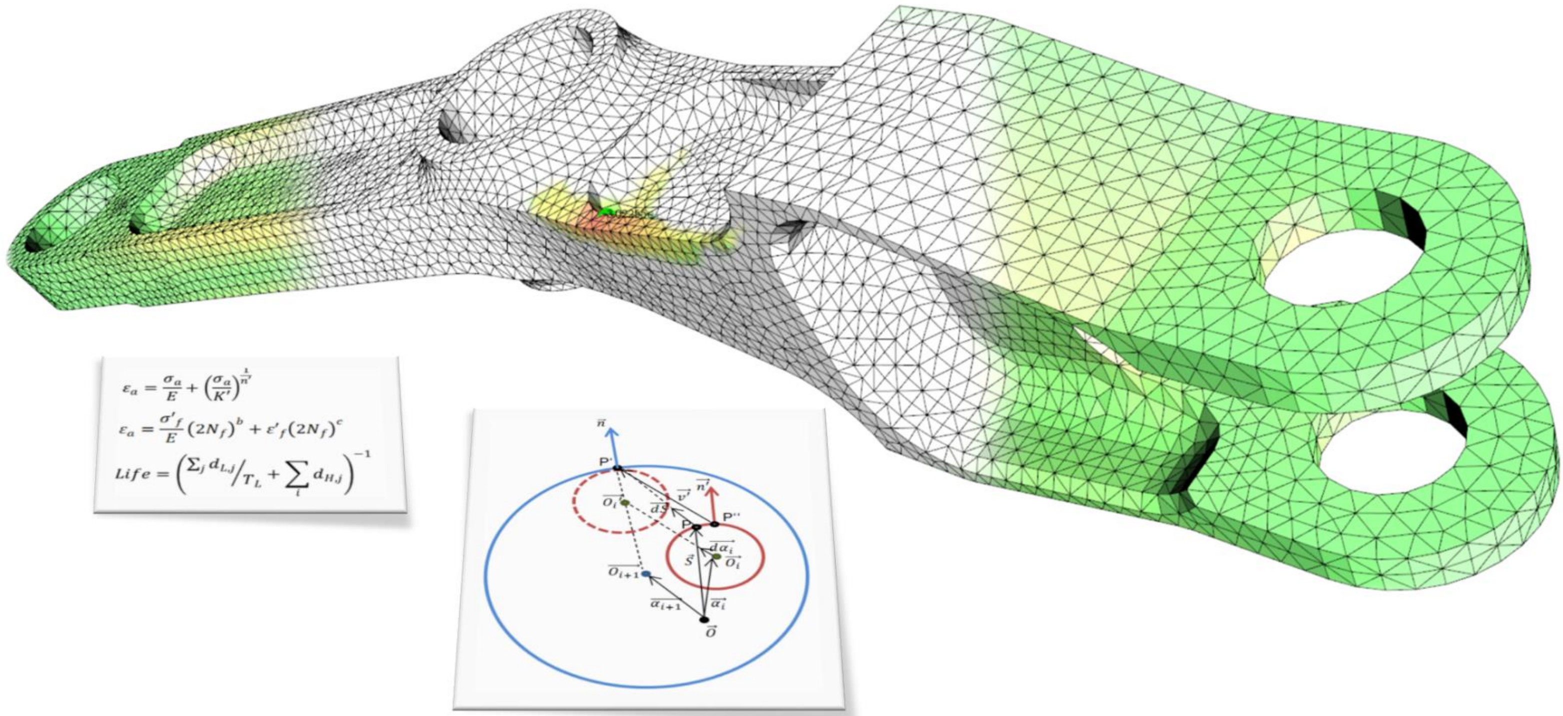
LIFING

Fatigue and Damage Tolerance Analysis Software



$$\varepsilon_a = \frac{\sigma_a}{E} + \left(\frac{\sigma_a}{K'}\right)^{\frac{1}{n'}}$$

$$\varepsilon_a = \frac{\sigma'_f}{E}(2N_f)^b + \varepsilon'_f(2N_f)^c$$

$$Life = \left(\sum_j d_{L,j}/T_L + \sum_i d_{H,j}\right)^{-1}$$

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 life due to loads which are well below the static allowables, and understanding how the cracks develop over the life once nucleated) are more and more topics that must be considered by the structural engineers with special care.

