ATESS

Excellimus Auxilio

Excellence In Support

Aerospace and Telecommunications Engineering Support Squadron

Update on Canadian Forces GBHEC PoD Study to MAPoDWG 20 April 2007

Capt DJ Butcher
NDTO/SMM
27 Feb 2007

Outline

- Past Updates
- ASNT 2006
- Progress to Date (BHEC real)
- Remaining Work (BHEC Modeling)
- Future Research
- Conclusion

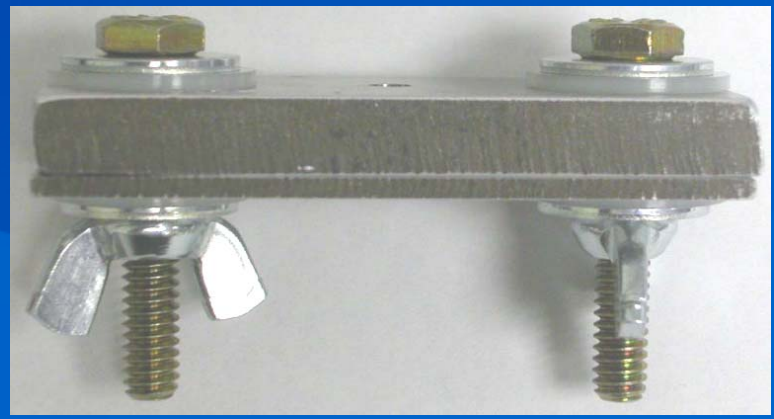
Past Updates

- Originally presented work to MAPoDWG at ATA 2005
  - Focus of project on updating current $a_{90/95}$ assumption of 0.050” and to investigate modeling PoD
- Further presentations have been made at:
  - Aging Aircraft 2006
  - ASNT Fall 2006 (presented by NRC)
- Project completion planned for End Jun 2007

ASNT 2006

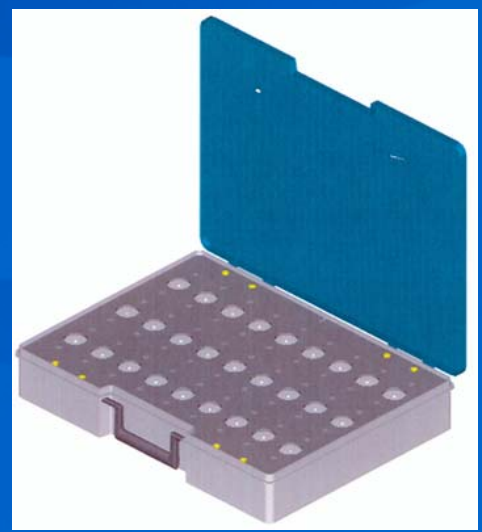
- Fatiguing of panels completed and cracks developed
  - Crack sizing in progress
- Coupons being water-jet cut from panels
  - in progress
- Blank coupons

