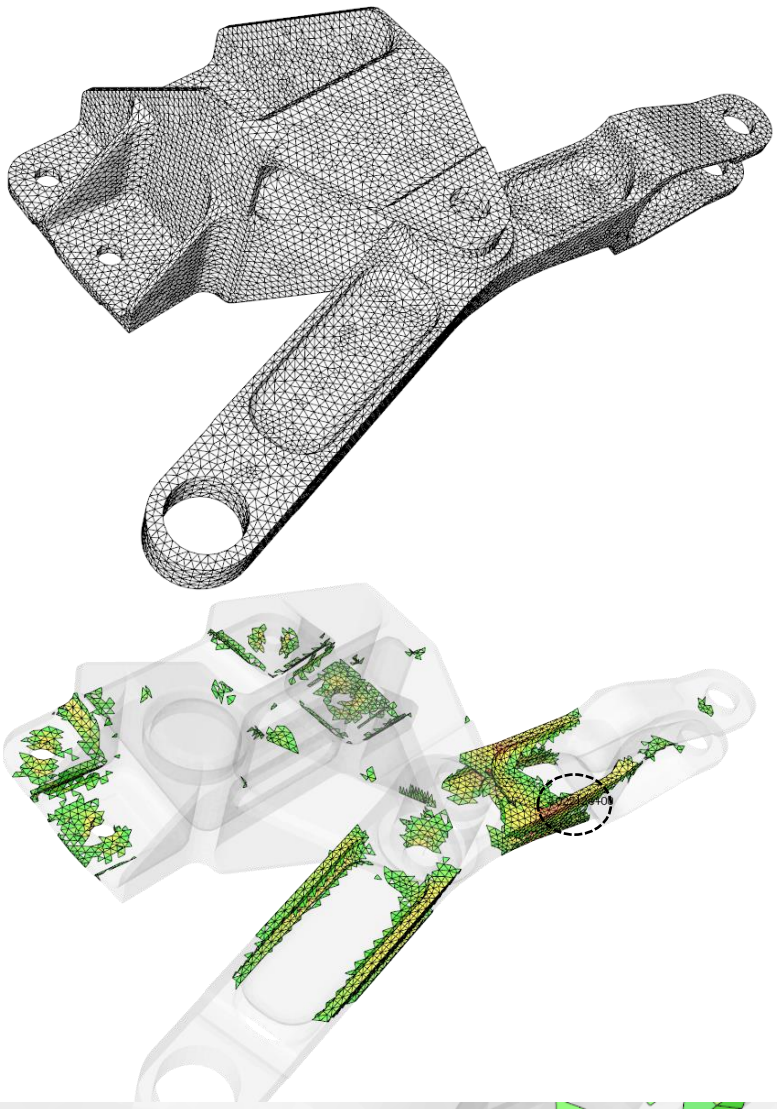
- **Equivalent Stress and Critical Plane methods.**
- **Neuber or Glinka E.S.E.D. methods for calculating plastic stress-strains.**
- **Hoffmann-Seeger or Dowling equivalent stress approach (for Proportional loadings).**
- **Pseudo Material approach (with Mroz-Garud multi-surface cyclic plasticity method).**
- **Smith-Watson-Topper, Morrow's, Manson-Halford, Brown-Miller and Fatemi-Socie parameters.**

