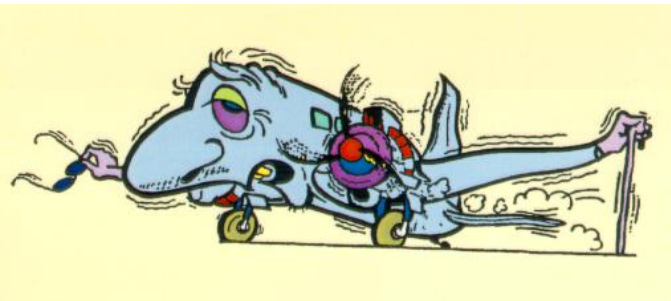


# “The Aircraft Structural Integrity Program Conference”

Austin, TX, 1-4 Dec, 2025

*Journeys in ASI*



*L. Molent AM*  
*Molent Aerostructures Pty/Ltd*

[www.molent.com](http://www.molent.com)



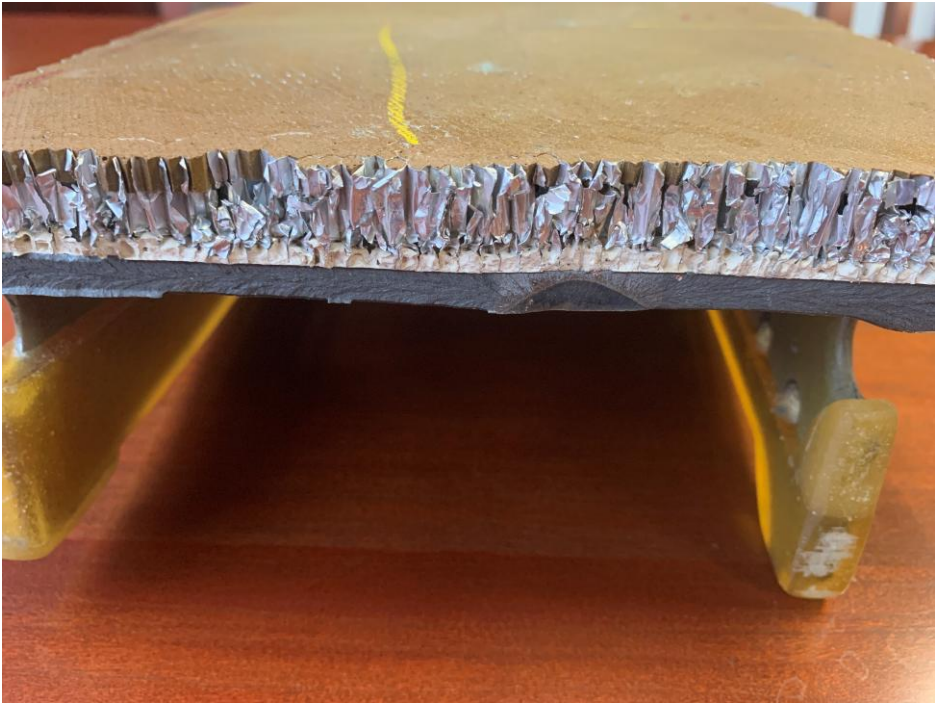
## Forward

- Dear Reader, this presentation was intended for the conference audience and may to you appear somewhat unclear.
- The journey begins with those that had a major impact on my career. Then I try to cover some work that may have impacted the USA and final some work that I hope had impact for you.
- If your pic is not there, its likely because I don't have one for general sharing....
- By necessity the data presented are limited/brief but each slide directs you to references where you can find more information.
- I hope you find it interesting.
- Finally, the great man, Jack Lincoln, was a friend of mine. He is sadly missed, and I am very honoured to receive this award.

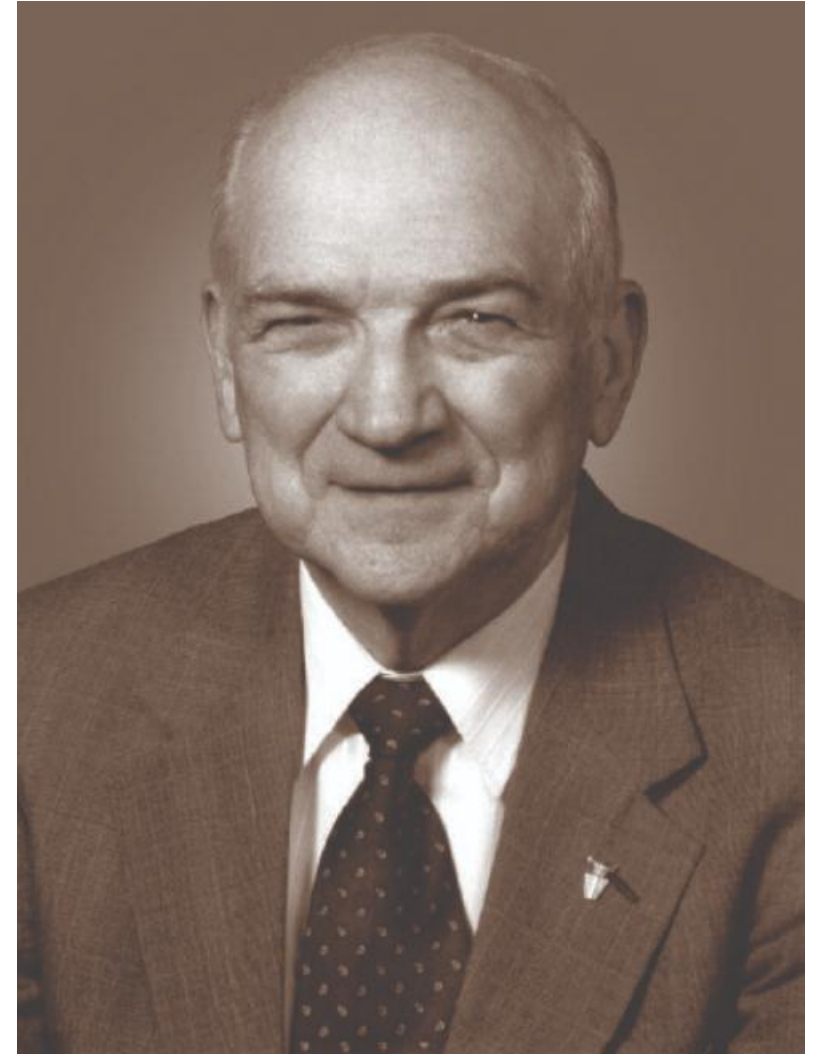


## Wow! I am so honored to be here!

- Jack was a friend and mentor (circa 1990)



Jack's door-stop! 1969 Failure



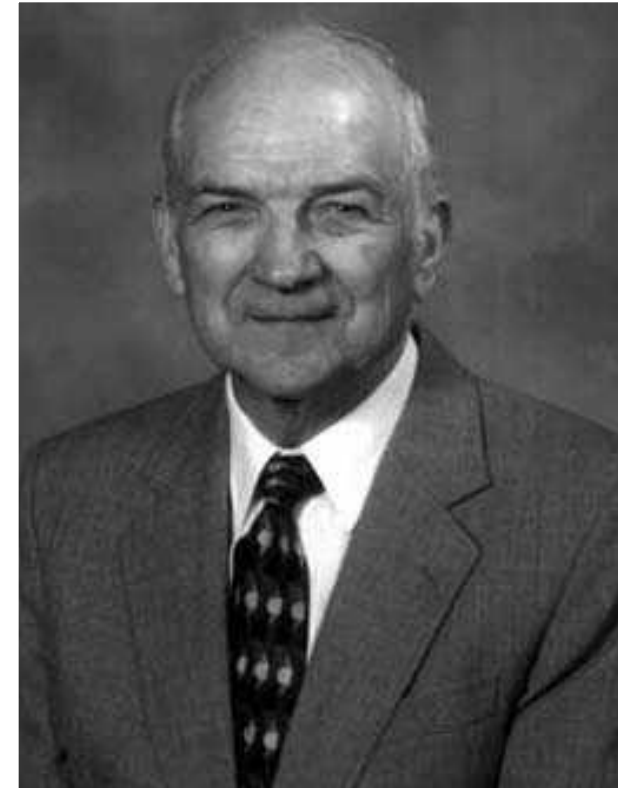
Dr. John (Jack) W. Lincoln, Ph.D., P.E. 1928 – 2002

# Compared Fictional Fatigue Engineer with Dr. Lincoln – Skip Grandt ASIP 2000



Hollywood

Dr. Honey  
“No  
Highway in  
the Sky”



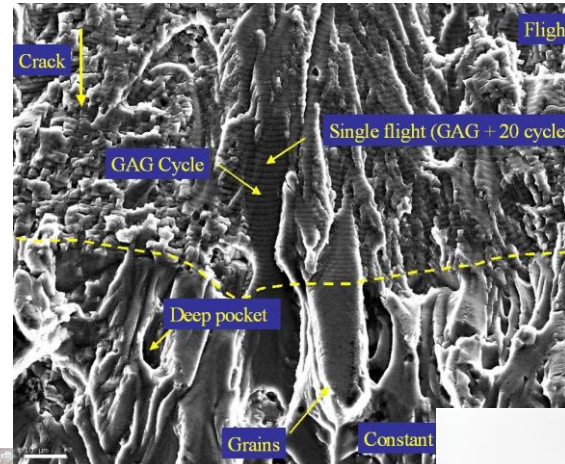
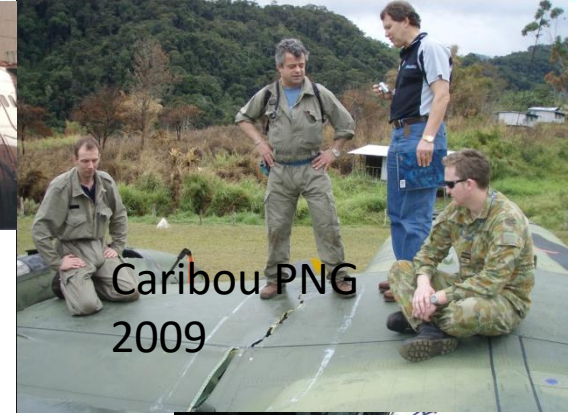
Real Life Hero



# About Me

## – Loris (Lorrie) Molent AM\*

- Aero Structures Consultant & Trainer
- Aeronautical Engineer
- Principal Research Scientist
- Head, Aircraft Structural Integrity (Retired) Aerospace Division Defence Science & Technology Group (DSTG) - Australia
- Experienced Aircraft Accident Investigation – Airframe (Retired)
- Failure Analyst NOT Designer
- \*Order of Australia



F111G Pulau Aur Malaysia 1999



# Acknowledgements



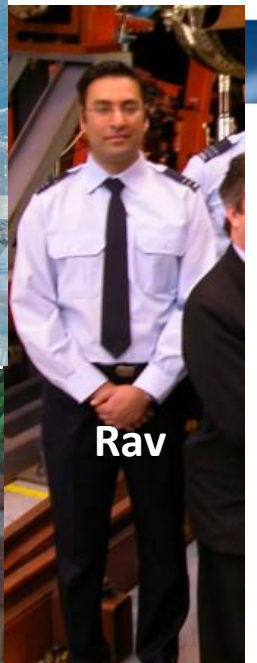
Jonesy



Crack Hunter



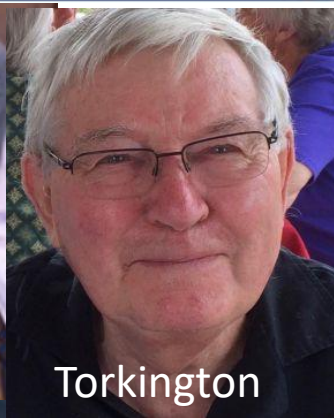
Hart-Smith



Rav



White



Torkington



RHYS



Wanhill



Goldsmith

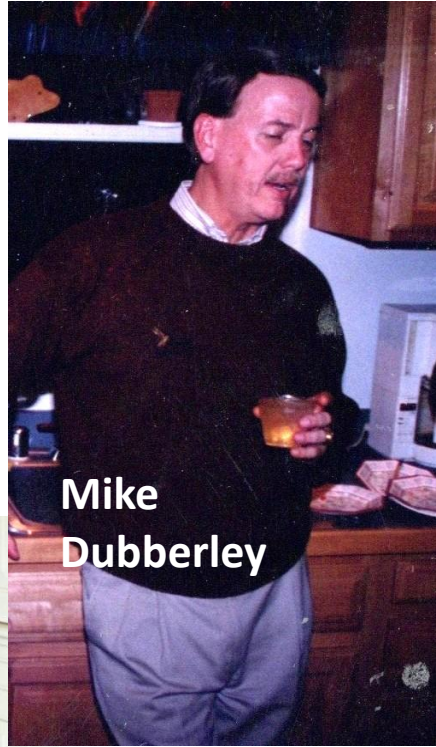


ASI Warrior

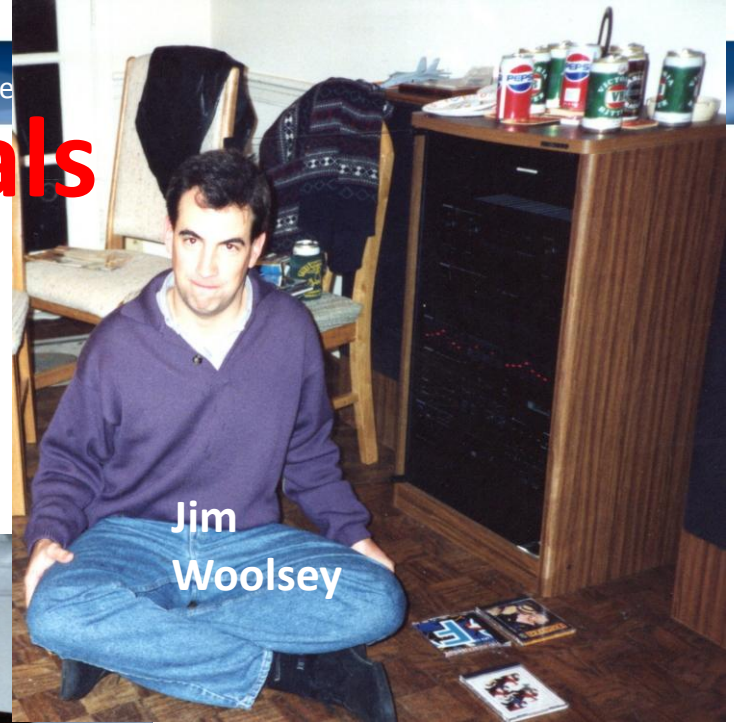
# Acknowledgements – A few Locals



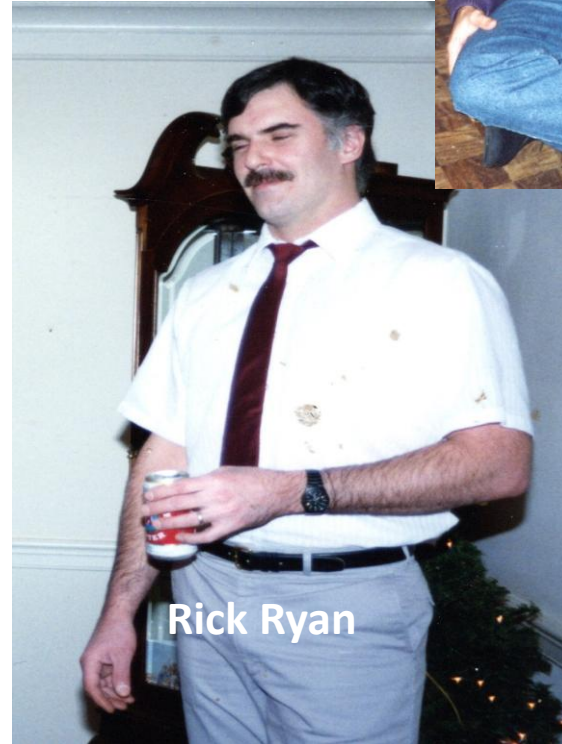
Tim Fallon



Mike  
Dubberley



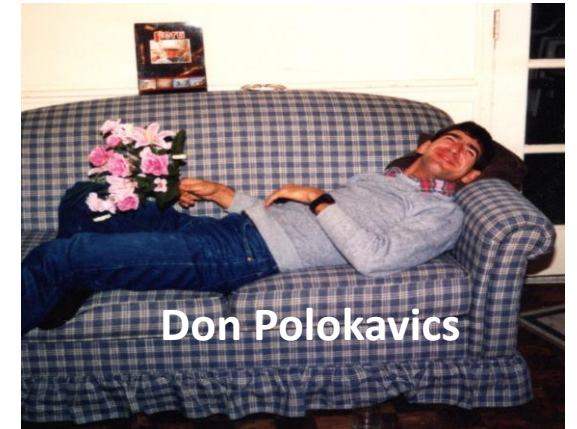
Jim  
Woolsey



Rick Ryan



Nam Phan



Don Polokavics



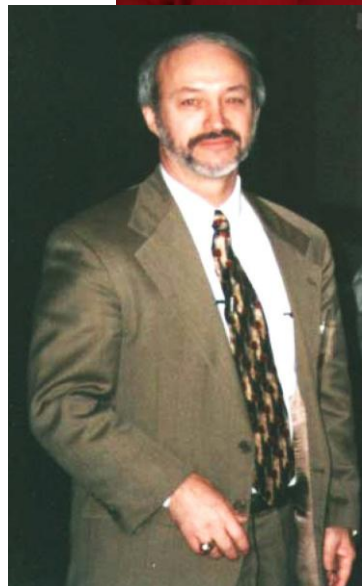
# Acknowledgements – A few Locals



Inger & Ulf  
Gorenson



Kim Jones



Larry Butkus



Jude Restis



# Acknowledgements – A few Locals



Gorelic



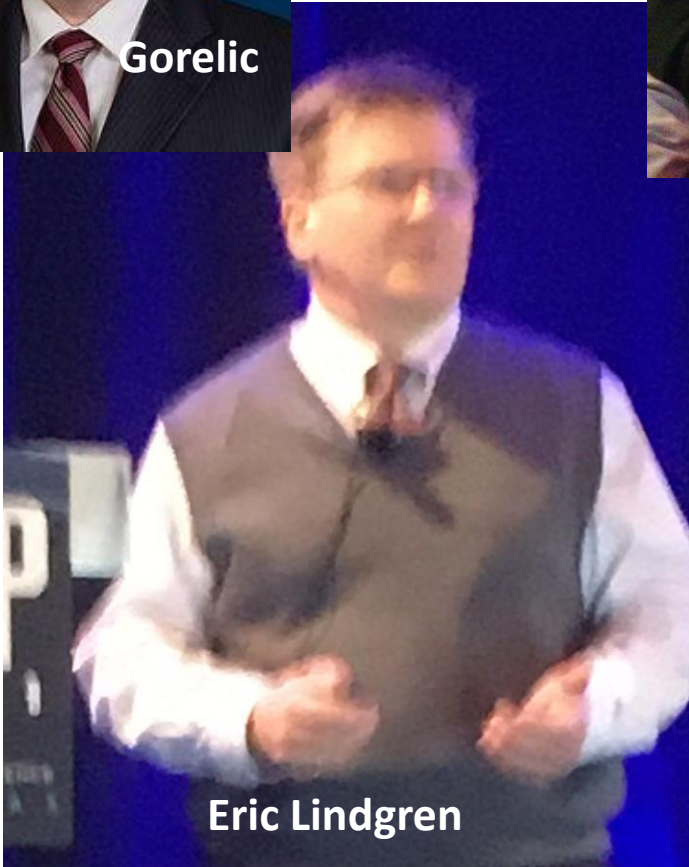
Ben Main



Ben Hillberry



Jim Newman



Eric Lindgren



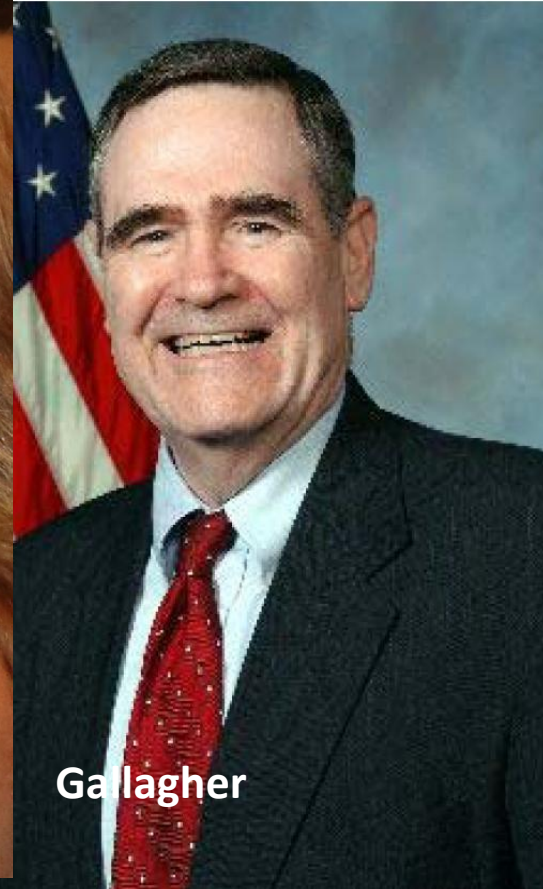
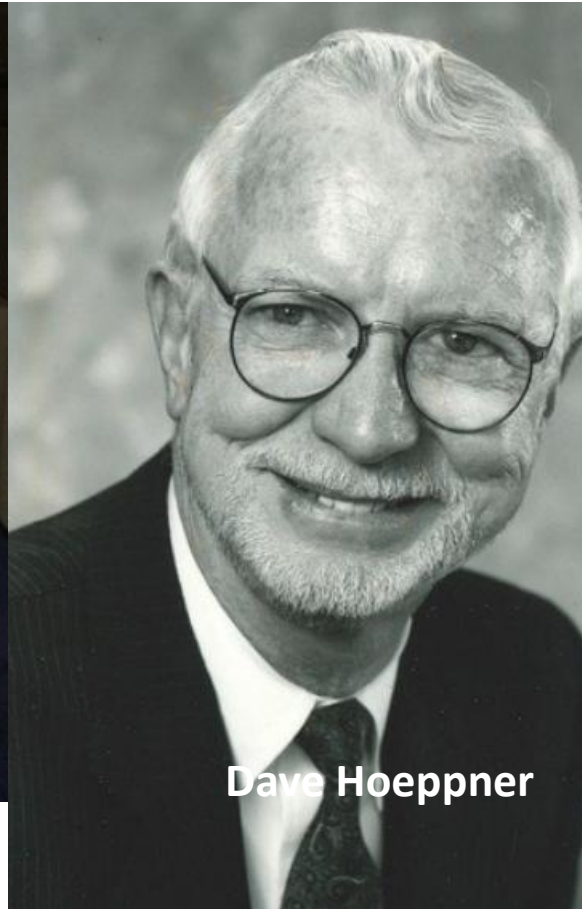
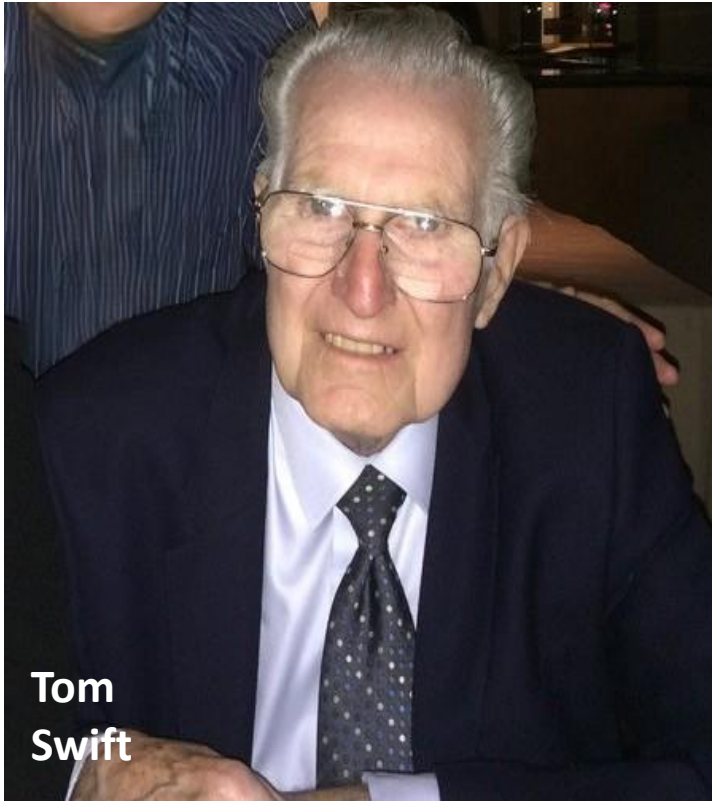
Bob Burns  
and  
Friend