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 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 can be involved in a fatigue assessment: crack nucleation (handled by the module Life), crack growth (handled by the module Growth).

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 and related GUI. 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 capabilities which are required for a fatigue or damage tolerance assessment.
- It provides all analysis details, such to allow the analyst to trace the calculation, step-by-step.
- 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.

Contact us at:

LIFING website: www.lifing-fdt.com

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FATIGUE - CRACK NUCLEATION

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.
FEM stresses are automatically surface resolved, then, based on given 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:

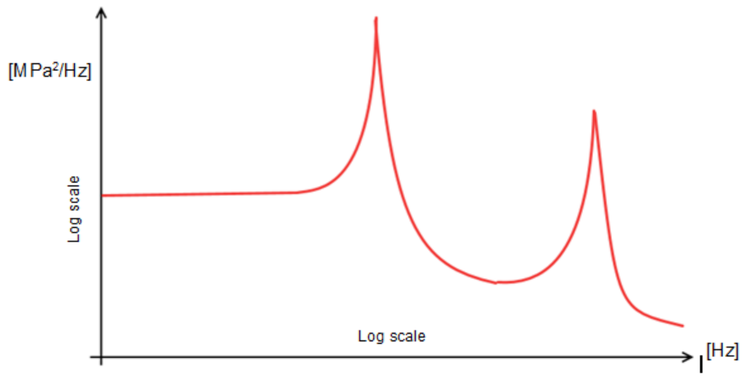
- Equivalent Stress methods
- Dang-Van, McDiarmid

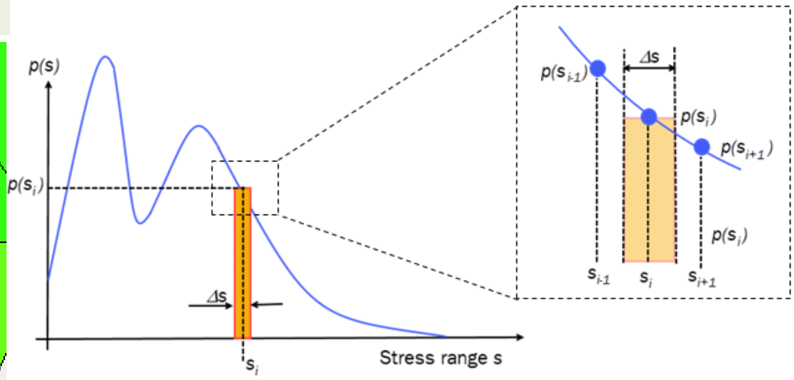
Conventional uniaxial methods for S-N curves (Goodman, Gerber, Soderberg, Walker, Smith-Watson-Topper, Haigh, MIL-HDBK-5J curves) are also implemented.