  - In process of labeling
- Coupons with EDM notches
  - In progress of notching

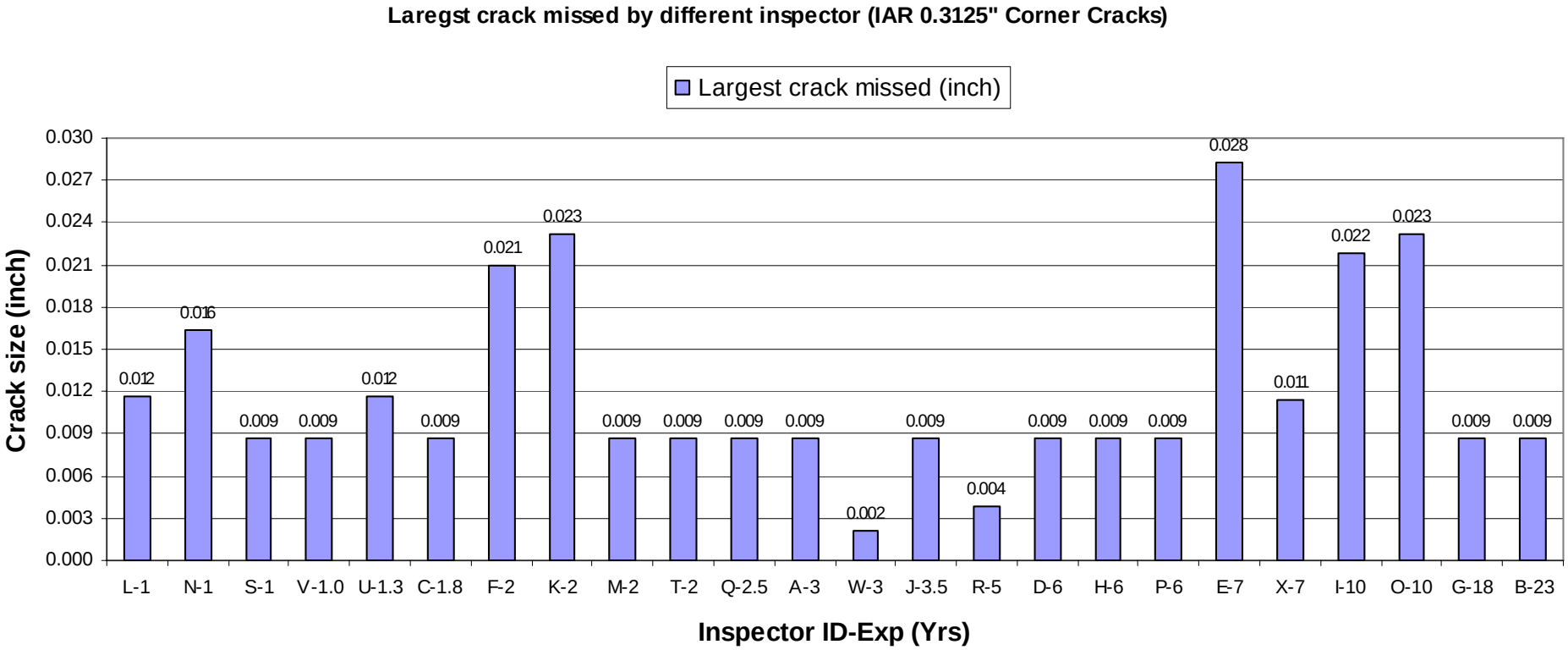


Progress to Date (BHEC Real)

- 1st set of coupons have been assembled into 16 boxes (26 coupons per box) and inspected by 24 different CGSB Level 2 NDT Techs
  - 1st layer 0.090”
  - 2nd layer 0.312”
  - 71 lab grown cracks
    - Measured by acetate replicas
    - Crack density reported at ASNT 2006
    - Lengths being confirmed by fracto
  - 35 EDM notches
  - 362 blanks
  - Cracks and EDM notches located on the corner of the 2nd layer faying surface

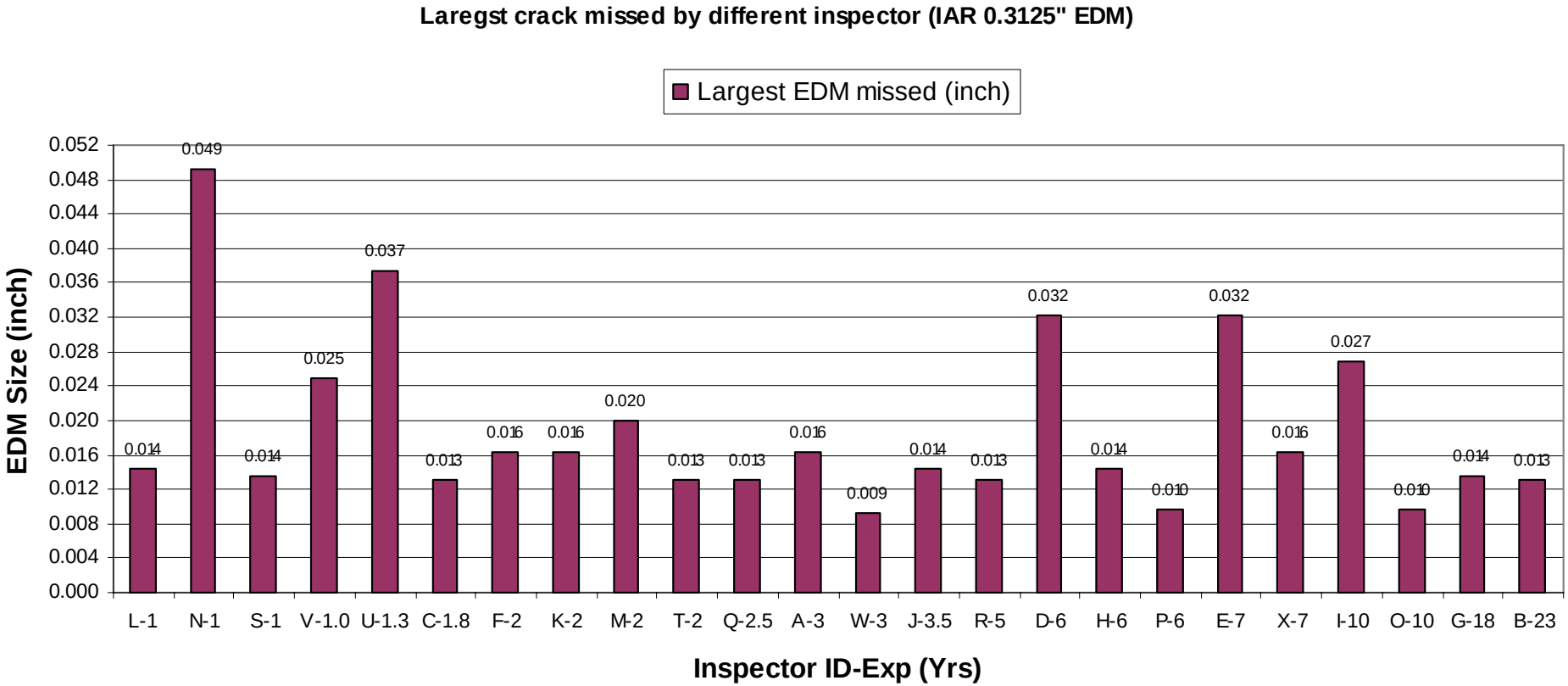


Progress to Date (BHEC Real)