Brussat

Dave  
Harper

# Acknowledgements – A few Locals

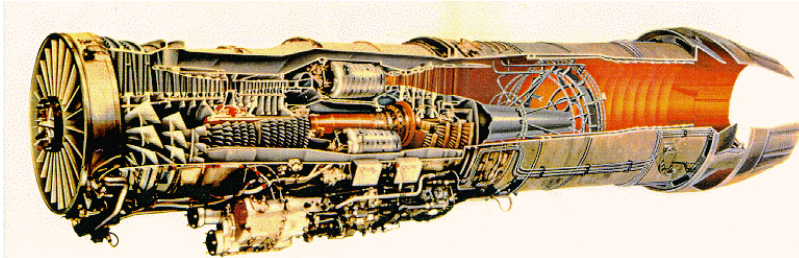


# Royal Australian Air Force

**RAAF**



**Owner, Maintainer, Regulator and Operator**



# But, what did I (we) do for you (USA)?

COMPOSITE REPAIR OF AIRCRAFT STRUCTURES  
The Australian Experience

By  
L. Molent  
Aeronautical Research Laboratory  
Melbourne Australia

ARL has pioneered the use of composite repairs to metal structures. This work has established Australia as a leading exponent of this technique in the world. Whilst initially developed for military aircraft the technique is now being applied more widely to civil aircraft. In view of the growing number of problems in the ageing aircraft fleet, and economical restraints, there is great potential for this technique to gain much wider use.

This presentation will highlight some examples of composite repairs, and briefly address the philosophy behind their design.

1991, and Bill Schweinberg  
said....

Presented at:

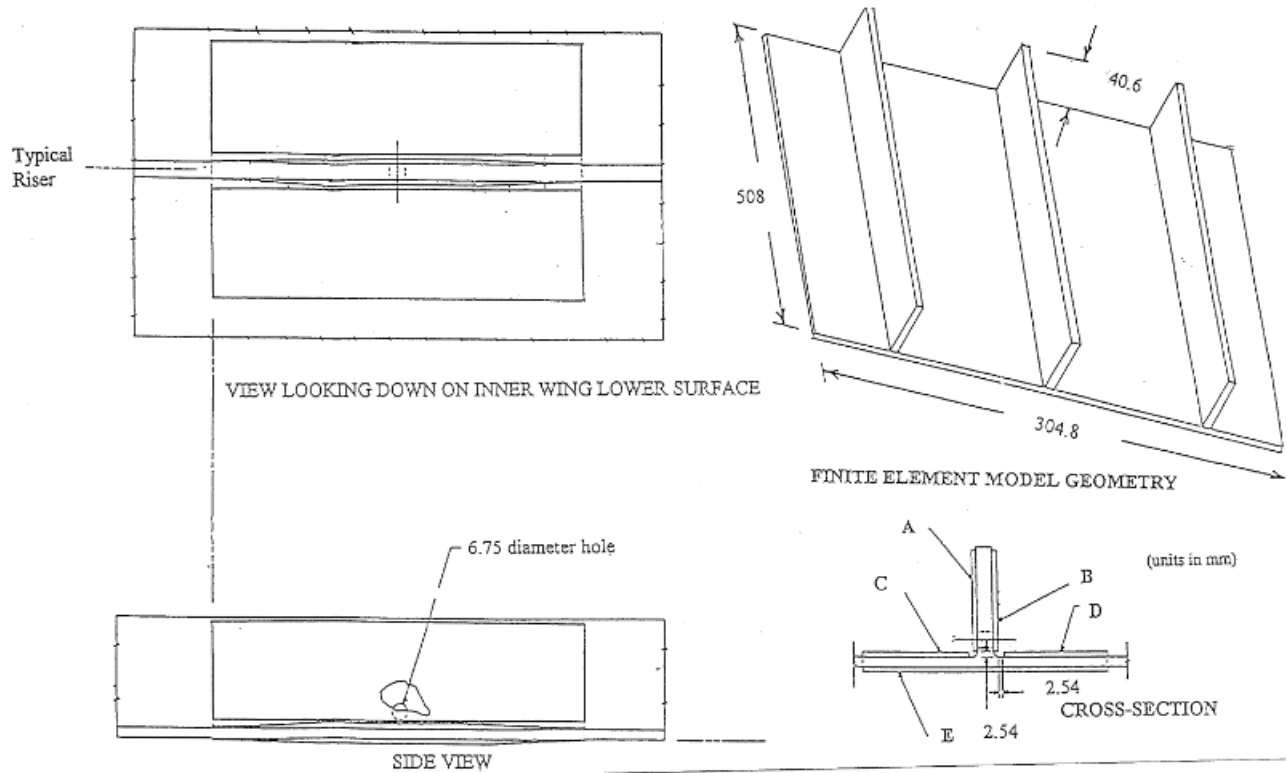
AIAA 1991 International Aerospace Engineering  
Conference and Show  
Feb 12 - 14 1991; Los Angeles USA.

A World Of Opportunity For Aerospace



# C141 Wing Weep Hole Cracking Repairs (circa 1993)

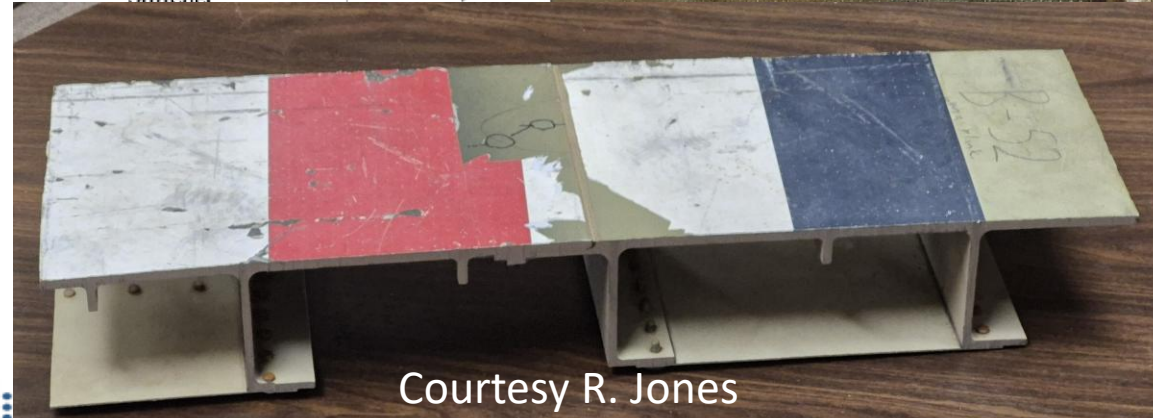
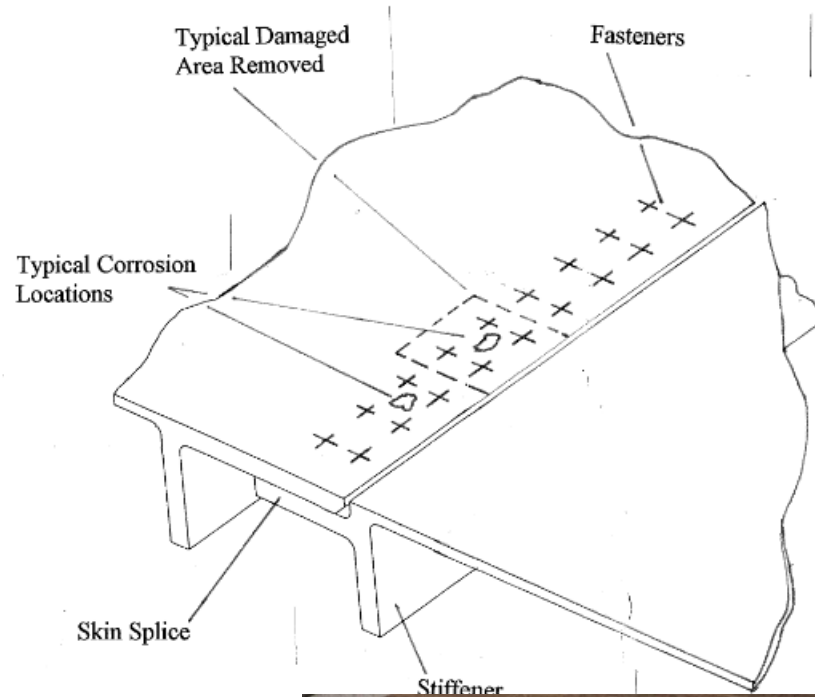
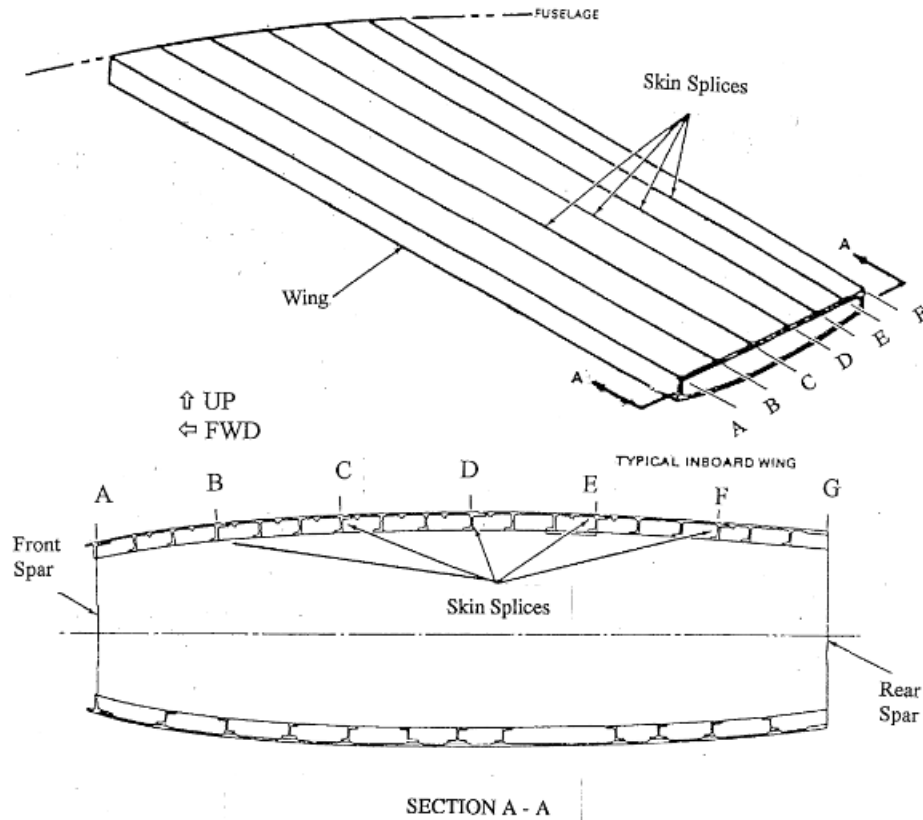
- So, you need to recover heavy lift capability Bill? [2,3]



- 120 aircraft repaired
- Usually 3 patches per repair
- 2300 bonded patches
- After 10 years – No problems (see Butkus [4])



# B52 Wing Corrosion Repairs (circa 1994) [5]



Not to Scale

Repair design and validation testing  
(Specimens with B52 wing Spec)

Courtesy R. Jones

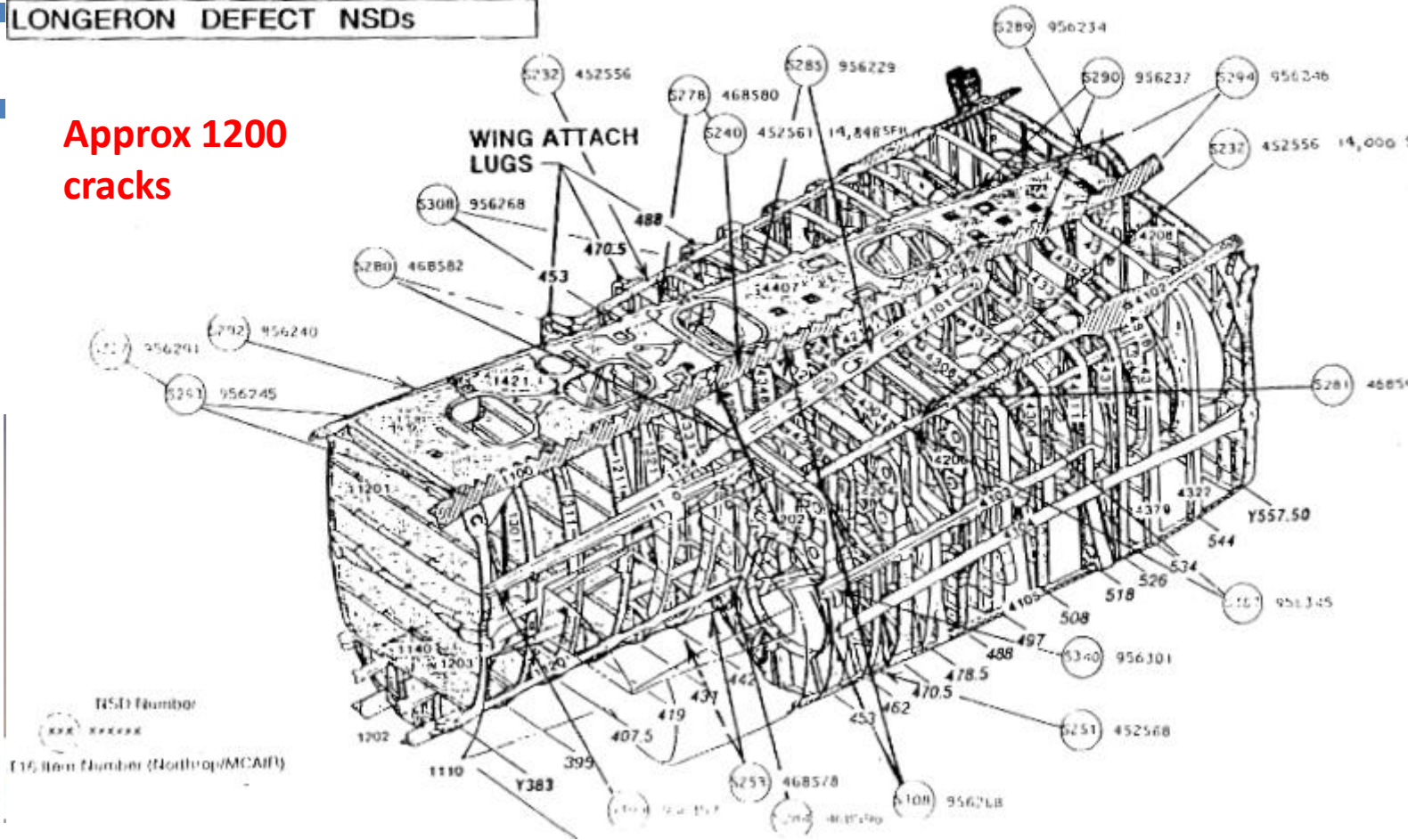
# ST16 Teardown Center Fuselage Critical NSDs

Ref.: ICM No. 334-1110-11489 and NAVAIR NOD LETTERS  
Cracks Discovered at 16,000 SFH Unless Otherwise Noted

Ser PMA265-2/2958-91  
Ser PMA265-2/3033-91

## LONGERON DEFECT NSDs

Approx 1200  
cracks



ibrious "Office" JP1 Crystal City

And ....



## F-16 N



The **F-16s sold to Iran** were initially ordered in the late 1970s, but the order was canceled in 1979... the US Navy were “pleased” to....

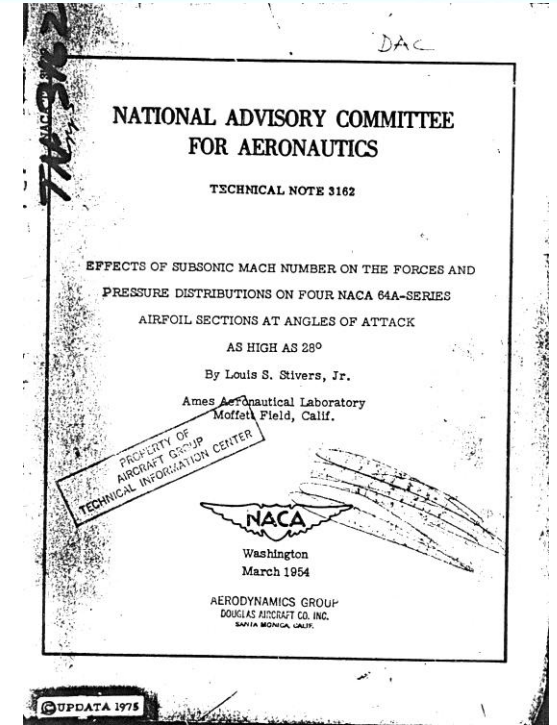


Circa 1991 cracks were detected at the main bulkhead attachment frames. The fleet was grounded, and I was sent to Miramar to “see what’s going on....” Who did I meet??

Wasn’t he surprised!!



# SuperSonic P3C Orion (circa 1991) [6]



At the 1992 P3C International Users Conference... Lockheed laughed at this suggestion and called me !#\$%!&\*

Transonic Compressibility



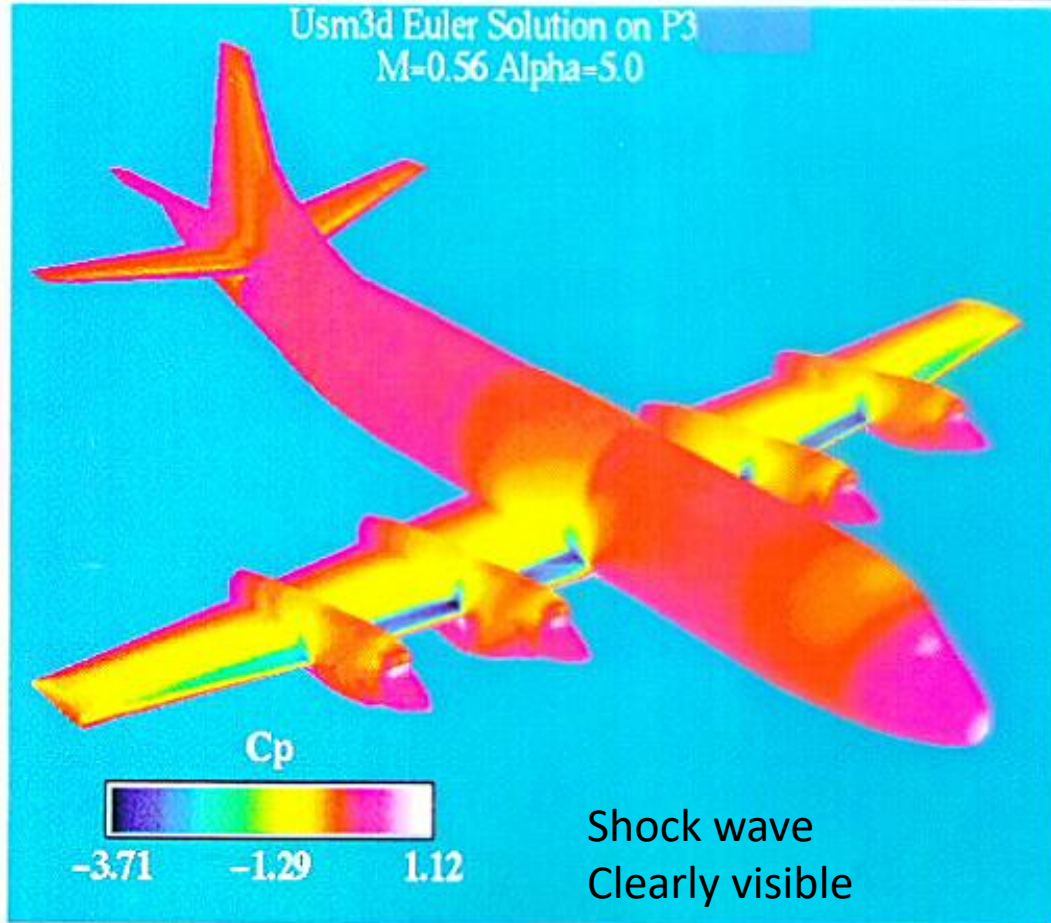
# Super Orion Con't



APPENDIX

## Surface Pressure Distributions

(4.5g case)



Lockheed White Paper on 1.5 factor [7]

Recertification test at DST



# Interesting times in 91...



- Hornet cleared to carry 15Klb modified cannon-barrel bomb...
- Boys & girls came home
- Service Life Bulletin (SLB) No. 3 released under my signature...