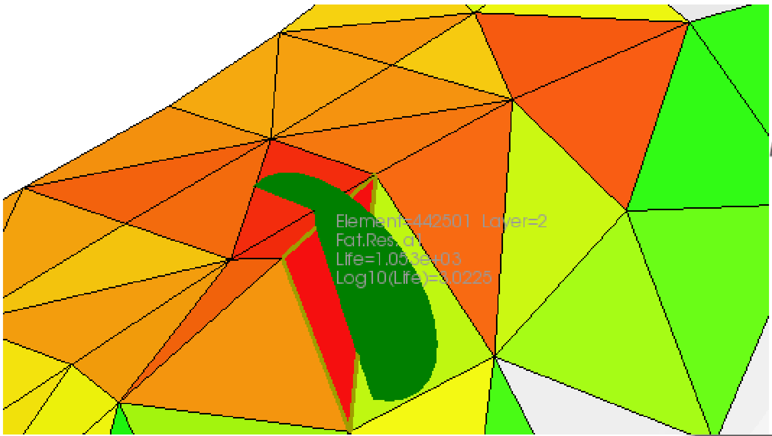
FATIGUE BASED ON PSD

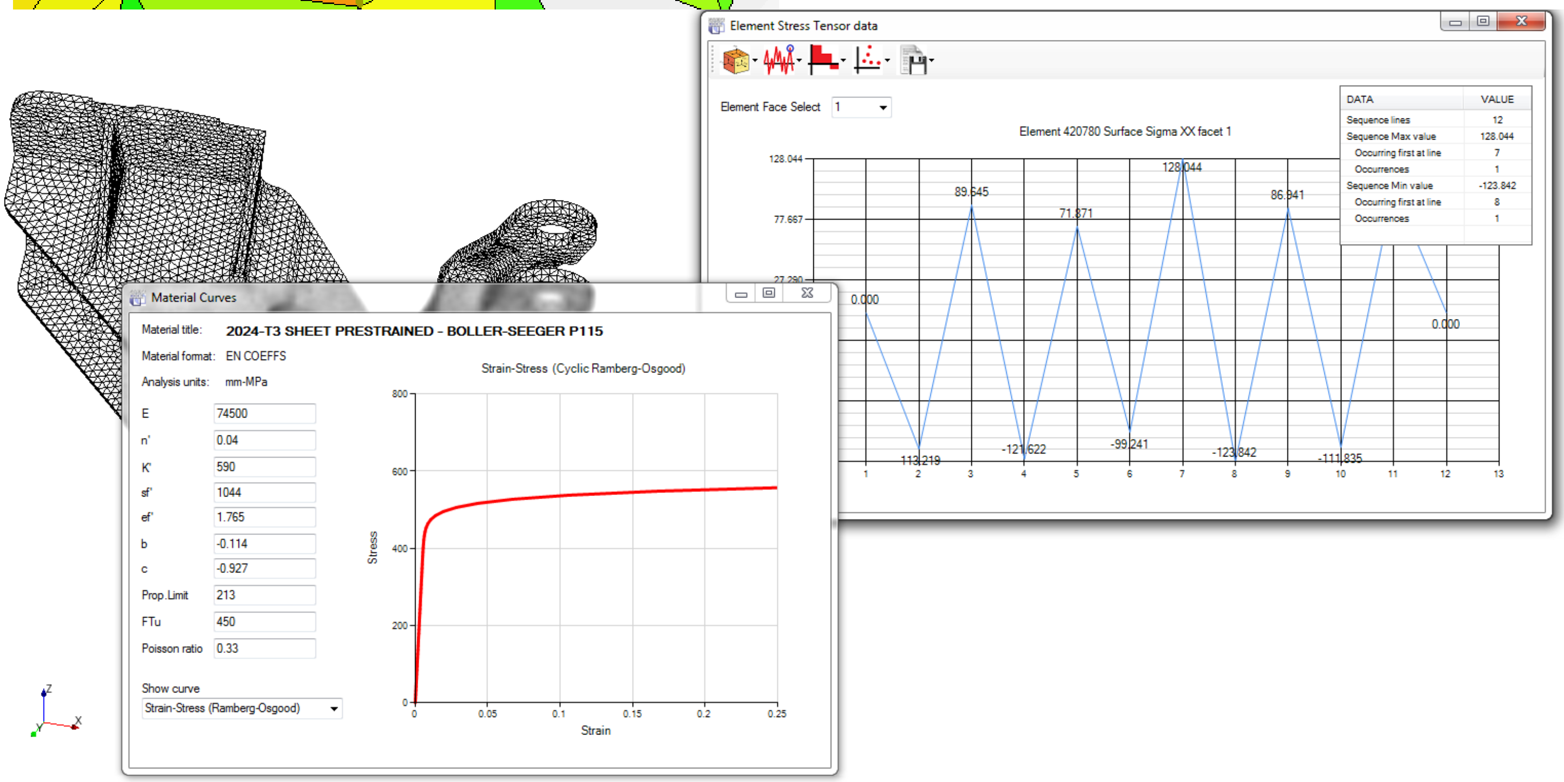
Other than conventional methods for fatigue calculation based on spectra in the time domain, also fatigue due to vibration can be assessed, i.e. in the frequency domain.
In this case LIFING imports the solution from a Frequency Response Analysis and calculates Von Mises per g stresses from the FEM calculated 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.





