VEHICLE TECHNOLOGY DIRECTORATE

Test-Analysis Correlation of a Crash Simulation of a Vertical Drop Test of a Commuter-Category Aircraft

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OUTLINE OF PRESENTATION

- ACKNOWLEDGEMENTS
- INTRODUCTION
- SUMMARY OF EXPERIMENTAL PROGRAM
- MODEL DEVELOPMENT
- TEST-ANALYSIS CORRELATION
- CONCLUDING REMARKS

ACKNOWLEDGEMENTS

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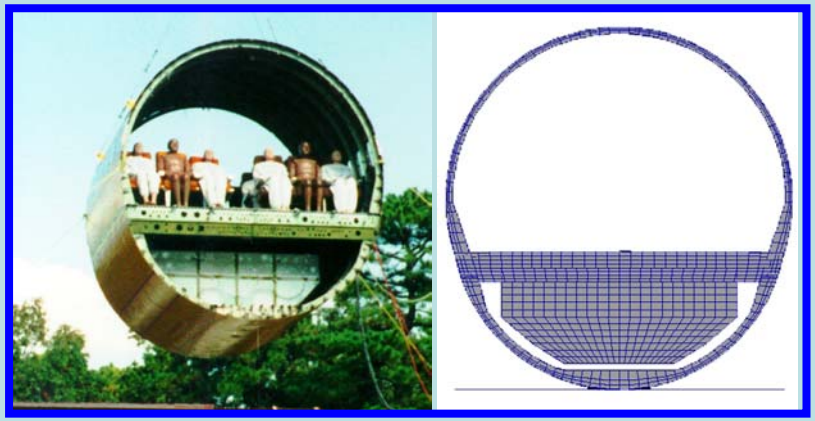
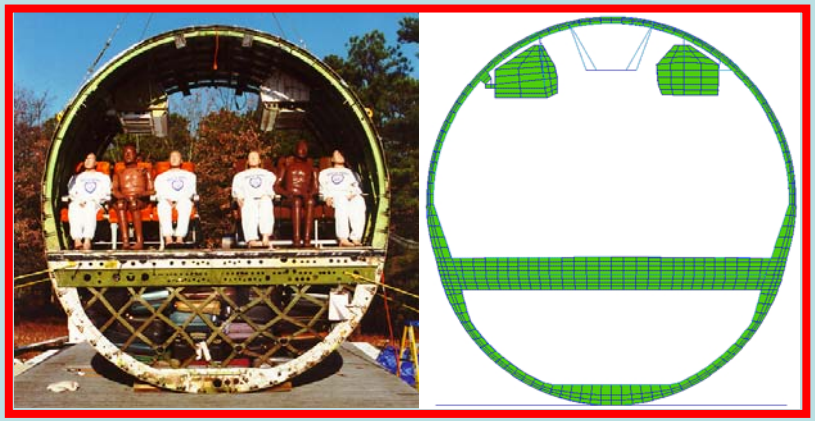
INTRODUCTION

- In 1998, the US Army Research Lab, Vehicle Technology Directorate entered into an Inter-Agency Agreement (IAA) with the FAA William J. Hughes Technical Center for the purpose of validating explicit transient dynamic simulations of airframe structures through extensive test-analysis correlation
- In 1999 and 2000, two vertical drop tests of B737 fuselage sections were conducted at the FAA. Finite element models were developed and the analytical predictions were correlated with test data to validate the models.



1999 Drop test of a B737 fuselage section with auxiliary fuel tank



2000 Drop test of a B737 fuselage section with luggage and overhead bins

INTRODUCTION

- This research transitioned into a new phase with the development of a full-scale, three-dimensional finite element model of a commuter aircraft, the ATR42, purchased by the FAA for crash testing.

OBJECTIVES OF THE PRESENTATION:

- To summarize the test set-up and experimental results
- To describe the model development process, and
- To present the test-analysis correlation

SUMMARY OF EXPERIMENTAL PROGRAM

The ATR42-300 aircraft is a twin turbo-prop high-wing commuter, manufactured by Aeritalia and Aerospatiale. It has a:

- wingspan of 80 ft.
- seating capacity of 42-50
- cruise speed of 304 knots/hr
- max take-off weight of 36,800 lb.

- Vertical drop test performed at the Dynamic Drop Test Facility at the FAA Tech Center in Atlantic City, NJ, on July 30, 2003.
- Aircraft drop height was 14 ft., for a impact velocity of 30 ft/s.
- Impact surface was concrete.
- Total weight of test article was 33,200 lb., including 8,700 lb. of water in the wing.

