



# **UH-1H MAIN ROTOR BLADE FATIGUE**

by

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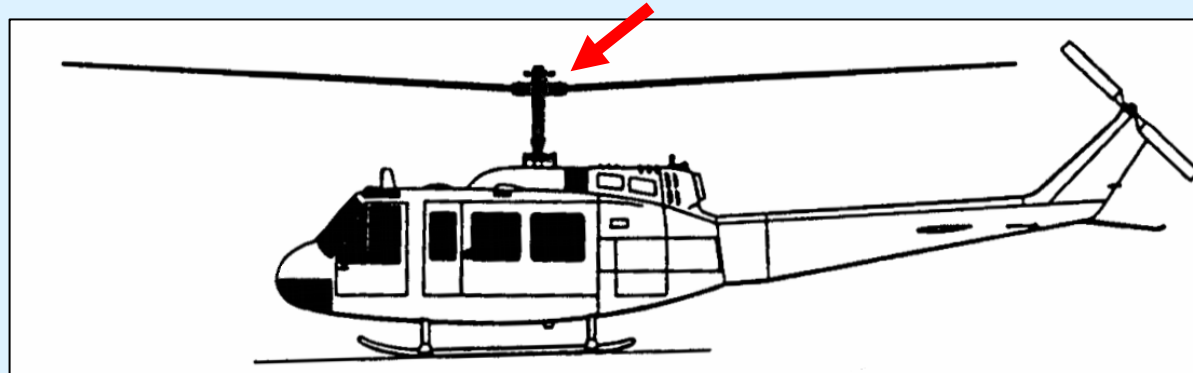
*ANZSASI Queenstown, June 2005*

# MAIN ROTOR BLADE FATIGUE

## PRESENTATION OUTLINE

- BACKGROUND
- BLADE CRACKING
- GRIP PAD DISBONDING
- BLADE INSPECTION
- NDI RESULTS
- CAUSAL FACTORS
- IN-SERVICE MANAGEMENT

# UH-1H MAIN ROTOR BLADE (MRB) FATIGUE



## BACKGROUND

- RNZAF AIRFRAME AVERAGE TSN APPROX 10,000 HRS
- US ARMY HOLD TYPE CERTIFICATE
- MAIN ROTOR BLADE SAFE LIFE 2,500 HRS (US ARMY SPECTRUM)
- RNZAF MAINTENANCE iaw US ARMY MANUALS
- RNZAF FREE OF SERIOUS MRB PROBLEMS SINCE 1965

# NZDF UH-1H OPERATIONS

## MEDIUM UTILITY HELICOPTER ROLE

Location of flight operations in 2000 - 2001:

- **NEW ZEALAND**
- **EAST TIMOR**
- **BOUGAINVILLE**
- **ANTARCTICA**



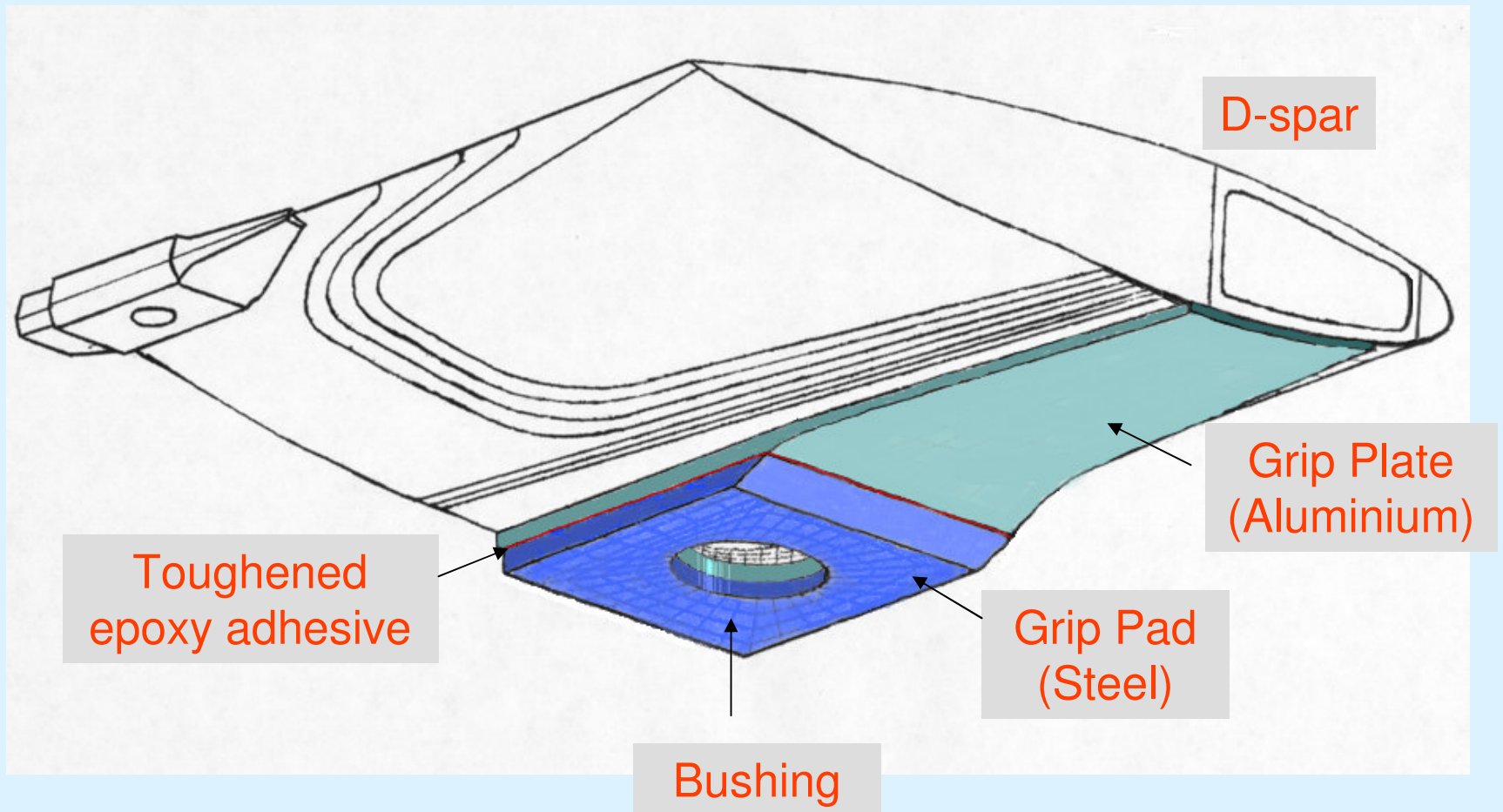


## **DEFECT INDICATION – NZ3816, EAST TIMOR 2001**

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# BLADE CONSTRUCTION

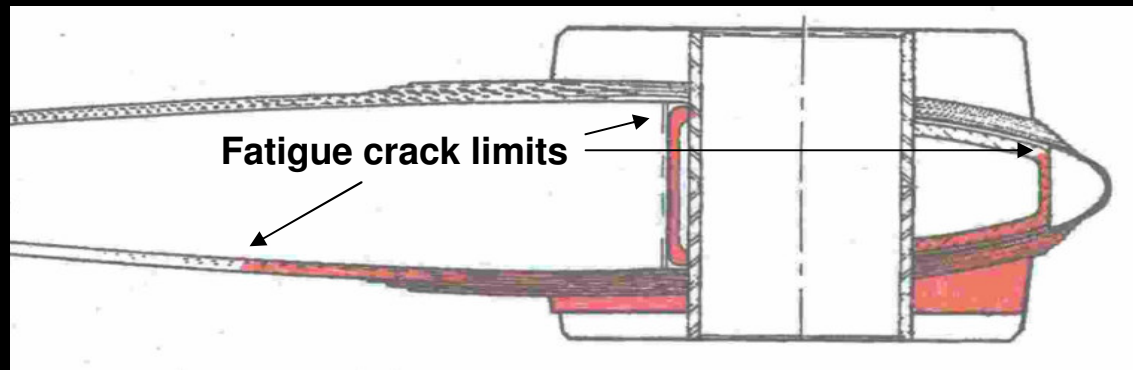
## ADHESIVELY BONDED METAL LAMINATE STRUCTURE