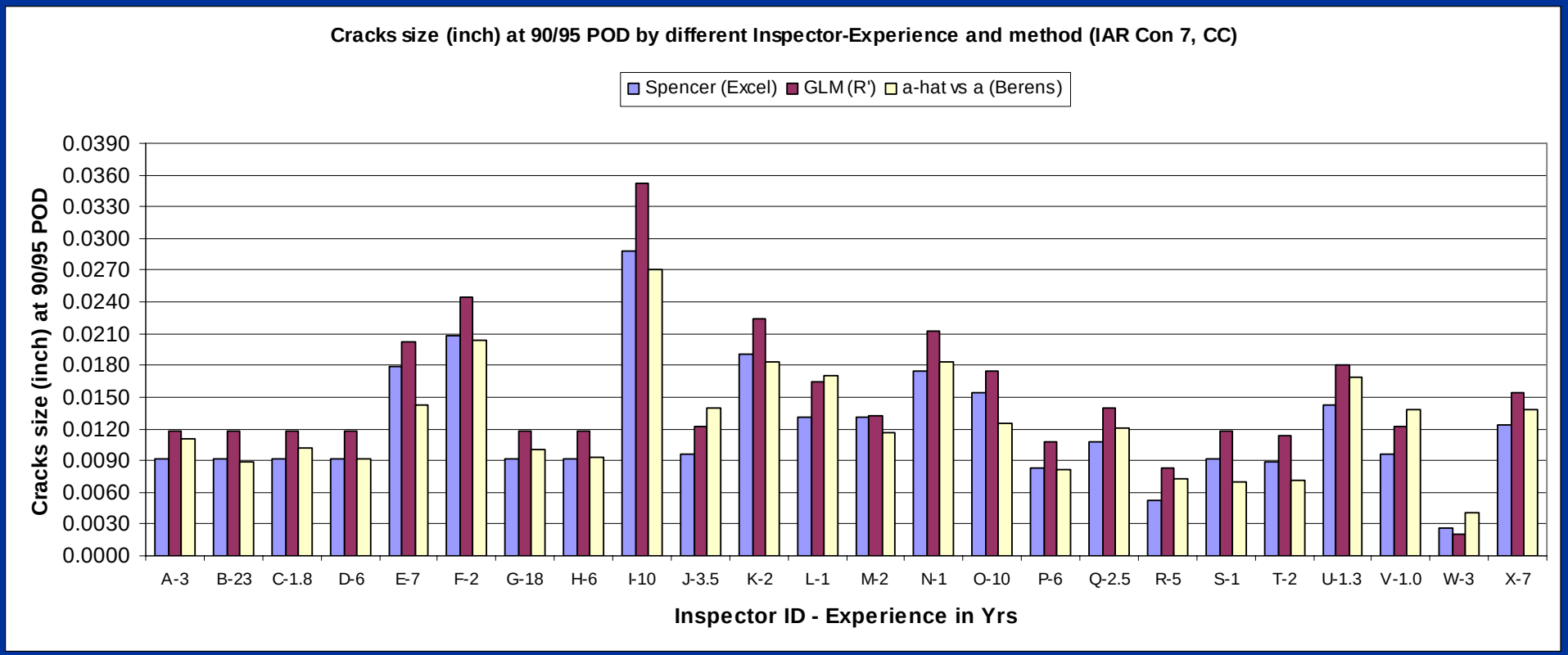
Plot of Largest Missed Crack (inch) vs Inspector (years of experience) at 2nd Layer Faying Surface

Progress to Date (BHEC Real)



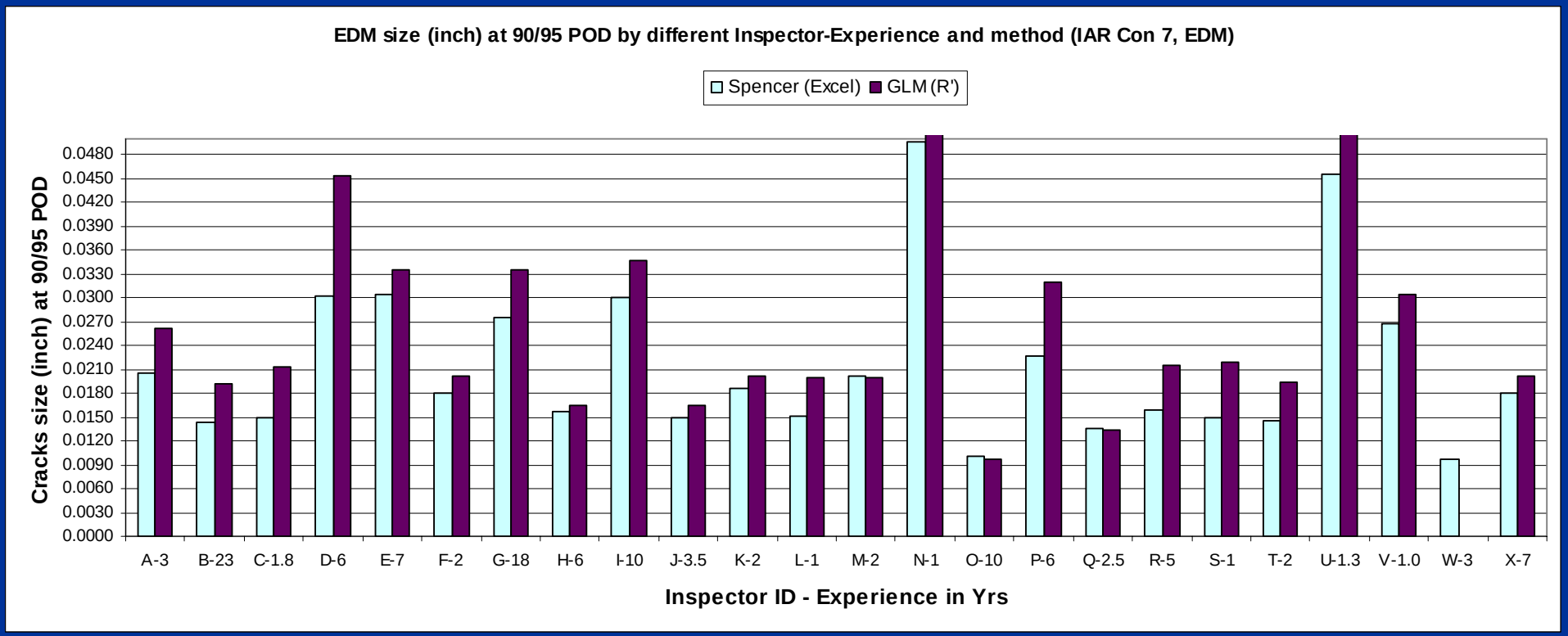
Plot of Largest Missed EDM Notch (inch) vs Inspector (years of experience) at 2nd Layer Faying Surface