SUMMARY OF EXPERIMENTAL PROGRAM

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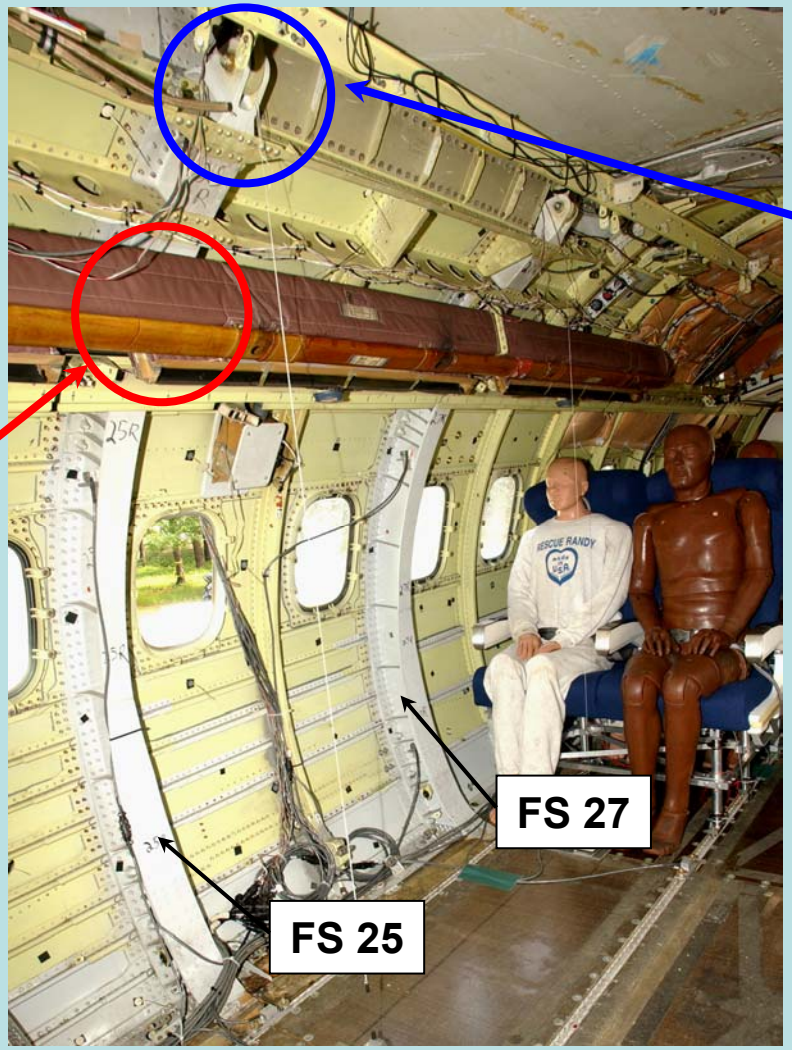
Details of the Wing/Fuselage Attachment

