F/A-18E/F FULL SCALE STRUCTURAL FATIGUE TESTING

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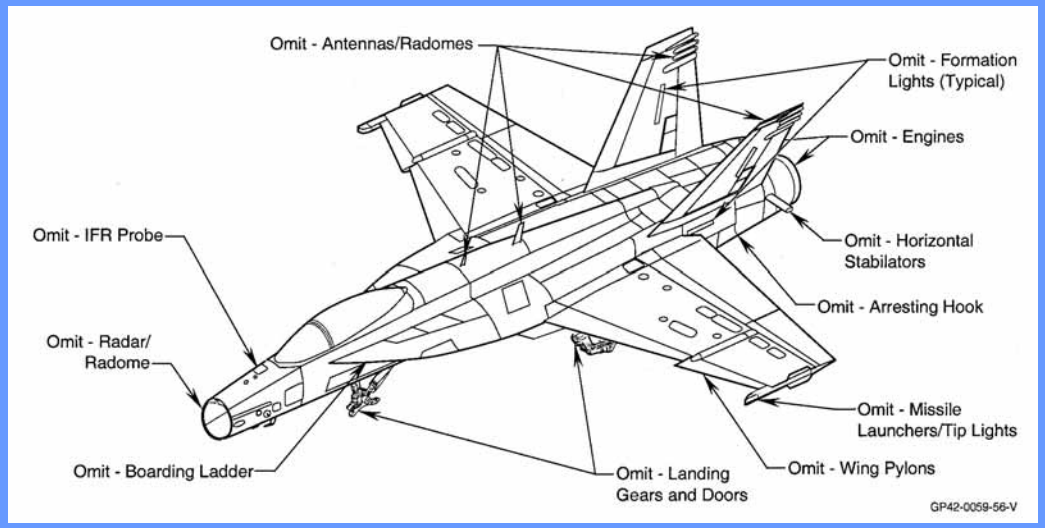
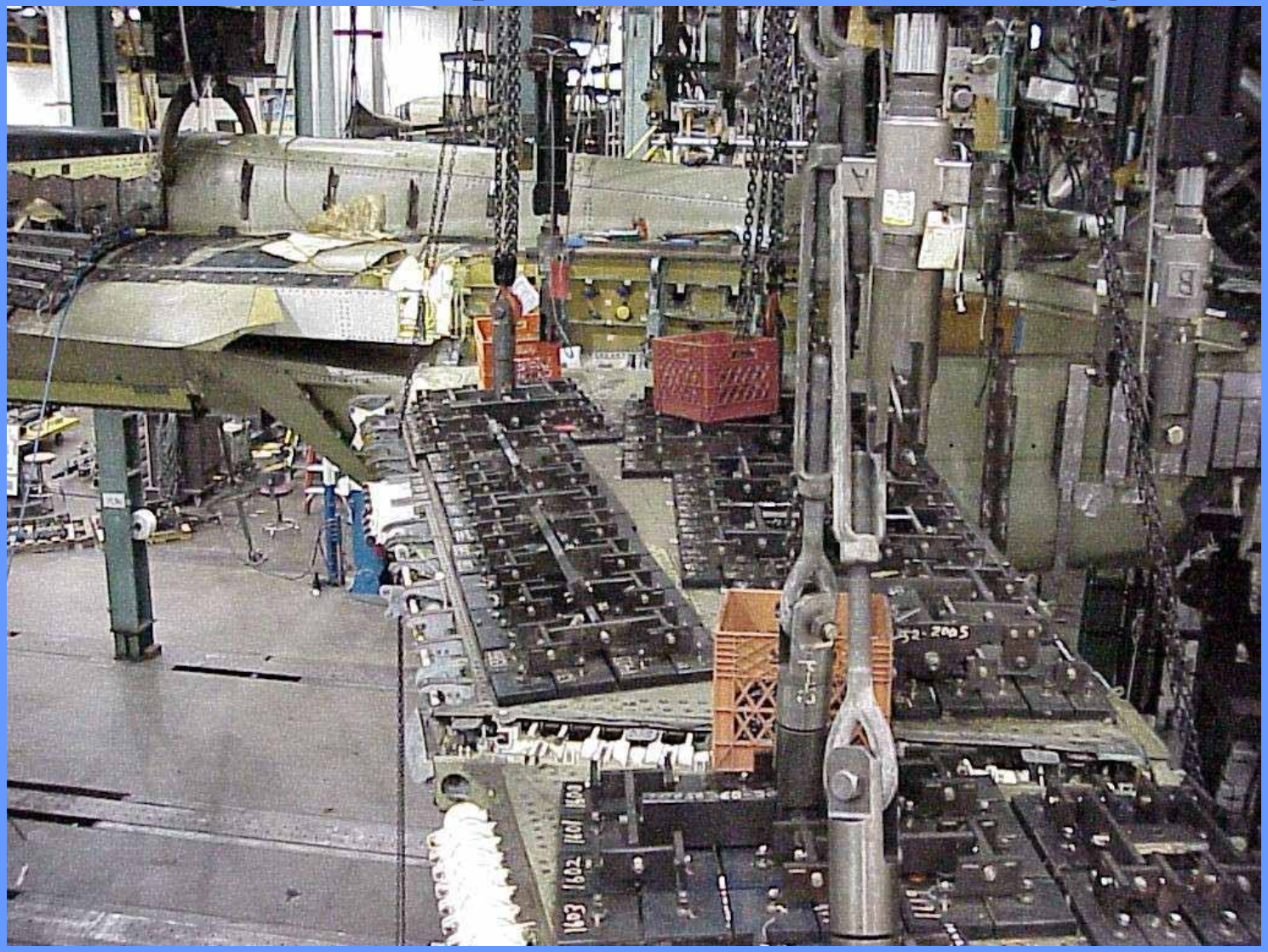
Full-Scale Fatigue Testing

- **Test Articles**
  - **FT50 represents the entire F/A-18E/F airframe**
  - **FT76 represents the new F/A-18E/F forward fuselage**
  - **FT77 represents the new F/A-18E/F wing**
- **Test Requirements**
  - **FT50 & FT77: Complete 18,000 simulated hours of fatigue cycling (3 lifetimes)**
  - **FT76: Complete 12,000 simulated hours of fatigue cycling (2 lifetimes)**