Don P: “Lorrie, Admiral wants to see you”  
 Lorrie: “That can’t be good”  
 Don P: “Yes”

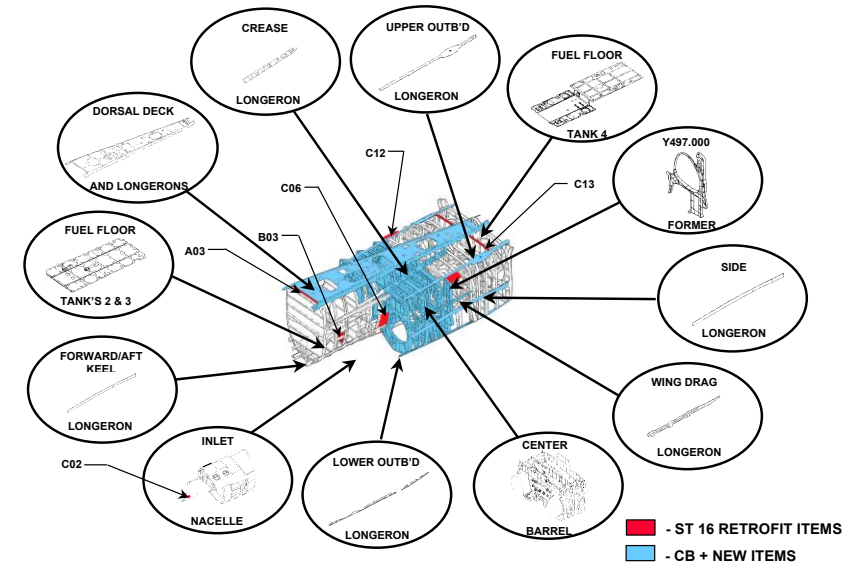
Admiral Dyer: “The RAAF want to sue us because of the limited life of the aircraft (sic SLB)”

Me: “Sad to hear that Sir”

Admiral: “You will get sadder, as we will sue you!”

Me: “yes, Thank you, Sir. ”

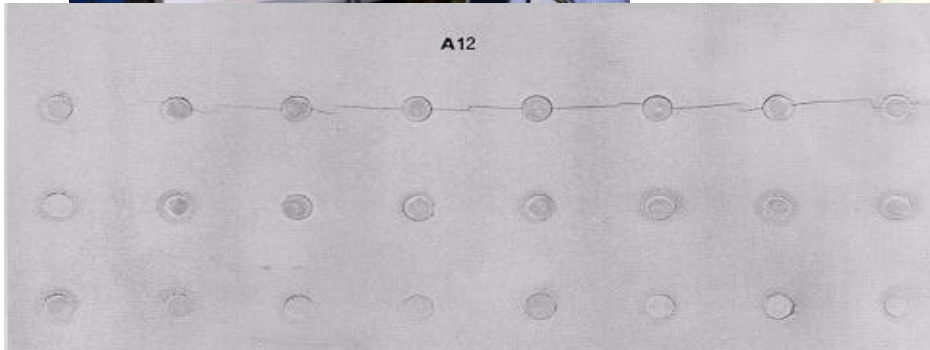
## Center Barrel + Work Content



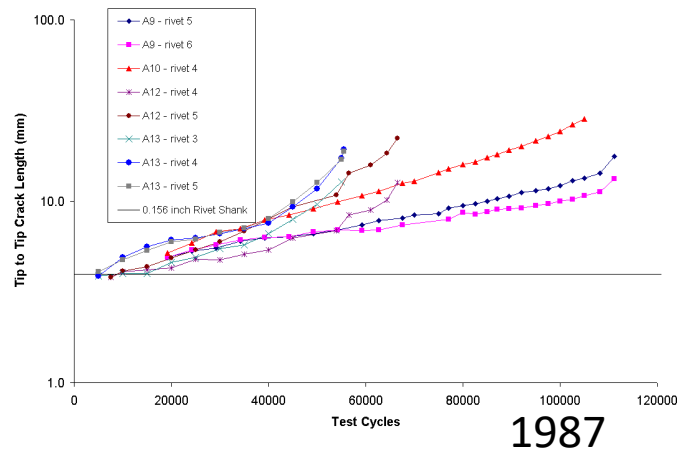
# Aloha Airlines Boeing 737 29 April 1988



Tom Swift in Oz



Lap Joint Specimen Crack Data



Data provided to  
FAA & Boeing

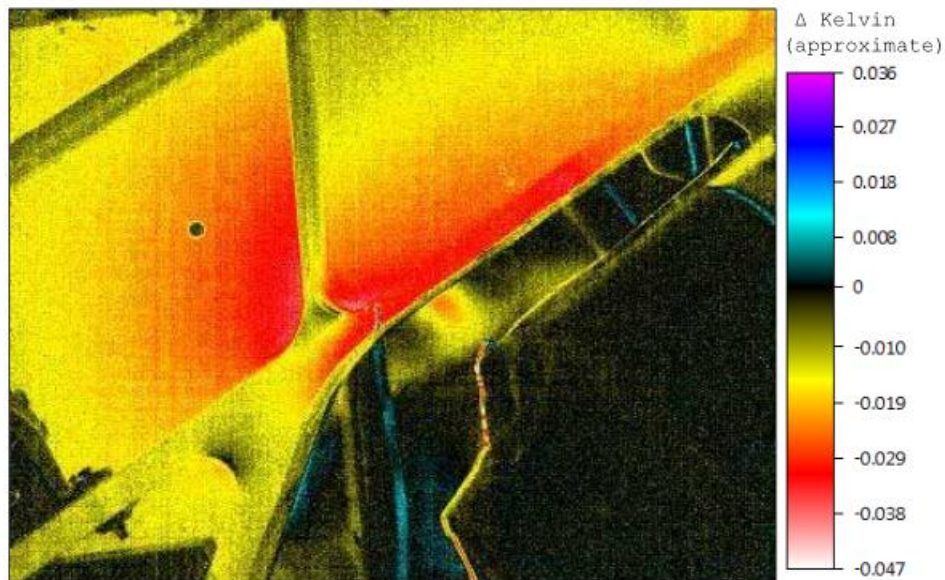
Ulf & Inger  
Goransen

See [8-10]

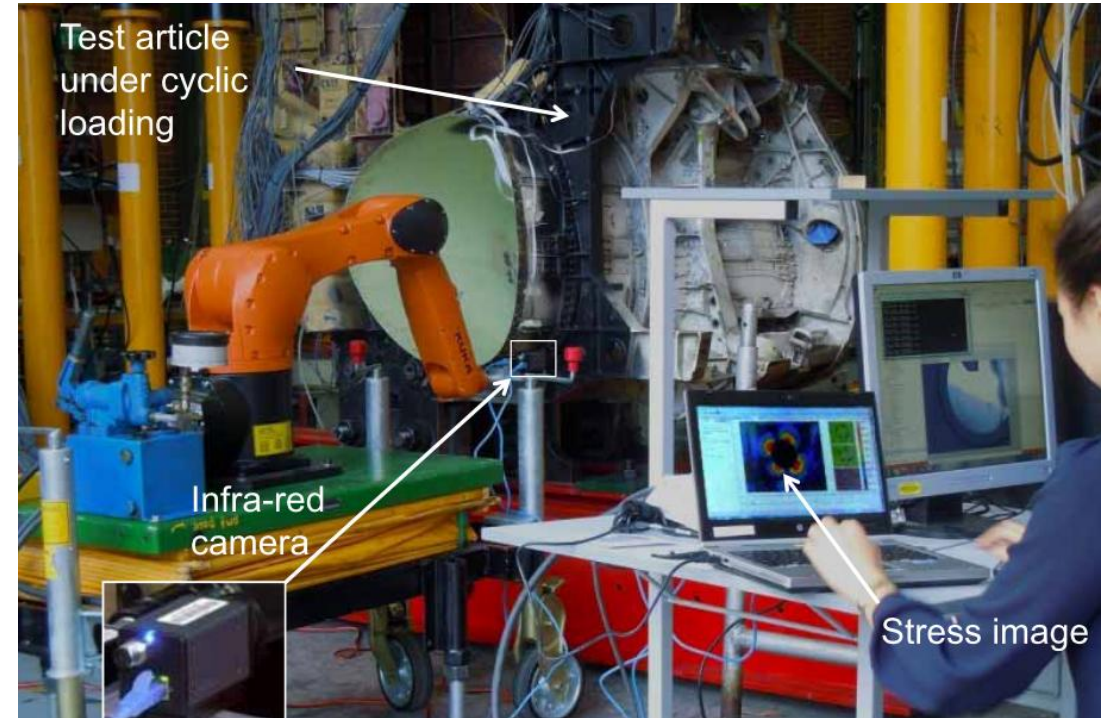


# F-35 (circa 2015)

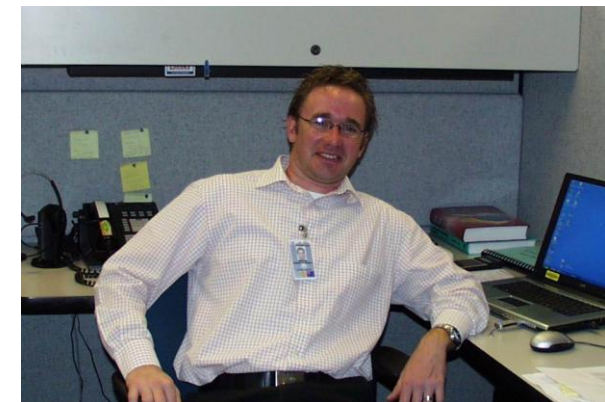
- Aussies embedded in JPO
- DST/RAAF push for 3<sup>rd</sup> lift time of testing
- RAAF put \$50M to secure 3<sup>rd</sup> Lifetime



DST Thermoelastic Stress Analyses (TSA) applied to CTOL FSDT to locate hotspots [11]



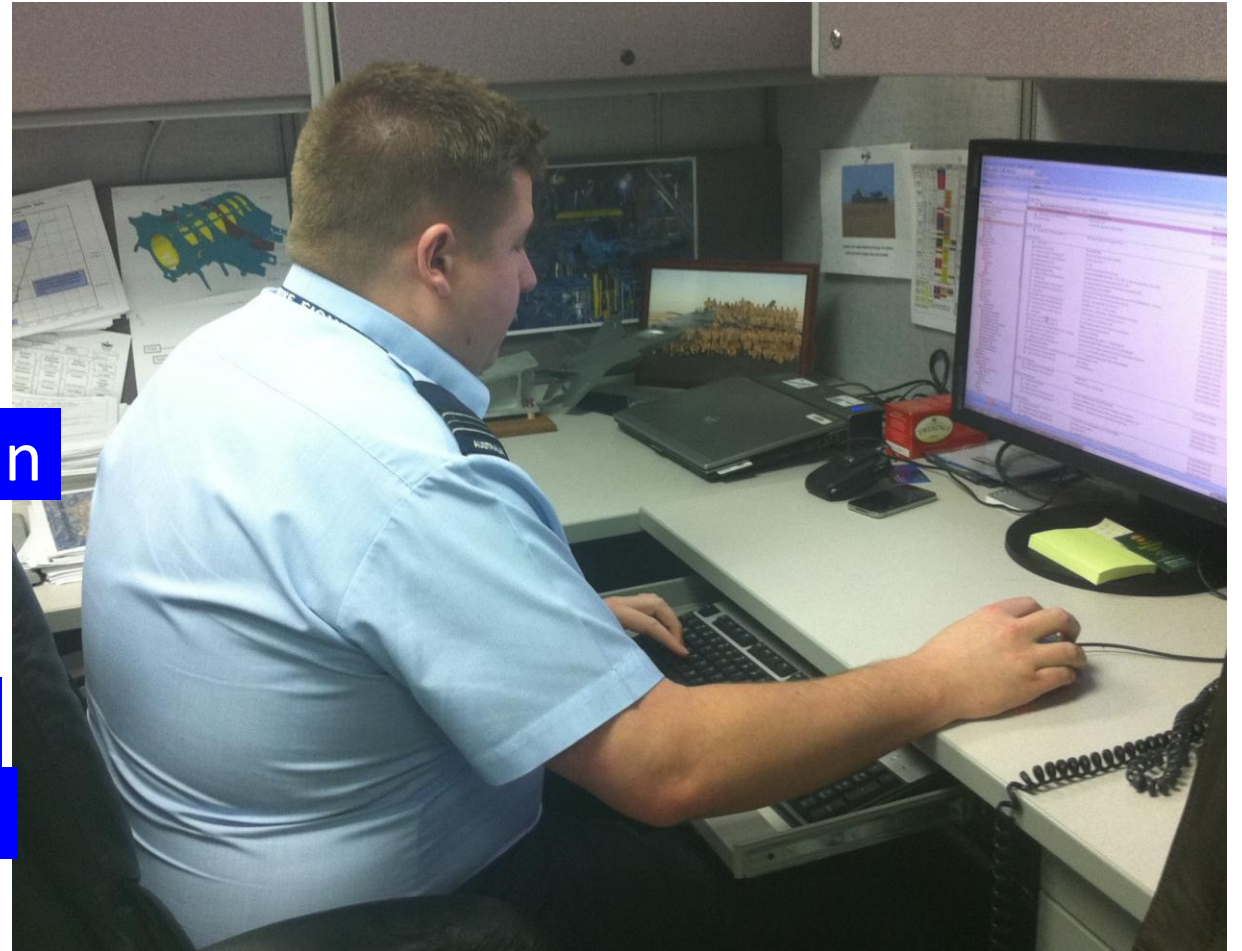
TSA on Hornet CB at DST



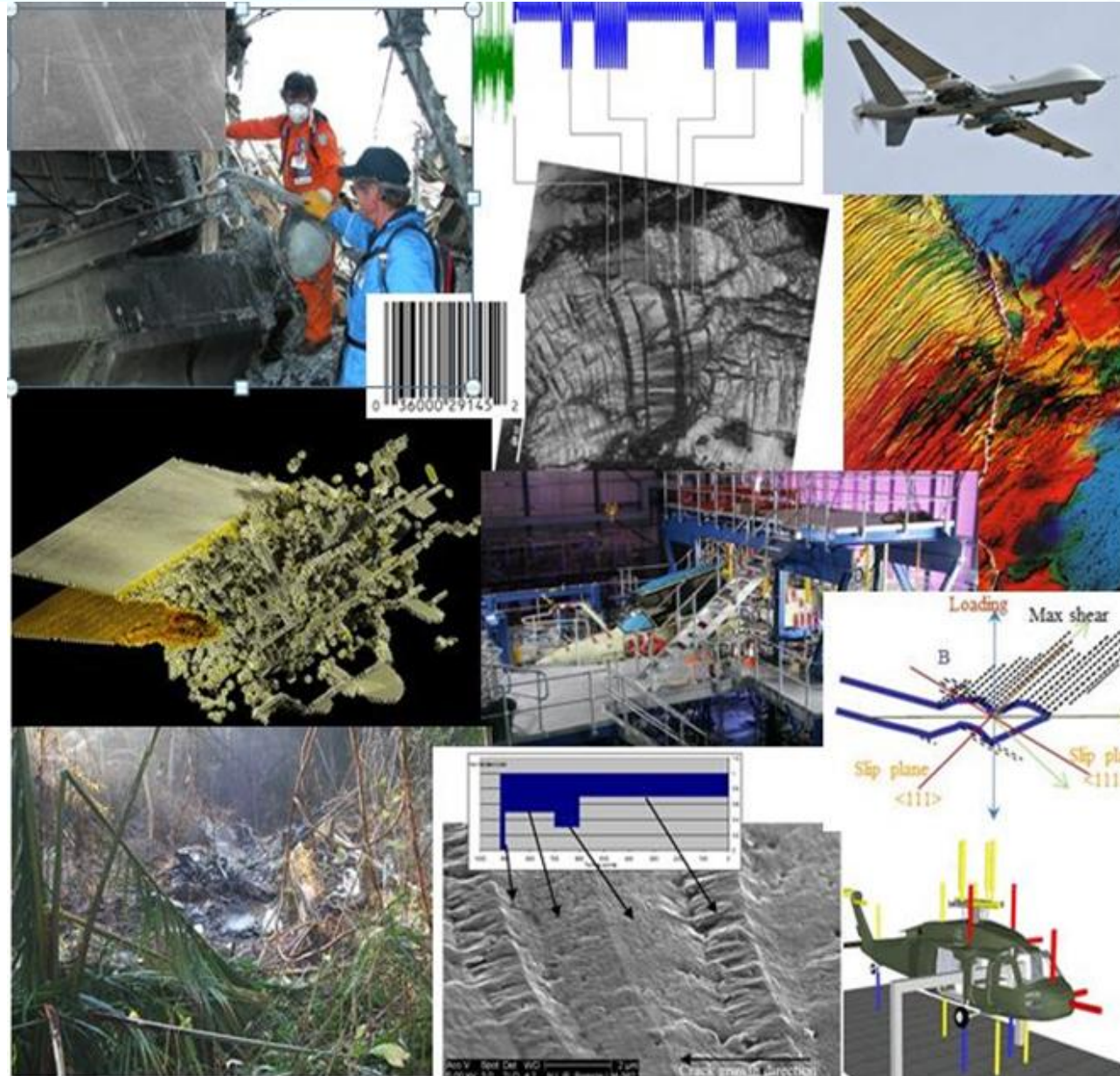
## F-35 (circa 2012)

Ben Main “Our Man” at the JPO

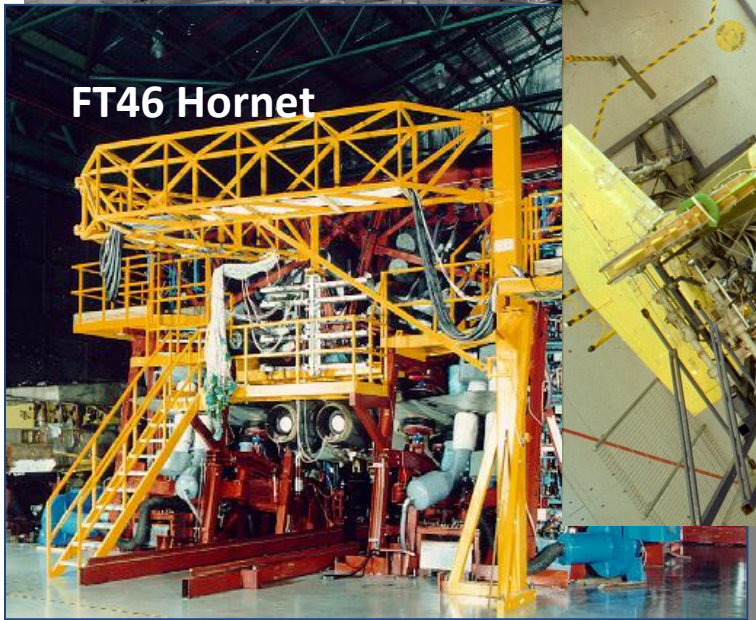
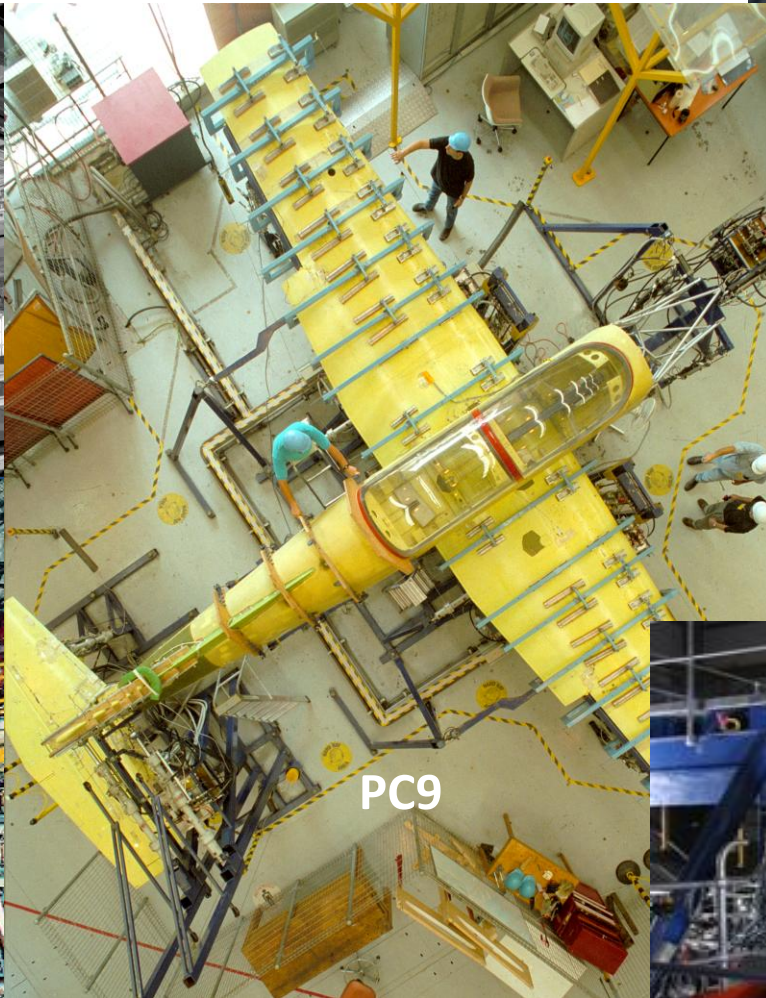
Adm Vanlet, May 2012, SASC:  
“Embedded right here in my office... an Aust Air Force Officer who is the deepest expert on service life issues...very comforting, as there is a long history between the US and Aust on the F/A-18 program....”