Progress to Date (BHEC Real)



Plot of $a_{90/95}$ (inch) vs Inspector (years of experience) for 2nd Layer Faying Surface Corner Crack

Progress to Date (BHEC Real)



Plot of $a_{90/95}$ (inch) vs Inspector (years of experience) for 2nd Layer Faying Surface EDM Notch

Progress to Date (BHEC Real)

- False Call Rate Fatigue Cracks:
  - Min 0%
  - Max 3.8%
  - Ave 1.1%
- False Call Rate EDM Notches:
  - Min 0%
  - Max 2.3%
  - Ave 1.8%

Progress to Date (BHEC Real)

- $a_{90/95}$ for Fatigue Cracks (average):
  - Hit-Miss (Spencer): 12.1 mils
  - MH 1823-2 Using R (Annis)*: 14.6 mils
  - a-hat vs a (Berens): 12.6 mils
- $a_{90/95}$ for EDM Notches (average):
  - Hit-Miss (Spencer): 20.5 mils
  - MH 1823-2 Using R (Annis)*: 26.6 mils
  - a-hat vs a (Berens): 27.4 mils**

* Generalized Linear Model as proposed by Charles Annis

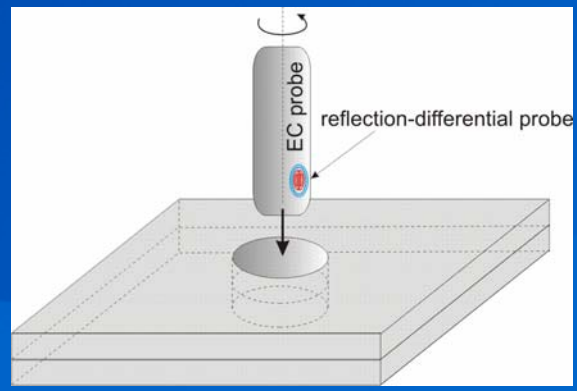
** Trenton Only (4 Inspectors)

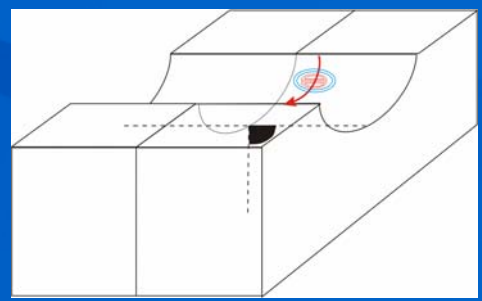
Remaining Work (BHEC Real)

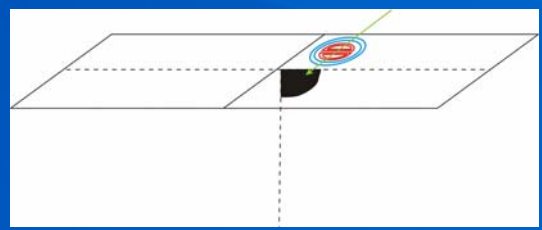
- Three remaining sets to be inspected:
  - CC in 0.090” back surface
  - Mid-Bore cracks in 0.090”
  - Mid-Bore cracks in 0.312”
- Inspection of induced cracks in real structure complete – waiting for fracto to confirm measurements
- Inspection of EDM notches in real structure complete – waiting for fracto to confirm measurements
- Comparison of modeled results and actual results
- Explanation of why $a_{90/95}$ is larger for EDMs as compared to cracks

Progress to Date (Modeling)