# BLADE SPAR CRACK ASSESSMENT

## FRACTURE SURFACE



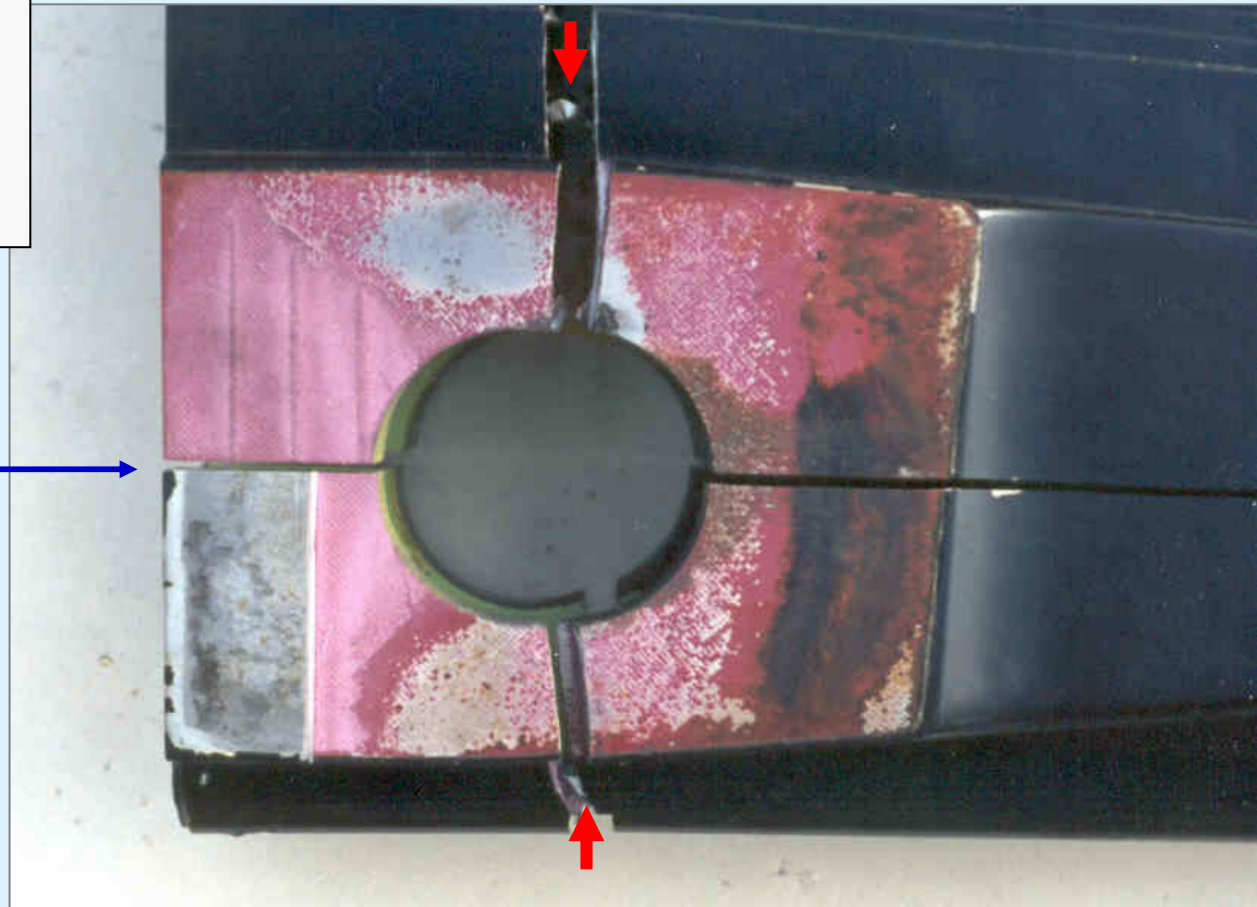
CHORDWISE C/S

# GRIP PAD DISBONDING

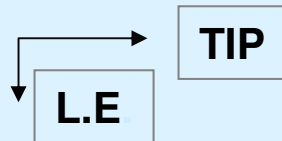
UNDER-SURFACE  
OF CRACKED  
BLADE

SAW CUT

GRIP PAD REMOVED  
AND BLADE CUT UP  
FOR FRACTURE  
SURFACE ANALYSIS



FATIGUE CRACK





# EPIDEMIOLOGY

## RESULTS OF DESTRUCTIVE TESTS

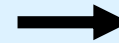
### TWO MRB CLASSES

#### Early-Model Blades

- MODERATE DISBONDS AT 2,500 HRS

#### Recent Blades

- SIGNIFICANT DISBONDS AT 1,000 HRS
- MANY BLADES IN SERVICE



# **DAMAGE ASSESSMENT**

- **GRIP PLATE CRACK GROWTH RATE WAS RAPID**
- **CRACKS CONCEALED BY GRIP PAD**
- **CRACKING PRECEDED BY GRIP PAD DISBONDING**
  - **SAFETY PREDICATED BY DISBONDING**

**SO,**

- **MANAGE SAFETY BY MONITORING DISBOND ONSET  
(SAFETY BY INSPECTION)**
  - **PRESCRIBED INSPECTION – CAREFUL VISUAL CHECK**

# FAILURE OF VISUAL INSPECTION

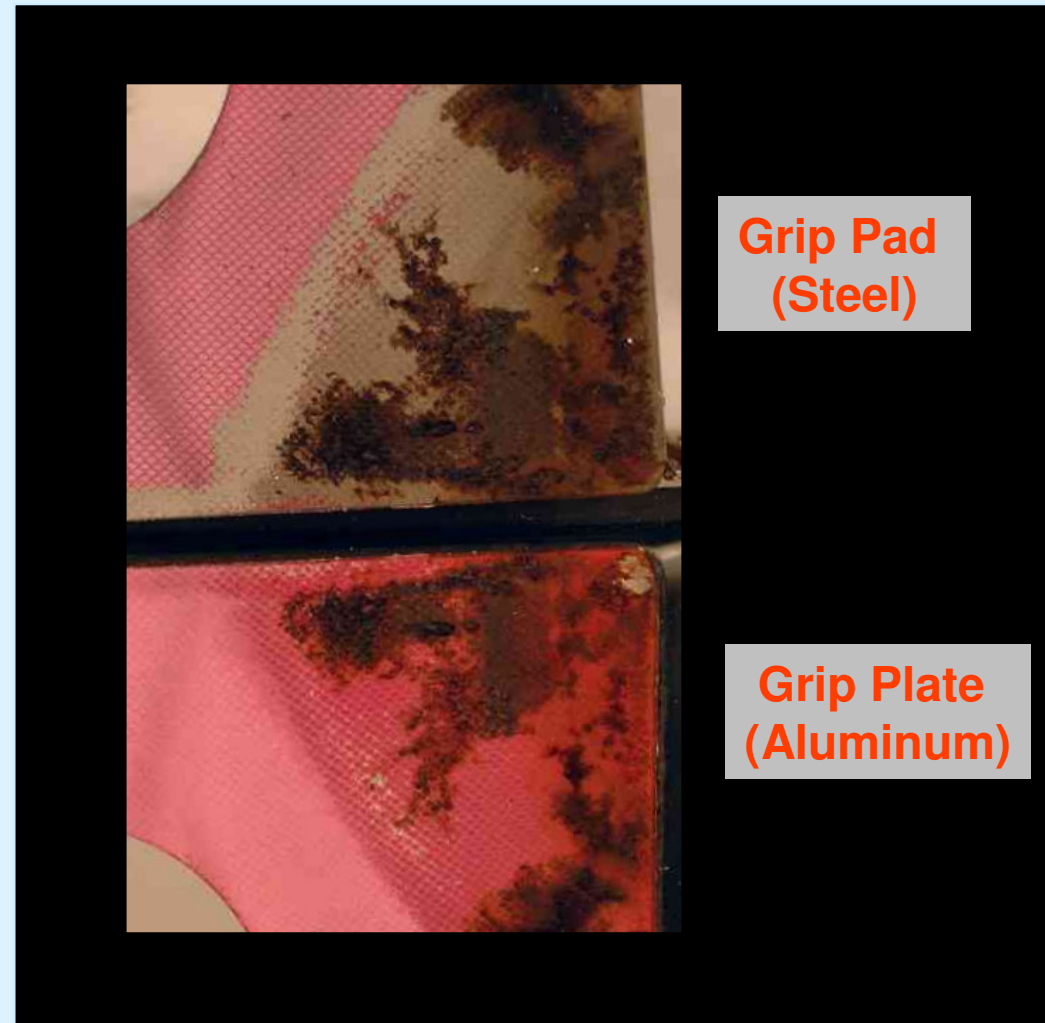
DISBONDING FOUND IN A  
BLADE REJECTED FOR  
OTHER REASONS AFTER  
1100 HRS IN SERVICE -