Tension-Compression Load System



FT50 Fatigue Test Setup

Strain Gages at Test Start	1643
Deflection Transducers at Test Start	89
Load Controllers	182
Lines per 1000 Simulated Flight Hours	448,492
Total Spectrum Lines in 2 Lifetimes	5,786,042 (including make-up cycling)
Pretest Surveys	27
Continuously Monitored Data Channels	1560
Maximum Lines Per Minute	14.1

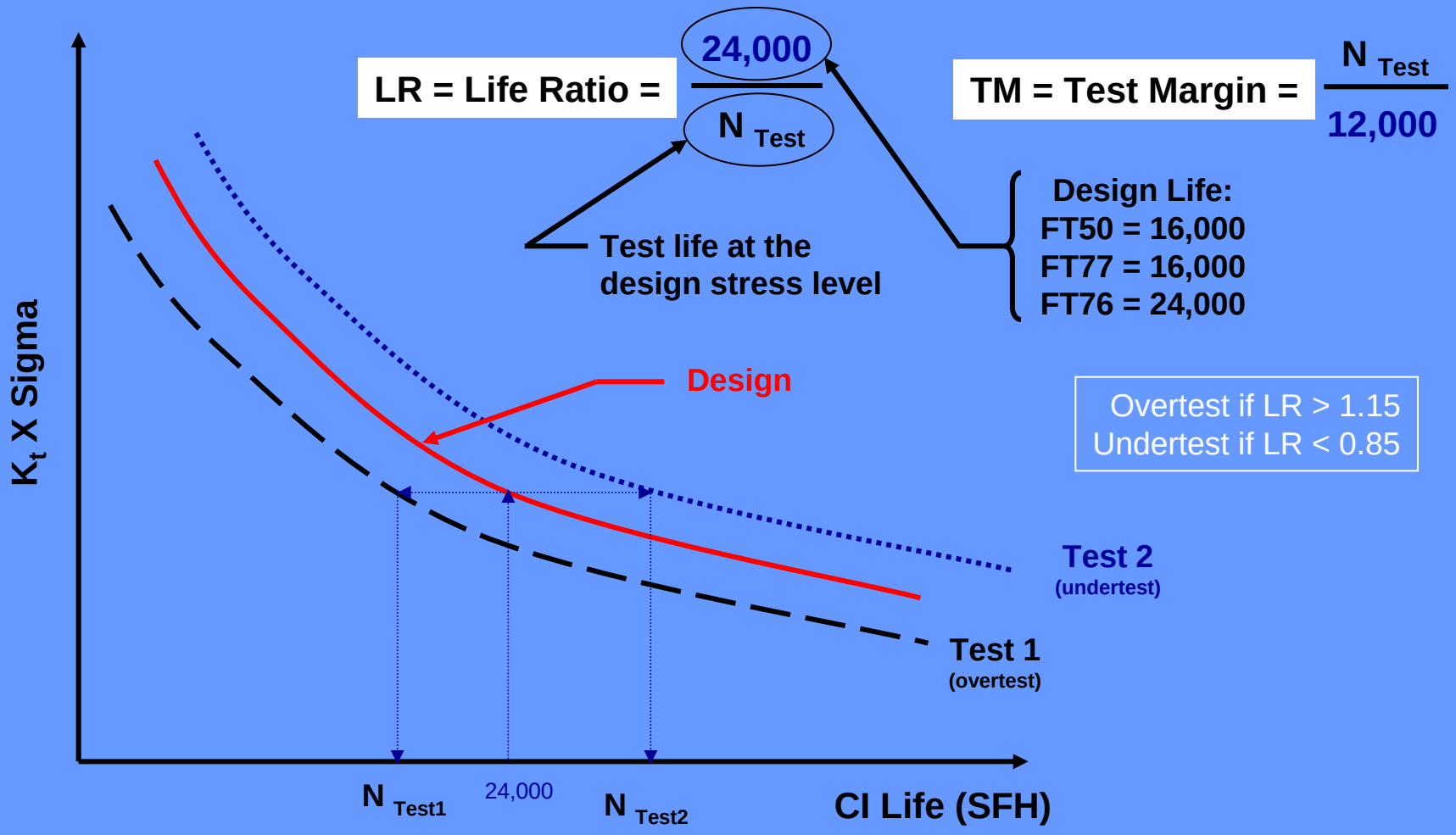
FT50 Fatigue Test Spectrum

- Symmetric maneuvers included both steady state and abrupt conditions from -2.5g to 8.5g
- Abrupt maneuvers only occur for positive Nz events
- Asymmetric maneuvers included 40%, 60%, 80%, and 100% lateral stick deflections and consist of -1g rolls, +1g rolls, and Rolling Pull-Outs (RPOs) up to 8.5g
- Negative 1g rolls were limited to rolling through 180 degrees and positive 1g rolls continued through 360 degrees
- Rolling angles (bank to bank) were dependent upon the entry g level for RPOs at Nz greater than 1g