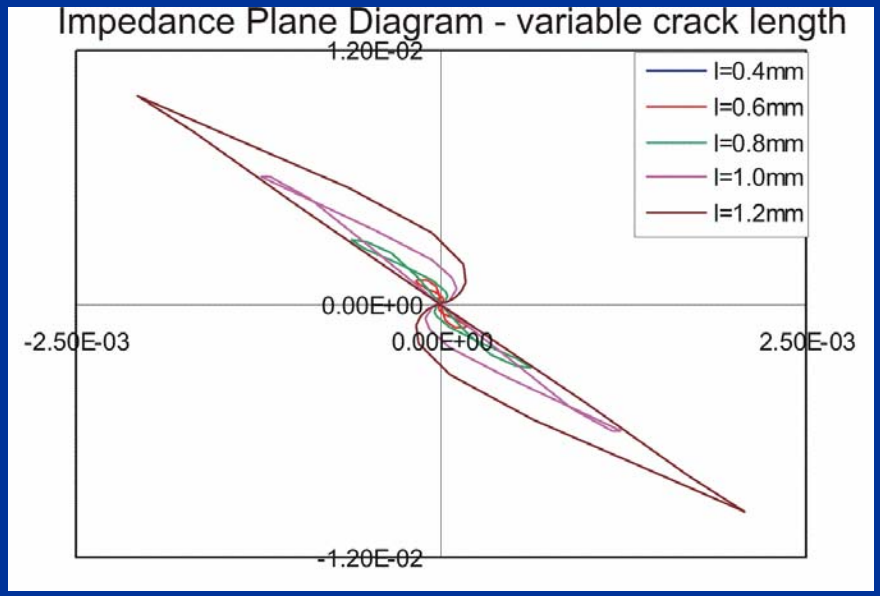
- Up to this point we have the ECSim package to model:
  - Defect length
  - Defect depth
  - Probe lift-off
  - Off-centre scanning
  - Frequency
  - Probe tilt
  - Material conductivity



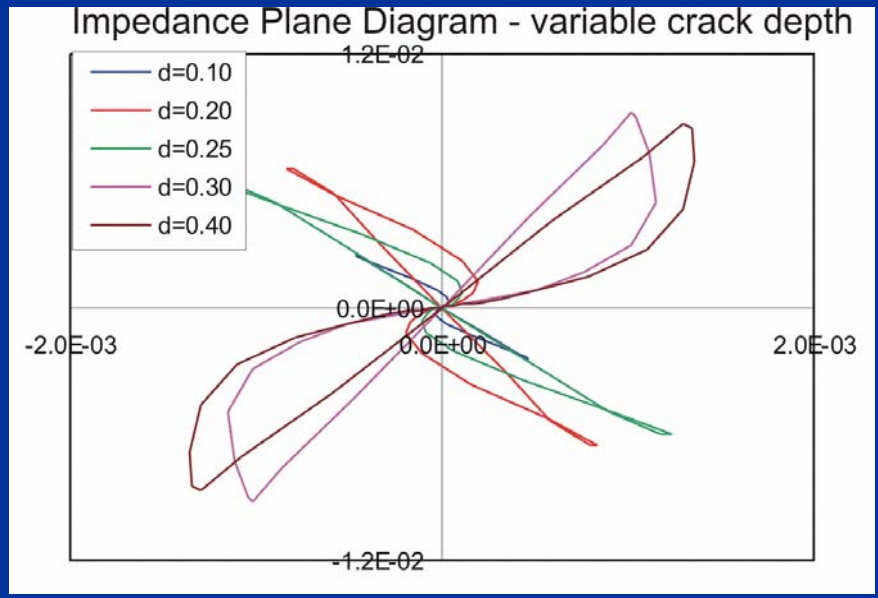




Progress to Date (Modeling)

