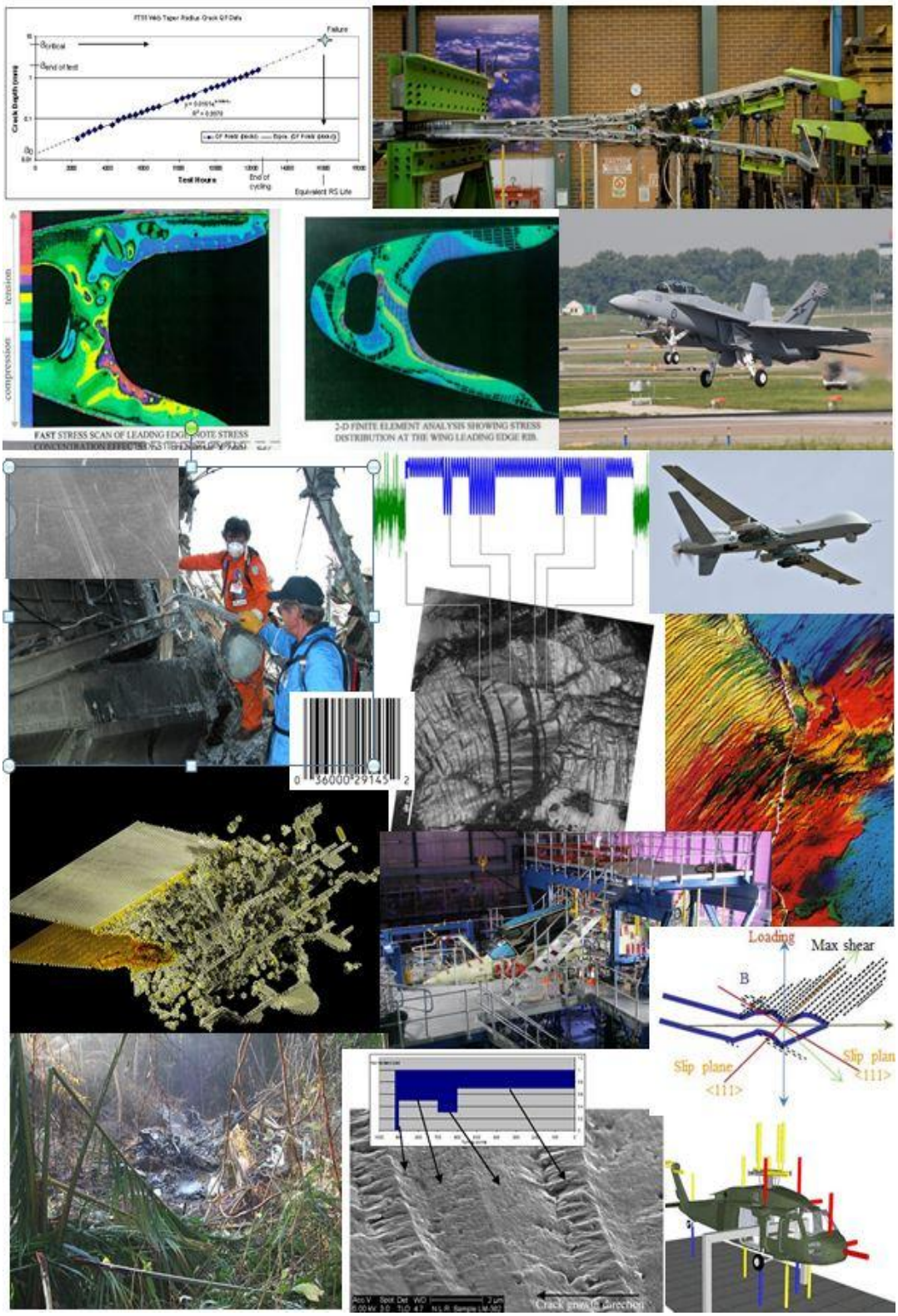
Aircraft Structural Failure Assessment & Emerging Structural Integrity Practices



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Aircraft Structural Failure Assessment & Emerging Structural Integrity Practices

Course to be tailored to your needs

Tentative Title: Analysis and Prevention of Aircraft Structural Failures

Tentative Course Topics (approx: 25 hours)

1. Introduction
   - Whom am I and why am I here?
   - Overview of Course
   - Accident Investigation: Learning from Failure. History, Statistics and Technology
   - Case Study: IL-76 accident in Timor Leste

2. Why Aircraft Fail
   - Structural Design Overview
     - Common failure modes in civil and military aircraft
   - Aircraft Structural Integrity Overview
   - Airworthiness frameworks and standards
   - Case Study: P3C Orion Leading-edge Separation