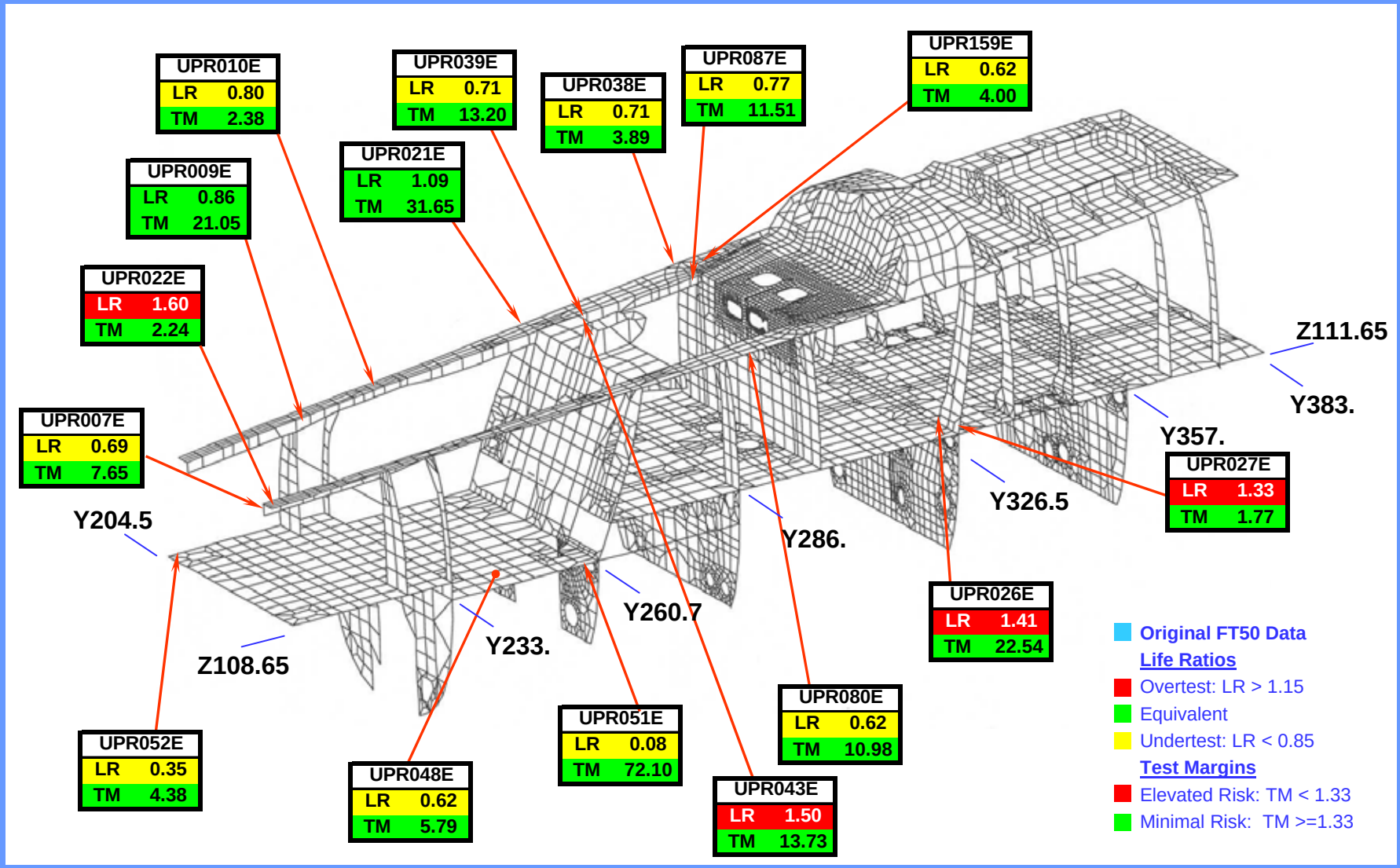
FT50 Fatigue Test Spectrum

- Ground-Air-Ground Cycles 15750
- Field Taxi Runs 8750
- Catapult Launches 2250
- Landings
  - Arrested 2250
  - Touch and Go 450
  - Field Carrier Landing Practice (FCLP) 6450
  - Field Mirrored Landing Practice (FMLP) 6600