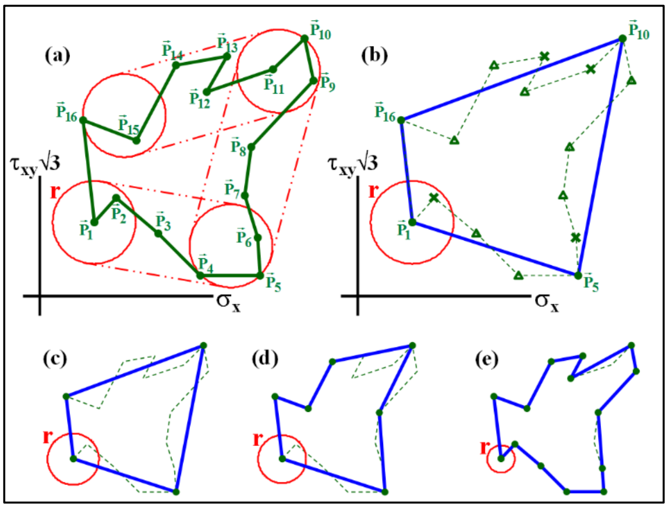


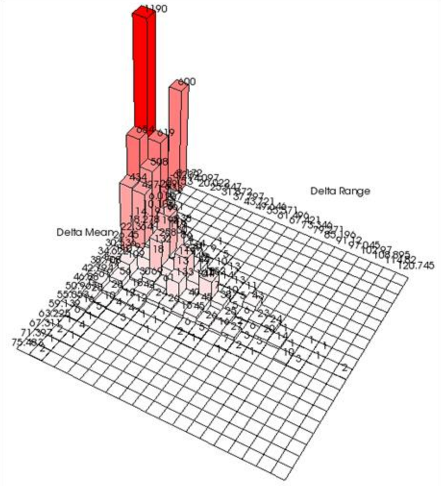


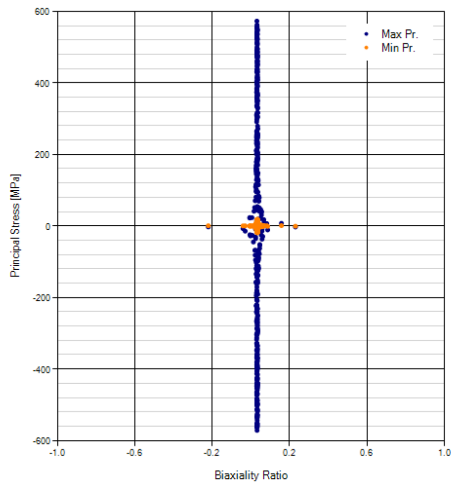
VIRTUAL STRAIN GAUGES, MULTIAXIAL ASSESSMENTS

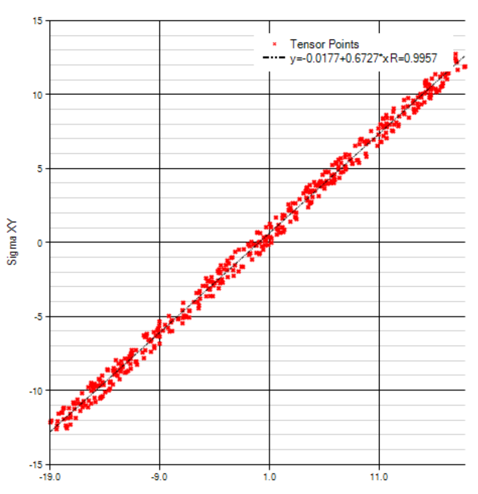
The user can put virtual strain gauges on the FEM surfaces and extract directly stress tensor time histories, or local Von Mises PSD in case of PSD based analysis, which can be processed:

- Filtering (uniaxial and multiaxial Racetrack Filter implemented)
- Counting (Rainflow, Range-Pair)
- Exceedence charts and Histograms are plotted
- Multiaxiality can be assessed with Max principal and biaxiality ratio charts









CRACK GROWTH

- 2D FEM can be imported or simply 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).
- Quick Crack Growth assessments can be performed on solid models section cuts using Newman-Raju models modified with Glinka's Weight Functions.

Alternatively SIFs databases calculated by other software can be imported. LIFING contains an interpolator which integrates CG Life based on the imported crack front SIFs 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 implemented).