# Best Practice Fatigue Management - Helicopters

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A presentation to: ASI Symposium

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# 1. Introduction – Effective Fatigue Management

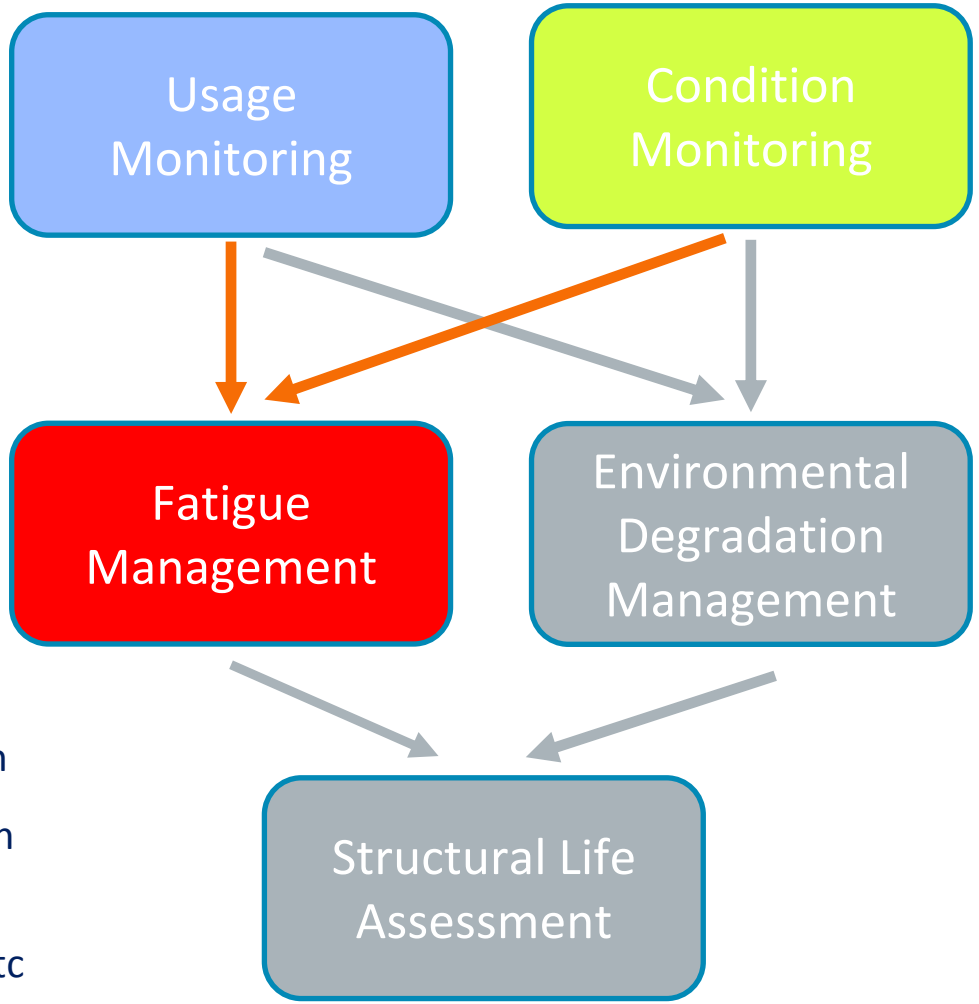
Degradation due to Metal Fatigue

Assumptions made during design and calculation of fatigue lives

- Understanding of assumptions
- Testing assumptions through usage monitoring
- Measuring fatigue drivers
- What is the aircraft condition telling us?