"Dog bone" beam



Upper bracket assembly

SUMMARY OF EXPERIMENTAL PROGRAM

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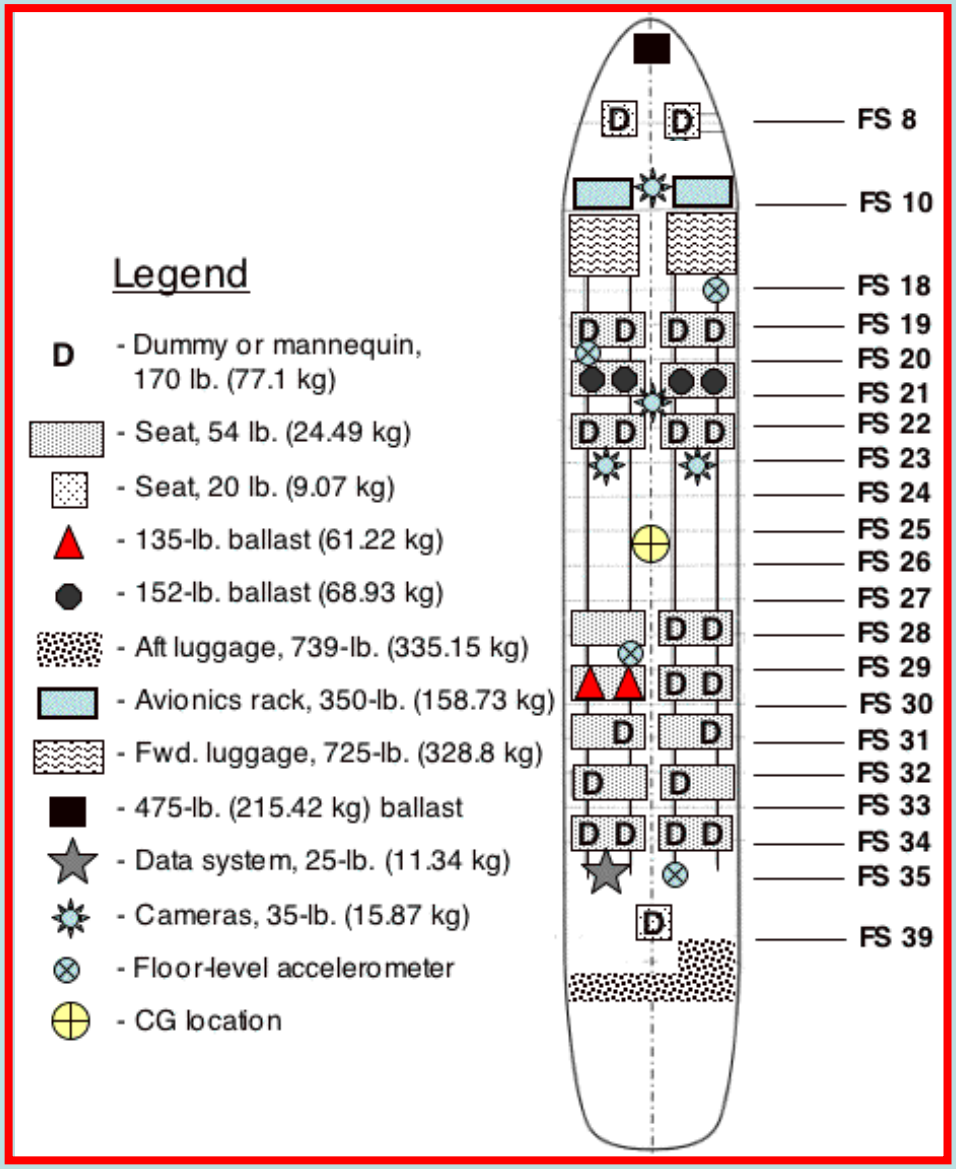
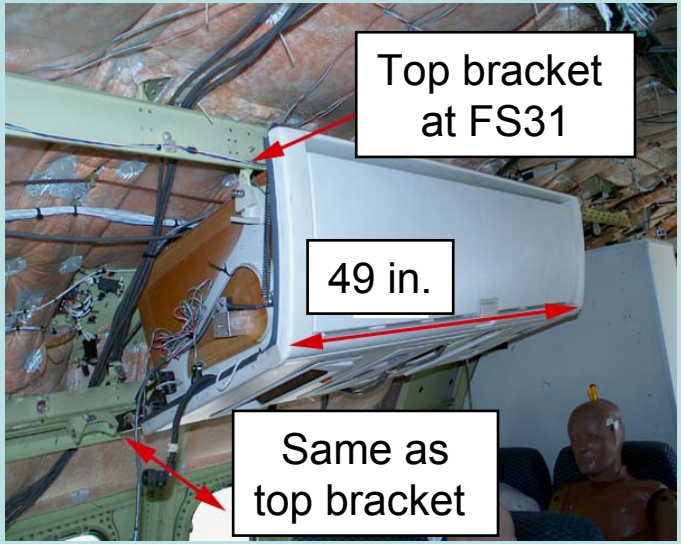


Photographs of the Aircraft Interior



SUMMARY OF EXPERIMENTAL PROGRAM

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Post-Test Photographs

MODEL DEVELOPMENT

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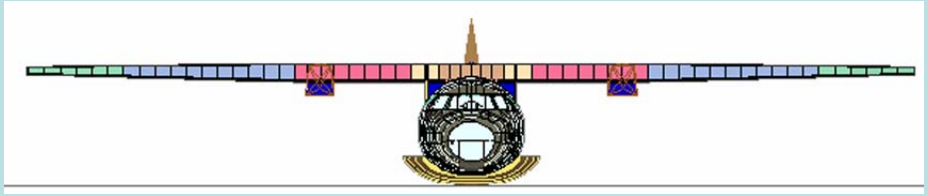
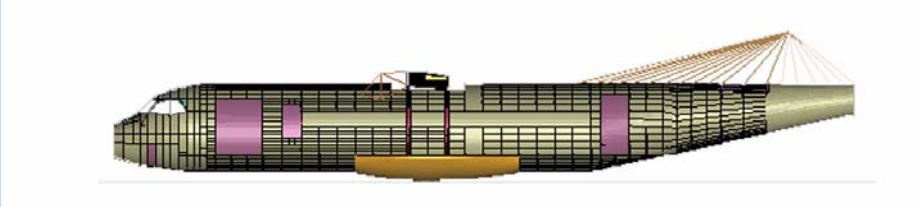
Finite Element Model

