

## WORKSHOP

20 July 2016  
room 126

# Multiaxial Fatigue

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Lecturer: Eng. **Domenico Quaranta (MSc, Aerospace Engineering)**

### Abstract

The seminar focuses on Multiaxial FEM assisted Fatigue Analysis theory and methodologies. After a brief introduction on uniaxial fatigue basic concepts, each step of the entire analysis process is detailed: from loads extraction, stress tensors time history assembling, filtering, derivation of elastic-plastic stress tensors sequence out of the FEM linear elastic calculated one, damage and life calculation. Methodologies based on Low Cycle Fatigue Critical Plane approaches are emphasized: Glinka-Buczynsky incremental Neuber/ESED and Kötting-Barkey-Socie Pseudo Material approaches are described, both with the Mroz-Garud multi-surface cyclic plasticity model. The most used multiaxial fatigue parameters are shown: Smith-Watson-Topper, Brown-Miller and Fatemi-Socie. High Cycle Fatigue methods are briefly mentioned; one of the standard methods is described, the Dang-Van.

As the speaker has extensive experience on coding fatigue analysis solvers, the topics are shown with emphasis on the computational/procedural standpoint.

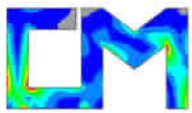
### Program

- 10.00 **Welcome and Workshop introduction**
- **Prof. Renato Esposito** – Machine Design Group, Faculty of Engineering, University of Salerno,
  - **Aeropolis rep.**
- 10.15 **Uniaxial fatigue and first part of Multiaxial Fatigue**
- 11.30 **Break**
- 11.45 **Second part of Multiaxial Fatigue**
- 13.00 **Discussion**
- 13.30 **End of seminar**

*Workshop organisation*

Prof. Roberto Citarella – Machine Design Group  
Department of Industrial Engineering - University of Salerno  
via Giovanni Paolo II, 132 - Fisciano (SA) - e-mail: [rcitarella@unisa.it](mailto:rcitarella@unisa.it)





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### Introduction

Fatigue in Metallic Components

Uniaxial Fatigue

Analysis Process

High and Low Cycle Fatigue (S-N model and e-N model)

Mean stress correction methods

Stress Concentration and Notch Factor

Elastic-Plastic stress calculation (Neuber and Glinka rules)

Fatigue Spectra and Time Histories

Filtering (racetrack Filter)

Spectrum, cycles, Rain-flow counting

### Multiaxial Fatigue

Analysis Process

2D, 3D Stress-Strain Tensors

FEM surface stress resolving

Stress Tensor time history assembling

Multiaxial Racetrack Filter

Biaxiality ratio

Multiaxial Fatigue Proportional and Non-Proportional Loadings

Elastic-Plastic stress tensors calculation in Proportional loading conditions

Dowling method

Hoffmann-Seeger method

Impact of biaxiality ratio on fatigue results

Elastic-Plastic stress tensors calculation in Non-proportional loading conditions

Socie pseudo-material method

Cyclic Plasticity Models

Mroz-Garud model

Proportional Loading reduction

Multiaxial HCF methods

Critical plane methods

Other methods

Example: Dang-Van method

Multiaxial LCF methods

Critical Plane Fatigue parameters

Smith-Watson-Topper

Brown-Miller

Fatemi-Socie

## Curriculum Vitae di Domenico Quaranta

Domenico Quaranta has extensive experience in the following fields:

- Stress Analysis, with both standard practice hand calculation and FEM
- FEM numerics
- Fatigue Analysis, with standard methods and FEM assisted methods
- Crack Growth and Damage Tolerance, with standard methods and FEM assisted methods
- Computational Fracture Mechanics

### From 2006 to 2017

- *Pilatus Aircraft Ltd. (Stans, Switzerland)*

Chief Stress Engineer for the Pilatus Trainers Engineering Structures Department (supporting the products PC-7, PC-9, PC-9(M), PC-MkII, PC-21).

Leader of the Fatigue-Damage Specialists Group.

Stress signatory authority for design.

Personnel training (static analyses using both FEM and hand calculation and for fatigue and damage tolerance analyses).

#### Relevant projects:

- PC-7 Trainer Life Extension: +50% Landings
- PC-9 Aft Fuselage Relieving: FEM assisted Fatigue Analysis aimed to justify/calibrate structural integrity and inspection regimes

### From 2000 to 2006

- *Client SICAMB-EUROCOPTER (Latina, Italy – Donauwörth, Germany)*

Responsible for the preliminary sizing and the stress analysis methodology definition of the AIRBUS A-380-800F Main and Upper Deck Cargo Doors.

- *Client AERMACCHI (Varese, Italy)*

Analysis, support to design, and certification reporting of the AIRBUS A-380 Trent 900 Nacelles (both Fixed Fan Duct and Thrust Reverser configurations)

- *Client AERMACCHI (Varese, Italy)*

Analysis and design of the M-346 front fuselage structures work package: stress analyses of frames and bulkhead frames, spars and longerons, stringers, metallic and composite skins and panels, brackets, junctions.

- *Client ALENIA SPAZIO (Torino, Italy)*

Analysis and design of the MDPS (Meteoroids and Debris Protection System) of the International Space Station – Node 2: stress analysis of mixed composite and metallic structures having “external shield” requirements for space debris and extra vehicular activities.

### Education

MSc - Aerospace Engineering at Politecnico di Torino, marks 110/110.

Computational Fracture Mechanics Advanced course at Cornell University (NY – USA)

Fatigue – Numerical aspects by G.Glinka (University of Waterloo, Canada)