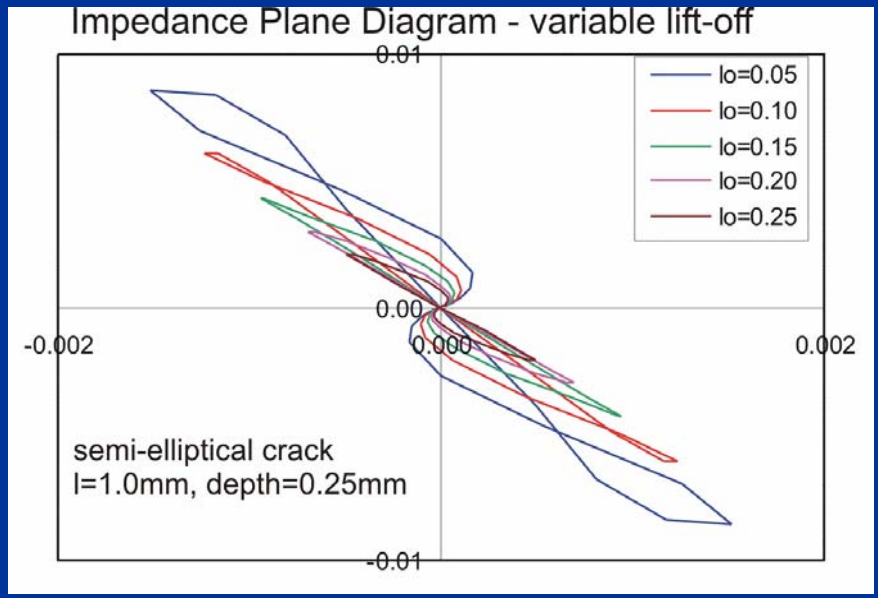


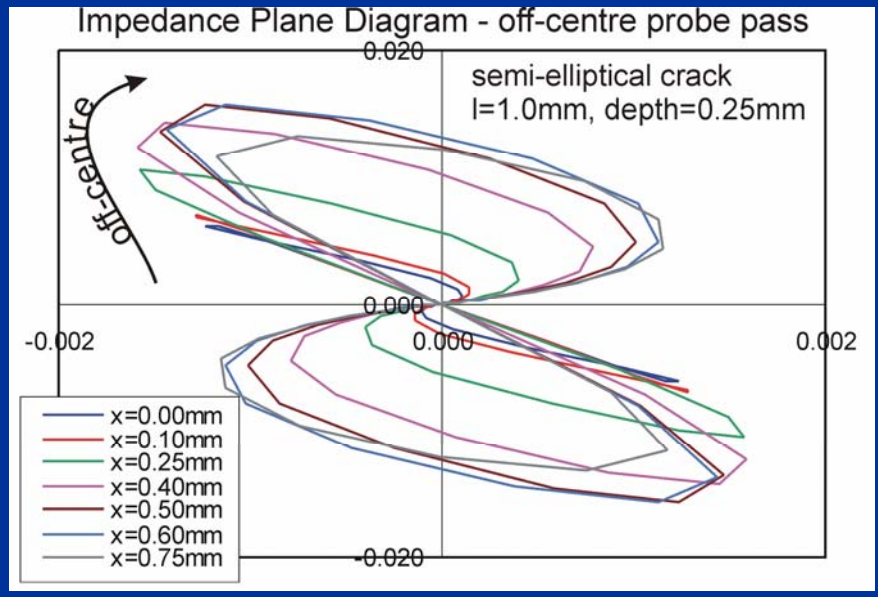
- semi-elliptical crack
- crack depth=0.25mm
- f=500kHz
- lift-off=0.1mm
- σ=18.5MS/m



- semi-elliptical crack
- crack length=1mm
- f=500kHz
- lift-off=0.1mm
- σ=18.5MS/m

Progress to Date (Modeling)

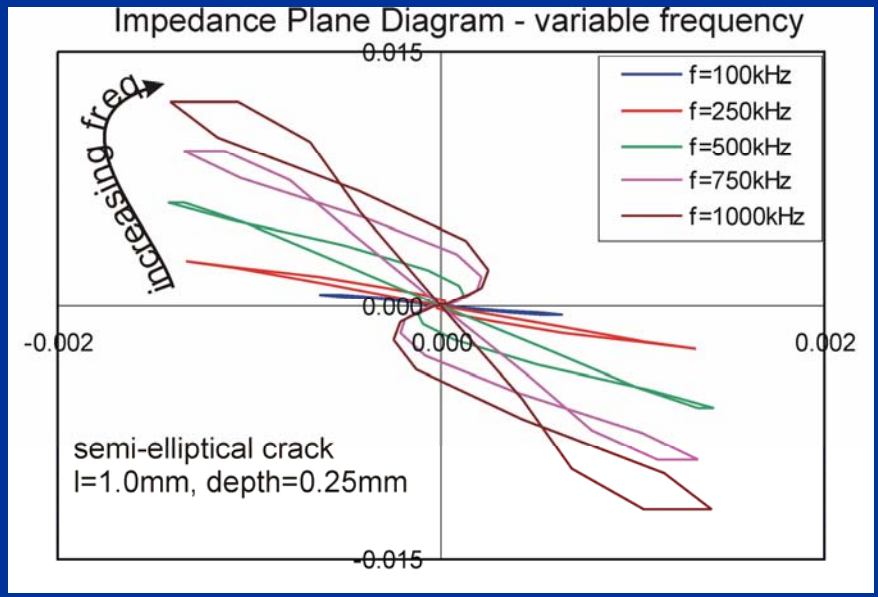


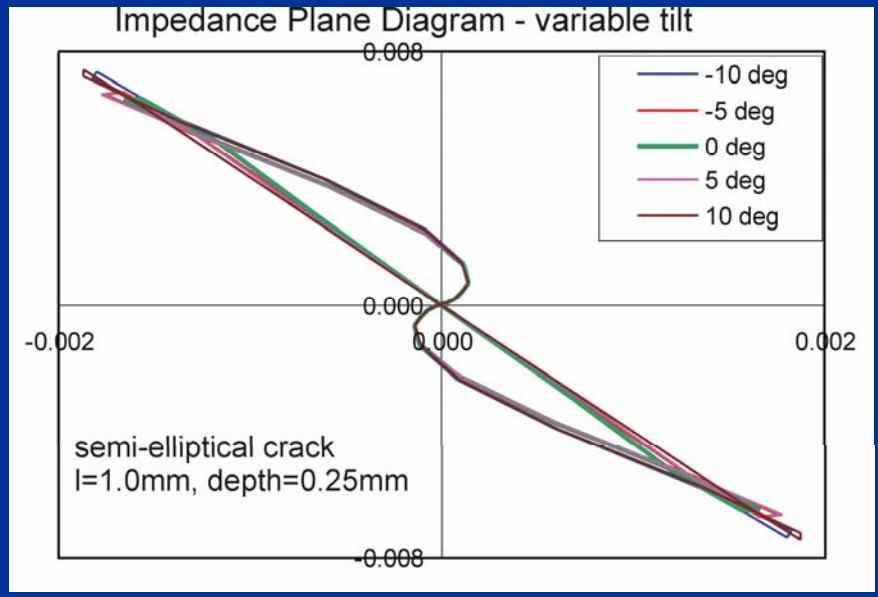


- semi-elliptical crack
- crack length=1mm
- crack depth=0.25mm
- f=500kHz
- σ=18.5MS/m

- semi-elliptical crack
- crack length/depth=1mm/0.25mm
- f=500kHz
- lift-off=0.1mm
- σ=18.5MS/m