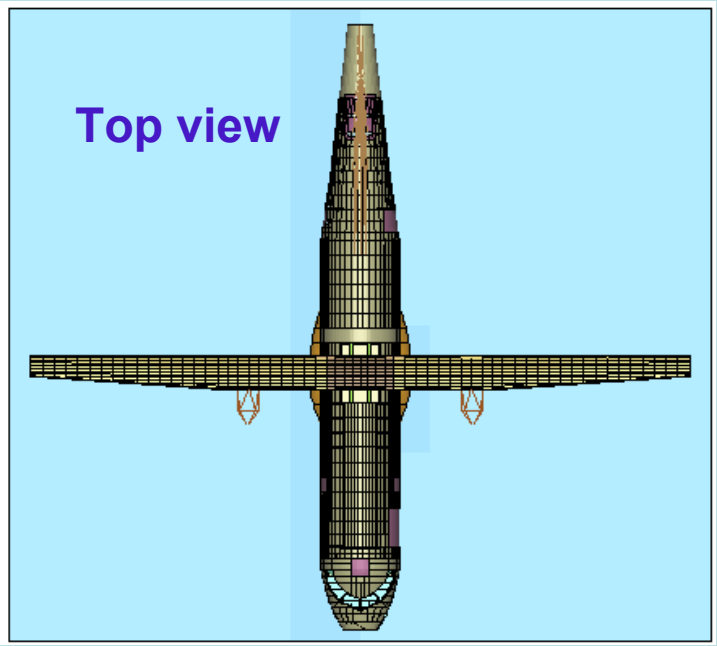
- 57,643 nodes
- 62,979 elements
  - 60,197 quadrilateral shells
  - 551 triangular shells
  - 526 beam elements
  - 1,705 point elements

