

## COURSE OUTLINE

7<sup>th</sup> to 11<sup>th</sup> September, 2009 – Hyatt Regency Hotel, Huntington Beach, California

# Applied Damage Tolerance

## Course Description

This course is designed to deliver the design, analysis and testing fundamentals that are necessary for airworthiness engineers to substantiate fatigue and damage tolerance of aircraft and aerospace structures and components. Students participate in a combined lecture and classroom setting using real world problems from their own work situations to learn the concepts of fatigue, fracture and damage tolerance assessment. Other recent developments in the area of fatigue and fracture mechanics, including the virtual testing, multiscale modeling and simulation will also be discussed.

The course will be delivered by Dr. Bob Farahmand and Dr. Damian Horrigan of TASS Inc.:

**Dr. Damian Horrigan**, Chief Technology Officer, has over 15 years of aviation experience with 7 in airline senior management roles. Formerly Director of Engineering at Air New Zealand Engineering Services, he was responsible for the fleet management of the Air New Zealand jet fleets. Prior to that he was Design Engineering Manager for Air New Zealand and Ansett Airlines, managing all of the modification and repair engineering. He has subsequently performed a significant amount of structures engineering and damage tolerance analysis for Part 25 aircraft and is a FAA DER including delegation in Damage Tolerance. He has published over 20 papers in international journals and a wide number of papers in published conference proceedings.

**Dr. Bahram Farahmand**, Chief Scientist, has over 30 years of fatigue & fracture mechanics analysis and testing experience with several major programs at Boeing. Dr. Farahmand is the former Boeing Technical Fellow, author of three books in the field of fatigue and fracture mechanics and the founder of virtual testing technique: Generating fatigue and fracture allowables through the extended Griffith theory by using a simple stress-strain curve (reducing cost and time of testing). Dr. Farahmand was involved in numerous programs at Boeing, author of several fracture control plans, numerous technical papers, and author of several inventions.

## Who should attend?

This course has been tailored for interested participants in the aerospace industry and for individuals who are actively involved in the analysis, substantiation, certification and maintenance of structural aspects of aircraft. This is an active participation course which requires the student to come prepared with relevant example problems from their current work situations. Numerous key example problems are worked during the course and are intermingled between the classroom theories that are delivered through the week.

## Benefits of attending

You will be able to have a much better understanding of damage tolerance assessment and substantiation techniques in the aerospace industry for application to:

- Modifications
- Repairs
- Corrosion prevention control
- Fatigue
- Widespread fatigue cracking
- Life assessment of pressurized tanks & welded structures
- Fracture Control Plans

Upon completion of this course, you will have firsthand experience in working on and completing a wide number of analysis problems that are of interest to all analysis engineers.





## APPLIED DAMAGE TOLERANCE

Join us at the Hyatt in Huntington Beach, California this September for this intensive five day educational experience in the concepts of fatigue, fracture, and damage tolerance analysis of aerospace structures.

\$1,995.00 USD

5 days of training  
Training materials

Demo access to TASS INC online DTA tools  
Breakfast, lunch and coffee breaks

7<sup>th</sup> to 11<sup>th</sup> September, 2009

### Hyatt Regency Huntington Beach Resort & Spa

21500 Pacific Coast Highway, Huntington Beach, CA 92648, USA  
PHONE 714-698-1234 HOTEL FAX 714-845-4990

[www.huntingtonbeach.hyatt.com](http://www.huntingtonbeach.hyatt.com)

Ask for the TASS Inc. hotel room rate of \$149.00 US per night  
(additional reduced resort fee of \$8.00 US per night will be charged by hotel)

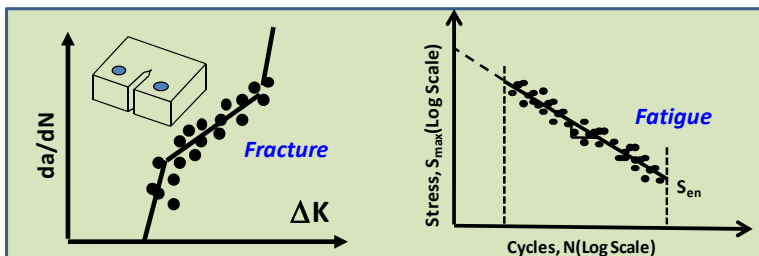
For more information or to register for this course, please contact:

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Kirkland, WA 98034 USA

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Book early as class size is limited in order to assure appropriate instructor – student time for problem solving.