# Back in Oz....



# FSFTs [12-15]

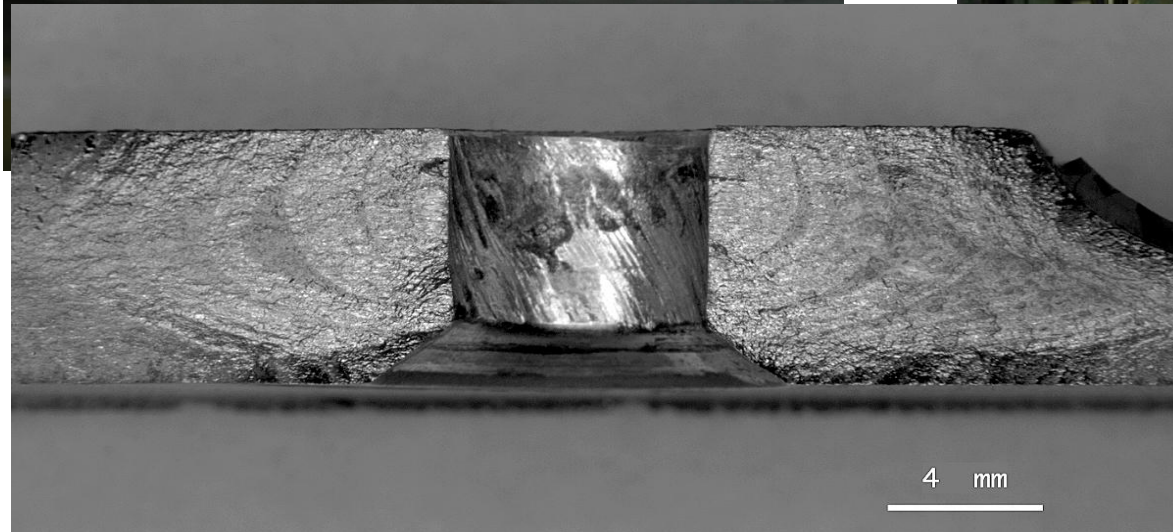
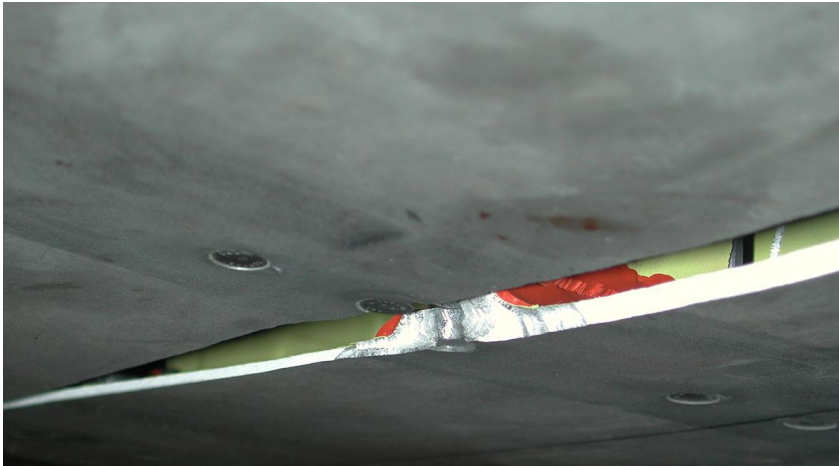


And ....

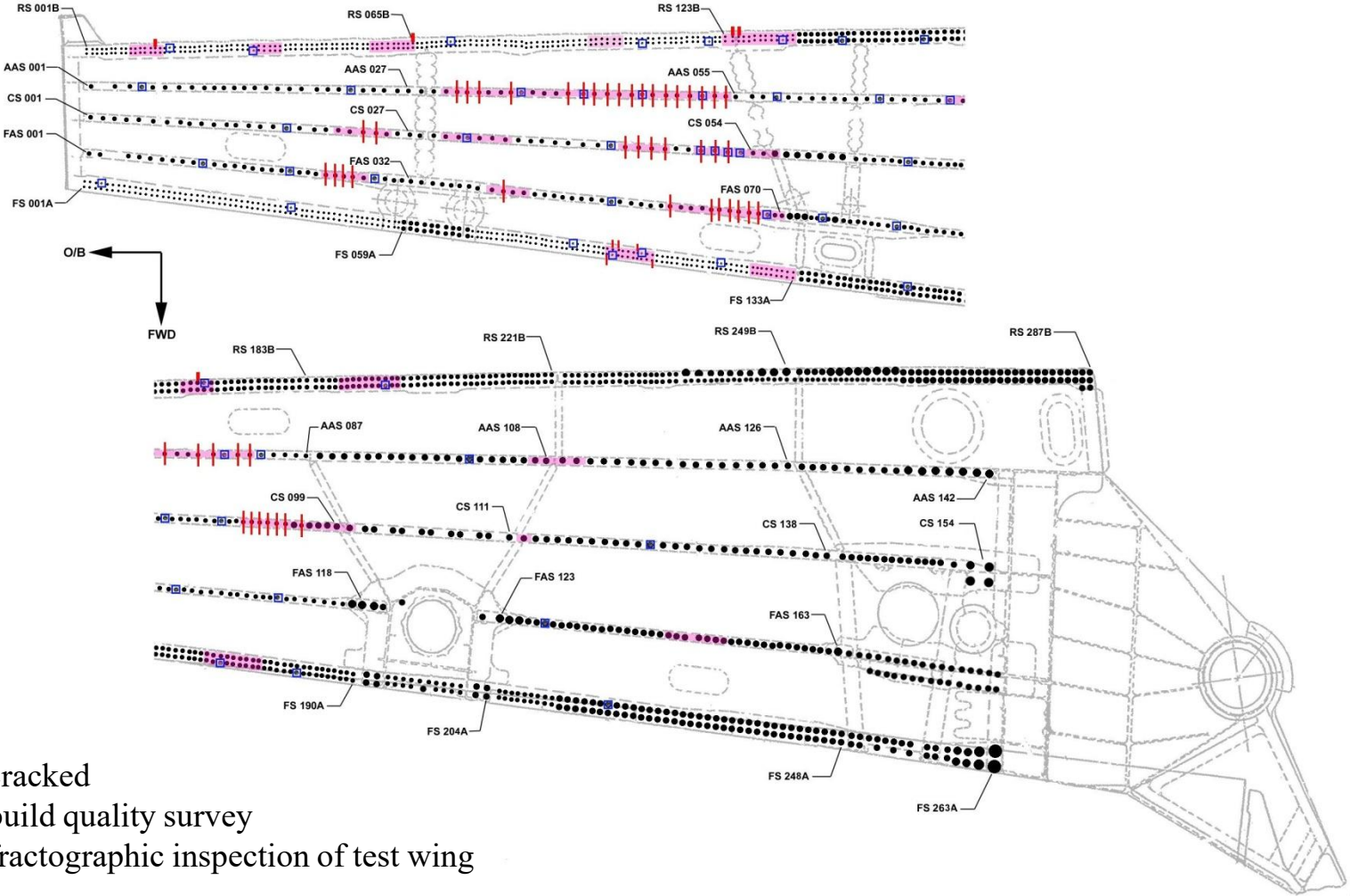


# F111 Wing Tests

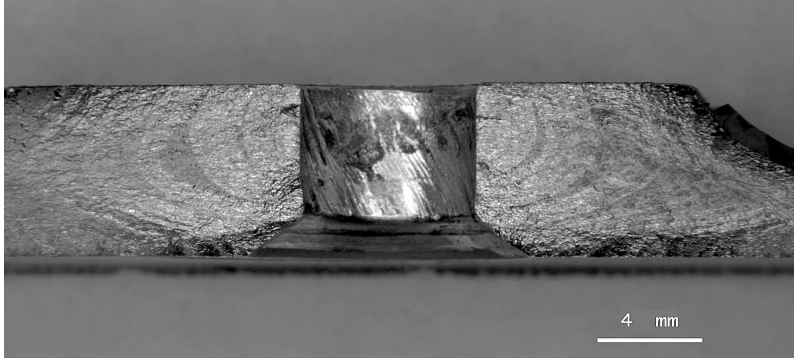
## RAAF Sole Operator Program



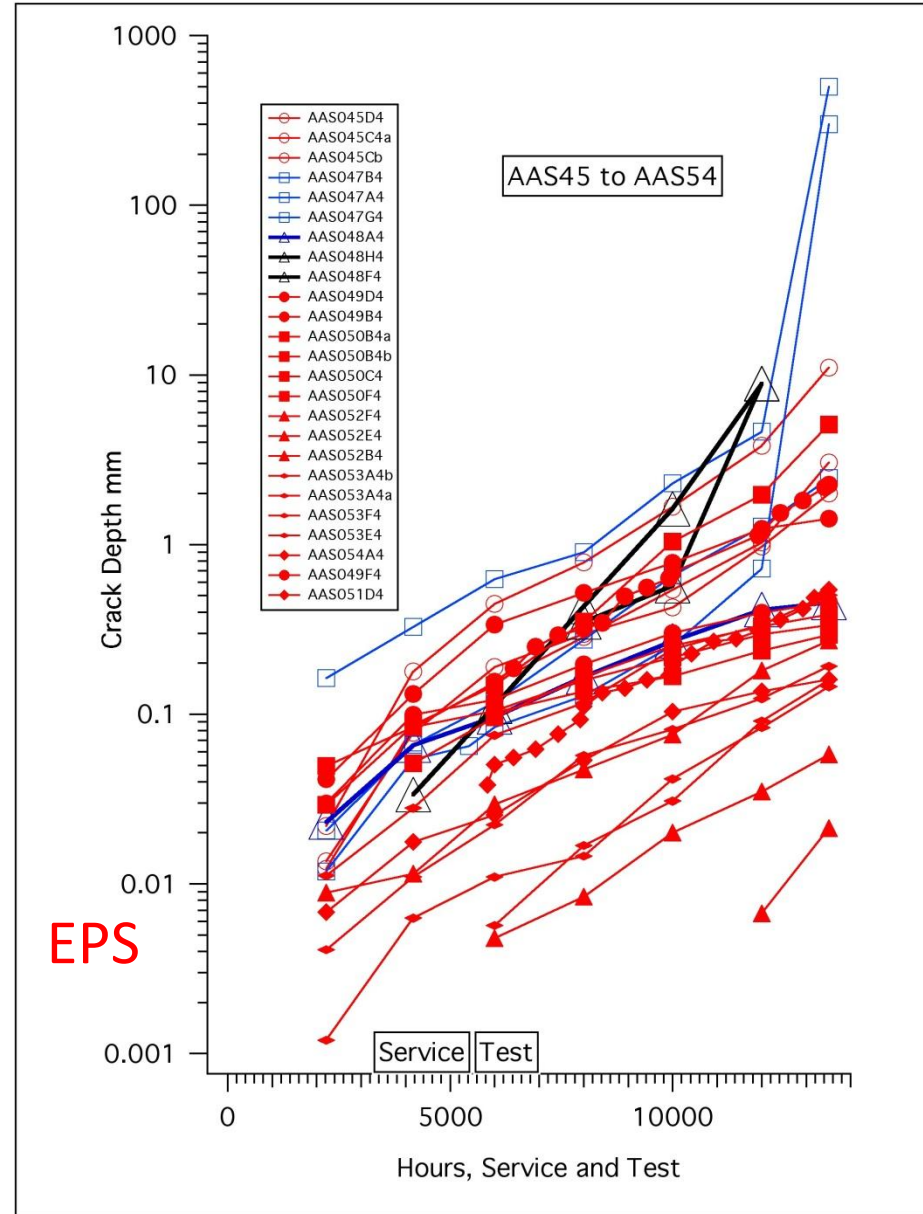
# Quantitative Fractography (QF)



# Test Results from QF



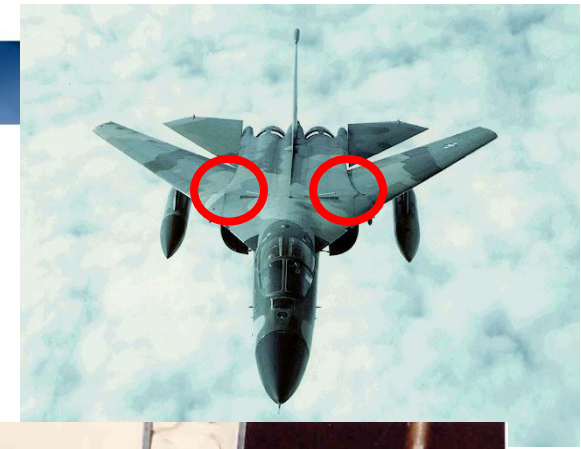
- High confidence due to CPLT marker bands
- Appeared in-service **more** severe than test
- Data  $\approx$  Exponential
- Data used to life fleet wings; along with condition assessment



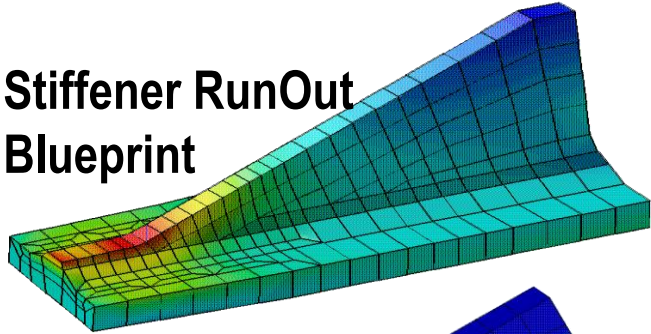
See [14-15]



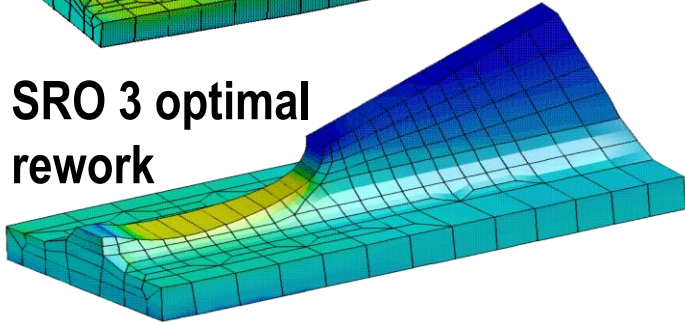
# F-111 WING MODIFICATIONS



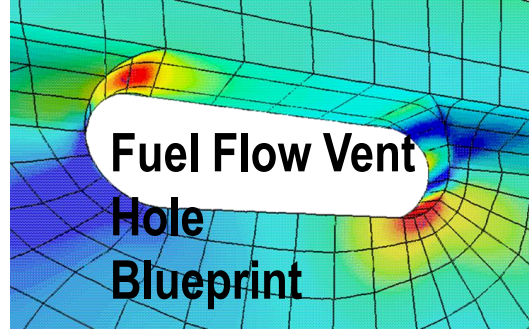
Stiffener RunOut  
Blueprint



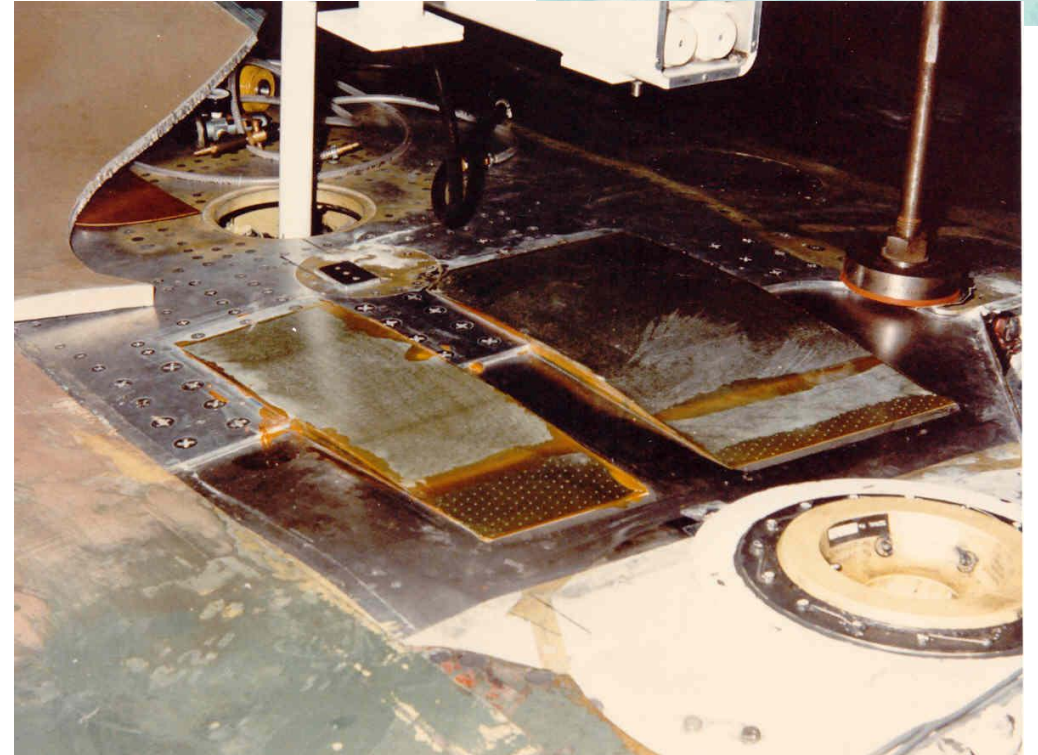
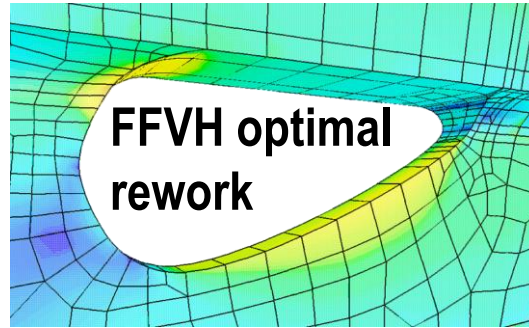
SRO 3 optimal  
rework



Fuel Flow Vent  
Hole  
Blueprint



FFVH optimal  
rework



Boron/Epoxy Strengthening Doublers [14,16]

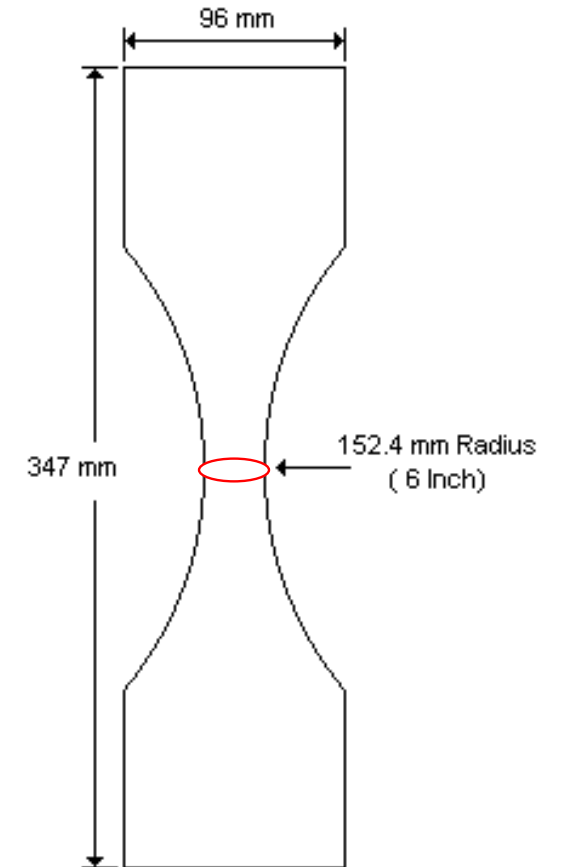
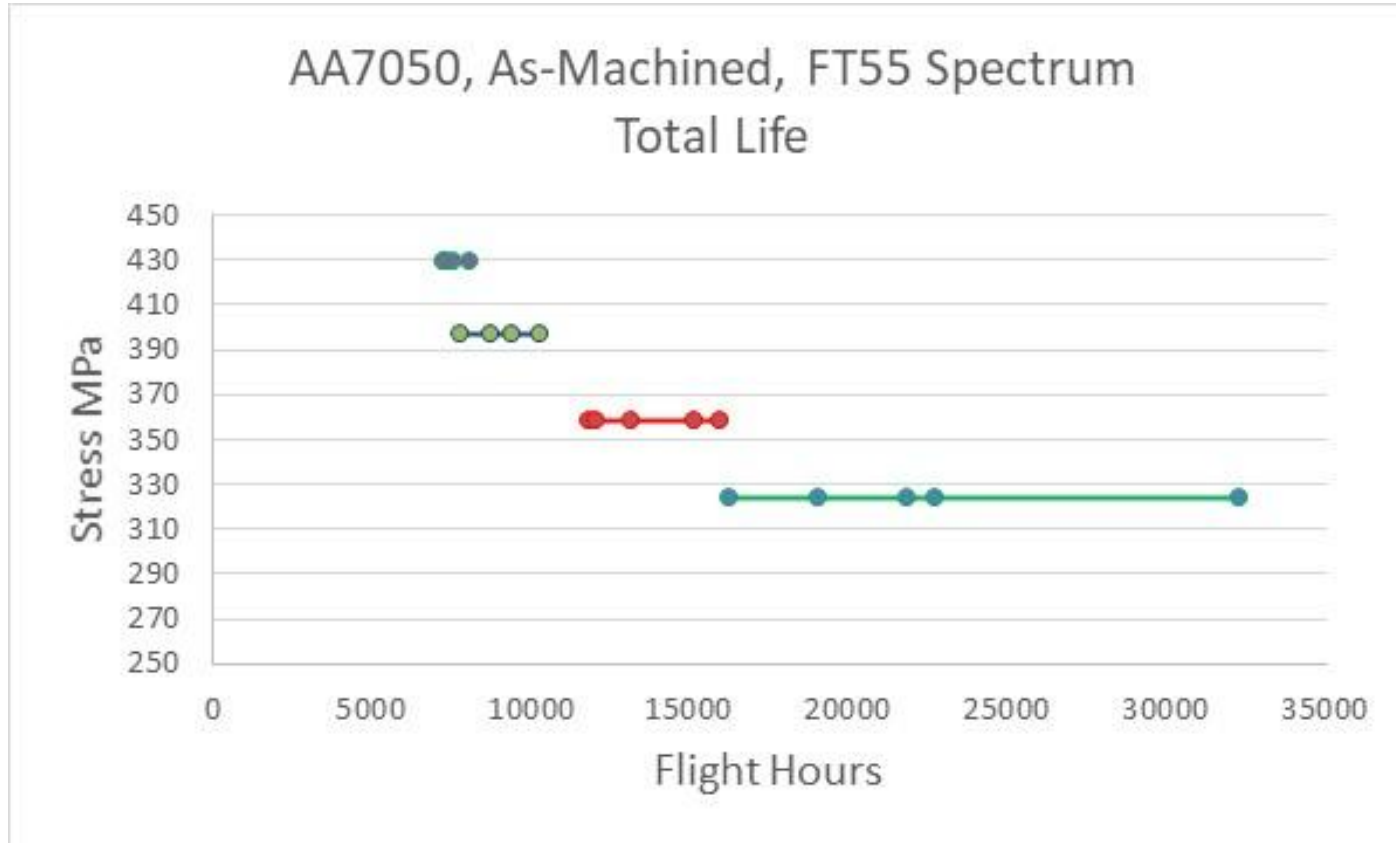
## The journey continues

- With cracks....