Progress to Date (Modeling)

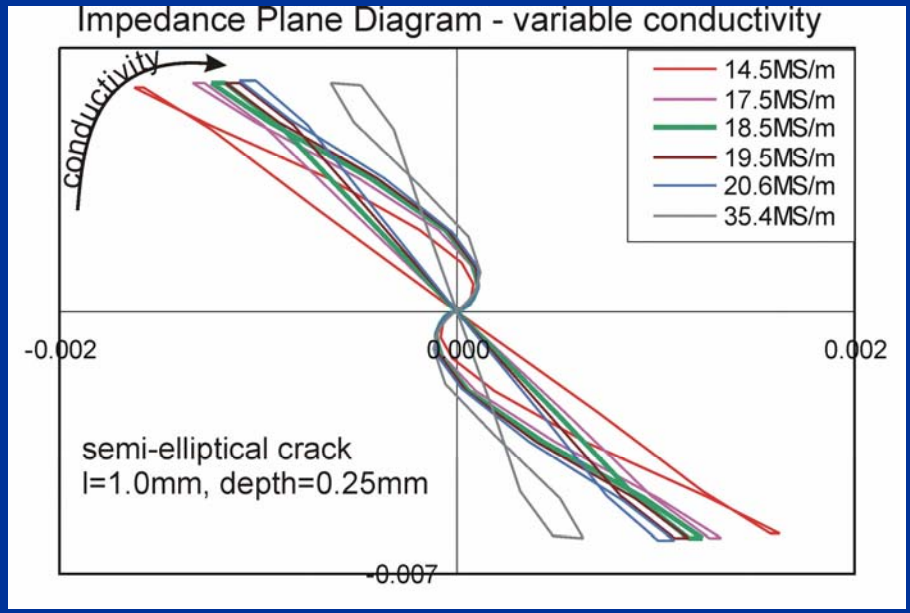




- semi-elliptical crack
- crack length=1mm
- crack depth=0.25mm
- lift-off=0.1mm
- σ=18.5MS/m

- semi-elliptical crack
- crack length/depth =1mm/0.25mm
- f=500kHz
- lift-off=0.1mm
- σ=18.5MS/m

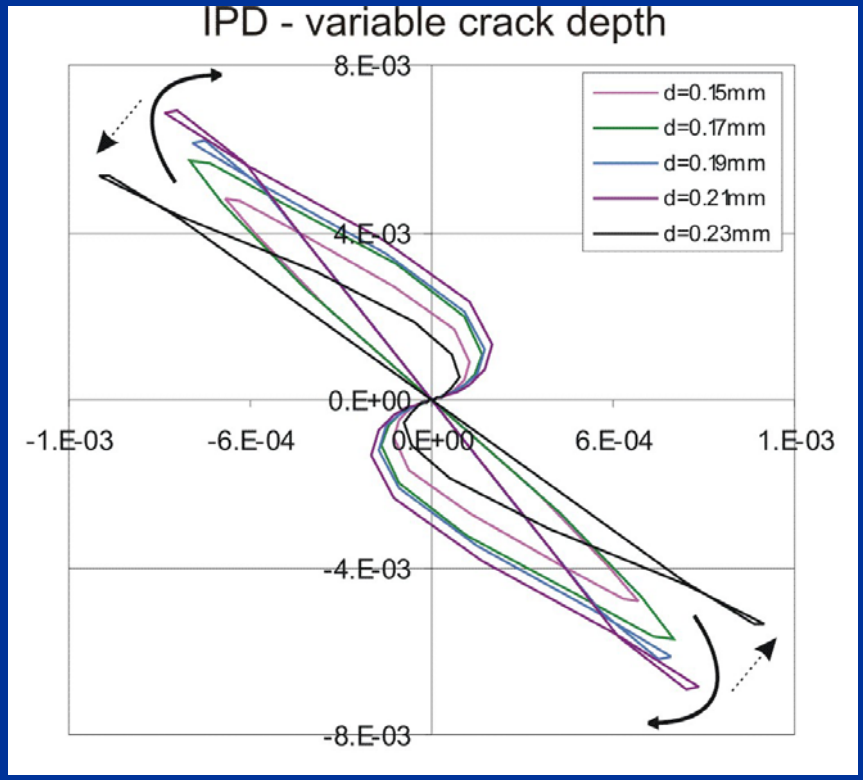
Progress to Date (Modeling)