- **LARGE DEFECT WAS NOT  
DETECTED BY EITHER:**

- BONDLINE VISUAL  
INSPECTION (IN A LAB  
ENVIRONMENT)

OR,

- COIN TAP-TESTING



# PERFORMANCE OF AVAILABLE INSPECTION METHODS FOR MEASURING GRIP PAD DISBONDING

METHOD	RESULT
VISUAL	- UNRELIABLE
DYE PENETRANT	- UNRELIABLE
COIN TAP TEST	- FAILED
ULTRASONIC TEST	- DIFFICULT TO INTERPRET

- EXISTING INSPECTION METHODS DID NOT PROVIDE ADEQUATE MEASUREMENT CAPABILITY

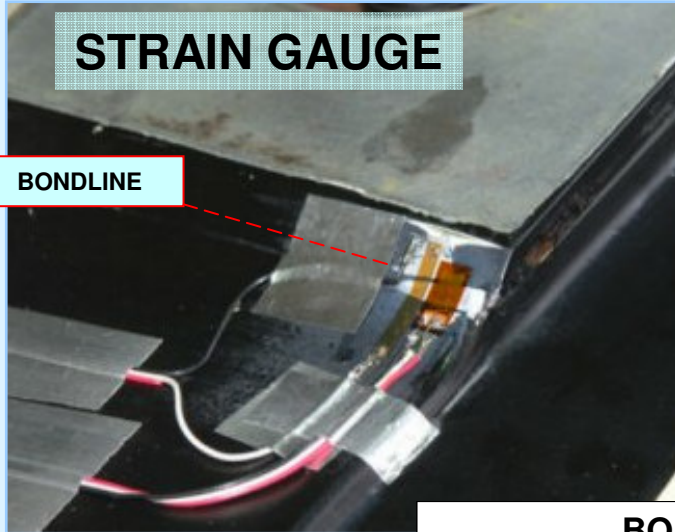
# **NEW INSPECTION TECHNIQUE**

## **- BONDLINE COMPLIANCE -**

# BONDLINE COMPLIANCE

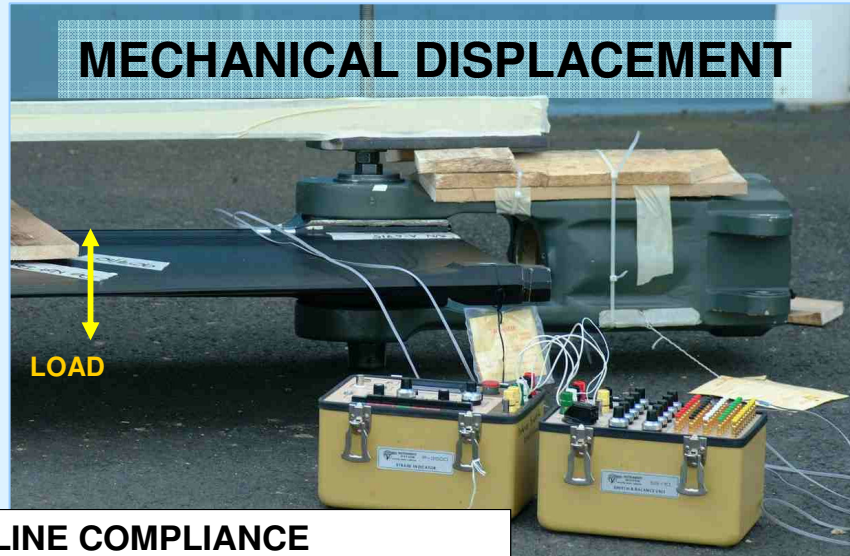
STRAIN GAUGE

BONDLINE

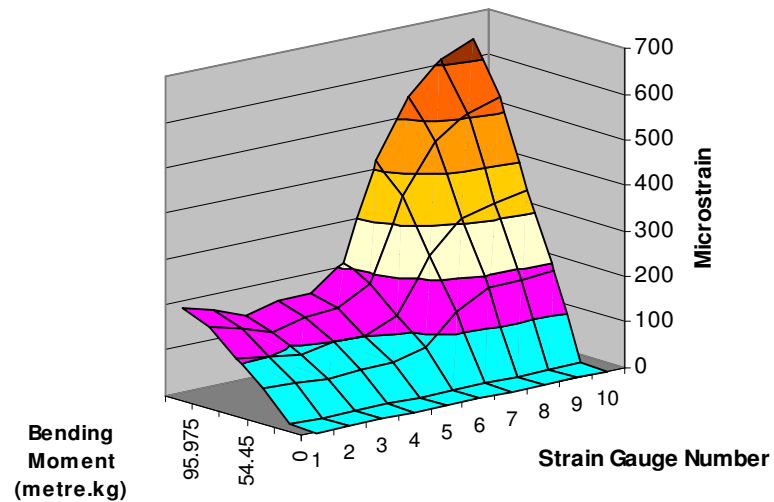


MECHANICAL DISPLACEMENT

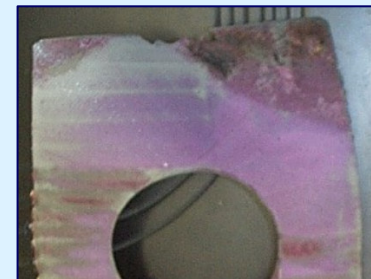
LOAD



BONDLINE COMPLIANCE

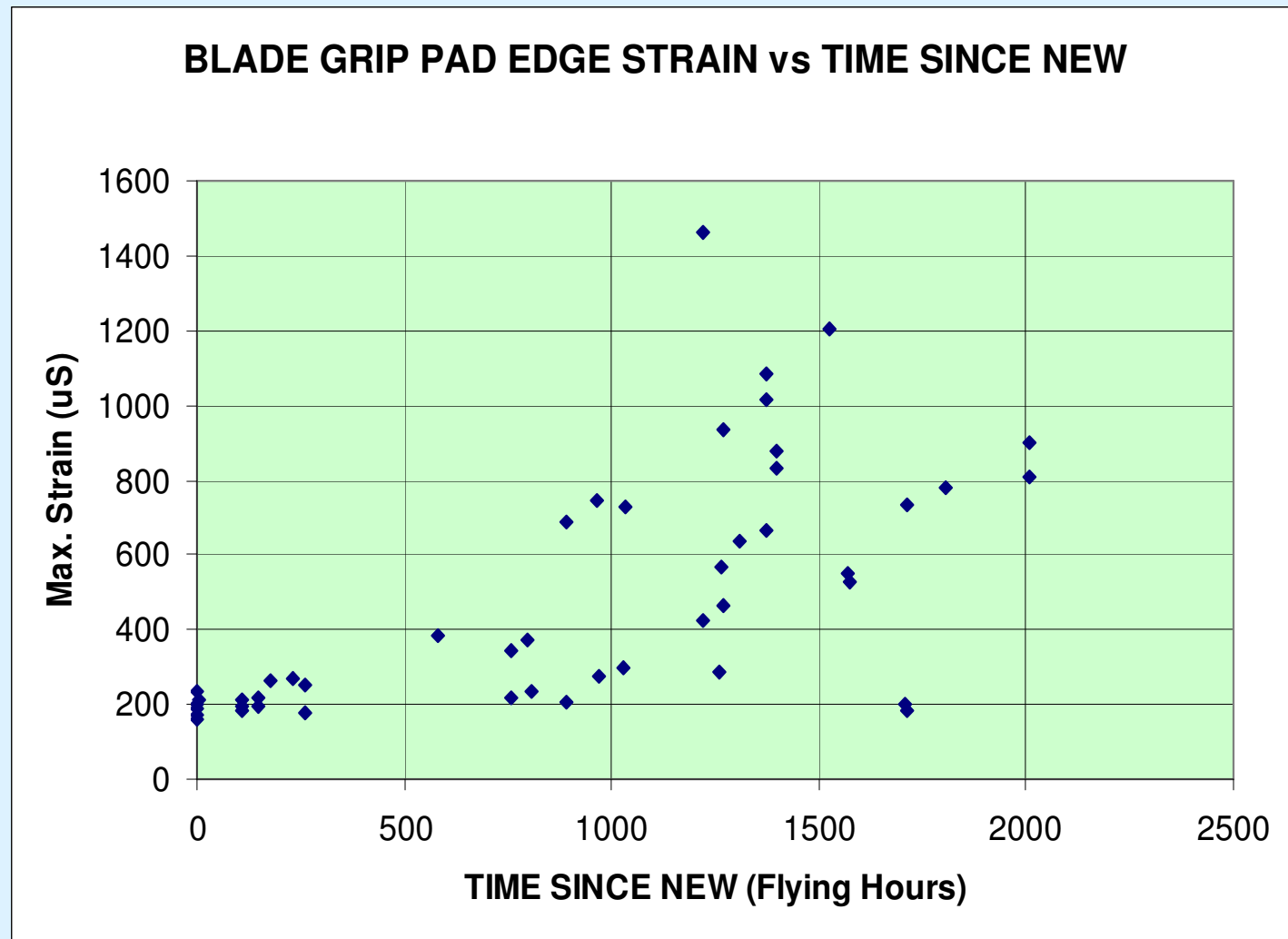


RESULT WITH  
MULTIPLE  
STRAIN  