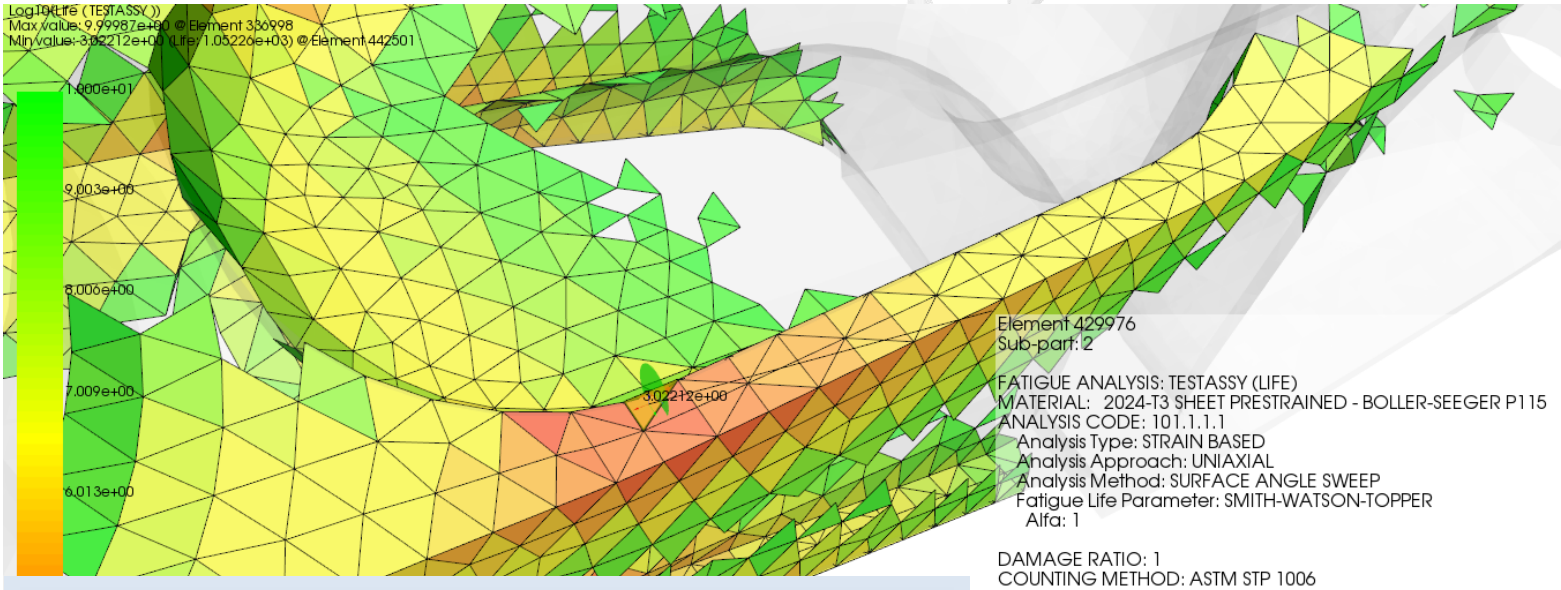
Multiaxial Fatigue Stress based approaches are implemented:

- **Equivalent Stress methods**
- **Dang-Van, McDiarmid**

Conventional uniaxial methods for S-N curves (Goodman, Gerber, Soderberg, Walker, Smith-Watson-Topper, Haigh, MIL-HDBK-5J curves) are also implemented.

Fatigue results, i.e. Life and crack initiation plan) are calculated in the entire FEM (multithread calculation).





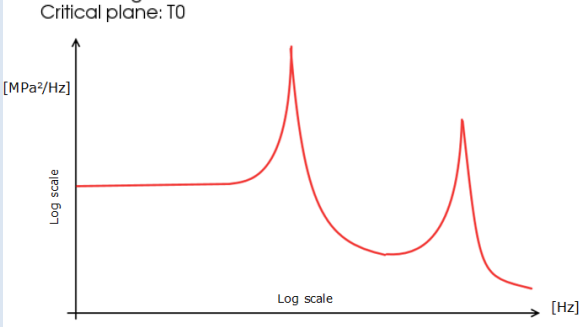
FATIGUE BASED ON PSD

Other than conventional methods for fatigue calculation based on spectra in the time domain, also fatigue due to vibration can be assessed, i.e. in the frequency domain.

In this case LIFING imports the solution from a Frequency Response Analysis and calculates Von Mises per g stresses from the FEM calculated complex stress tensors.

Based on a user defined Power Spectral Density (PSD), LIFING calculates life with Dirlik (notoriously the most accurate approach), Narrow Band and Stainberg methods.

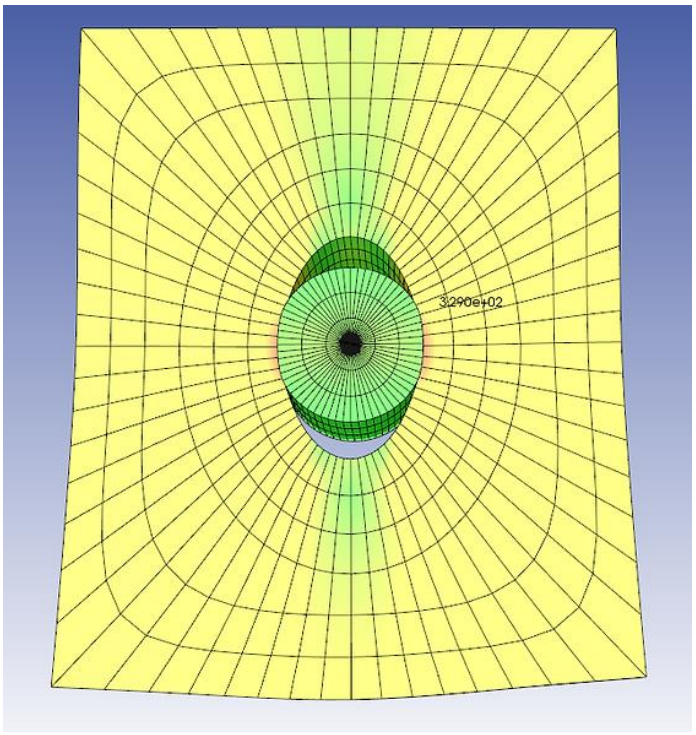
PSD signal can be superposed to static conditions, defining mean stress offsets.