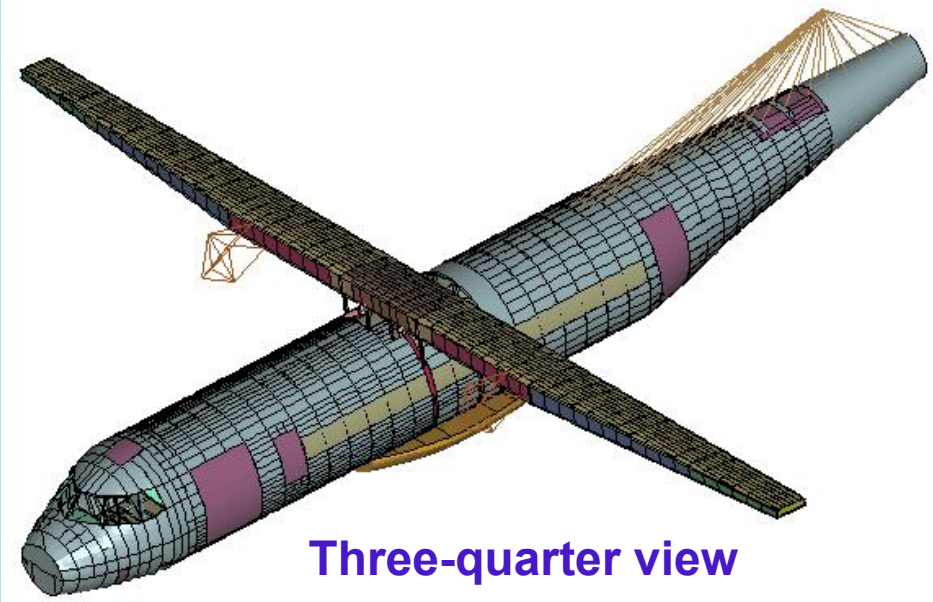


Front view



Side view





Three-quarter view

MODEL DEVELOPMENT

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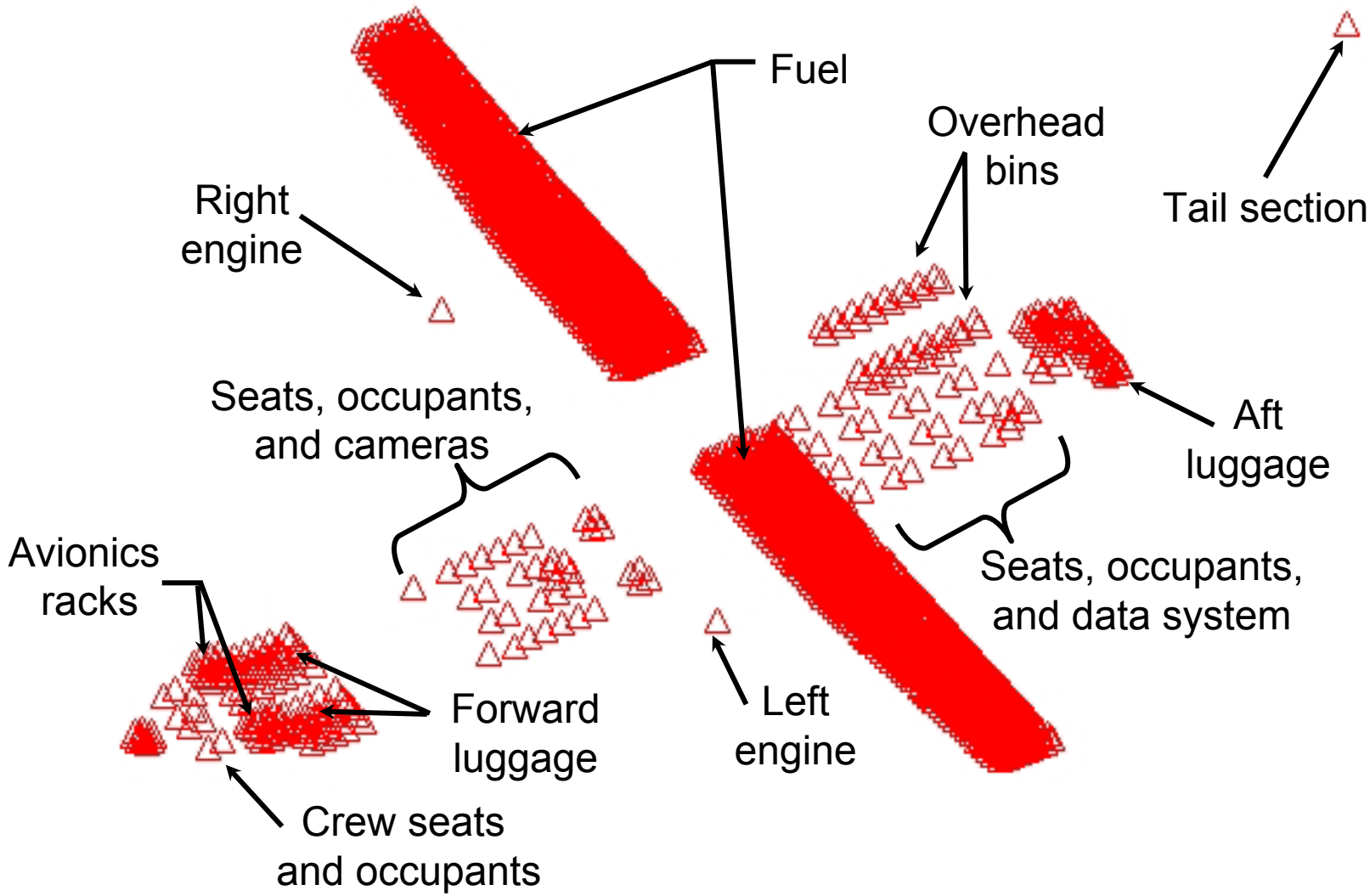
Point Elements



TEST-ANALYSIS CORRELATION

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Weight and Balance Comparison