Extensive Assessment Of Loading Accuracy of Full-Scale Fatigue Test



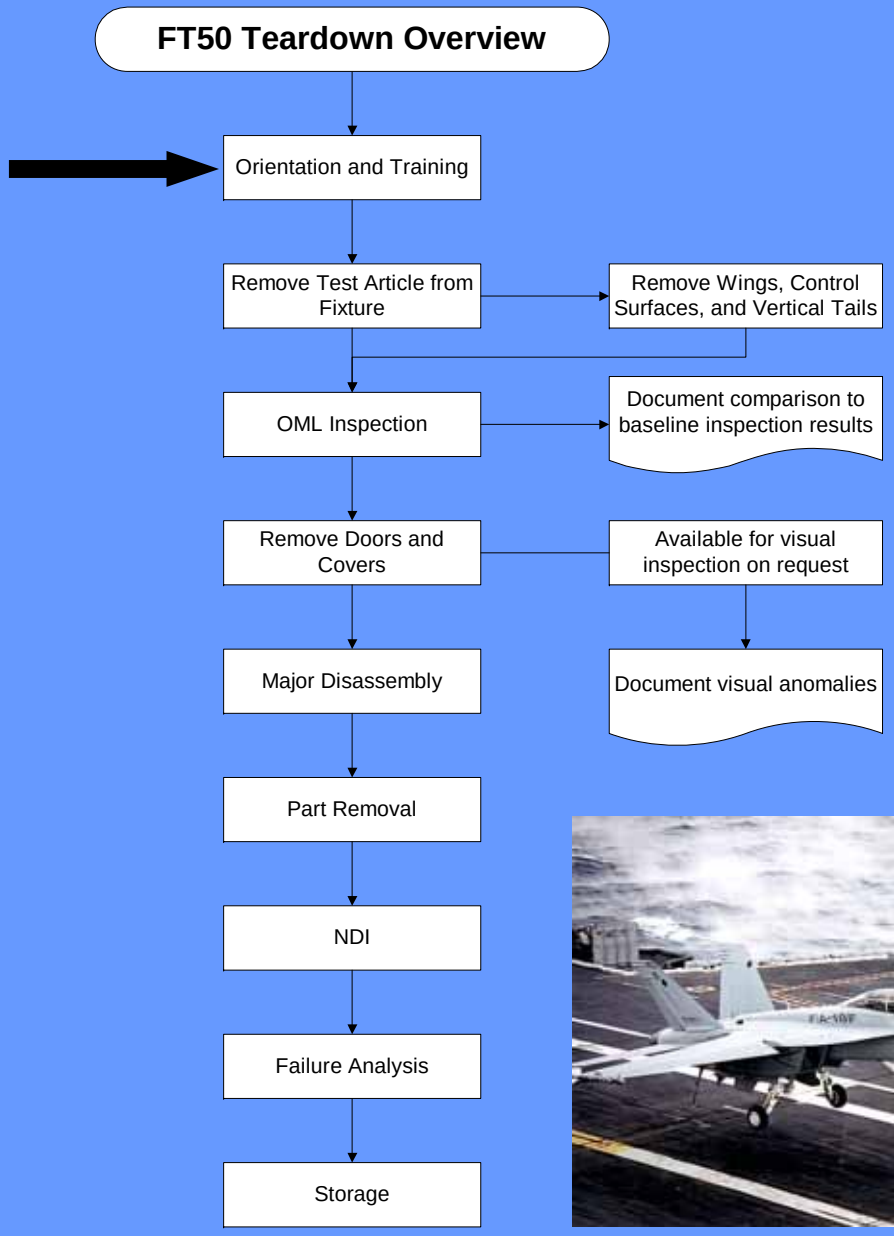
Results of FT76 Fatigue Test Accuracy



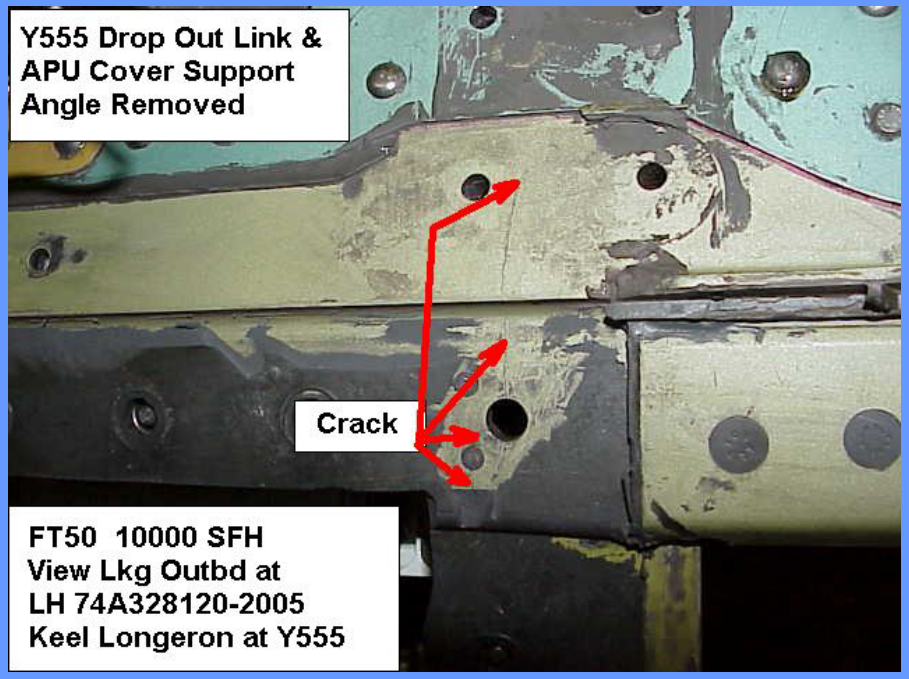
Extensive coordination with United States Navy to define expectations and processes

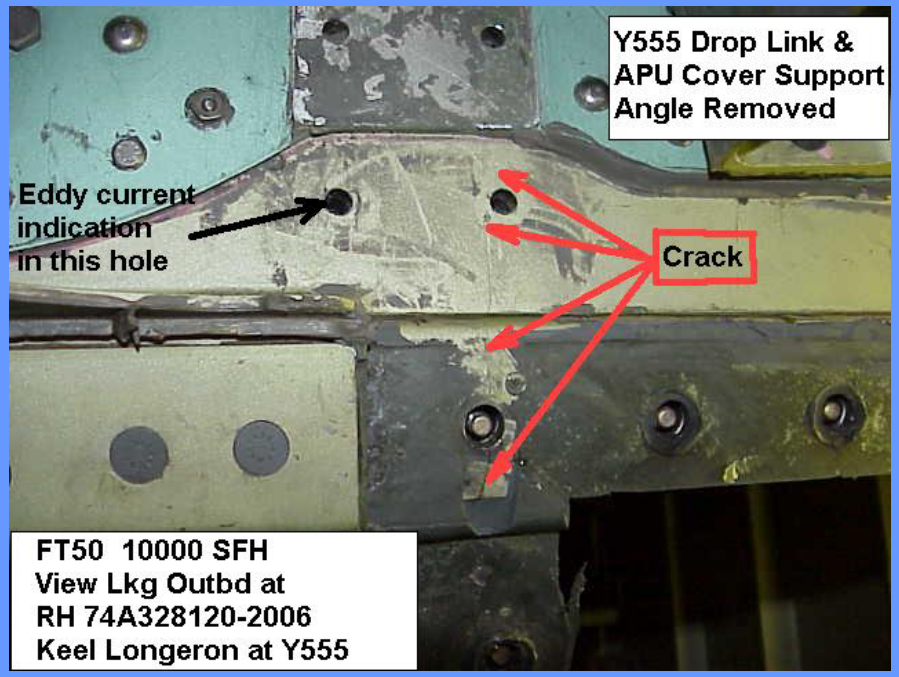
Eddy Current used as the primary NDI technique