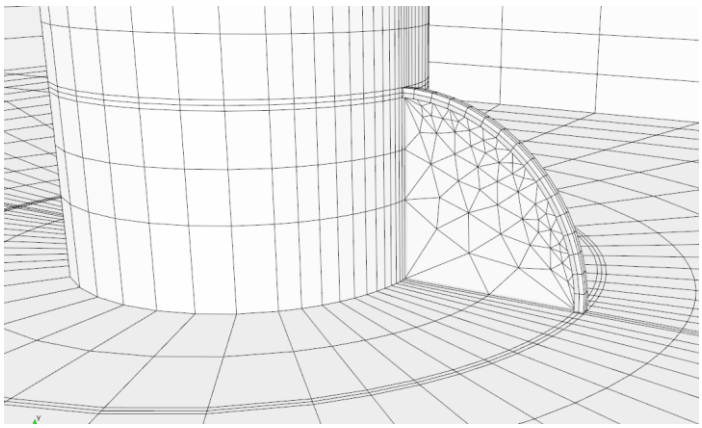


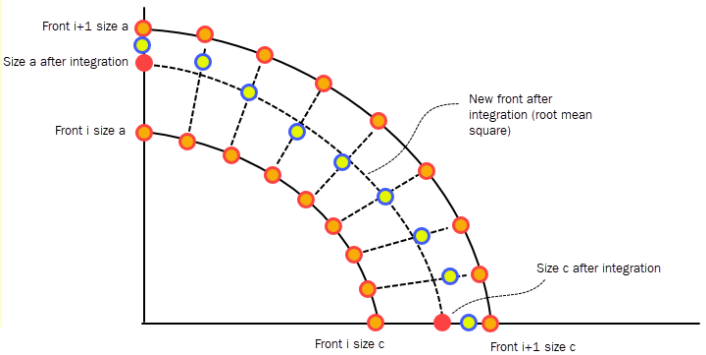
CRACK GROWTH

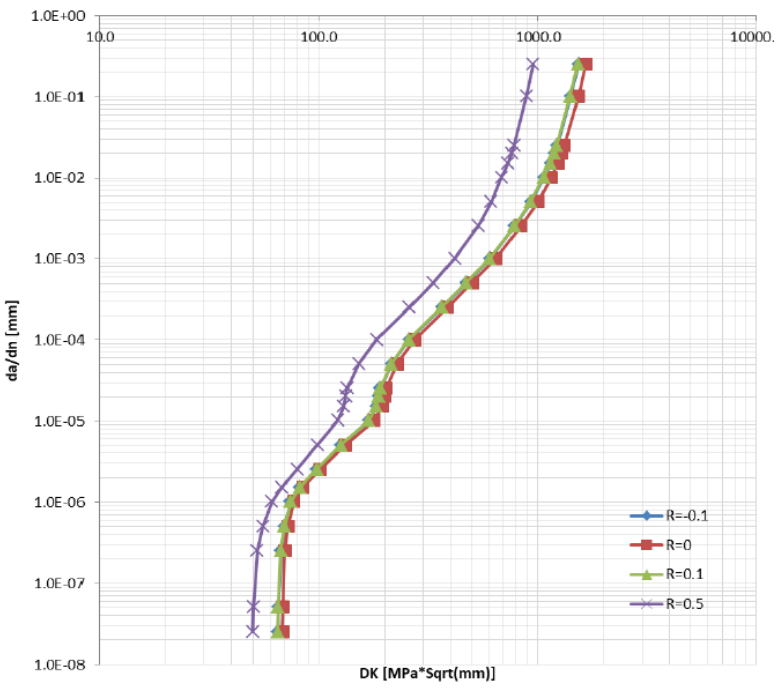
- 2D FEM can be imported or quickly created with the **QUICK2DFEM** module.
- Crack(s) are introduced by the user (multiple cracks, i.e. wide-spread fatigue is analyzed), or are automatically introduced at fatigue hot spots.
- Second order quarter point elements are used at the crack tips.
- Crack(s) are automatically propagated (FEM is remeshed, calculated, based on sub-model boundary conditions, and Stress Intensity Factors are step-by-step calculated with J-Integral.
- Typical for quick assessments of repairs: cracks can be propagated, stop-drilled, re-initiated at the stop drill hole, then propagated again.
- The mesh can be altered with introduction of holes and 'misdrilled holes'.
- 3D solid models can be created by extruding (linear or circumferential) the 2D mesh created with the **QUICK2DFEM** module.
- Crack Fronts can be created automatically and Stress Intensity Factors calculated with M-Integral.
- This feature allows the estimation of Crack Growth Life in generic 3D sections and patches with holes (also countersunk).
- Joints with contacts are handled and neat fit, clearance, interference fit joints and cold working can be simulated.
- Quick Crack Growth assessments can be performed on solid models section cuts (the cut section can meshed, extruded, with applied stress) and CG can be performed in the specific, generic, section.