The critical importance of the short cracks or low delta K regimes



# In the beginning: Fatigue Coupon S-N Results [17]



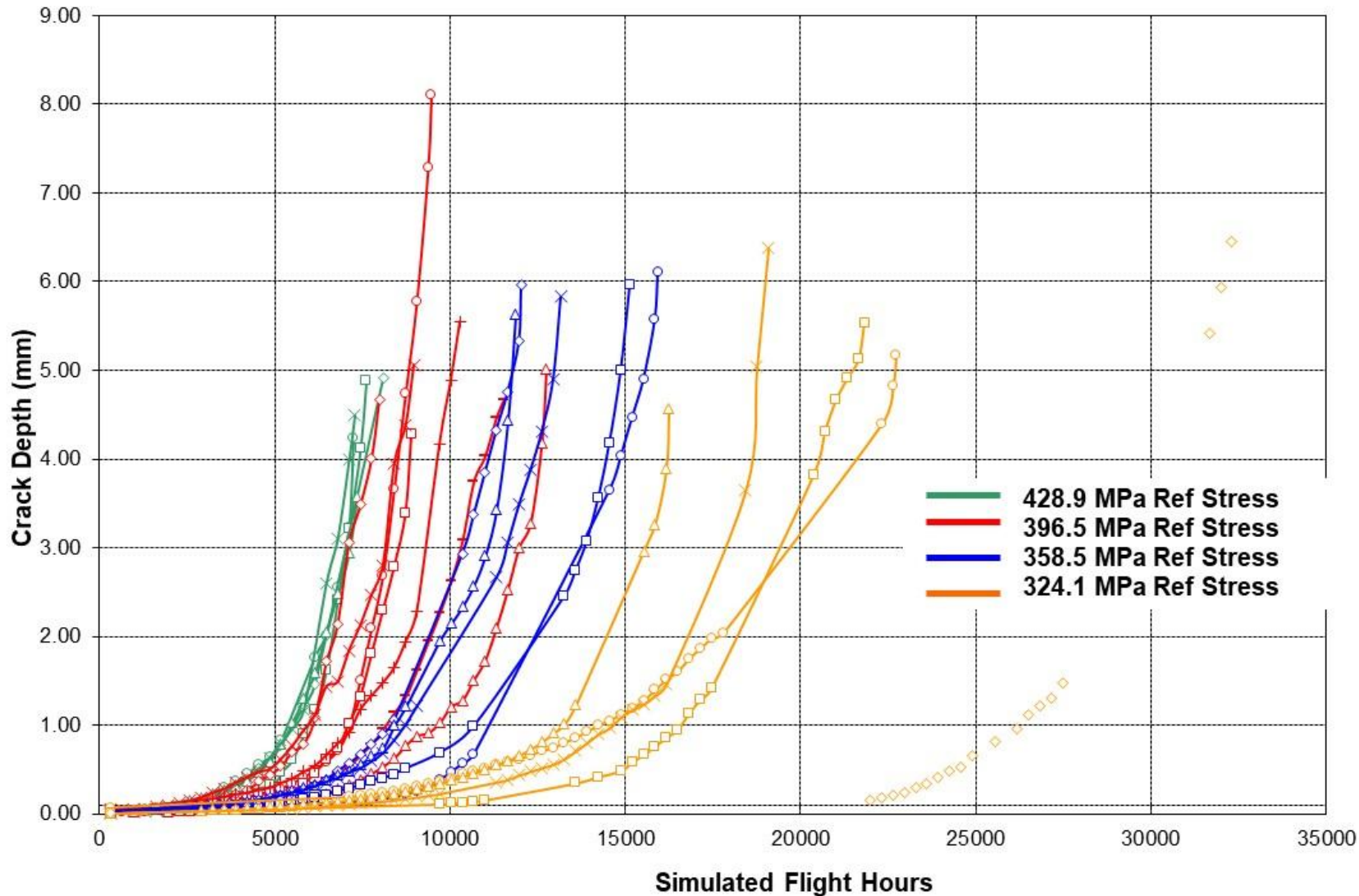
Specimen thickness: 6.25mm

7050-T7451 Aluminum alloy

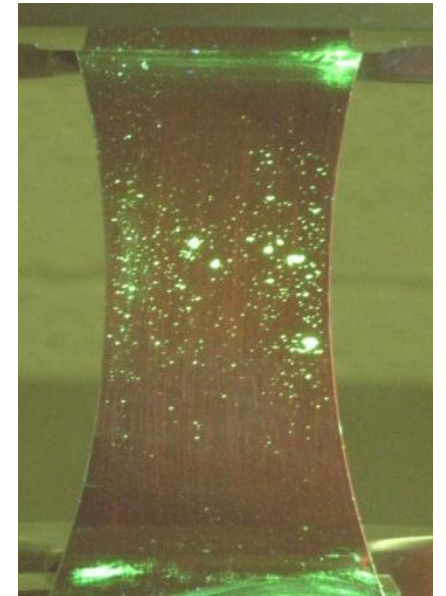
- Nominal test section is 28mm wide by 6.25mm thick
- Analytical  $K_t$  of 1.055
- Four or Five Coupons per Stress level



# Fatigue Coupon Crack Growth QF Results

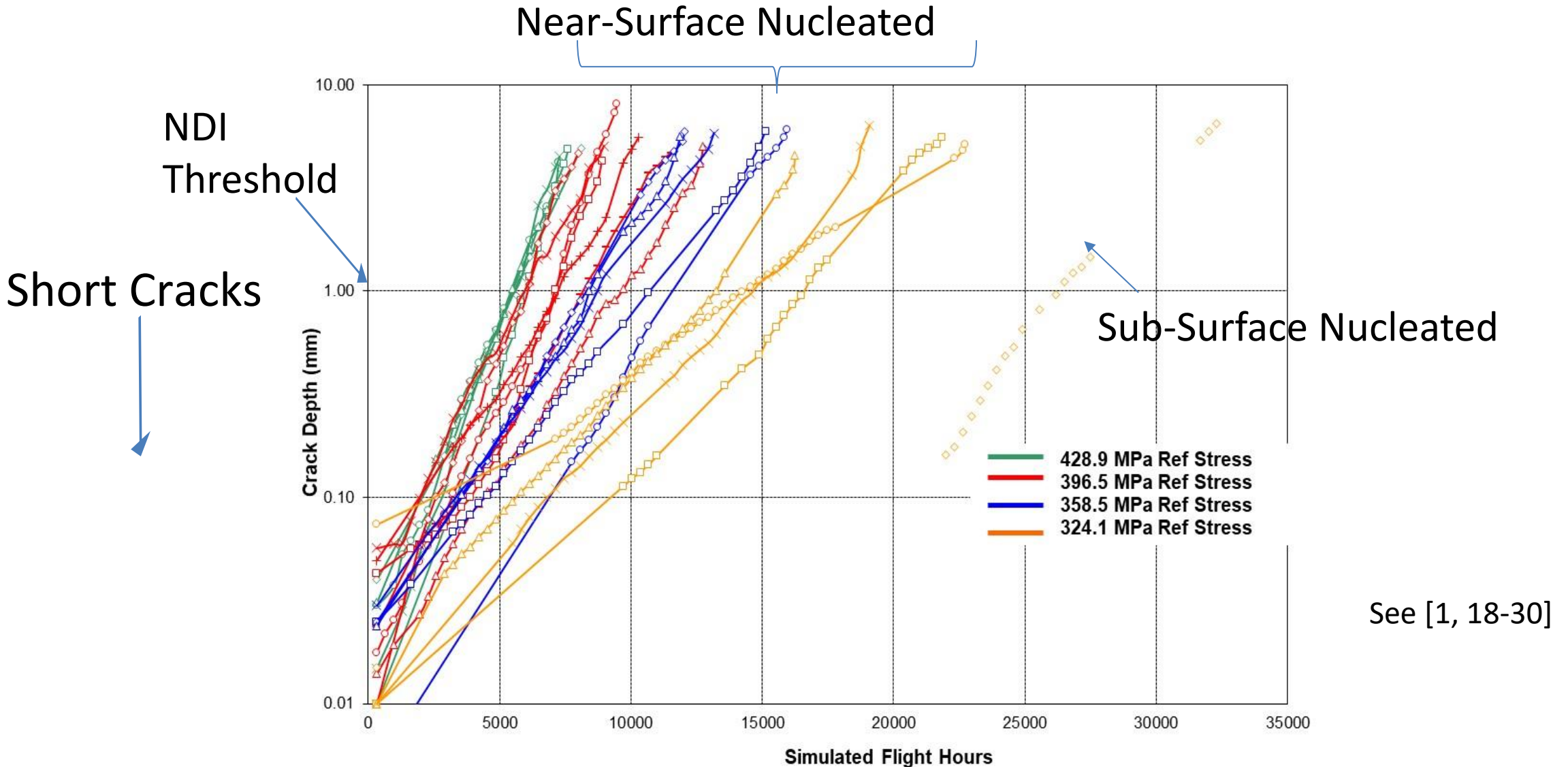


Each point is 1 block of crack growth from Quantitative Fractography (QF)

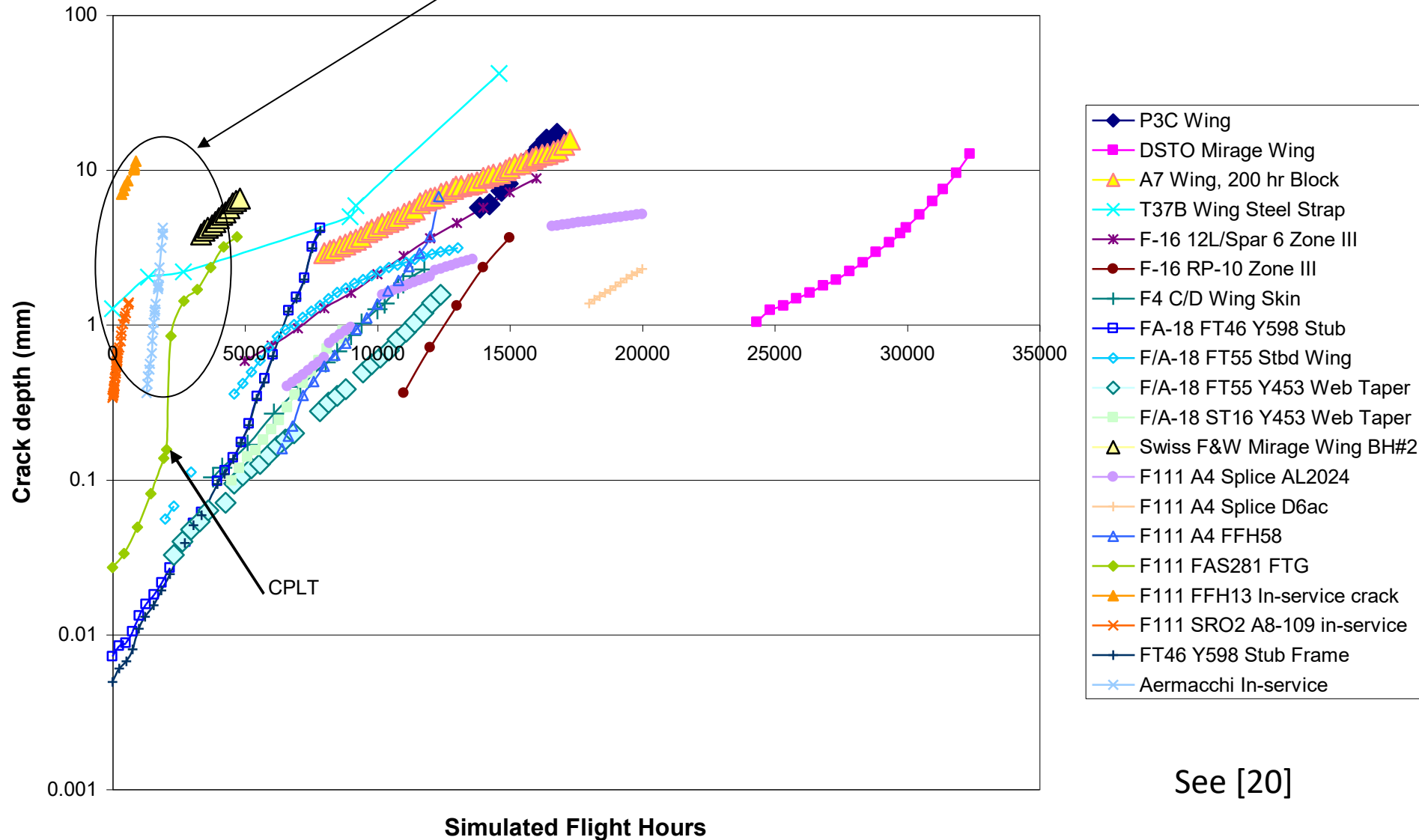


Lead Cracks Only

# Fatigue Coupon Crack Growth Results - Exponential



# A few In-Service and FSFT results



See [20]



# Ye ol' 1963 Paris Re-Visited [18]

$$\frac{da}{dN} = C\Delta K^m = C\left(\beta\Delta S\sqrt{\pi a}\right)^m \quad (1)$$

$$\ln\left(\frac{da}{dN}\right) = \ln C + m \ln K \quad (2)$$



ICF Jun 17

Integrating:

$$a_f = a_0 e^{C\pi(\Delta\sigma\beta)^2 N_f} \quad \text{For } m = 2 \quad (3)$$

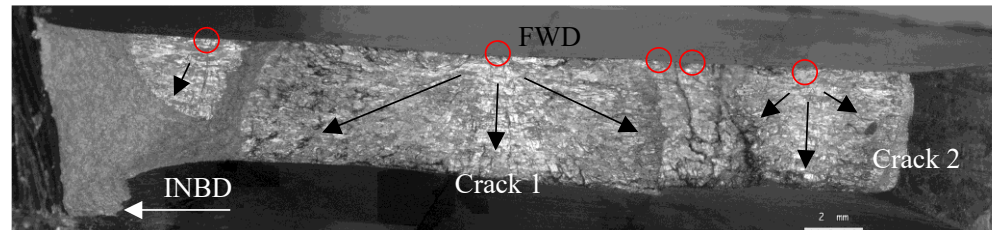
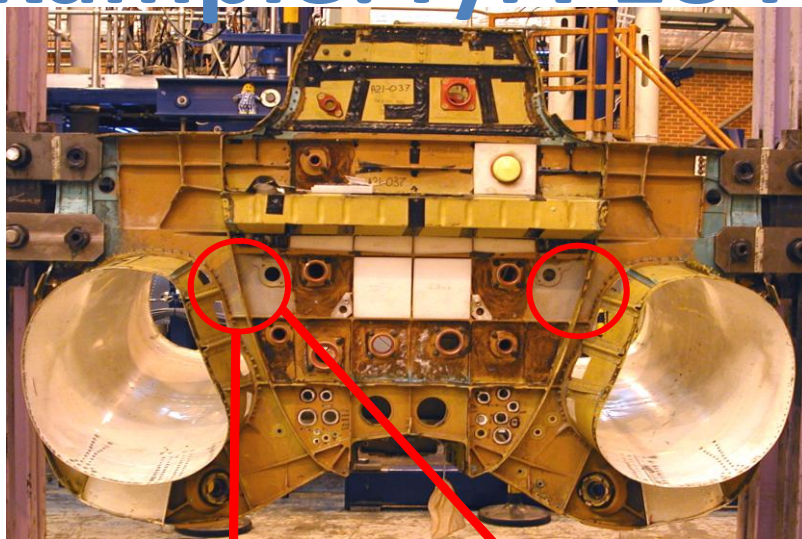
$$a_f = \left[ a_0^{(1-\frac{m}{2})} + N_f C (1-\frac{m}{2}) (\Delta\sigma\beta\sqrt{\pi})^m \right]^{\left(\frac{1}{1-\frac{m}{2}}\right)} \quad \text{For } m \neq 2 \quad (4) \quad \text{LEFM}$$

Where  $a$  is the crack length at cycle  $N$ ,  $\Delta K$  is the stress intensity range (or similitude parameter), constant width correction factor  $\beta$ , and  $C$  and  $m$  are nominally material constants,  $a_0$  is the initial crack size,  $a_f$  is the final crack size and  $\sigma$  (or  $S$ ) is the far field stress.

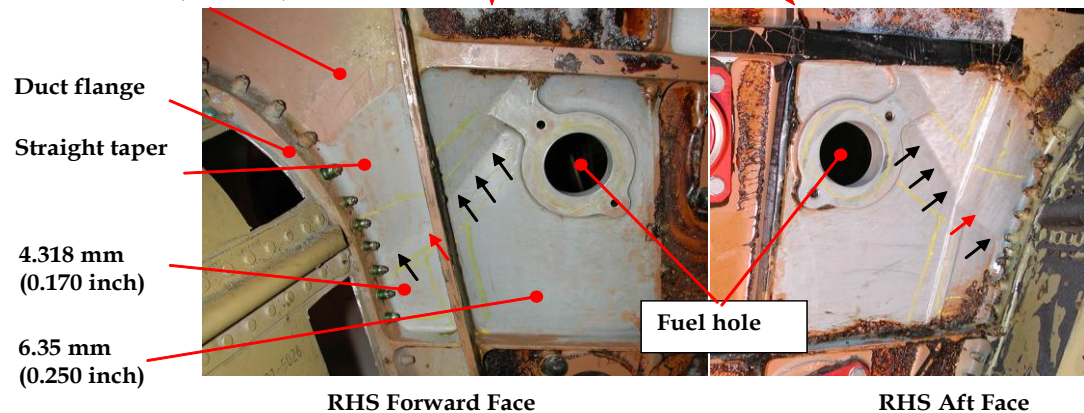
**What about the long-neglected Equation 3 ....???**



# An Example: F/A-18 FSDT “Web-taper”



57.15 mm (2.25 inch)

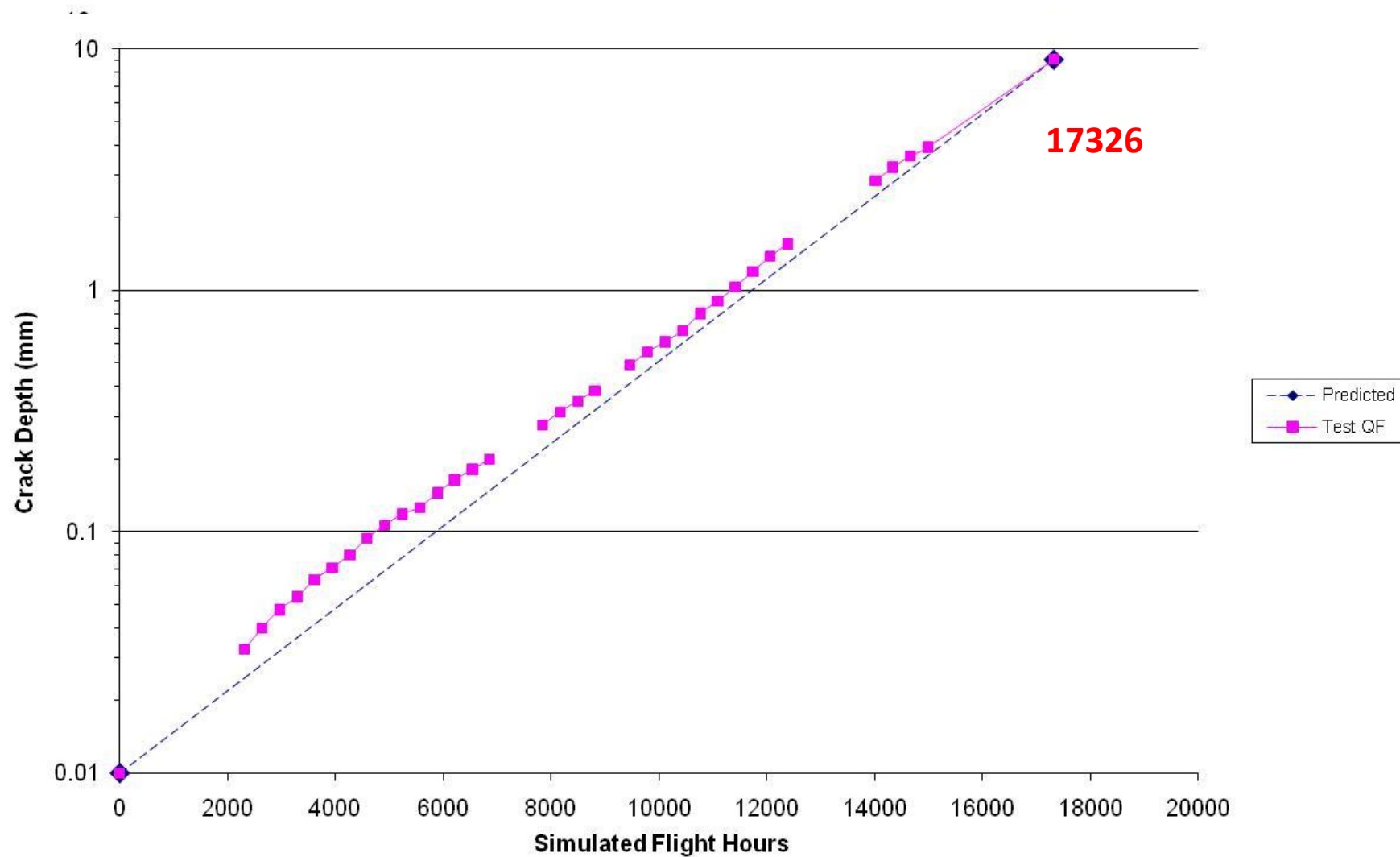


Complex geometry  
High Stresses  
Multiple origins

**Teardown: At 17326 SFH crack depth was 9.04mm deep (FT55)**



# My Prediction: F/A-18 FSDT “Web-taper” Crack



Typical NOT  
Surrogate,  
See [21-23]