GAUGES





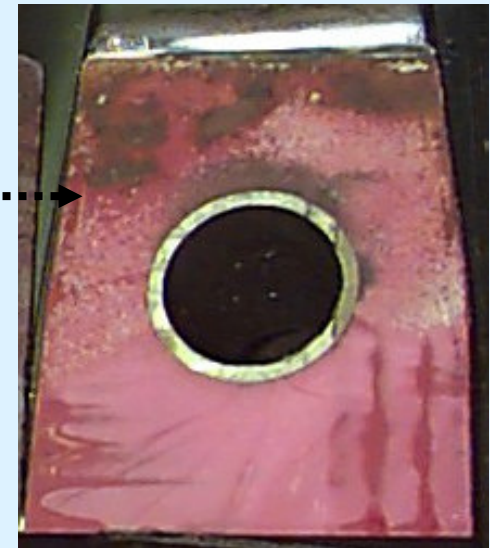
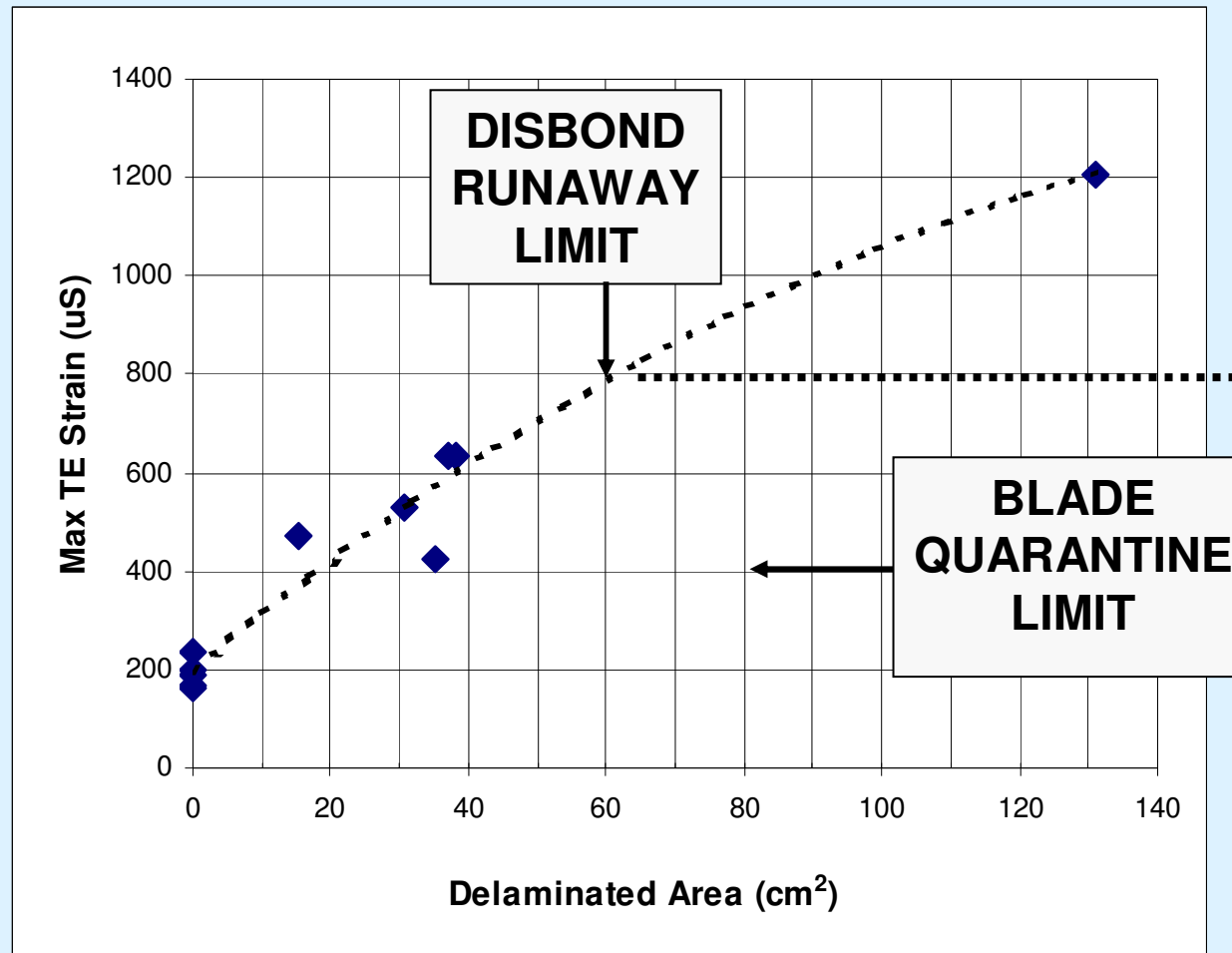
# STRAIN GAUGE INSPECTION RESULTS



# **OPTIONS TO KEEP FLYING**

- 1. BUY MANY NEW BLADES AND REPLACE VERY EARLY**
  - VERY EXPENSIVE**
  - IMPOSSIBLE SUPPLY PROBLEM**
  
- 2. ADOPT SAFETY BY INSPECTION**
  - DEFINE SAFE DISBOND SIZE**
  - DETECT AND MONITOR SUB-CRITICAL DEFECTS**
    - USING THE STRAIN NDI METHOD**