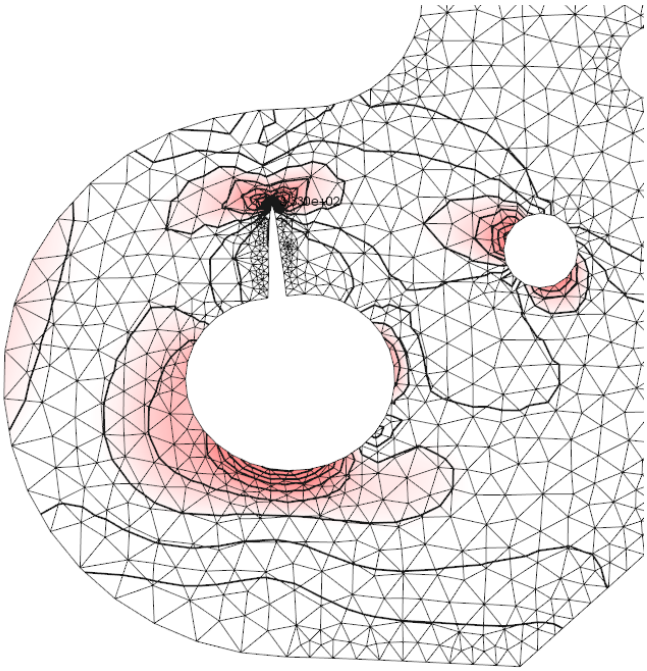
Alternatively SIFs databases calculated by other software can be imported. **LIFING** contains an interpolator which integrates Crack Growth Life based on the imported crack front Stress Intensity Factors database.
Once the crack propagation simulation is performed, Crack Growth Life is calculated by integrating da/dN model.
This can be given in tabular format or by means of NASGRO model (database 3.0 implemented).











LOAD CONSTRUCTION

The use of accurate loads in a FDT assessment is crucial. We can use the best available numerical method to calculate crack initiation or crack growth, but is the input loads are wrong, the assessment results are useless!

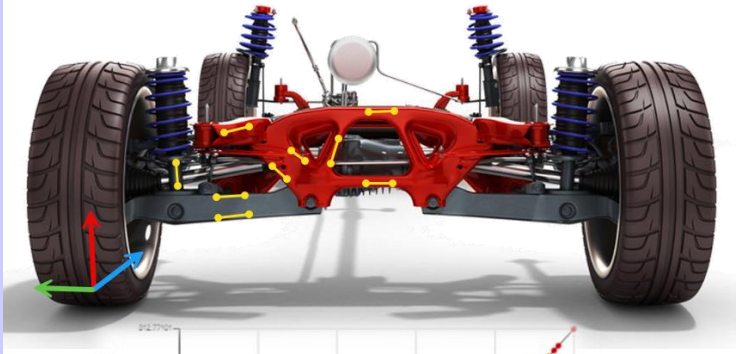
LIFING offers the tool to derive real loads from a set of strain gauge/accelerometers/sensors data collected in a test campaign.