	Test Article	Model
Weight, lb.	33,200	33,120
CG location, in.		
CG_x	469.2	471.5

TEST-ANALYSIS CORRELATION

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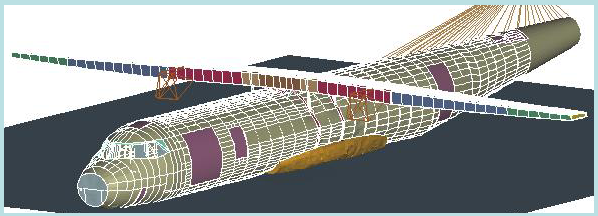
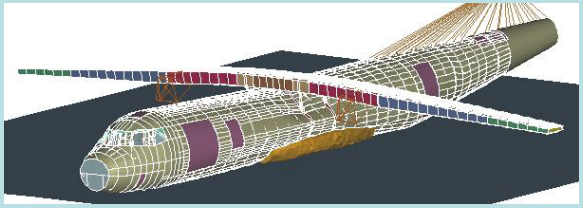
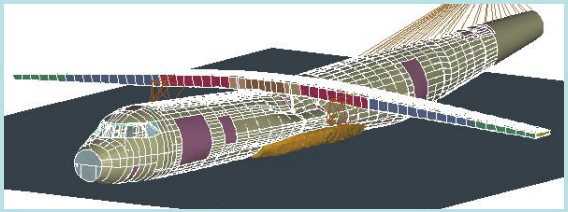
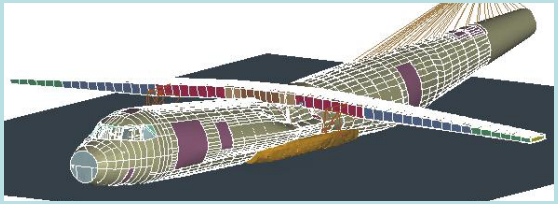
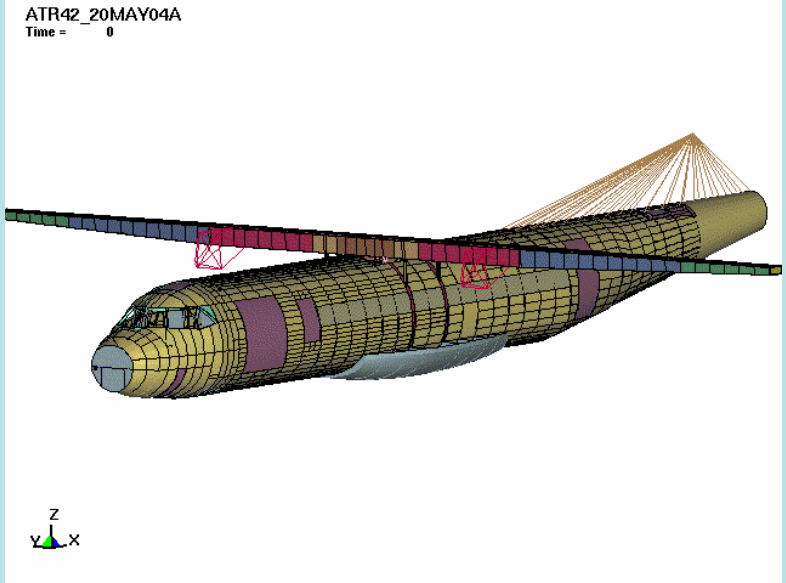
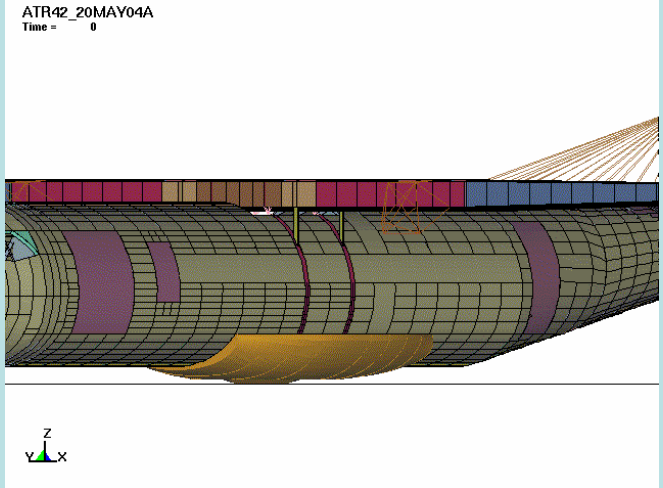
Comparison of Structural Deformation