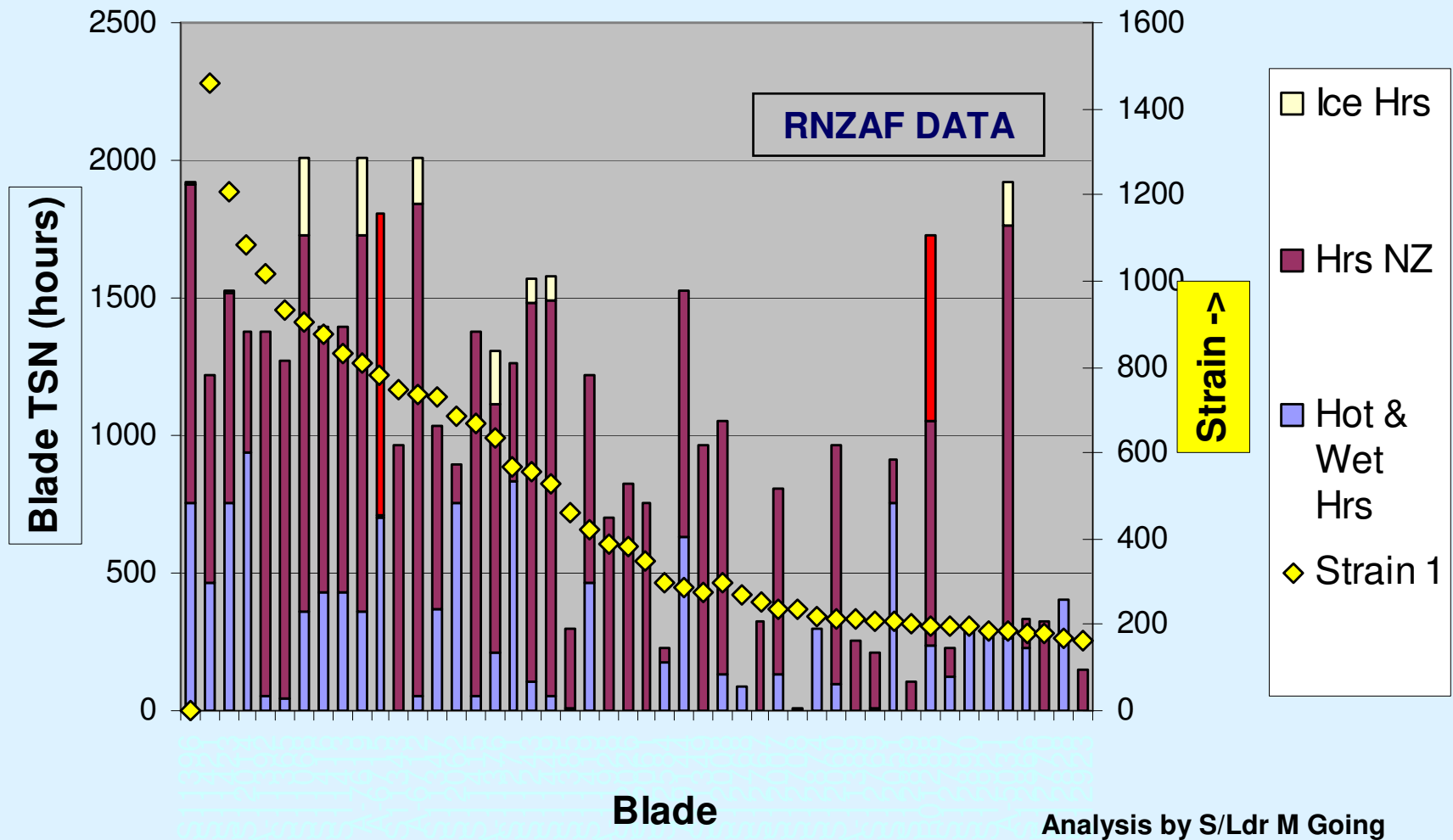
# DISBOND AREA / STRAIN RELATIONSHIP



# CAUSAL FACTORS

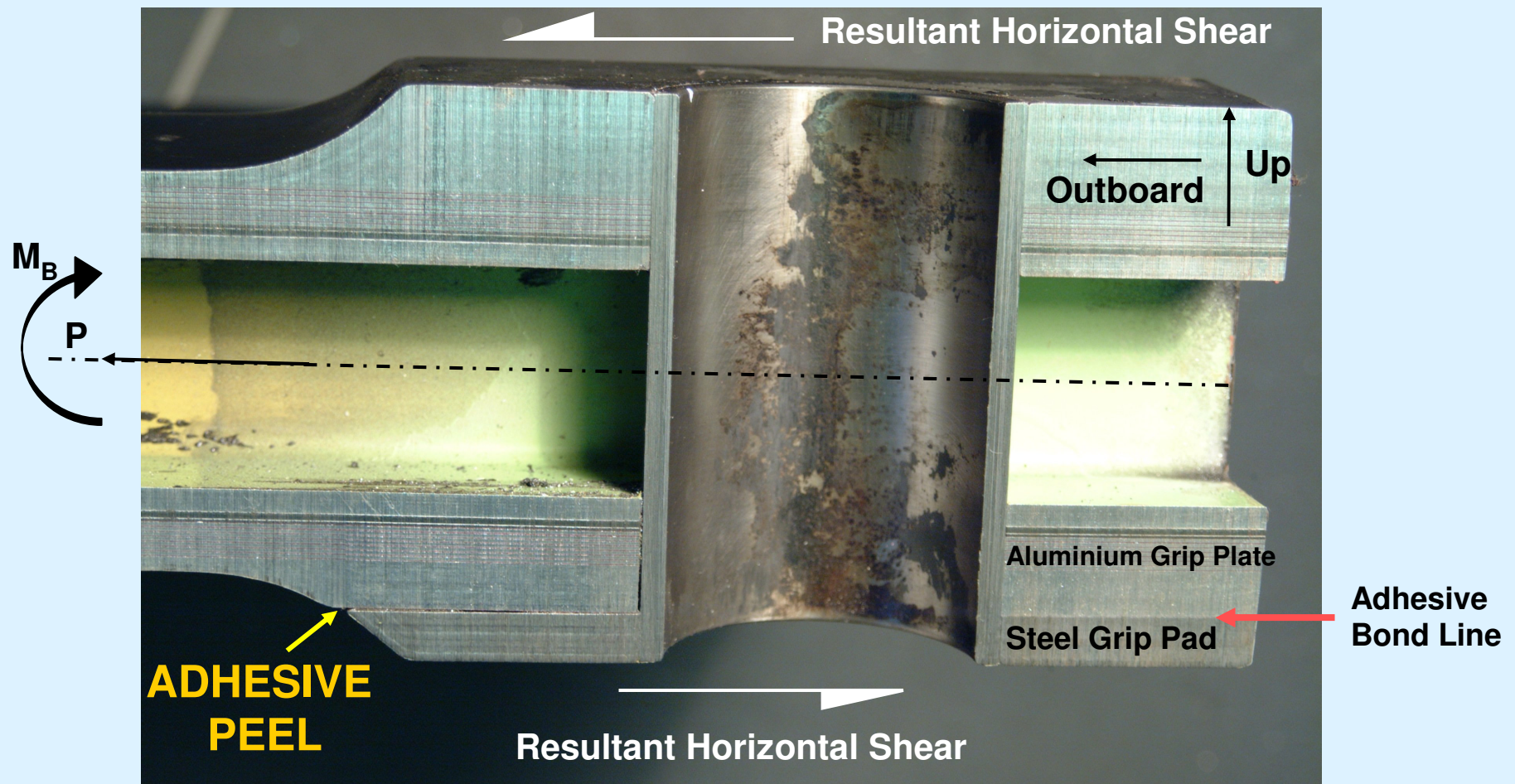
# EFFECT OF OPERATING ENVIRONMENT

- Little correlation between damage and environment



# MAIN ROTOR BLADE ATTACHMENT FITTING

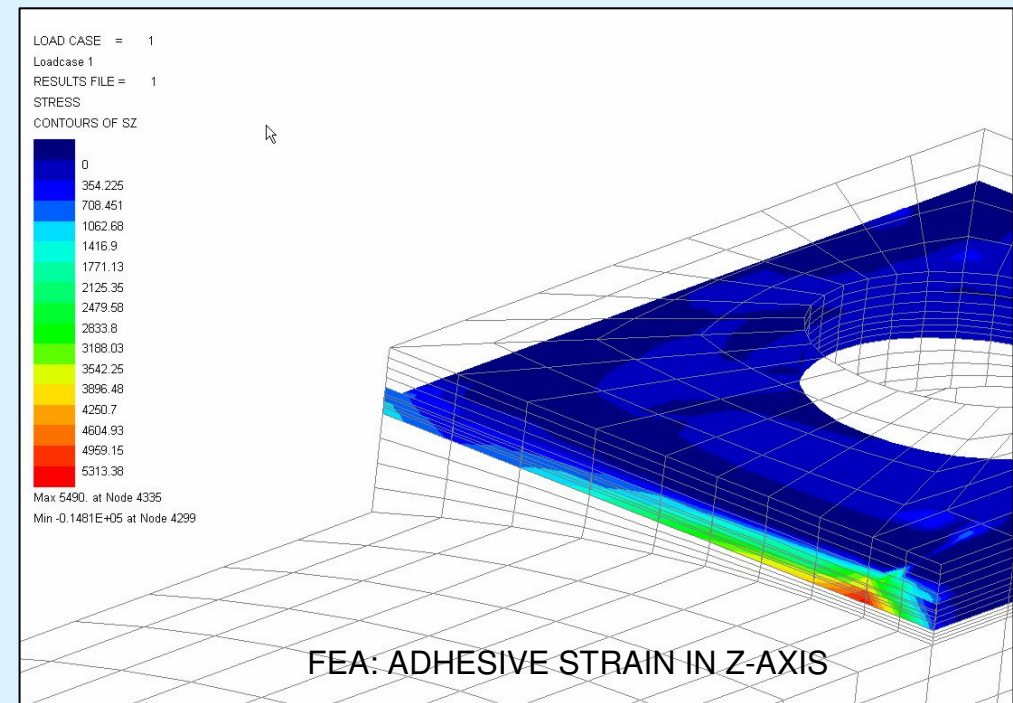
## - LOAD TRANSFER





# FATIGUE?

- HIGH PEEL STRESS IN THE ADHESIVE
- DEMANDING LOADS SPECTRUM?



Analysis by S K Campbell (DTA)

# **IN-SERVICE MANAGEMENT**

## **SAFETY BY INSPECTION**

- **STRAIN NDI FOR DISBOND MONITORING**
- **CONTINUOUS ANALYSIS OF RESULTS**
  - **REDUCED BLADE LIFE CONFIRMED**
  - **INSPECTION METHOD IMPOSES AN UNAVOIDABLE MAINTENANCE PENALTY**

# **SUMMARY**

**THE BLADE WAS AFFECTED BY AN EXCEPTIONALLY LARGE FATIGUE CRACK**

- THE HELICOPTER WAS SAVED BY CONSERVATIVE DESIGN**
  - MULTIPLE LOAD PATHS**
  - REDUNDANT STRUCTURAL ELEMENTS**
- FLIGHT SAFETY IS NOW MAINTAINED BY BONDLINE STRAIN INSPECTION**
- THE INSPECTION IS BASED ON EXHAUSTIVE ANALYSIS OF IN-SERVICE DEFECTS**

## **Acknowledgements**

### **RNZAF**

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### **DTA**

**Mr S K Campbell  
Mr I P Gatehouse**

### **Bell Helicopter Textron Incorporated**