Damage Tolerance – Methods & Applications (DTMA2011)

Course Content

No.	Topics	Hours/Days	Dates	Lecturers	Place	Outline of topics
1	Introduction, Regulations	5/1	Mar 1	M. Růžička (FME CTU in Prague) J. Papuga (FME CTU in Prague) J. Běhal (VZLÚ)	Room No. 223 FCE CTU in Prague,	Course outline and focus; history of research related to fatigue, its application in development of components; factors affecting the strength and durability of structures; failure types, their combinations; non-destructive inspections and testing; criteria of fatigue design; Damage Tolerance approach history; current state; circular CS 25, paragraph CS 25.571; safe-life certification, damage tolerance certification acc. to CS 25.
2	Fatigue	5/1	Mar 2	M. Růžička (FME CTU in Prague) J. Papuga (FME CTU in Prague)	Room No. 17 FME CTU in Prague,	Stress and strain under cyclic loading; change of material response during cycling; hard and soft loading; cyclic stress-strain curve; S-N curve; Manson-Coffin curve; Basquin curve; stress-based fatigue analysis and factors to be included; mean stress effect; notch effect; damage cumulative rule; rain-flow; strain-based fatigue prediction; damage parameter; focus of the analysis: low-cycle v. high-cycle fatigue; fatigue limit; giga-cycle fatigue; multiaxial loading; multiaxial fatigue analysis; thermal effects.
3	Fracture Mechanics & Fractography	10/2	Mar 16 - 17	J. Kunz (FNSPE CTU in Prague) A. Materna (FNSPE CTU in Prague) J. Siegl (FNSPE CTU in Prague)	Room No. 17 FME CTU in Prague,	Linear fracture mechanics; stress intensity factor; modes of crack front loading; brittle fracture; correction functions, FEA-models calibration; linear superposition; fracture toughness and factors that affect it; ductile fracture; non-linear fracture mechanics; plastic zone around the crack front; J-integral, R-curves; COD concept; fatigue crack growth and factors that affect it – stress redistribution, plastic zone, loads interaction, crack closure and opening; crack growth under multiaxial loading; short cracks growth; relation between fatigue limit and SIF threshold; relation between SIF threshold and notch factor; applicable software, its usability for specific problems; inspections and their intervals; setting the safe inspection interval; fractographic analysis of fracture surface; crack growth reconstruction for constant and variable amplitude loading; marking of fracture surface.

No.	Topics	Hours/Days	Dates	Lecturers	Place	Outline of topics
4	Reliability & NDT Methods	10/2	Mar 23 - 24	G. Dohnal (FME CTU in Prague) P. Kopřiva (FNSPE CTU in Prague) J. Běhal, jr. (ATG) M. Boháčová (VZLÚ)	May 23: Room No. 17 FME CTU in Prague May 24: VZLÚ a.s.	Statistic distributions, their parameters; statistical processing of experimental measurements – examples; probabilistic content of reliability factors; deterministic v. stochastic solution; design with a failure probability; simulation methods; hypotheses testing; probability of defect detection; methods for PoD curves evaluation, examples of their practical application; comparison of individual methods and their aspects (demand factor; applicability; price; predicative value); stress redistribution analysis; visual inspections; penetration fluids; ultrasonic detection; X-ray detection; magnetostrictive methods; methods using vacuum; strain-gauging; optical fibres; piezo-sensors; acoustic emission; thermo-sensitive methods; modern optical methods (holography); analysis of dynamic response; piezo-actuators; transition to SHM (Structural Health Monitoring), its main aspects.
5	Metallic Structures	6/1	Apr 20	V. Očenášek (SVÚM) H. J. Schmidt and B. Schmidt (AeroStruc)	Room No. 17 FME CTU in Prague,	Materials used for metal aircraft structures; their static and fatigue properties; certification of materials; material databases; examples of designs and their applicability within DT; analysis of available materials used in aircraft industry as regards DT; material or supplier replacement evaluation; multiple load paths; difference between fail-safe and damage tolerant approaches; aspect of failure detectability; crack stoppers; crack front branching; availability of material data; primary members identification in the airframe; damage extent; inaccessible parts and joints, tests of primary structure parts.
6	Composites, Their Analyses	6/1	Apr 27	B. Cabrnoch (Inter Informatics) R. Doubrava (VZLÚ) A. Johnson (DLR)	Room No. 17 FME CTU in Prague,	Differentiation of composites; composites with long fibres; fiber and matrix types; production technology; composite micromechanics; elastic moduli; anisotropy; orthotropy; isotropy; fibre-glass, lay-up, marking; lamina strains and stresses; strength criteria; introduction to classic lamination theory; stresses and strains in fibre-glass; spring-back effects; fibre-glass failures, delamination; fatigue of composites, stiffness degradation; experimental strain analysis; optical methods, ultrasonic measurement; FEA-modelling of composite structures; sandwich structures; analysis of sandwiches.

No.	Topics	Hours/Days	Dates	Lecturers	Place	Outline of topics
7	Composite Structures	6/1	Apr 28	R. Růžek (VZLÚ) A. Johnson (DLR)	Room No. 17 FME CTU in Prague,	Materials used for composite aircraft structures; their static and fatigue properties; certification of materials; examples of designs and their applicability within DT; aspect of failure detectability; differences in failure modes between metals and composites; analysis of available materials used in aircraft industry as regards DT; availability of material data; joining metal and composite materials – bonding, riveting, bolts, combined joints; sandwich structures; damage identification, DT aspects of the composite use; impact tests; numerical simulation; certification of a structure with defects; damage extent; inaccessible parts and joints; new trends in the production of composite parts.
8	DT – knowledge integrating, practicing	12/2	May 4-5	H. J. Schmidt, B. Schmidt (AeroStruc)	Room No. 17 FME CTU in Prague,	Overview of typical parts DT certified by European aircrafts; statistics and results of inspections; example of DT certification of a metal sample; application of computational tools; experimental campaign; certification procedure; extent of tests; NDT system; in-service actions; example of DT certification of a composite sample, differences in the certification and experimental procedure; SHM systems; workshop in teams designing specific parts, analysis of existing structures; identification of evaluated areas; admissible damage analysis; inspections; certification of typical parts, DT applicability on various parts of aircraft structures.

TOTAL hours	**60**	