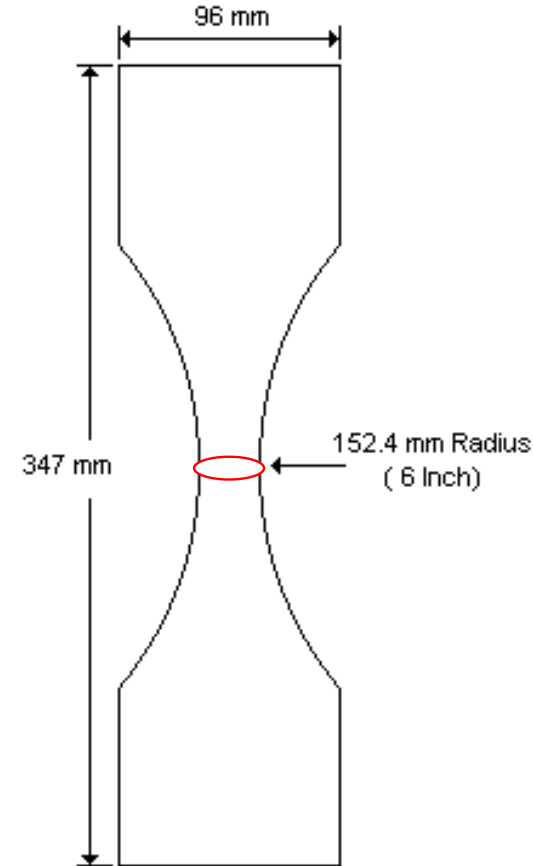
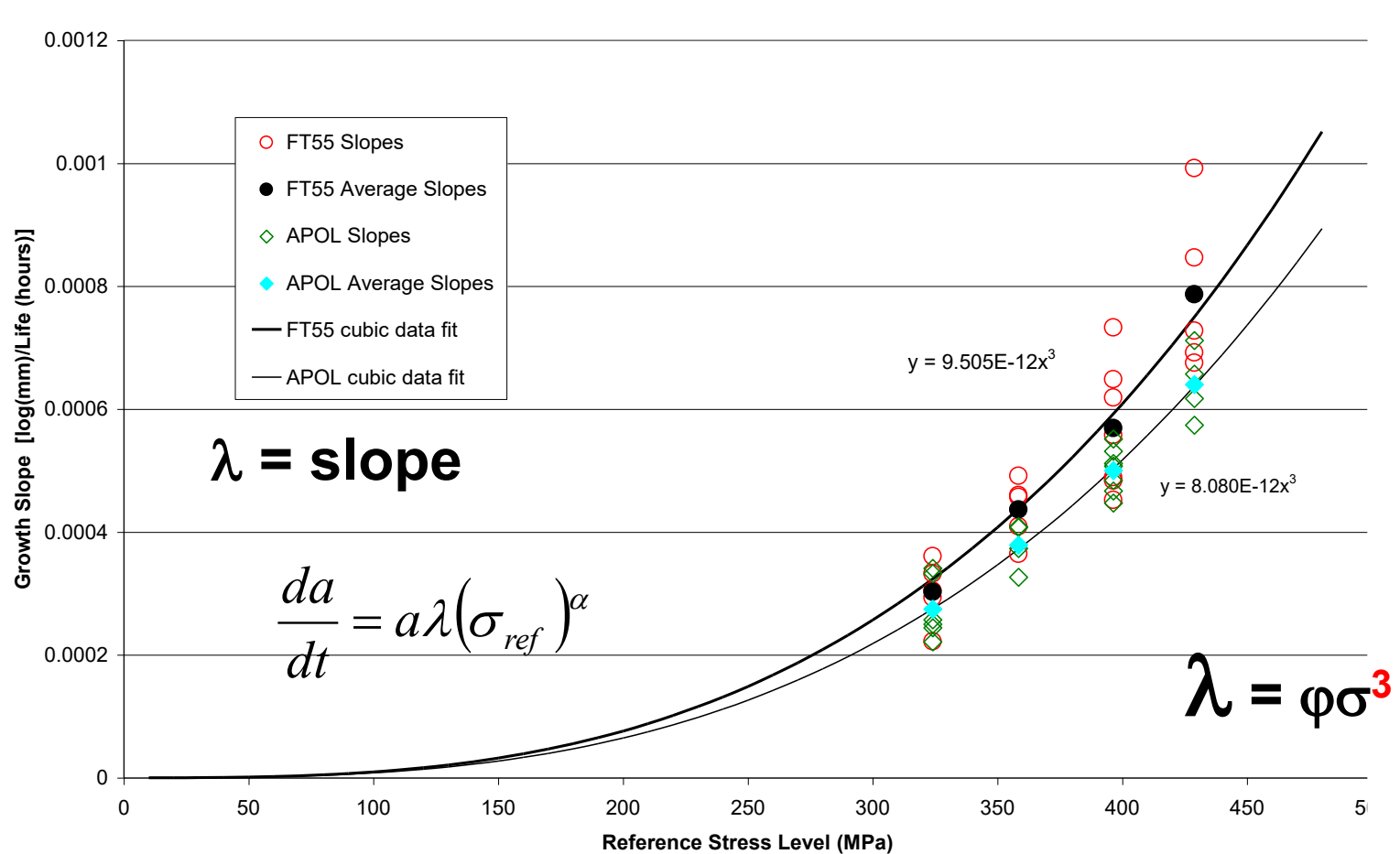


# Cubic Rule [29-31]

(Frost and Dugdale model (circa 1958 [29]) – Constant Amplitude

**Predict lives for same spectrum, material and Kt, at different stresses.**

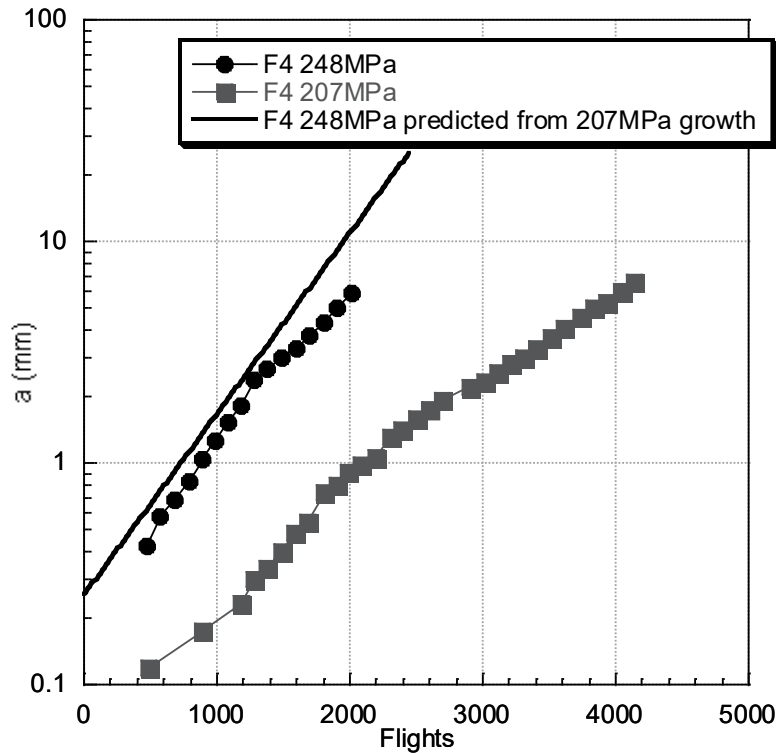
From previous QF data.  
Best fit = Cubic



# Cubic Prediction – F-4 coupon test data

Used in RAAF Hornet and P3C etc structural **repair** manuals

$$a_2 = a_{0_2} e \left( \frac{\sigma_2}{\sigma_1} \right)^3 \lambda_1 N$$



See [30]

USAF Damage Tolerance Design Handbook. 1998. Wright Patterson AFB, USA



# Effective Block Approach [35-37]

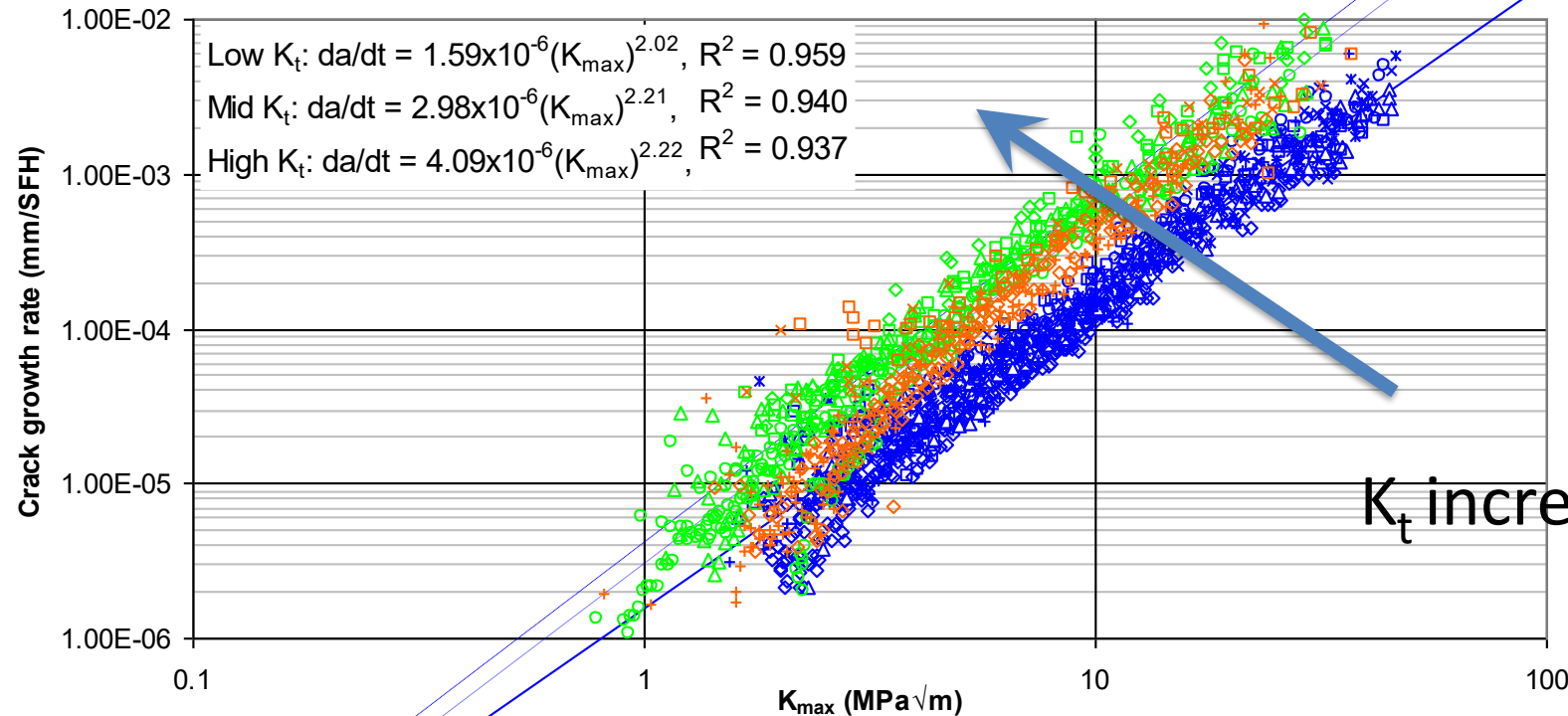
(Gallagher’s mini-block [32-34])

$$da/d\text{block} = a\lambda(\sigma_{\text{ref}})^3$$

$$da/d\text{block} = C (K_{\text{ref}})^2$$

Treat a Block of Variable Amplitude data like Contant Amplitude

Paris-Type Curve (all)



|                                |                                |                                |                                |
|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| ◇ Low $K_t$ - 270MPa, etched   | + Low $K_t$ - 300MPa, etched   | △ Low $K_t$ - 330MPa, etched   | * Low $K_t$ - 360MPa, etched   |
| x Low $K_t$ - 390MPa, etched   | □ Low $K_t$ - 420MPa, etched   | ○ Low $K_t$ - 450MPa, etched   | ○ High $K_t$ - 155MPa, etched  |
| △ High $K_t$ - 200MPa, etched  | □ High $K_t$ - 225MPa, etched  | ◇ High $K_t$ - 250MPa, etched  | + Mid $K_t$ - 194.0MPa, etched |
| ◇ Mid $K_t$ - 215.6MPa, etched | x Mid $K_t$ - 291.1MPa, etched | □ Mid $K_t$ - 323.4MPa, etched | — Paris fit, low $K_t$         |
| — Paris fit, high $K_t$        | — Paris fit, mid $K_t$         |                                |                                |

Hornet spectrum, AA7050 at 3  $K_t$  values



# The Hartman-Schijve Variant [34-38]

$$da/dN = D^* (\Delta\phi)^\alpha$$

$$\frac{da}{dN} = \left( \frac{D(\Delta K - \Delta K_{thr})}{\sqrt{\left(1 - \frac{K_{max}}{A}\right)}} \right)^\alpha$$

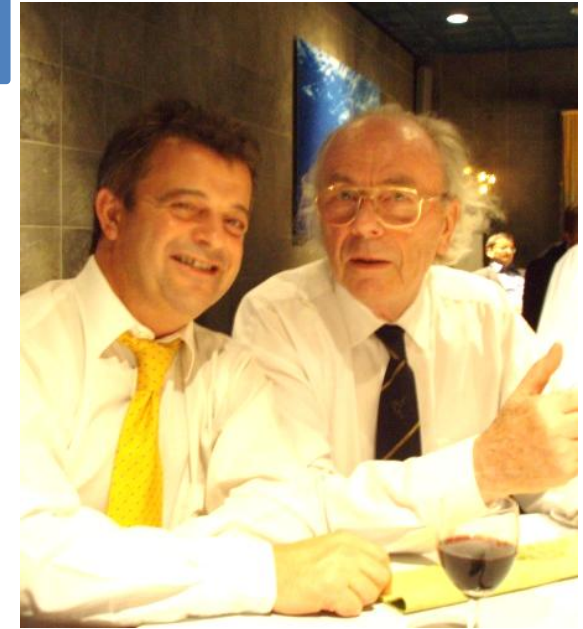
Where A is a constant related to fracture toughness

This equation has the advantage that it allows D to be determined directly from the slope of ONE da/dN versus  $\Delta K$  curve ( $\alpha \sim 2$ )

Note: different  $\Delta K_{thr}$  for short & long cracks

Not ASTM 647 fatigue test standard value of  $\Delta K$  at da/dN of  $10^{10}$  m/cycle

Fits BOTH short & long crack growth rate data. Short cracks are important!!



# Variability in CG rate? E.g. Hillberry et al. data [37]

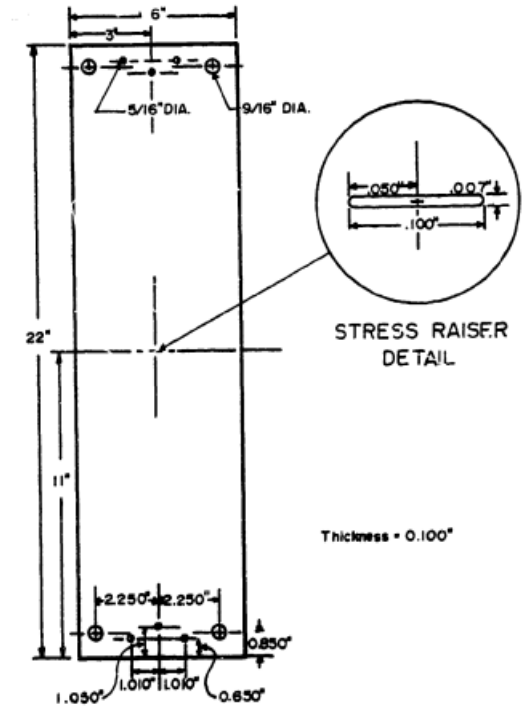
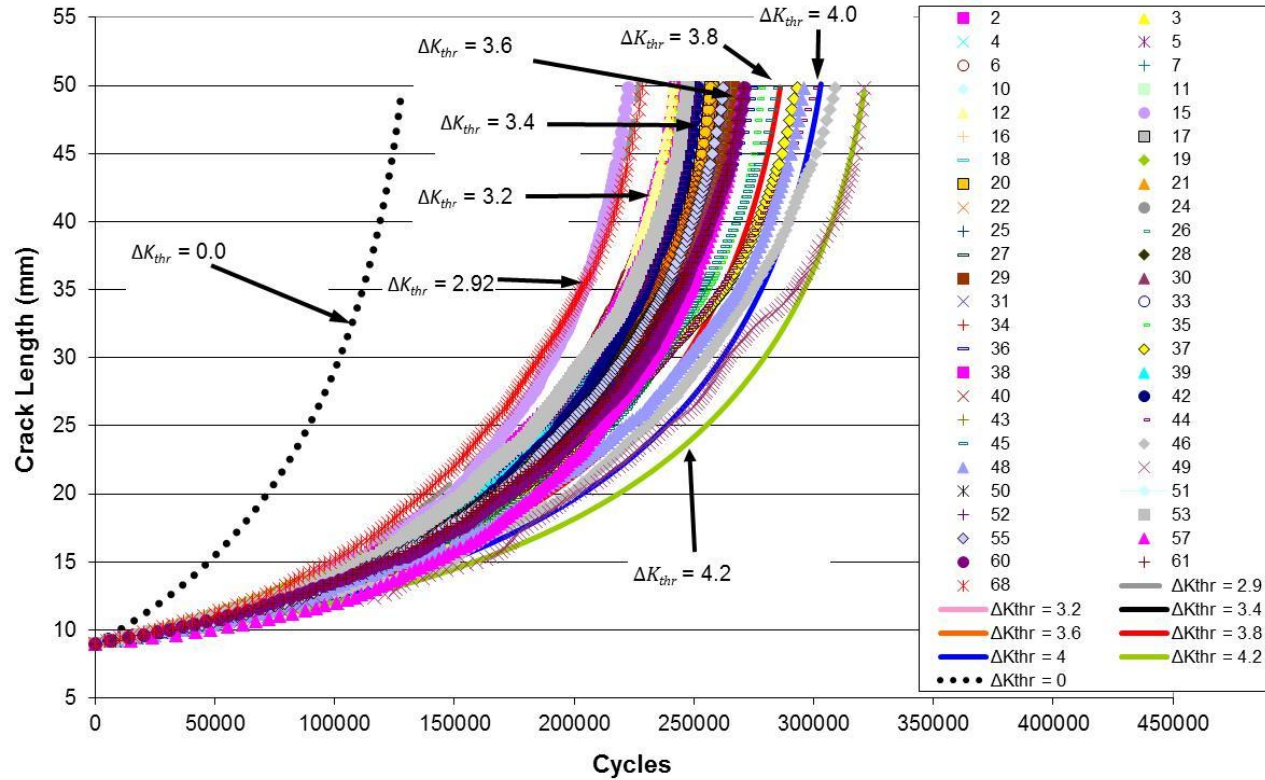


Figure 21. Test Specimen

Crack growth data from Virkler et al. [39] AA2024-T3 and computed variability with various  $\Delta K_{thr}$ .

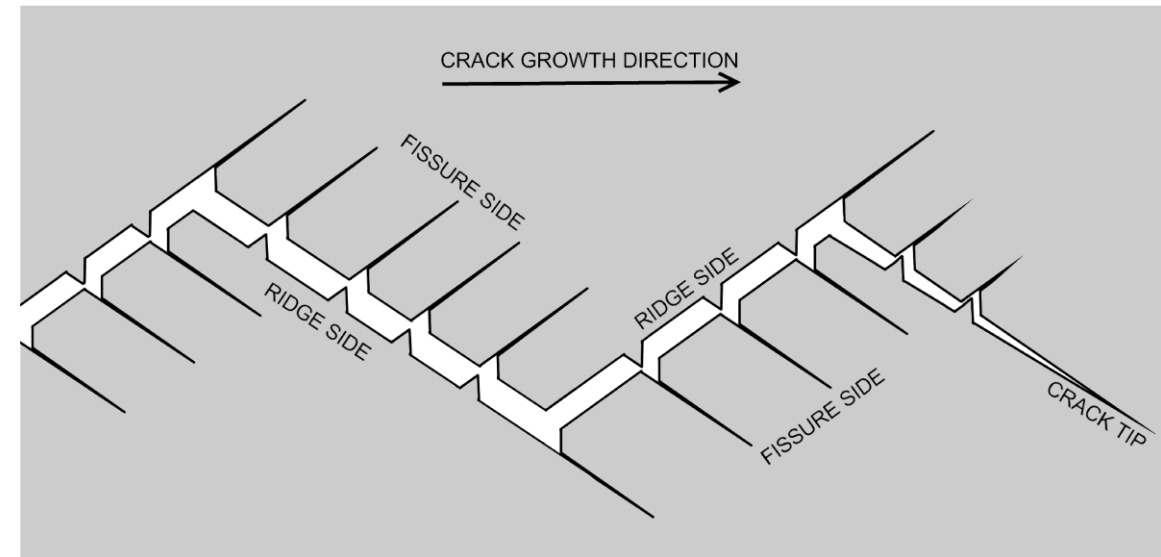
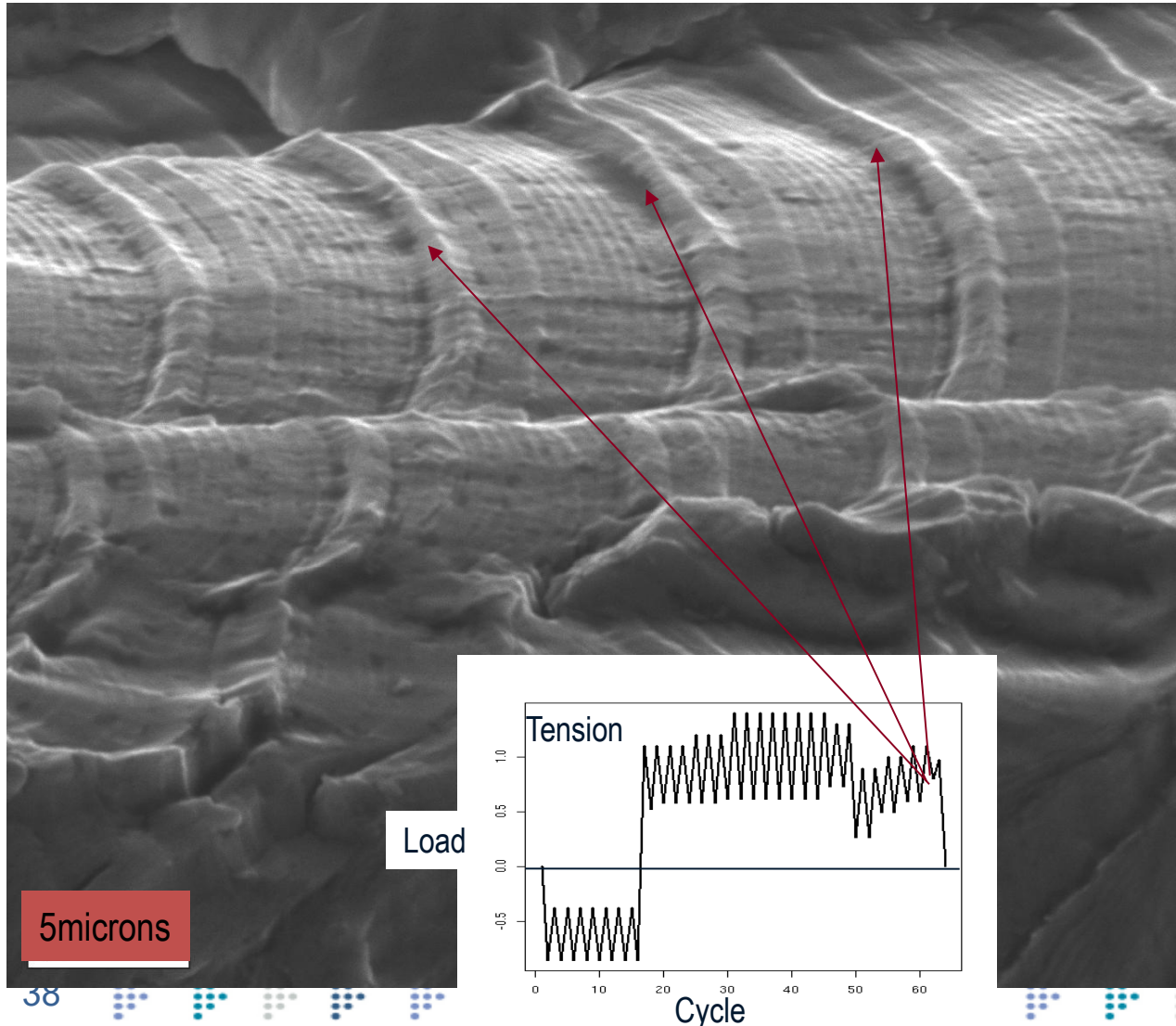
Half-crack length plotted.

