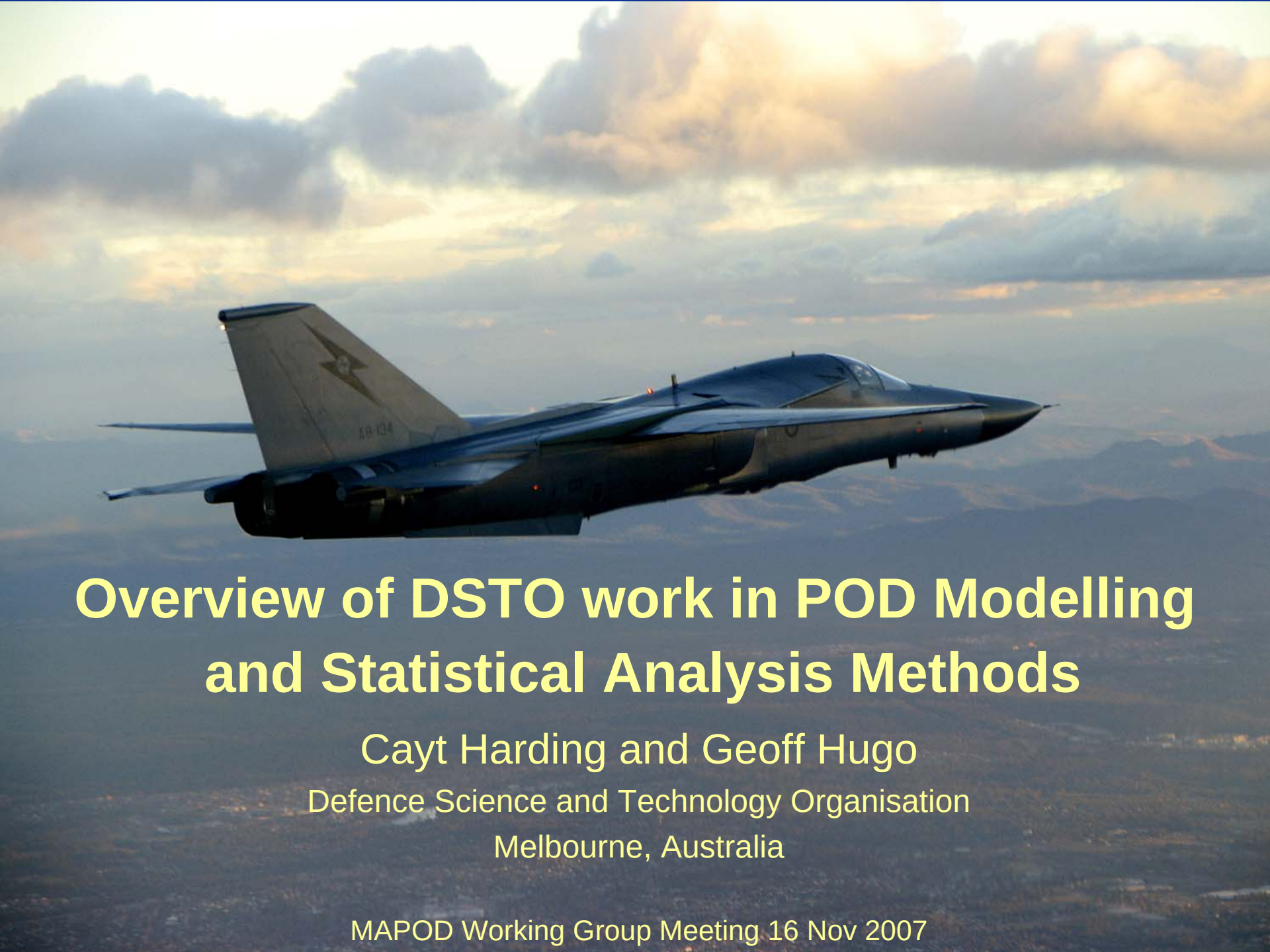


# Overview of DSTO work in POD Modelling and Statistical Analysis Methods

Cayt Harding and Geoff Hugo
Defence Science and Technology Organisation
Melbourne, Australia

MAPOD Working Group Meeting 16 Nov 2007

# MAPOD for Inspection of Lower Wing Skin Fastener Holes

Australian Government
Department of Defence
Defence Science and Technology Organisation

Automated ultrasonic C-scan inspection for cracks at fastener holes

- Full A-scan data capture and technician review of stored data

MAPOD approach outlined at April MAPOD WG meeting

- Transfer function approach
- Refer to JCAA 2007 paper (Harding, Hugo and Bowles)

Progress

- Data obtained from field POD trials
  (previously reported results were for laboratory data)
- Modelled human factors inherent in operator recognition of crack indications within C-scan data

# Transfer Function Modelling Response for Cracks in Wings

Australian Government
Department of Defence
Defence Science and Technology Organisation