Looking for cracks that are 0.030” or larger

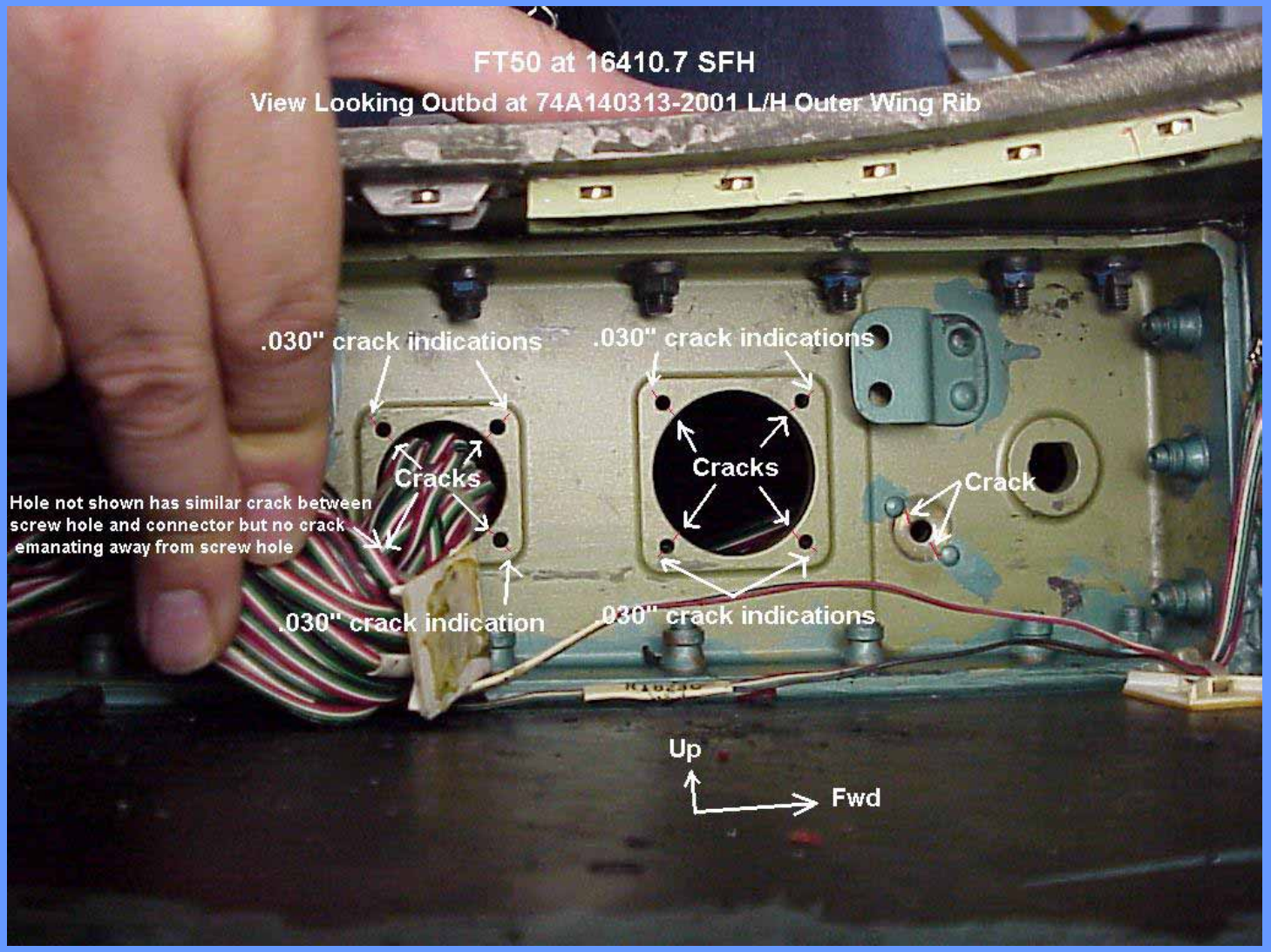


FT50 keel longeron Y555 cracks at 10,000 SFH



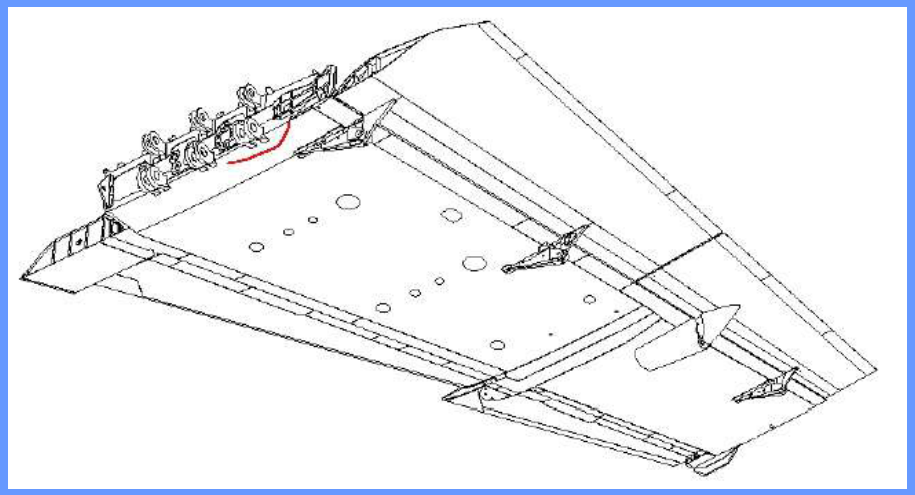


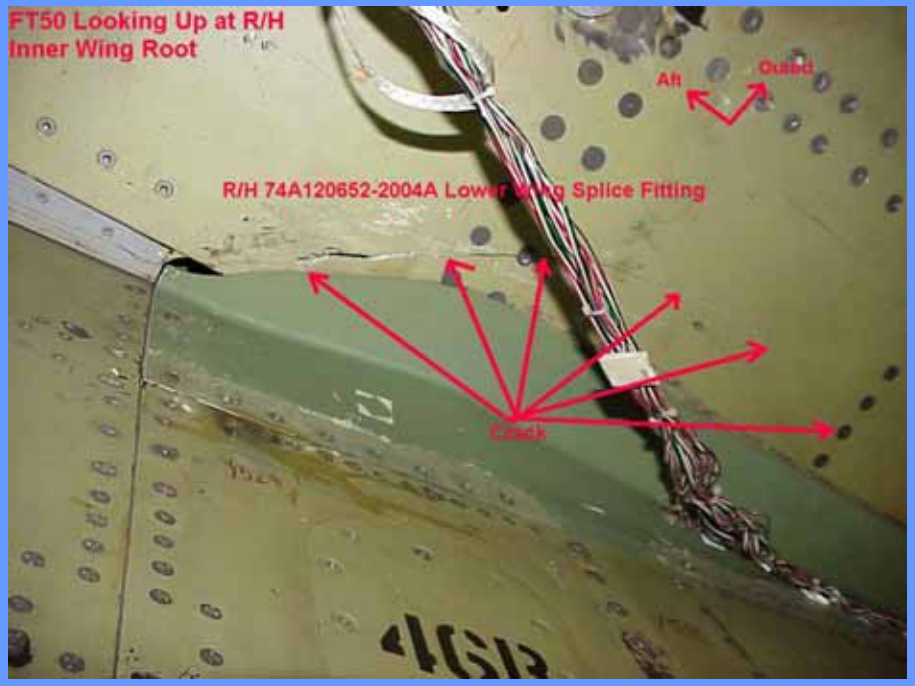
FT50 right-hand outer wing electrical cut-out cracks at 16,410 SFH