Also collapses Stress Ratio (R) data....



# Cracks and Fissures [39-41]

- Loading changes the plane on which growth occurs.
- This changes the profile of crack surface.
- It produces ridges on one side which match depressions on the other.
- Alternative crack formation mechanism



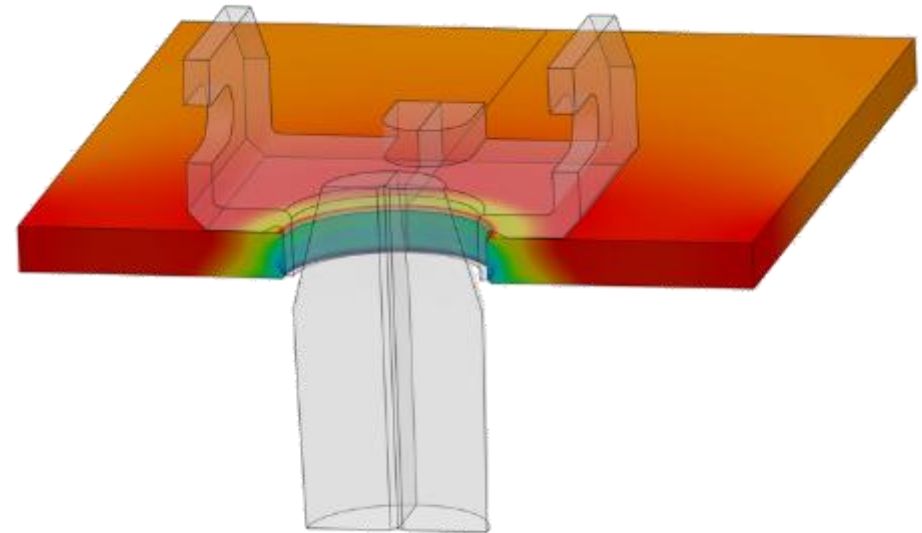
# Corrosion #\$\$%@^&



F35B on deck showing signs of corrosion causing discolouration – Source: *US Finds Solution to Corrosion Problem on F-35 Jets*, Aeronaut Media 13 Jul 25

## PART WORKS

- We can “handle” pitting corrosion, see [43]
- Prevention better than repair
- Elephant: Corrosion in fracture critical parts



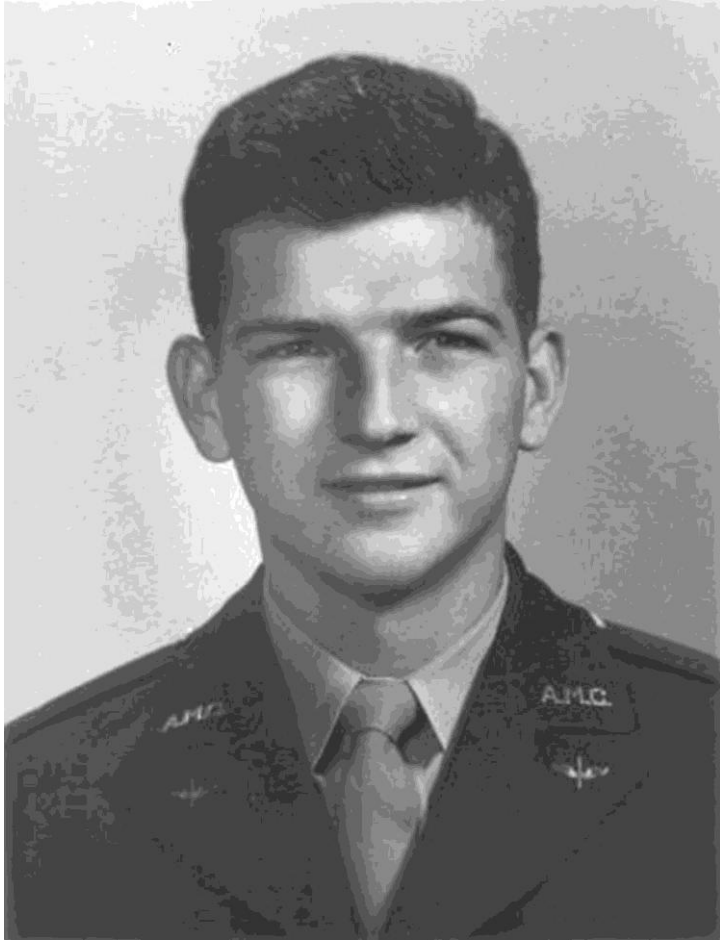
Cold Expanded & Bonded Bush Mod or Repair [42]



## Conclusions

- With you, I have been on a fabulous ASI journey
- We did some good things and learnt much
- Many achievements made possible because of a sovereign Air Force with sovereign ASI expertise
- You trusted me. I am so grateful and proud. I think Jack would be too!
- Much more to learn – I wish you all a successful journey
- ASI is much more than fatigue! Fatigue is all about cracks and we have some useful tools
- Master the rules before you bend them!

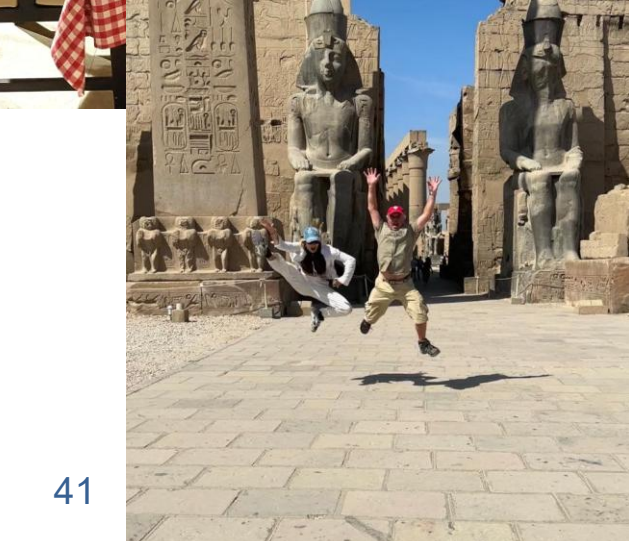




Thanks Bryan



# Final acknowledgment – Long Suffering Family



# Questions



No Highway in the Sky

# Bibliography

1. Molent L. Aircraft Fatigue Management, SpringerBriefs in Applied Sciences and Technology, 2024
2. Rees, D. and Molent, "Analysis Of Candidate Bonded Repairs For Cracks In The Weep Holes Of USAF C141 Aircraft", ARL-Tech Note- 62, Dec 1993
3. Schweinberg W.H. and Fiebig J.W., Case histories: advanced composite repairs of USAF C-141 and C-130 aircraft, Advances in the bonded composite repair of metallic aircraft structure, Baker, A.A., Rose, L.R.F. and Jones, R. (eds.), Elsevier Science Ltd, 2002.
4. Butkus, L. Residual Strength of Bonded Repairs After 10 Years of Service, ASIP, Nov 2006.
5. Molent, L., Enke, N., Wallace, G. and Jones, R., Thermomechanical analysis of bonded repaired skin splice joint specimens, ARL-TECH-R-24, Jan 1994
6. Molent, L., Structural Investigations into the Collapse of the Wing Leading Edges of Orion P-3C, proc. PICAST2 - AAC6, Melbourne 20-23 March 1995
7. Moon R.N. and Bell T.C, Discussion of structural limit and ultimate load levels in aircraft strength and rigidity, White Paper, Lockheed Martin, 1 August 1994
8. Molent, L., Wallace, G. and Currie, A., "Crack Growth and Repair of Multi-site Damage of Fuselage Lap Joints", ARL-STR-TM-534, Feb. '90
9. Molent, L. and Jones, R. Crack growth and repair of Multi-Site Damage of fuselage lap joints, Engineering Fracture Mechanics Vol. 44, No. 4, pp. 627-637, 1993
10. Jones R, Molent L and Pitt, S. Understanding crack growth in fuselage lap joints. Theo and App Fracture Mechanics 2008; 49:38-50



## Bibliography cont'

11. McDonald M et al. In Situ Thermoelastic Stress Analysis of the F-35 - An Improved Approach to Airframe Structural Model Validation, ASIP TX, 2015.
12. Molent L. A brief history of structural fatigue testing at Fishermans Bend Australia. Advanced Materials Research Vols. 891-892 (2014) pp 106-114
13. Main B, Molent L, Singh R and Barter S. Fatigue crack growth lessons from thirty-five years of the Royal Australian Air Force F/A-18 A/B Hornet Aircraft Structural Integrity Program, Fatigue 2020; 133:.
14. Swanton G, 40 Years of F-111 Aircraft Structural Integrity Support by the Defence Science and Technology Organisation, Proc of AIAC 2013, Melbourne, 10-11 Mar 2009.
15. Boykett R, Walker K and Molent L. Sole operator support for the RAAF F-111 fleet. 11<sup>th</sup> Joint NASA/FAA/DOD Conference on Aging Aircraft, Phoenix, 21-24 Mar 2008
16. Molent, L., Callinan, R.J. and Jones, R. Design of an all Boron/Epoxy reinforcement for the F-111 wing pivot fitting: Structural Aspects, J. Composite Structures 11 (1989) pp57-83
17. Pell R.A., Molent L. and Green A. The fractographical examination of F/A-18 aluminium alloy 7050-T7451 bulkhead representative coupons tested under two service spectra and two stress levels, DSTO-TR-1629, Oct 2004
18. Molent L, Barter SA and Wanhill RJH. The Lead Crack Fatigue Lifting Framework, J Fatigue; 33 (2011) 323–331
19. Molent, L., S.A. Barter and Wanhill, RJH. The lead crack concept 30 years on, Proc. ICAF, Delft, the Netherlands, July 2023.
20. Molent, L. Fatigue Crack growth from flaws in combat aircraft. J Fatigue 32 (2010) 639-649



# Bibliography Con't

21. Molent, L. and Fox, MR. Crack-like effectiveness of some discontinuities in AA2024, *Fatigue Fract Eng Mater Struct.* 2023;1–14
22. Gallagher JP and Molent L. The equivalence of EPS and EIFS based on the same crack growth life data, *Fatigue* 2015; 80:162–170
23. Molent L., A review of equivalent pre-crack sizes in aluminium alloy 7050-T7451, *Fat Fract Eng Mat Struct* 2014;37: 1055-74
24. Wanhill, R.J.H., Molent, L. and Barter, S.A. (2023) Milestone Case Histories in Aircraft Structural Integrity. In: Aliabadi, Ferri M H and Soboyejo, Winston (eds.) *Comprehensive Structural Integrity*, 2nd Edition, vol. 1, pp. 325–348. Oxford: Elsevier.
25. White P., Molent L. and Barter S., Interpreting fatigue test results using a probabilistic fracture approach, *Fatigue* 27/7 pp752-767, 2005
26. Jones, R., Molent, L. and Pitt, S., Crack growth of physically small cracks, *International Journal of Fatigue* 29 (2007), 1658-1667  
Molent L, Barter SA, A comparison of crack growth behaviour in several full-scale airframe fatigue tests, *Int J Fatigue* (2007); 29: 1090-1099
27. Molent L, Barter SA, A comparison of crack growth behaviour in several full-scale airframe fatigue tests, *Int J Fatigue* (2007); 29: 1090-1099
28. Wanhill, R.J.H., Molent, L. and Barter, S.A., *Fatigue crack growth and lifing analyses for metallic aircraft structures and components*, Springer briefs in Applied Science and Technology, the Netherlands, 2019.
29. Frost NE and Dugdale DS. The propagation of fatigue cracks in test specimens. *Journal Mechanics and Physics of Solids* 1958; 6: 92-110



## Bibliography con't

30. Barter S., Molent L., Goldsmith N. and R. Jones. An experimental evaluation of fatigue crack growth. *Journal Engineering Failure Analysis*, Vol 12/1 pp 99-128, 2005.
31. Molent L. and Jones R., A stress versus crack growth rate investigation (aka stress – cubed rule), *Int J Fatigue* 2016; 87:435-443.
32. Gallagher J. & Stalnaker H.D., (1978) Mini-block approach with characteristic stress)
33. Gallagher JP and Stalnaker HD, Developing normalised crack growth curves for tracking damage in aircraft, *Aircraft* Feb 1978.
34. Gallagher, J P. Estimating fatigue-crack lives for aircraft: techniques, *Exp. Mech.*,16 (11), 425-433, 1976
35. Molent, L., McDonald, M., Barter, S., Jones, R., Evaluation of Spectrum Fatigue Crack Growth using Variable Amplitude Data, *Fatigue* (2007); 30/1; 119-137
36. Zhuang W.Z., McDonald M, Phillips M and Molent L. Effective block approach for aircraft damage tolerance analyses. *J Aircraft* Vol. 46, No. 5, Sept–Oct 2009.
37. Huynh J, Molent L and Barter S. Experimentally Derived Crack Growth Models for Different Stress Concentration Factors; *J. Fatigue* 2008, Vol 30/10-11 pp 1766-1786
38. Hartman, A. and Schijve J. The effects of environment and load frequency on the crack propagation law for macro fatigue crack growth in aluminum alloys. *Eng Fracture Mechanics* 1970;1(4), pp 615-63
39. Jones R, Molent L, Walker K. Fatigue crack growth in a diverse range of materials. *J. Fatigue* 40 (2012) 43–50



## Bibliography Cont'

40. Jones R, Molent L and Barter S. Calculating crack growth from small discontinuities in 7050-T7451 under combat aircraft spectra. *J Fatigue* 2013; 55: 178-182.
41. Molent L. and Jones R. The influence of cyclic stress intensity threshold on fatigue life scatter, *Int J Fatigue*, 2015; 82: 748-756
42. Virkler DA, Hillberry BM. and Goel PK., The statistical nature of fatigue crack propagation. Technical Report AFFDL-TR-78-43, 1978, USA: Air Force Wright Aeronautical Laboratory, Ohio
43. White, P. A guide to the program EASIGRO for generating optimised fatigue crack growth models. DST-Group-TR- 3566, DSTO, Melbourne, Australia, Feb 2019
44. White P, Barter S and Molent L. Observations of crack path changes caused by periodic underloads in AA7050-T7451; *Int Journal of Fatigue* 30 (2008),1267-1278.
45. Krkoska M., Barter S.A., Alderliesten R.C., White P., Benedictus R., Fatigue Crack Paths in AA2024-T3 and AA7050-T7451 Treatment When Loaded with Simple Underloads Spectra, in proc. of Crack Paths 2009.
46. Restis J et al., Bolt Hole Corrosion and Fatigue Damage Repair in Hybrid Structure, ASIP 2022.
47. Molent, L. and Wanhill, R. Management of Airframe In-Service Pitting Corrosion by Decoupling Fatigue and Environment. *Corros. Mater. Degrad.* 2021, 2, 493–511
48. Molent L and Haddad A. A critical review of available composite damage growth test data under fatigue loading and implications for aircraft sustainment, *Composites Struct* 2020; 232: 111568
49. Molent, L. and J.D. Roberts, Bonded Repair Application to the Boeing 747-400 Pressure Test Article - August 1990, ARL-STR-TM-573, Mar '92



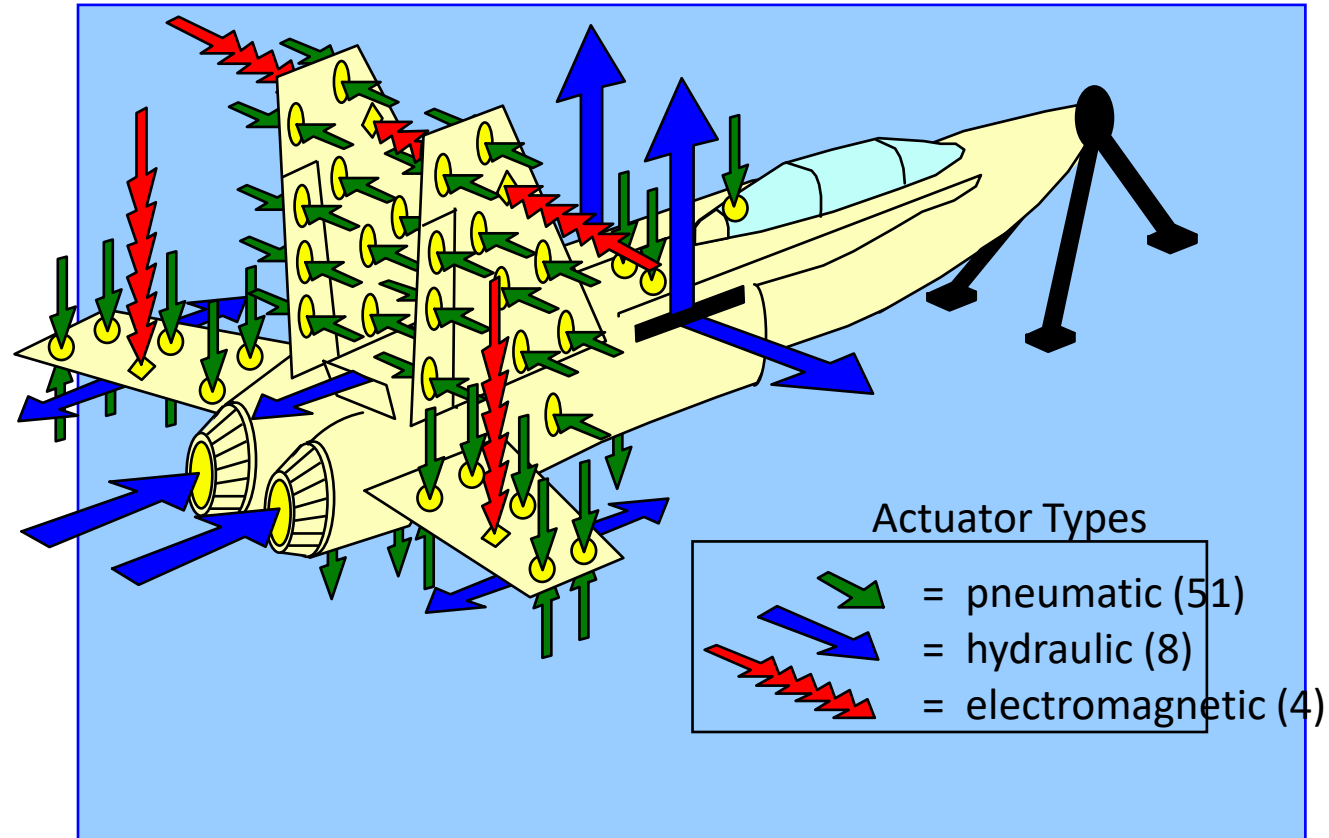
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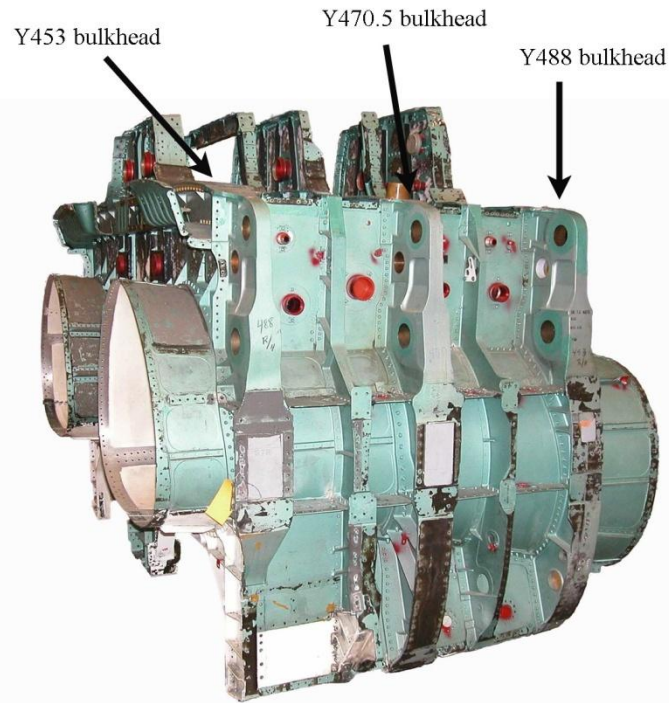
# Back-up Slides



# FT46 – Simultaneous manoeuvre and buffet



# Eighteen F/A-18 Centre Barrel Tests [13]



- Fleet life extension of > 10%
- \$400M in real savings
- Delay purchase of JSF by 10 years

**Material:** 7050-T7451 Aluminium Alloy

**Weight:** ~ 500 kg (bare structure)

**Fracture Critical**

# Caveats (departure from exponential) [1,18]

- Sub-surface (in vacuum)
- Residual stresses
- Quasi static tearing
- Periodic Overloads
- Change in geometry
- Slow starting crack (e.g. multiple local nucleation sites)
- Growth towards neutral axis (load shedding)
- Discontinuity not initially crack-like
- Change in Usage



# Top NAVAIR Priority post Gulf1



## VIDEO RECORDER/CAMERA SYSTEM



- DESIGN REQUIREMENTS
  - UTILIZE OFF-THE-SHELF TECHNOLOGY TO MAX. EXTENT POSSIBLE
  - MAINTAIN COMMONALITY BETWEEN F/A-18C/D AIRCRAFT
  - 2 HOUR RECORDING TIME
  - ENHANCED RESOLUTION
  - GREATER COMMONALITY WITH EXISTING COMMERCIAL & PRIVATE PLAYBACK EQUIPMENT