Assume ultrasonic response for defect of size $a$ follows:

$$\log(r) = \beta_0 + \beta_1 \log(a) + \varepsilon$$

$$\varepsilon \xrightarrow{d} N(0, \delta)$$

Transfer function for predicted response from cracks in wings:

$$\beta_{0,CW} = \beta_{0,CS} + \beta_{0,EW} - \beta_{0,ES}$$

$$\beta_{1,CW} = \beta_{1,CS} + \beta_{1,EW} - \beta_{1,ES}$$

$$\delta_{CW}^{\ 2} = \delta_{CS}^{\ 2} + \delta_{EW}^{\ 2} - \delta_{ES}^{\ 2}$$

ES – EDM in specimens

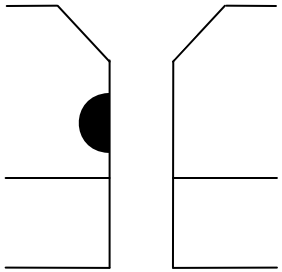
EW – EDM in wings

CS – cracks in specimens

CW – cracks in wings

# Modelled POD for Mid-bore Cracks

Australian Government
Department of Defence
Defence Science and
Technology Organisation



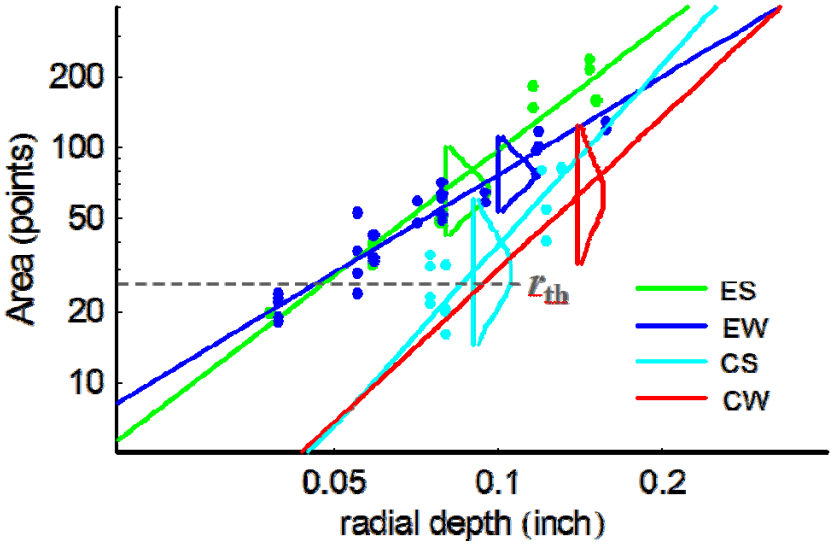
Mid-bore crack

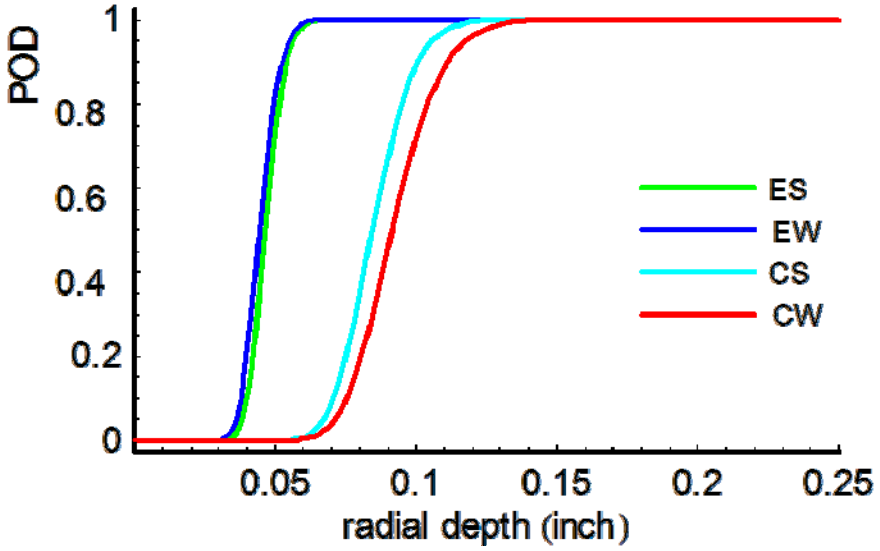
ES – EDM notches in specimens

EW – EDM notches in wings

CS – cracks in specimens

CW – cracks in wings (predicted)