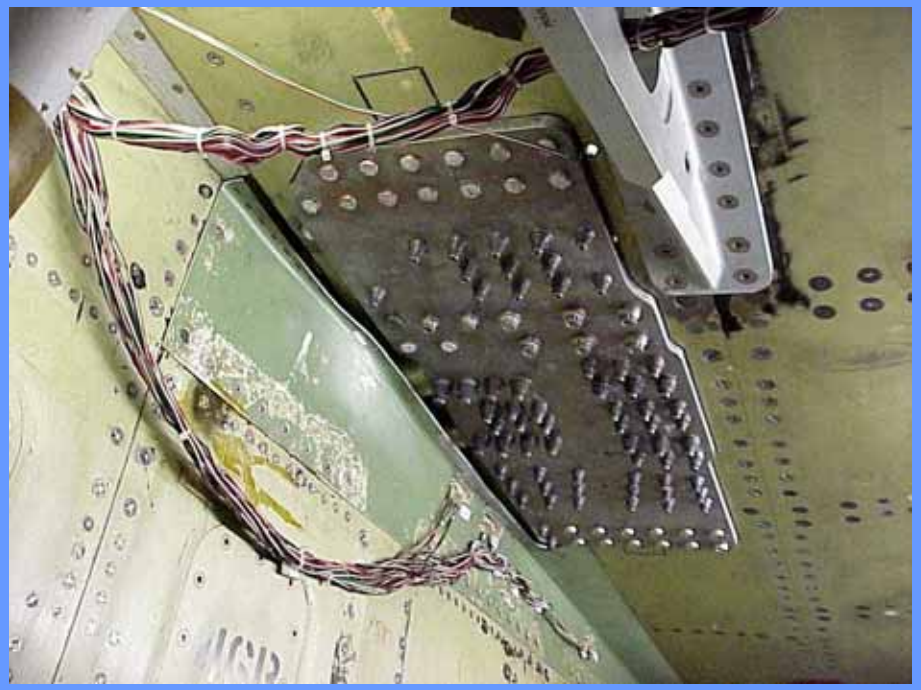


FT50 Leading Edge Extension (LEX) cracks at 15,000 SFH

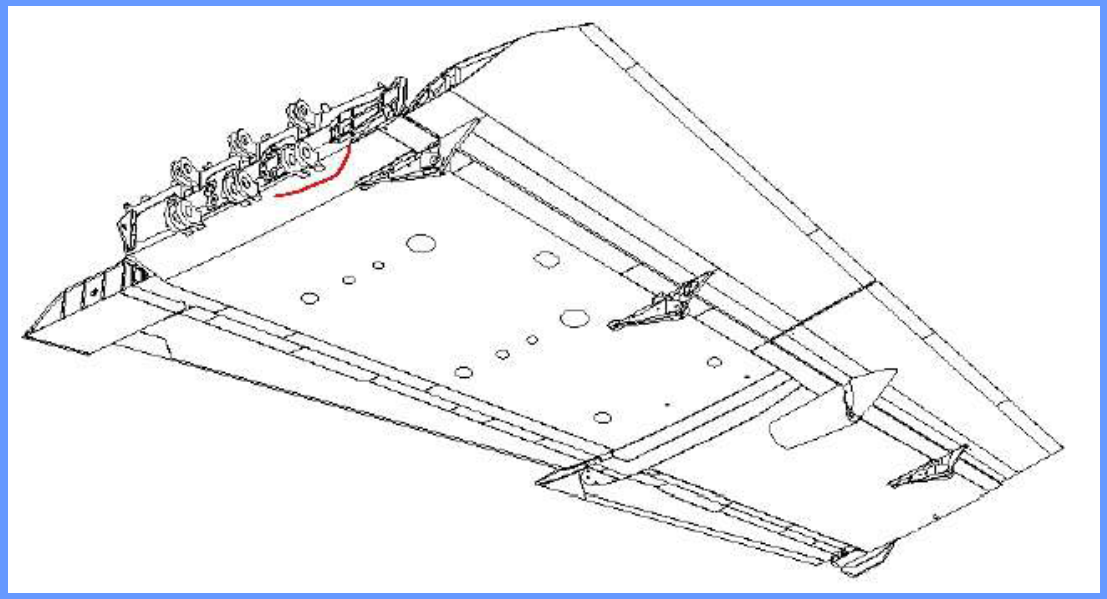
17” Crack on FT50 Right Wing Root Lower Surface