12/16/91

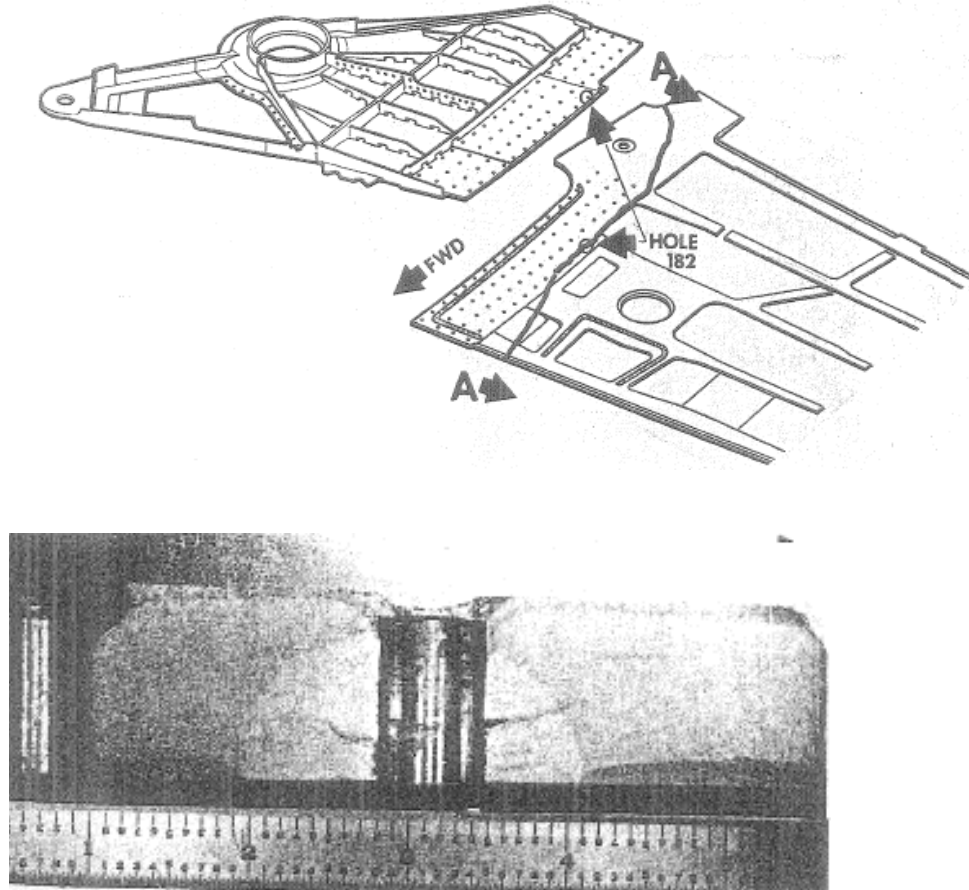


# Boeing 747-400 FSFT Bonded Repairs 1990 [49]

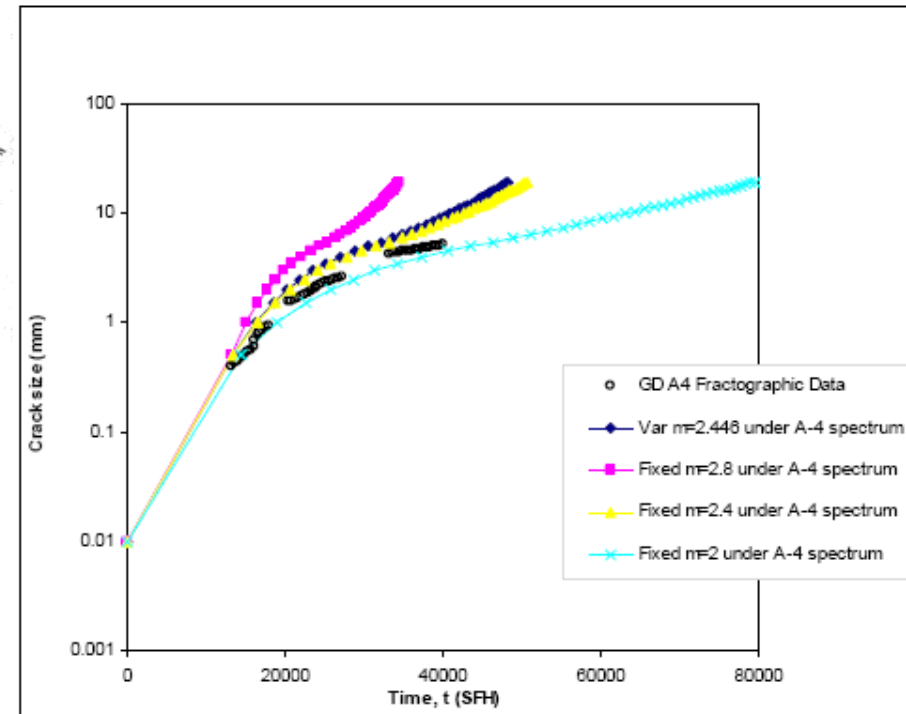


# EBA Example (varying m)

Figure 1 FRACTURE SURFACE OF L/H LOWER WING SKIN

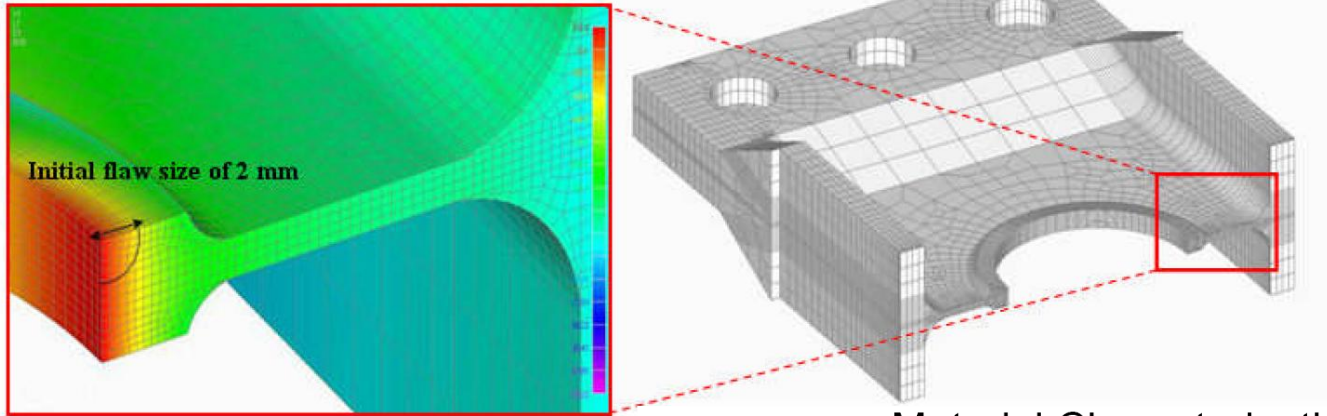


m = 2 best (i.e. exponential)

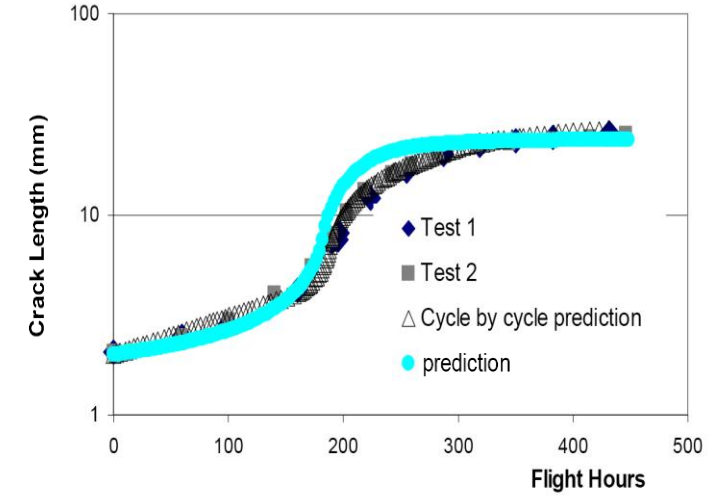
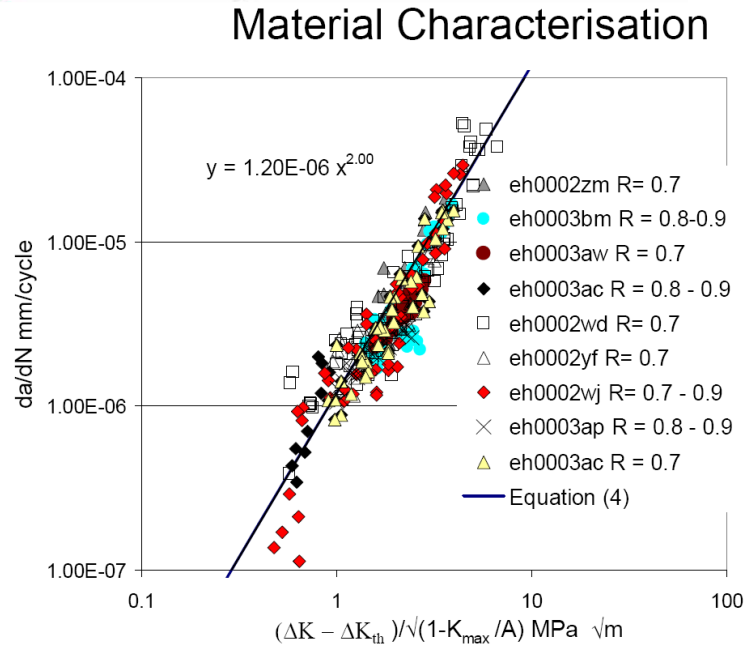
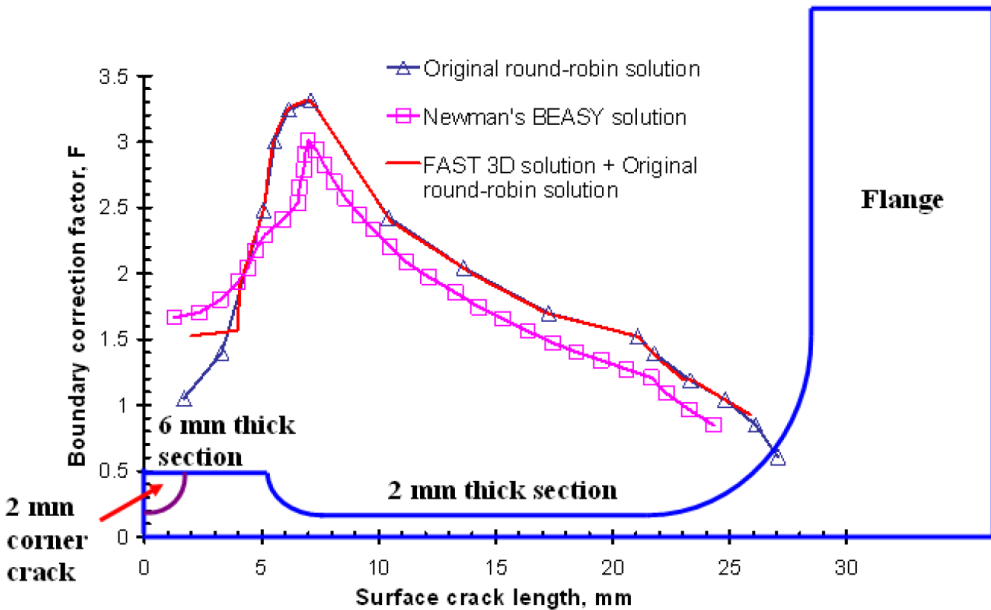


**EBA prediction of the OEM's F111 (A4) full-scale fatigue test data (FZS-12-327, 1972)**

# H&S VA example; AA7010-T73651 flanged plate with lightening hole tested to ASTRIX spectrum



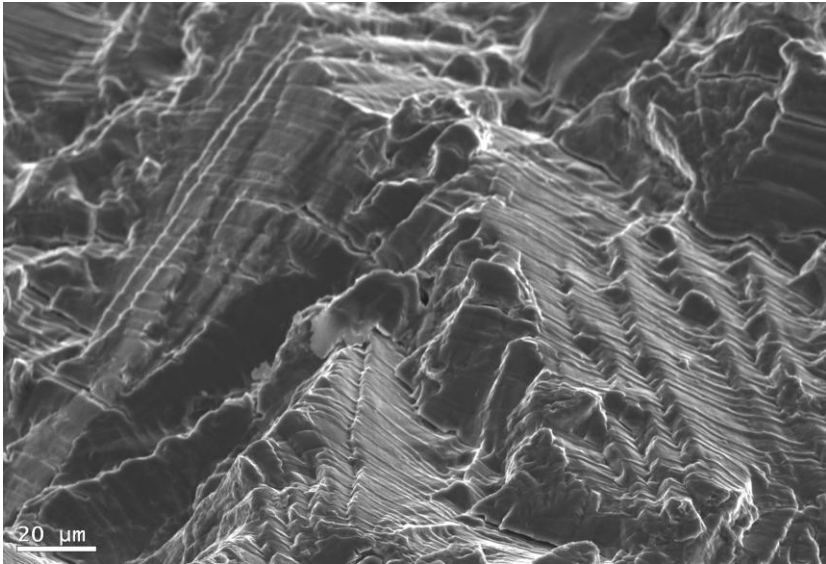
Data courtesy Prof Irvine Cranfield.  
Analyses by Prof R. Jones, Monash.



PREDICTION

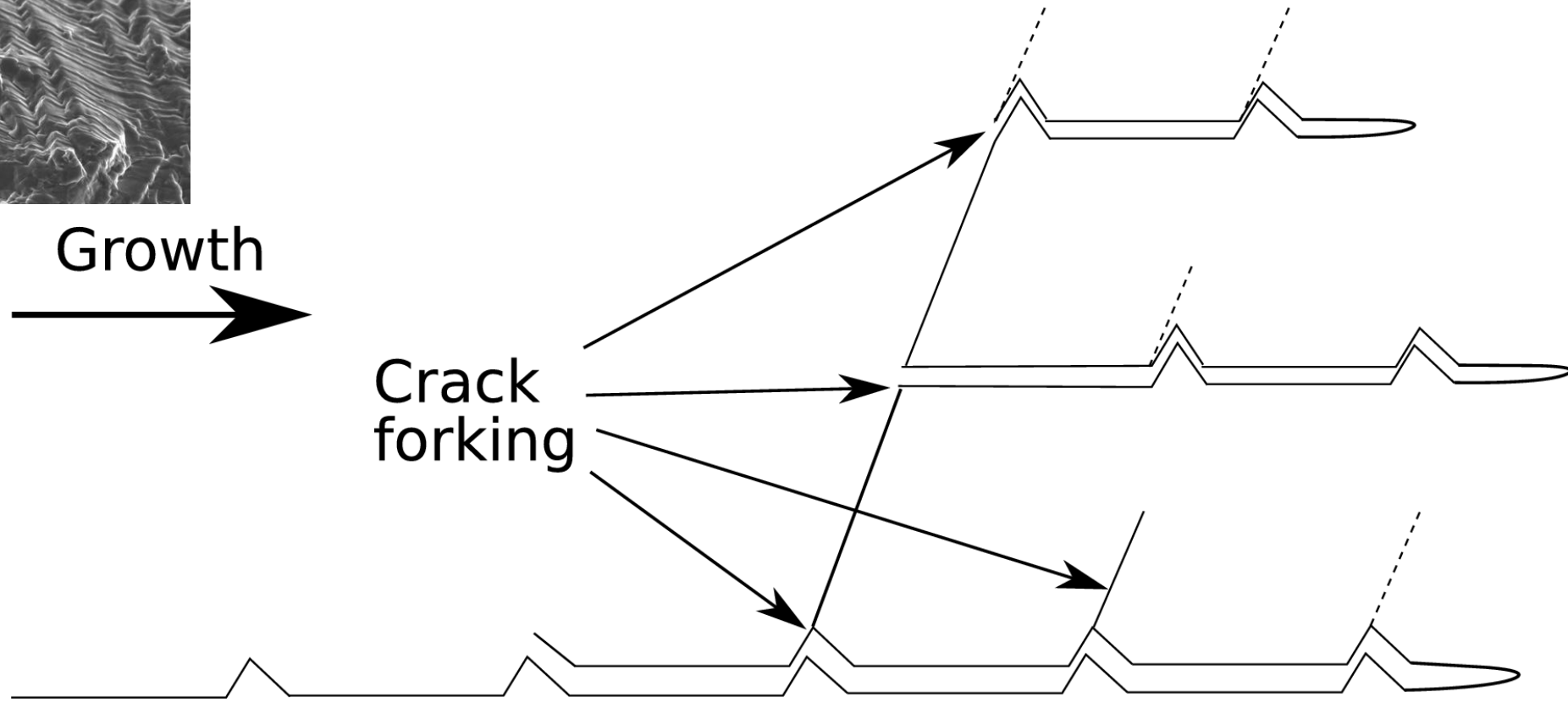


# Periodic underloads produce a family of fissures [44,45]



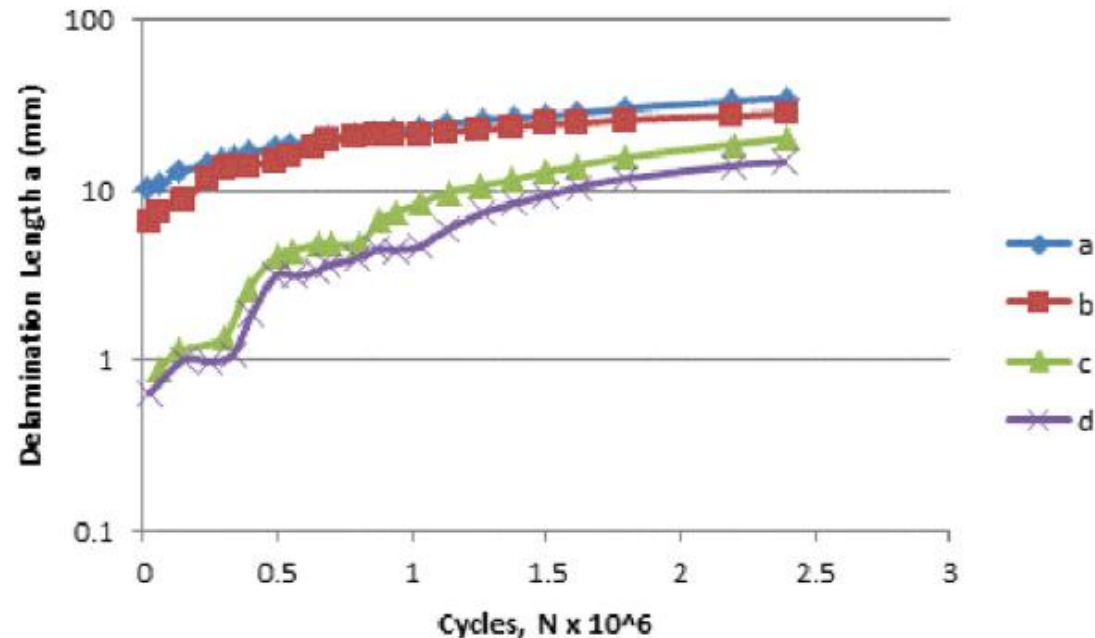
Growth  
→

Crack  
forking



## Damage Growth in Composites [48]

- Challenging the no growth design/sustainment basis
- General behaviour: Short period rapid growth followed by plateau



Development of delamination cracks in the interface between bonded metallic sheets and a composite laminate under cyclic loading ( $\Delta\sigma = 198$  MPa,  $R = 0.1$ ) as a function of fatigue cycles, where the lengths of four delamination cracks in a specimen are shown

# Molent et al. ASIP Presentations

1. K. Walker and L. Molent, 'Development of an automated procedure for correlation of two sets of range mean pair fatigue sensor data', In Proc: ASIP Conference 1991.
2. L. Molent, 'A Review of a Strain and Flight Parameter Data Based Aircraft Fatigue Usage Monitoring System', In Proc: ASIP Conference 1996,
3. L. Molent, 'Proposed Specifications for a Unified Strain and Flight Parameter Data Based Aircraft Fatigue Usage Monitoring System', In Proc: ASIP Conference 1998.
4. S. Barter, K. Sharp, L. Molent and G. Clark, 'Repair and Life Assessment of Critical Fatigue Damaged Aluminium Alloy Structure Using a Peening Rework Method', In Proc: ASIP Conference 2000.
5. L. Molent, S. Barter, D. Conser and P. White, 'Overview of the F/A-18 Aft Fuselage Combined Manoeuvre and Dynamic Buffet Fatigue Test', In Proc: ASIP Conference 2002.
6. S. Barter, L. Molent and M. McDonald, 'Fleet Fatigue Life Interpretation from Full-Scale and Coupon Fatigue Tests', In Proc: ASIP Conference 2005,
7. S. Barter, L. Molent and L. Robertson, 'Using Service Growth from Teardown to Aid Aircraft Lifting', In Proc: ASIP Conference 2009,
8. L. Molent, S. Barter and W. Foster, 'Verification of an Individual Aircraft Fatigue Monitoring System', In Proc: ASIP Conference 2011
9. L. Molent, 'The Influence of Pitting Corrosion on Structural Integrity', In Proc: ASIP Conference 2013,
10. B. Main, S. Barter, W. Foster, M. Gordon, L. Molent and L. Weibler, 'Hornet Outer Wing Static Testing (HOWSAT) Program for RAAF Classic Hornet Service Life Management', In Proc: ASIP Conference 2015,
11. L. Molent, C. Forrester, N. Rajic and A. Groszek, 'Durability and Damage Tolerance of Composite Structure: Preliminary Investigations', In Proc: ASIP Conference 2017,
12. K. Walker, R. Evans, X. Yu, L. Molent, B. Main, J. Hodges and M. Hill, 'Analytical modelling of fatigue crack behavior under representative spectrum loading in the F/A-18 A/B Y508 wing root shear tie', In Proc: ASIP 2018.
13. B. Main, L. Molent, R. Singh and S. Barter, 'Lessons from 35 years of the RAAF F/A-18A/B ASIP', In Proc: ASIP 2022.



# “Chuck. Sorry to have hassled you for over 30 years....” (your mate Lorrie)



HOME > NEWS > ARTICLE DISPLAY

## Babish awarded highest civilian recognition

*/ Published August 05, 2020*