Time, s	Test Article	Model
0.05		
0.10		
0.15		
0.20		

Comparison of Structural Deformation





TEST-ANALYSIS CORRELATION

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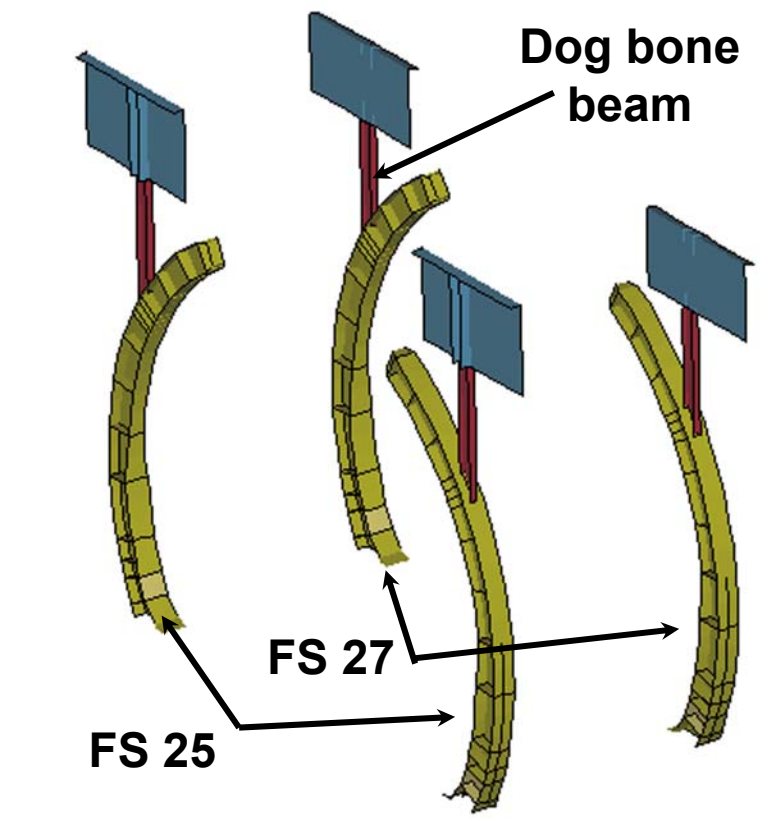
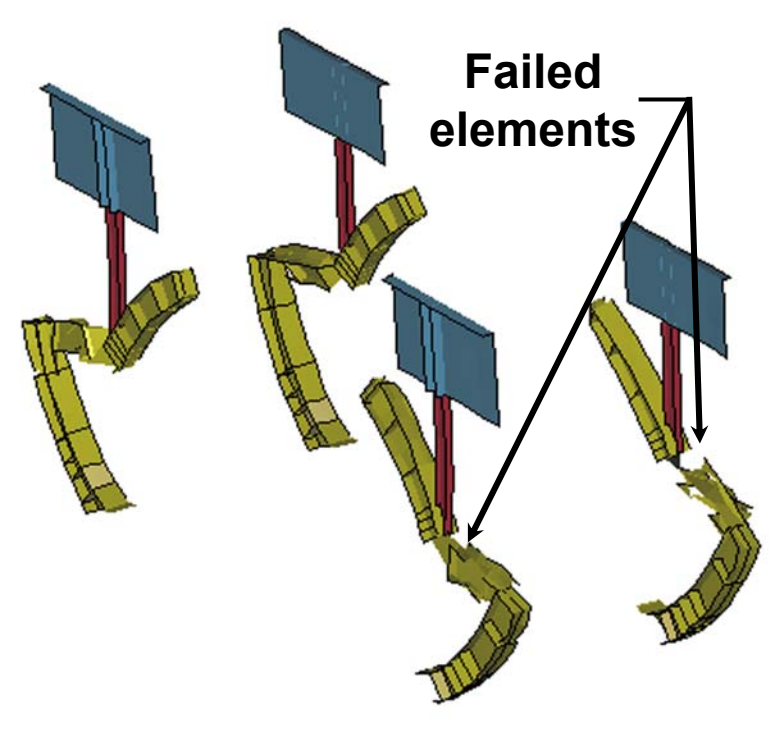
Comparison of Structural Deformation