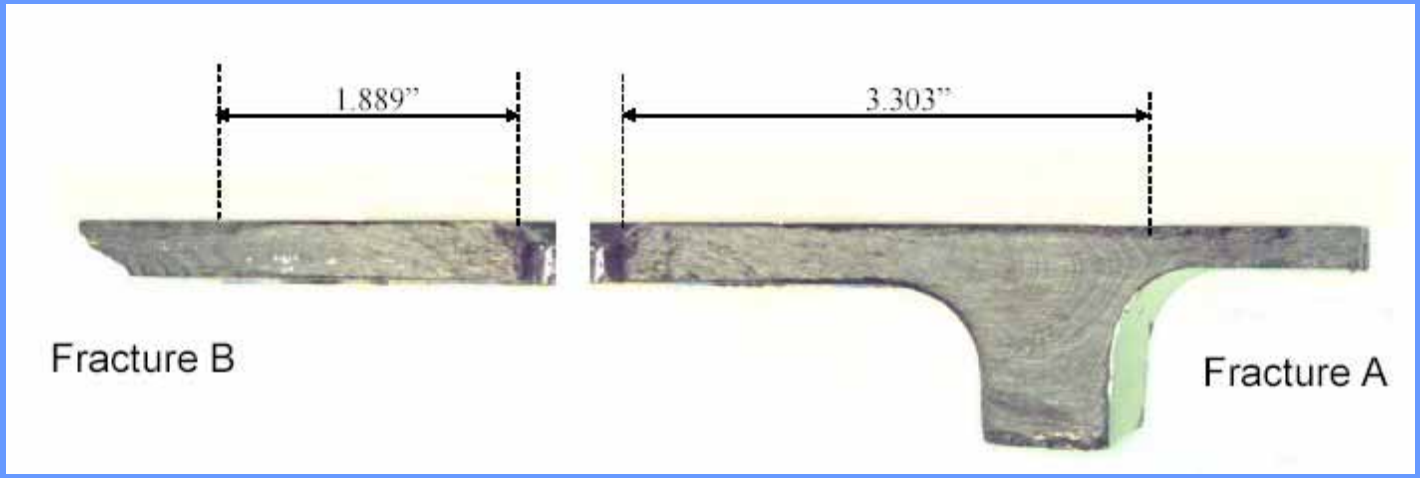




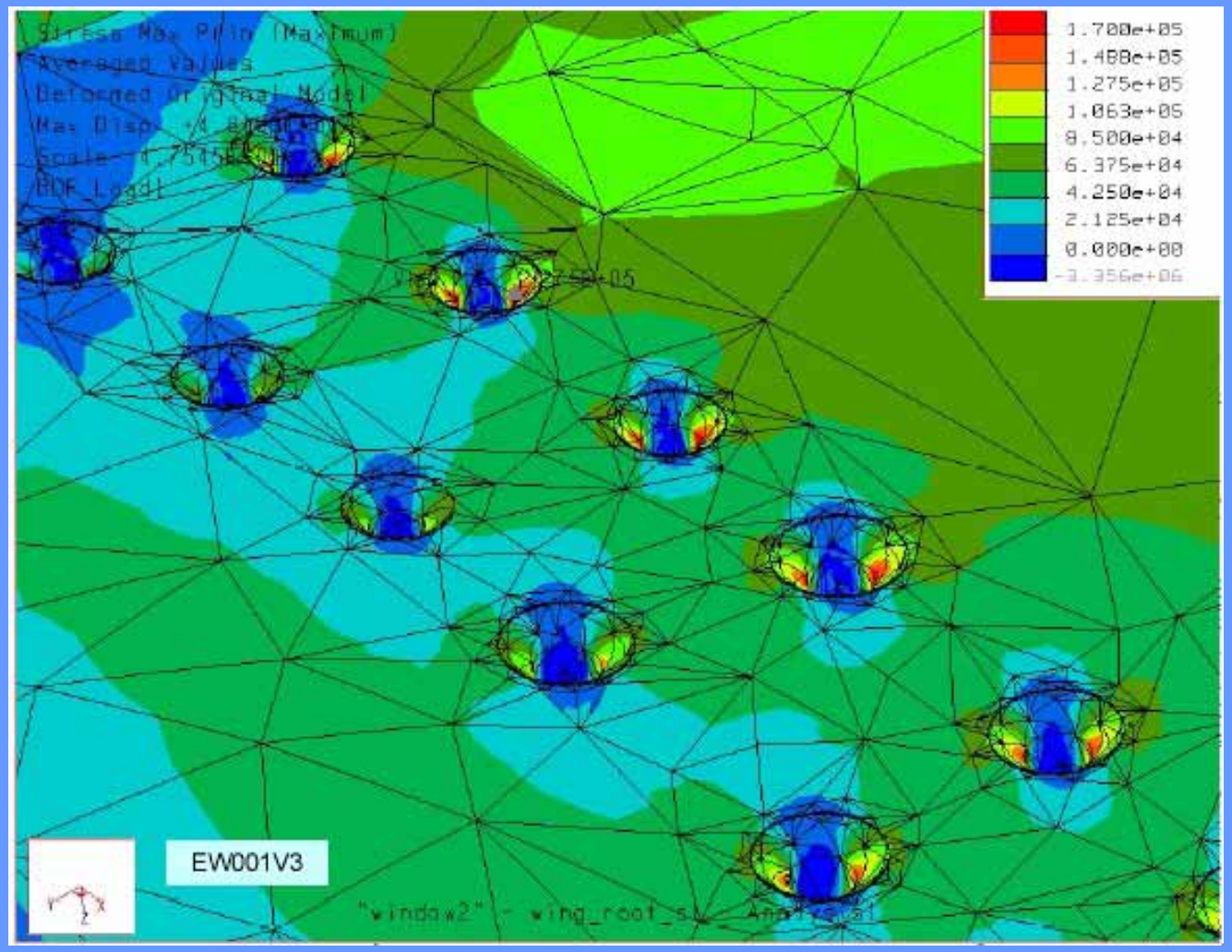


Failure analysis example (wing root failure)

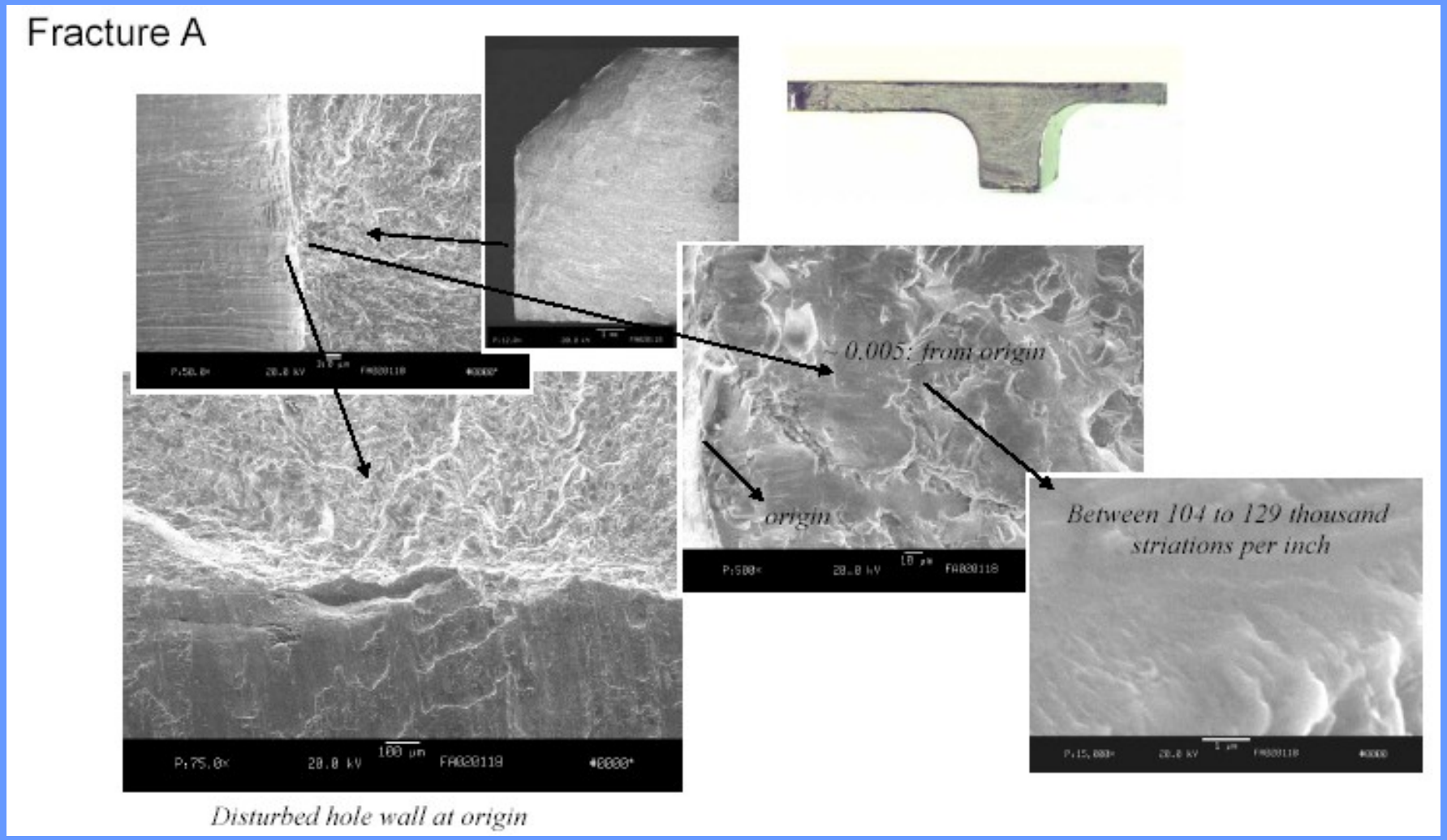




Detailed models were constructed to characterize the stress field at the countersink holes