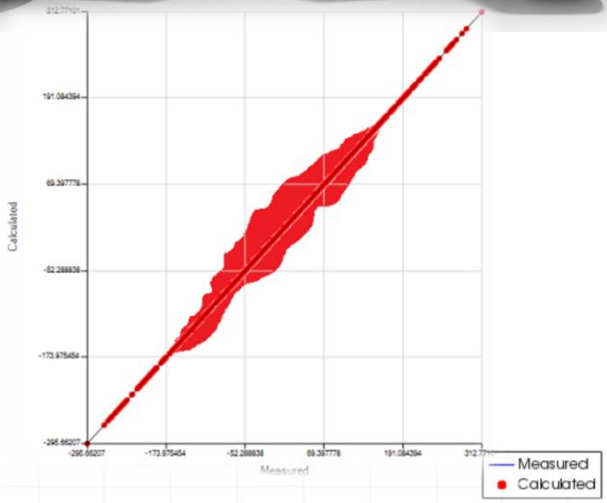
The workflow is simple and straightforward:

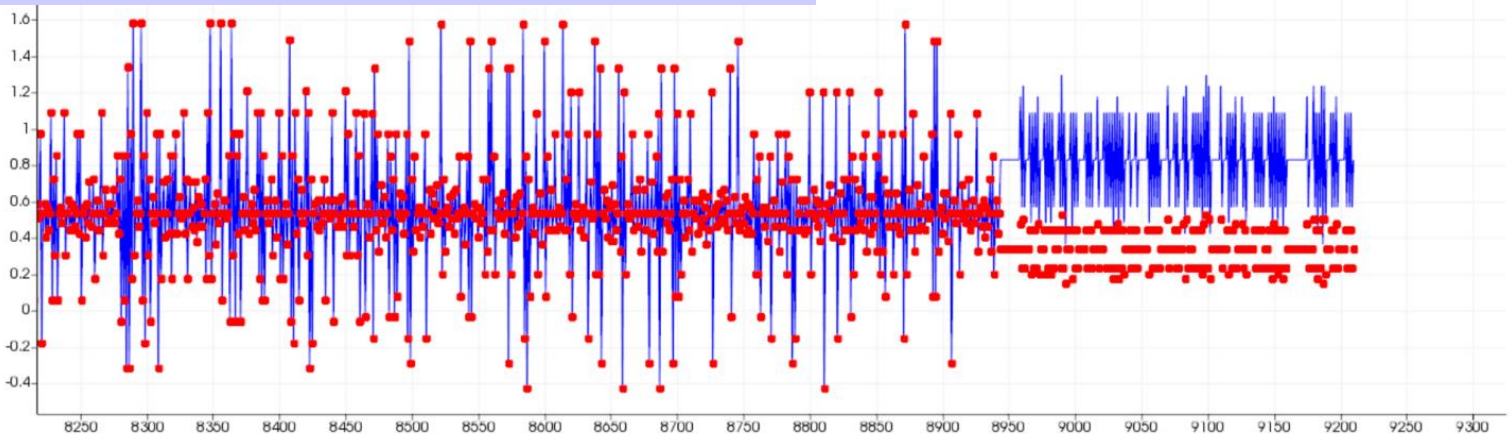
- **Run a FEM 'Digital Twin' of the real structure, with Unit Loads whose combination can represent the instantaneous operative loads.**
- **Calculate the Loads 'Influence Matrix' on the basis of stresses calculated at the positions where sensors have been placed in the test.**
- **Use the 'Influence Matrix' to calculate the time history of combined unit loads providing, at sensor positions, the 'best results' (matching the real measured stress sequences).**

This tool can be used in multiple applications such as:

- **Design optimizations.**
- **Life extensions (in aerospace applications).**
- **Fatigue Test article definition.**







ANNOTATIONS and ATTACHMENTS

Traceability and Reporting are key factors for a FDT assessment, especially when the assessment is aimed to provide compliance to specific requirements.

LIFING provides the capability to store in the database not only the FEM, the stress data and calculated fatigue results. Also additional information can be stored and retrieved when necessary. The database could therefore contain analysis requirements, test data, images, annotations taken by the analyst. No limits to the amount of information to store.

A dedicated GUI is available to store, modify, show, delete all the 'Annotation' and 'Attachments'.

Annotations are can be grouped or categorized in families (e.g. group of critical locations requiring redesign, group of locations which have shown fatigue issues reported by customers, group of locations where specific surface treatments have been performed... Any kind of category can be defined allowing the analyst to use LIFING also as a multi-purpose graphical database.