Accidents caused by fatigue cracking

- Super Puma (2009 and 2016) - transmission
- Boeing 234LR Chinook (1986) - transmission
- Lots more … Just not discussed as seminal moments like Aloha, F-111, B-47, Comet, etc

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# 2. Approaches to Fatigue Management - Helicopters

Component Retirement Times (CRTs)

- Safe life based on crack initiation
- Replace components before safe life
- Assumptions made when calculating CRTs
- Not all critical components will have a CRT

Design Usage Spectrum

- Composite worst case usage spectrum
- Damage is caused by the loading action on the component
- Load spectrum and manoeuvres
- Changes in usage
- Measuring complicated fatigue drivers


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# 3. Challenges for Helicopter FM

## Technical Challenges

- Complicated set of fatigue drivers
- Difficult to measure loads on high speed rotating components
- Full scale fatigue testing with high cycle fatigue loads
- Access to design data

## Cultural Challenges – misconceptions

- Helicopters are inherently safe due to conservative design factors
- Safe life components are safe because they are replaced
- Fatigue is a fixed wing problem
- Regulations are written for fixed wing and are not applicable to helicopters
  - Regular exemptions from Aging Aircraft Audits

## Less resources and experience

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# 4. DASRs and RSIP

## Perception that the regulations are written for fixed wing aircraft

- Same physical action (metal fatigues), same need to test design assumptions
- Different approaches and outcomes

## Changing requirements under the DASRs (less prescriptive)

- The need to do fatigue management (as a concept) will not change
  - Current ASIP requirements form an Acceptable Means of Compliance for Aircraft Structural Integrity.
  - Alternative management strategies need to be approved by the Regulator

## US Army currently developing RSIP

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# 5. Component Retirement Times

Is it possible for the ADF to overfly CRTs?

- Assumptions made in the calculation of CRTs:
  - Pristine Condition – what happens if I have damage to the component, including corrosion?
  - Usage Spectrum – am I measuring all fatigue drivers, and what happens if I am outside the DUS?
  - Loads – how do we know if our missions are causing loads greater than assumed?
- The system may preclude overflying the nominal hours, but does not preclude exceeding the component safe life
- Effective FM requires effective usage and condition monitoring


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# 6. Individual Asset Tracking

Traditional ADF Fatigue Management tracks usage severity against the airframe

AFHRS are tracked against individual components

Ensures that fatigue accrual on individual components does not exceed fatigue life of the component

- Allows for rotating of components to between aircraft or sub-fleets to smooth fatigue accrual

Previous study shows that usage severity trends towards fleet average overtime

- This may not be true if aircraft are fitted for specific roles and components are not rotated.
- Safety
- Cost of ownership

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# 7. Health and Usage Monitoring Systems

## Vibration Monitoring

- Indicates damage to rotating components before damage becomes critical
  - Gear box, drive shaft and bearings

## Rotor Track and Balance

- Including vibration monitoring

## Usage Monitoring

- Engine and Structural monitoring
- Telemetry data
  - Acceleration, roll rates, data for Flight Manoeuvre Recognition
  - Feeds into FM / FMR

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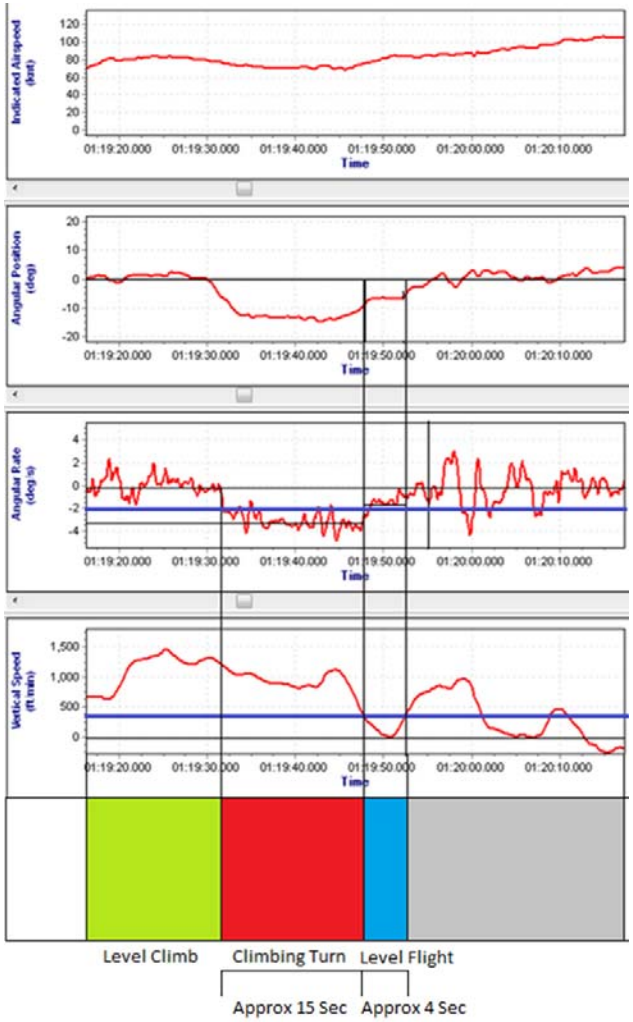
# 8. Flight Manoeuvre Recognition