Failure surface of crack emanating from flaw at fastener hole in wing root lower skin



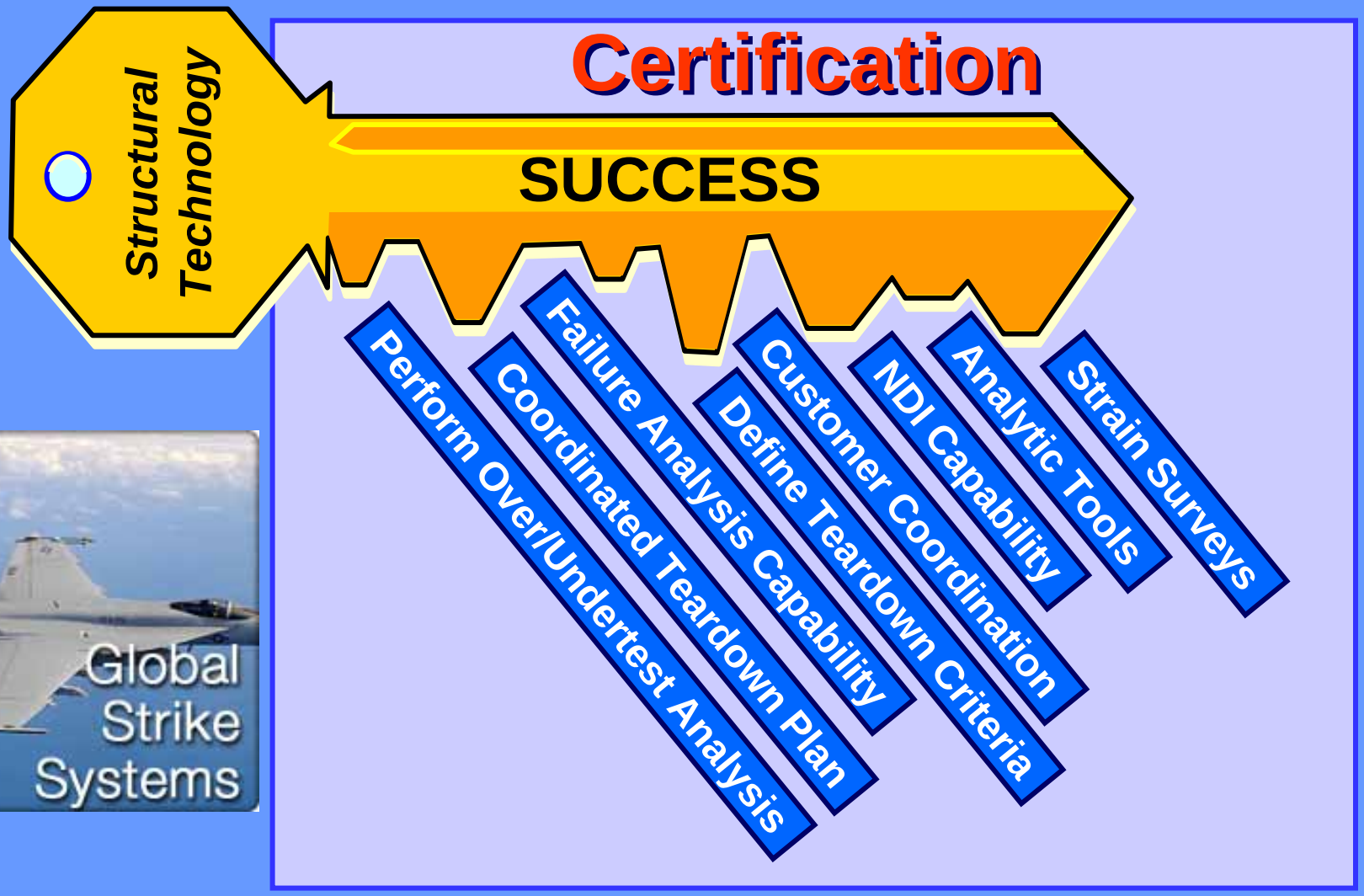
- **Probability analysis was performed early in the F/A-18E/F program to determine the scatter factor that was to be used during fatigue analysis of structural components**
  - **A scatter factor of 1.0, i.e., design for 12,000 SFH and test for 12,000 SFH, would correspond to a 50% probability that a crack will initiate after two lifetimes (12,000 SFH) of testing**
- **The E/F program incorporated a scatter factor of 1.33 (design for 16,000 SFH) into all fatigue design allowables which corresponds to an 18% probability that a crack will initiate after two lifetimes**

- **Stretch testing the FT50 test article to three lifetimes (18,000 SFH) corresponds to an effective scatter factor of 0.89 since the structure was only designed for 16,000 but was tested for 18,000 SFH**
- **This scatter factor corresponds to a 65% probability that a crack will initiate after two lifetimes**
- **Therefore, the number of cracks identified on the FT50 test article is not unexpected**

Summary of cracks on FT50 at completion of 18,000 SFH of testing

	Crack Summary	
FT50 Component	Parts	Total
Wing	43	641
Forward Fuselage	53	492
Center Fuselage	133	1119
Aft Fuselage	56	293
Mechanisms	2	3
Vertical Tail	9	45
Totals -->	**296**	**2593**

Many Parameters Required To Successfully Complete Test Program



F/A-18E/F Test Conclusions

- **The F/A-18E/F full-scale fatigue test programs are a solid success as expressed by United States Navy**
  - "Superb" technical performance expressed by customer
  - FT50 2nd lifetime testing completed ahead of schedule
- **Comprised multiple full scale fatigue test articles that certified the airframe to meet the intended design life**
- **Successful in identifying structure that is capable of exceeding the intended design life**
- **Success of the F/A-18E/F airframe continues to be realized by utilizing the E/F structural platform as the foundation of the EA-18G program**
  - Next generation of electronic attack aircraft for the United States Navy

EA-18G

Electronic attack variant of the F/A-18E/F