3. Aircraft Accident and Incident Investigation & Forensics Overview
   - Enhancing Aircraft Safety by Accident Investigation
   - Aircraft Materials Overview
   - Failure Examination and Analyses Techniques
   - Failure Analyses of Composites
   - Non-Destructive Inspection (NDI)
   - Light Globe Filament Analyses
   - Wreckage Distribution and Mapping
   - Graphical Replay Software
   - Safety Culture
   - Case study: Eurocopter Squirrel AS350 Heavy Landing

4. Fatigue
   - What is Fatigue? (ideal versus production materials)
   - Qualitative Fractography
   - Fatigue Mechanisms (crack paths)
   - Scatter factors
   - Short cracks
   - Case Study: AeroMacchi Wing Separation

5. Sources of Fatigue Failures in Service
   - Manufacturing and Maintenance Errors
   - Classic Aircraft Accidents

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- Compendium of Defect Types
- Case study: History of Structural Integrity Issues with F111 wing pivot

6. Fatigue Analyses
   - Fatigue design approaches (Classical safe life, fail safe and damage tolerant)
   - Probabilistic failure analyses
   - Novel Methods
     - Lead Crack Framework
     - Cubic rule
     - Effective Block Approach

7. Fatigue Testing
   - Fatigue testing: materials, components
   - Full-scale structure
     i. Overview (philosophy)
     ii. Case study: F18 Manoeuvre and Dynamic Buffet Test
     iii. Case study: Unanticipated F111 Wing Failure
   - Test Interpretation

8. Fatigue Loads and Modes
   - Individual Aircraft/ Operational Loads Monitoring
   - Multiple site damage in riveted lap joints
   - Case Study: Aloha Airlines B737

9. Fatigue crack prevention
   - Good design practices
   - Employing crack propagation models to prevent failures
   - Damage tolerance
   - Case Study: Nomad Tail Separation

10. Damage and Repair[1]
    - Types of corrosion
    - Analysis and control of corrosion cracking in airframe structures
    - Bonded composite structural repair: development and applications
    - Case Study: F111 Wing Pivot Fitting Repair

11. Examination (If required)

[1] Subject to time constraints

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Shorter Course

	Subject	Comments	Duration (hr)
1.	Introduction	A little info about the author and over view of course contents	0.5
2.	What is metal fatigue?	As the crack growth (CG) tools to be presented may be novel some, contextual background is required. Fatigue issues specific to airframes are discussed.	1
3.	Lessons from classic aircraft accidents and incidents	The root causes leading to fatigue failures are emphasized i.e. manufacturing and maintenance flaws	1
4.	Short cracks, Fatigue Variability or Scatter	What factors contribute to scatter in fatigue lives emphasizing initial defects which is an essential concept in the CG models. The importance of the short crack regime	1
5.	Quantitative Fractography (QF) and the measurement of fatigue CG	QF is a key tool in the analyses of fatigue and the method is briefly described. Data generated through QF was used to develop our CG tools	1
6.	Typical in-service maintenance flaws	Manufacturing and in-service induced maintenance flaws are the primary contributors to in-service aircraft fatigue failures. The presentation describes typical in-service flaws through a number of case studies	1
7.	The Lead Crack Fatigue Life Assessment	The foundation CG method used by the RAAF (Hornet, Pc9, F111 etc)	1
8.	The cubic stress rule	A simple means of predicting the CG rate for a spectrum at an untested stress level from the results at a different stress level. Used in RAAF Hornet and P3C structural repair manuals.	1
9.	The Effective Block Approach (Spectrum Fatigue Crack Growth Evaluation using Variable Amplitude (VA) Data	A novel means of utilising VA CG data to predict the crack growth of an untested spectrum	1

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10.	The Hartman-Schijve CG Equation Variant (optional)	This lifing methods can utilizes long crack data for use in predicting the CG of short cracks relevant to fighter type aircraft.	1
11.	Probabilistic Failure Analyses	Probabilistic failure analyses provides a means of quantifying the probability of failure (POF) as an aircraft ages. A summary of one approach to estimating POF is presented	1
12.	Fatigue loads, usage & loads monitoring systems	Describes fatigue loads and the philosophy and practice of fatigue monitoring	1
13.	Surface finish knock down factors	As machined, polished versus anodised, etched etc	1
14.	Summary of Aust Hornet fatigue testing programs	Emphasising the application of buffet loads to empennage	1
15.	Hornet Centre Barrel testing	The centre barrel/fuselage test program	1
16.	Good fatigue design practice	Tips for fatigue resistant and fail-safe design	0.5
17.	General discussions		0.5
18.	Wrap-up		0.5
19.		Total (Estimated) Time	16
Note	Bibliography provided for each topic		
	Supplemental		
			0.5
	Bonded Repair	Bonded Repair 101	1
20.	US Navy Lifing	A brief over-view of the USN design philosophy	0.5
21.	Failure and Fracture mechanisms and typology (optional)	This presentation covers some observations on the formation of progression marks (i.e. crack path changes) on the surface of AA7050-T7541 mainly due to the application of underloads and proposes a mechanism for the formation of these	1

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