Prifysgol Abertawe
Swansea University

Module Name:	**Damage Tolerance and Component Lifing**
Module Code:	**EGTM10**
Presenter(s):	**Professor John Evans/Dr Mark Hardy and Mr Steve Williams (Rolls-Royce plc)**
Credit Rating:	**10**
Venue:	**College of Engineering, Swansea University**

Synopsis:

Damage tolerant design is the prevention of failure in engineering structures containing cracks or defects. The module applies these design techniques, based on Linear Elastic Fracture Mechanics (LEFM), to structures and components in gas turbine engines. It covers the stress conditions in the components, the derivation of LEFM principles and their application to both static and cyclic loading states.

Under cyclic fatigue conditions, subsequent to crack initiation, a crack will grow in a structural metal on a cycle by cycle basis until it reaches a critical size that leads to an overload failure in the final cycle. Linear elastic fracture mechanics (LEFM) based techniques are now a popular tool used by the lifing engineer to predict the behaviour of fatigue cracks and ultimately a safe life for an engineering component. These "damage tolerant" techniques will be reviewed in this module. The module is reinforced by a detailed, computer based case study.

Intended Outcomes:

After completing this module the student will demonstrate:

- An awareness of stress intensity based criteria for quantifying static fracture behaviour.
- Appreciation of the importance of crack tip plasticity in fracture toughness measurements.
- Understanding of the critical differences between plane stress and plain strain toughness criteria.
- An ability to apply fracture mechanics principles to ductile - brittle transitions.
- A fundamental understanding of the relationship between fracture mechanics parameters and fatigue or stress corrosion crack growth conditions.
- Understanding of the factors that fundamentally control crack growth response.
- Competency in fracture mechanics calculations relating to static fracture, fatigue and stress corrosion behaviour.

Module Aims:

On completion of the module students will demonstrate an understanding of the mathematical approaches to the prediction of crack growth (both under static and cyclic loading situations) and how these techniques are applied to the lifing of safety critical components in high performance applications.

Syllabus:

The module will cover the following:

- Typical service failures illustrating the engineering requirement for fracture mechanics (Examples from aerospace, ships, bridges, power industries),
- Micromechanisms of fracture (Characteristic features of ductile, brittle, fatigue, stress corrosion)
- Energy balance and brittle fracture (Griffin criteria, strain energy release rate, experimental measurements),
- Stress intensity factors (Stress fields, definitions, infinite and finite geometries, plastic zones),
- Plane stress/Plane strain and fracture toughness measurements (Definitions, fracture modes, experimental measurements),
- Elastic-plastic fractures (Crack opening displacement, J integral and their measurement),
- Design criteria for static fracture (R-curves, interactions between ductile and brittle fracture),
- Application of stress intensity factors to fatigue and stress corrosion crack growth rates (Growth laws, mean stress effects, thresholds, closure, Walker relationship),
- Damage tolerance principles (Database lifing, damage tolerant methods, probabilistic lifing),
- Fracture response and material structure (Static fracture and fatigue crack growth, stress corrosion, optimising

material behaviour).

Assessment:

5,000 word assignment to be submitted within three weeks, after the course presentation