## Analysis of Usage data to determine actual flight manoeuvres

- Data from Flight Data Recorder or HUMS
- Algorithms match flight data to DUS manoeuvres
- Tested against flight test data to validate

## FMR outcomes can input to effective fatigue management

- Allows capture of a higher percentage of fatigue drivers than traditional UM
- Test assumptions made in FM / CRTs
- Requires flight manoeuvres to be linked to fatigue damage

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# 8. Flight Manoeuvre Recognition

| | Tail Rotor Gearbox Output Shaft | Main Rotor Shaft | Rotating Swashplate | Main Rotor Hub | Tail Rotor Retention Plates | Main Transmission Housing | Forward Bellcrank | Main Rotor Spindle | Main Rotor Blade Cuff and Bolts | Stabilator Acutator Upper Attachment Bolt | Main Rotor Blade Tip Cap | Main Rotor Blade | Tail Rotor Blade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FMR % Capture | 63.62 | 64.48 | 99.33 | 47.98 | 51.20 | 100.00 | 98.10 | 19.57 | 97.60 | 100.00 | 86.35 | 87.42 | 68.30 |
| FAMIS2 % Capture | 0.80 | 11.80 | 5.50 | 28.40 | 1.40 | 4.80 | 47.40 | 5.20 | 50.70 | 1.40 | 38.60 | 36.40 | 62.30 |


| | Tail Rotor Gearbox Output Shaft | Main Rotor Shaft | Rotating Swashplate | Main Rotor Hub | Tail Rotor Retention Plates | Main Transmission Housing | Forward Bellcrank | Main Rotor Spindle | Main Rotor Blade Cuff and Bolts | Stabilator Acutator Upper Attachment Bolt | Main Rotor Blade Tip Cap | Main Rotor Blade | Tail Rotor Blade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mix x FMR USF | 0.61 | 0.76 | 0.36 | 0.92 | 0.73 | 0.34 | 0.65 | 0.90 | 0.19 | 0.32 | 0.56 | 0.61 | 0.88 |
| FAMIS2 Only | 1.11 | 0.99 | 1.08 | 1 | 1.14 | 0.71 | 0.89 | 0.98 | 0.25 | 0.87 | 0.92 | 0.71 | 0.9 |

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# 9. Complications of Through Life Support Arrangements

Defence are looking to pursue efficient aircraft support arrangements to reduce cost of ownership

Different approaches to fleet management

- Traditional  System Program Offices (SPOs)
- Commercial TLS contractor
- Managing aircraft as part of a international / foreign military fleet
  - C-17
  - Romeo

Thorough understanding of how fleet management is performed

- How will the Australian sub-fleet be management if usage diverges from rest of the fleet?

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# 10. Communication, Training and Relationships

Fatigue Management starts during the helicopter design and lasts for the whole of the aircraft's life

Requires an understanding of design assumptions, aircraft usage and condition, and modifications

Requires inputs from OEM, operators, and maintainers

This requires that all the people within the system understand the importance of fatigue management and their role within it

- Training of operators, maintainers to deliver appropriate information to the FM system
- Decision makers understanding the impact of acquisition strategy / TLS contracts / modification programs on FM
- Understanding of different priorities and pressures within the system
- Continuous communication

Helicopter Structural Engineering Familiarisation Course

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