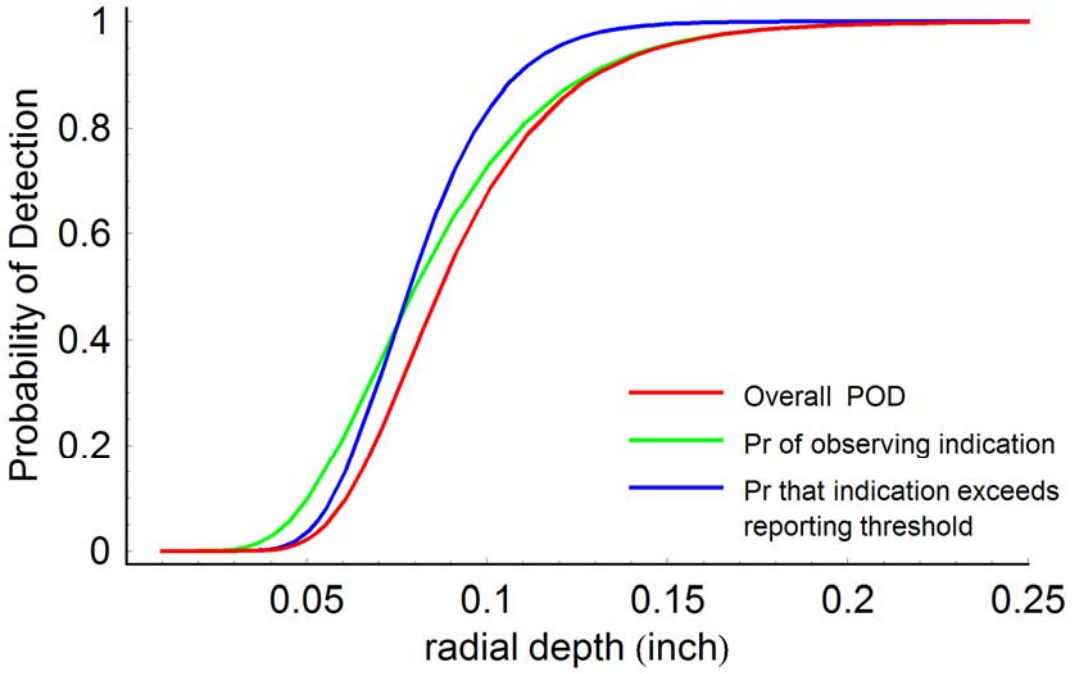


# Incorporation of Human Factors

Australian Government
Department of Defence
Defence Science and
Technology Organisation

Modelled effect of human factors through a variable threshold, $r_{th}$, for detection



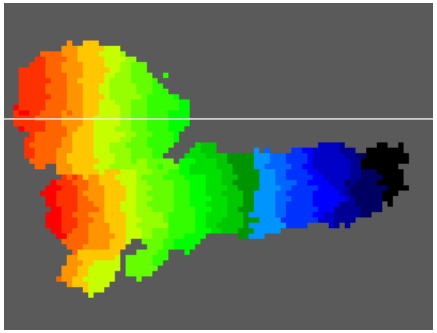
# Inspection of a Fatigue Test Wing Under Load

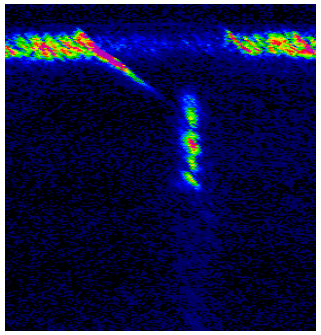
Australian Government
Department of Defence
Defence Science and Technology Organisation

Full-scale fatigue-test wing inspected with automated UT system at completion of fatiguing

- Wing loaded during UT inspection to open any cracks present in lower skin
- Smaller cracks detected clearly only with load applied
- Larger cracks detected by UT equally well without load
- Waiting on fractography to confirm actual crack size

*Results for genuine fatigue cracks in full-scale test wing confirm previous results for cracks in laboratory specimens*





# Statistical Analysis of POD Data

Australian Government
Department of Defence
Defence Science and Technology Organisation

DSTO has conducted large-scale simulations to test analysis methods for hit-miss POD data

- Selected numbers of hit-miss observations per data set (between 40 and 2000 data points)
- Up to 5000 simulated data sets for each data set size
- Compare distributions of fitted $a_{50}$, $a_{90}$ and $a_{90/95}$ values
- Compare incidence of lower confidence limits which are non-conservative relative to assumed true POD curve
- Whole curve and single percentile CL's examined

*Observed significant differences between different analysis methods, especially for confidence limits*

- Some methods gave non-conservative rates >> 5% for (supposedly) lower 95% confidence limits

# POD Data Analysis Benchmarking Exercise

Australian Government
Department of Defence
Defence Science and Technology Organisation

*Proposal:* DSTO would like to participate in a limited exchange of simulated data sets to compare the statistical analysis methods in use by different practitioners

- Each participant runs data sets through their preferred implementation of the statistical analysis
- Two possible exercises
  - Small number of interesting data sets, and/or
  - Large number of simulated data sets for a comprehensive assessment
- Establish the consistency (or otherwise!) of different implementations of the analysis methods

*We would volunteer to provide simulated hit/miss data sets to interested parties and then compile the results for the next MAPOD WG meeting*

- Details to be negotiated off-line if there is interest
- We are also interested in a similar exercise for $\hat{a}$ vs $a$ data, if someone else were able to lead it (i.e. provide the data sets)