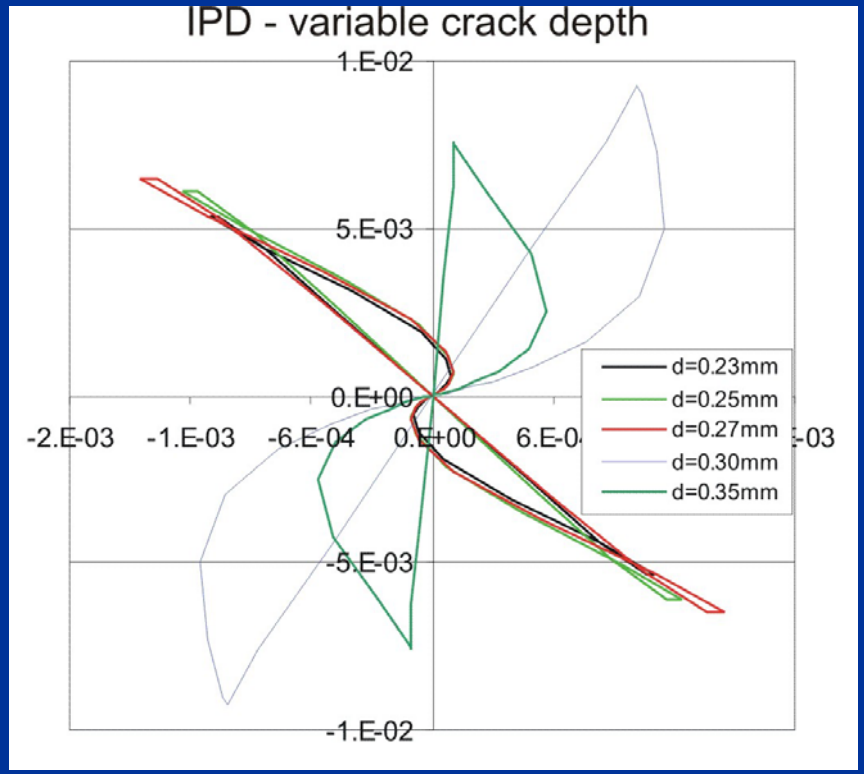


- semi-elliptical crack
- crack length=1mm
- crack depth=0.25mm
- lift-off=0.1mm
- f=500kHz

- At this point 7 variables have been modeled
- Most of the changes in variables have given the anticipated results with the exception of crack depth
- Further investigation on next slide

Progress to Date (Modeling)

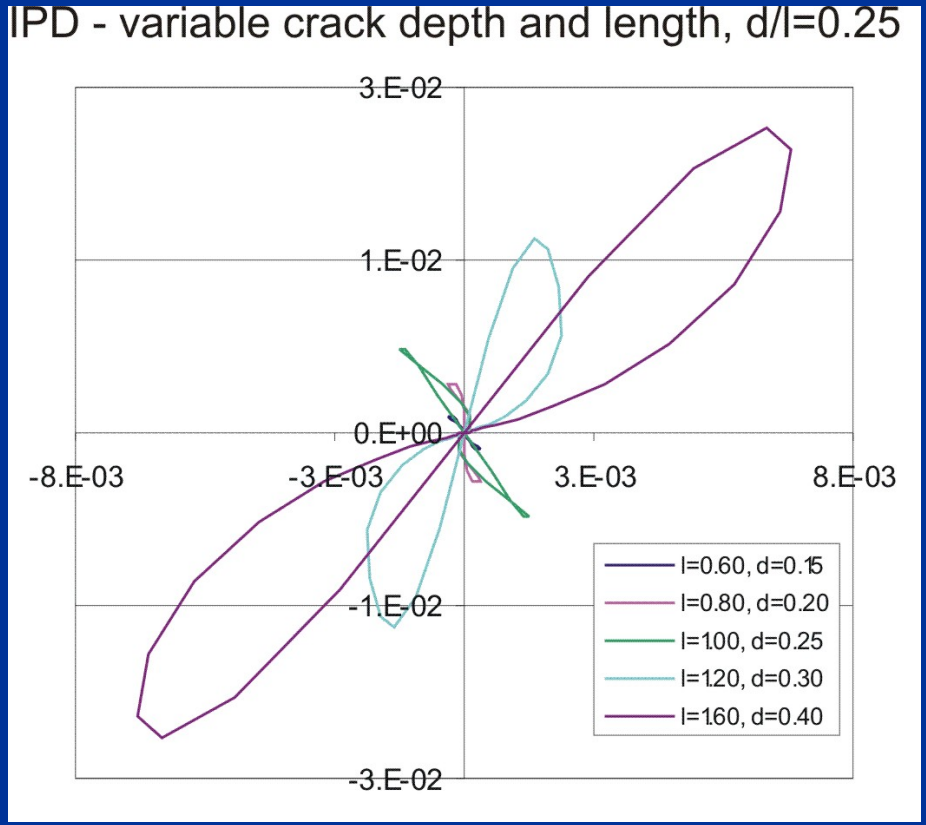




- There are some software issues with crack depth

- semi-elliptical crack: crack length=1mm
- f=500kHz, lift-off=0.1mm, σ=18.5MS/m

Progress to Date (Modeling)



- When crack length and depth are changed at the same time the eddy current impedance plane diagram has a typical appearance

Remaining Work (Modeling)

- Once all the empirical data is recorded direct comparisons will be made between the models and real responses from real cracks
- Explanations of odd behaviors
  - Odd Modeling behavior for 0.23mm - 0.30mm deep cracks
- Handbook will be developed on how to use the modeling to estimate PoD on other similar structures (ie LM Box Wing Struct)
  - Use of Modeling
  - Discussion on Transfer Functions

Future Work After Project Completion

- Further analysis of Data (to be determined)
- More inspections to assess other variables (to be determined)
- Further investigations of Eddy Current Modeling (to be determined)
- Royal Military College NDT Graduate Program
  - Capt Holly Lemire Thesis - improving reliability estimates as part of technique development
  - Will use current PoD project to baseline her work
  - She will continue to work with the MAPoDWG once the GBHEC PoD project is complete

ATESS

Questions?

Final Results will be presented at ASIP 2007

Excellimus Auxilio

Excellence In Support