GEOMETRY

Plate Thickness,  $t$   
Plate Width,  $W$   
FLAW SIZE: (Use  
a (in/L) = 0.2250  
c (in/L) = 0.2250  
a/c (in/L) = 1.000

Material Propert  
:Mat: UTS : YS  
:No. : :  
: : : :  
: I : 180.0: 170.0:  
:Mat: : : : :  
:No. : C : n :  
: : : : : :  
: I : 200.00:

FATIGUE SPECTRUM

S : M : NUMBER  
T : A : OF  
E : T : FATIGUE  
P : L : CYCLES  
I : I : 200.00:

ANALYSIS RESULTS

# ADVISORY: Cracking  
# Transition to  
# a = 0.25911  
# at Cycle No.  
Size: c = 0.278126E-01, a/c = 0.8994, Total Cycles = 99.300856

The screenshot shows a software interface with various input fields and buttons. A 'Click Here' button is highlighted. The interface includes sections for 'GEOMETRY', 'FLAW SIZE', 'Material Propert', 'FATIGUE SPECTRUM', and 'ANALYSIS RESULTS'. The 'ANALYSIS RESULTS' section shows a 'Transition to' point at cycle number 99.300856.



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## Course Outline

### DAY 1

**Introduction And History of Failure:** Several structural failures will be reviewed – Lessons learned

**Fundamentals of Fatigue (S/N):** High cycle fatigue and variability of fatigue data, Crack initiation, Intrusion and extrusion concepts, Cumulative damage, Minor's rule and limitations, Constant life diagram

**Strain to Life Concept:** Low cycle fatigue, Hysteresis loop, Softening & hardening, Coffin Manson strain to life ( $\epsilon/N$ ), Universal slope method

**Neuber's concept:** Neuber's relationship, Modified Neuber's relationship, Residual stresses, Stress concentration, Fatigue notch sensitivity factor

**Factors Influencing Fatigue Life:** Mineralizing, Shot peening and laser peening

**Examples – Problem Solving**

### DAY 2

**Sonic Fatigue:** How to prevent sonic failure

**Griffith Energy Approach:** Fixed grip and constant load concepts, Energy release rate, Theoretical strength

**Linear Elastic Fracture Mechanics (LEFM):** Stress intensity factor concept, Mathematical derivation of K, Geometry and load corrections, Irwin's crack tip plasticity, Von Mises and Tresca yield criteria, Crack tip plastic shape and size, Plane strain and stress fracture toughness ( $K_{Ic}$  &  $K_{IIc}$ ), Dependency of  $K_{Ic}$  on plate geometry, Material anisotropy, Resistance curve concept

**Examples – Problem Solving**

### DAY 3

**Part-Through Cracks:** Surface crack stress intensity factor, Fracture toughness, Kle, Leak before burst concept

**ASTM Testing Standards:** The ASTM E391, ASTM E561, ASTM E720

**Elasto-Plastic Fracture Mechanics:** The J-Integral,  $J_{Ic}$  tests, Fracture mechanics of ductile metals theory, Virtual testing

**Fatigue Crack Growth Rate:** Three stages of crack growth, Paris and the FNK equations, ASTM E647 requirements, Effect of residual stresses on crack growth, Crack closure concepts, Law of similarity

**Examples – Problem Solving**

### DAY 4

**Variable Amplitude Loading:** Flight cycles, Cycle counting techniques, Exceedence concept, Rain flow technique, ASTM E1049, Equivalent cycle, Retardation phenomenon

**Residual Strength:** Residual strength diagram, width effect & requirements, Net section yielding, Feddersen concept, Multi site damage & failure criterion, Wide spread fatigue damage, Stiffened structure and crack arrest, Plastic collapse & failure diagram

**TASSGRO Tutorial**

**Examples – Problem Solving**

### DAY 5

**Fracture Control Plan:** Main elements of FCP, NDI inspection methods (liquid, magnetic, Eddy, ultrasonic & Radiographic), Initial flaw size & probability of detection, special inspection

**Environmental Effects:** Environmental assisted corrosion, Examples of corrosion, Intergranular crack corrosion, Hydrogen embrittlement, Factors causing stress corrosion, Pit corrosion & fatigue life, Pit corrosion & crack growth, Establish the threshold value ( $K_{IEAC}$  &  $KEAC$ ),  $da/dt$  versus  $DK$ , ASTM E1681,

**Bolted Joints:** Critical region of a bolt, Threaded fasteners &  $K_t$ , Preload & fatigue life, Fracture analysis of a bolted joint

**Welded Joints:** Fusion welding, Porosity, Residual stresses, Mismatch, Friction stir welding (FSW), Parameters affecting the FSW, Static & fracture test of welded joints, Heat affected zone, nano-welding

**Examples – Problems Solving**