Time = 0.00 s



Time = 0.25 s

TEST-ANALYSIS CORRELATION

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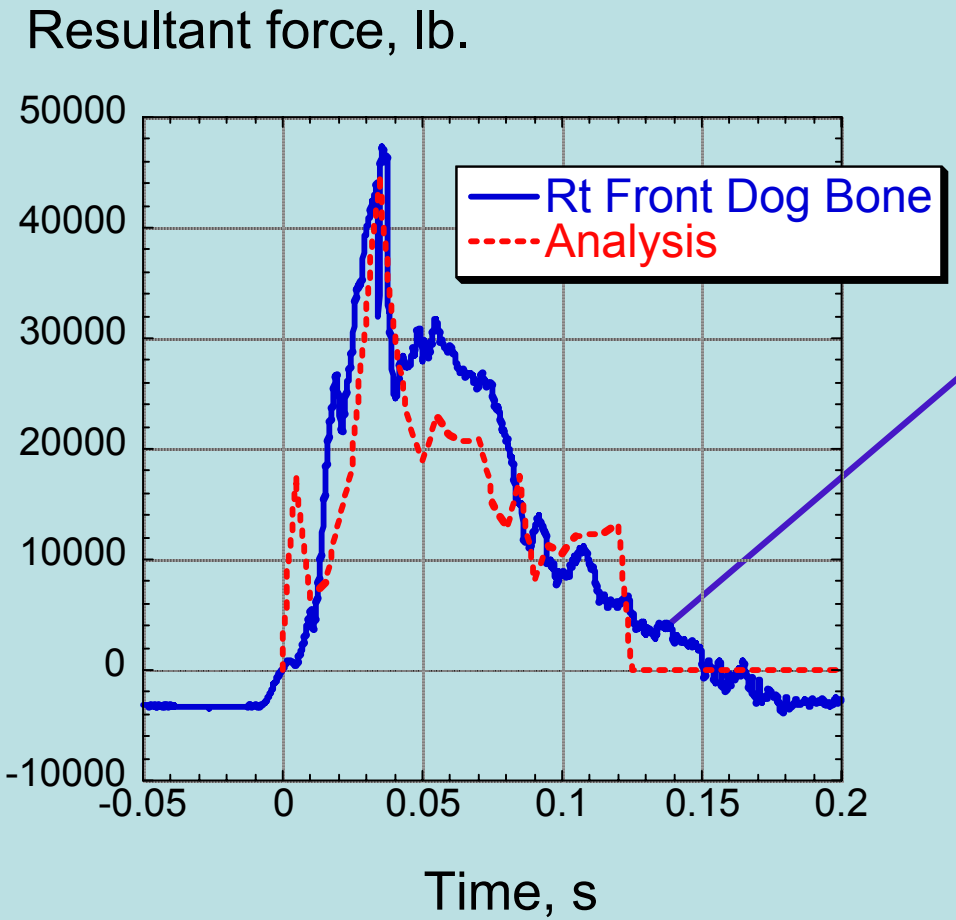
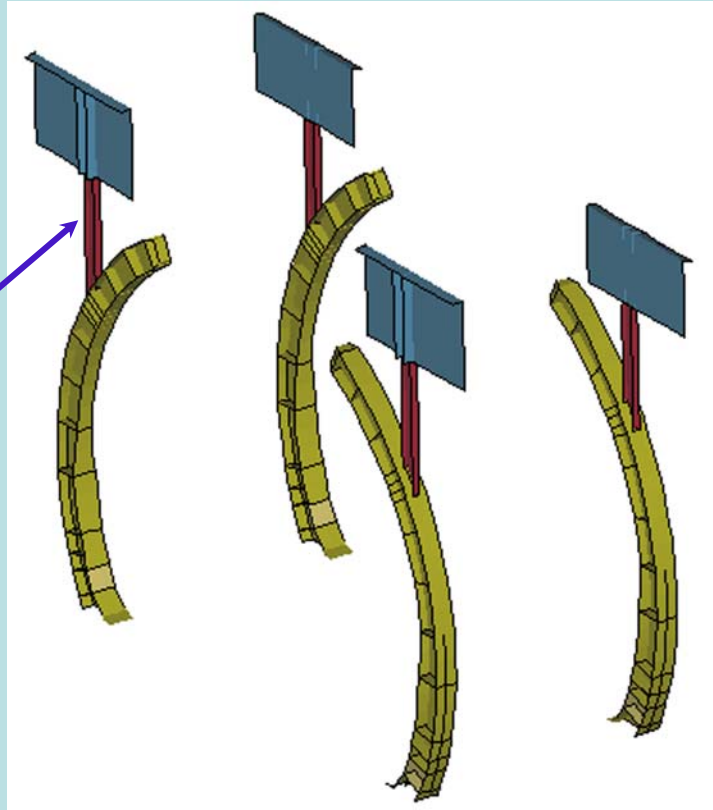
Comparison of Dog Bone Forces





TEST-ANALYSIS CORRELATION

Comparison of Floor-Level Time-History Responses

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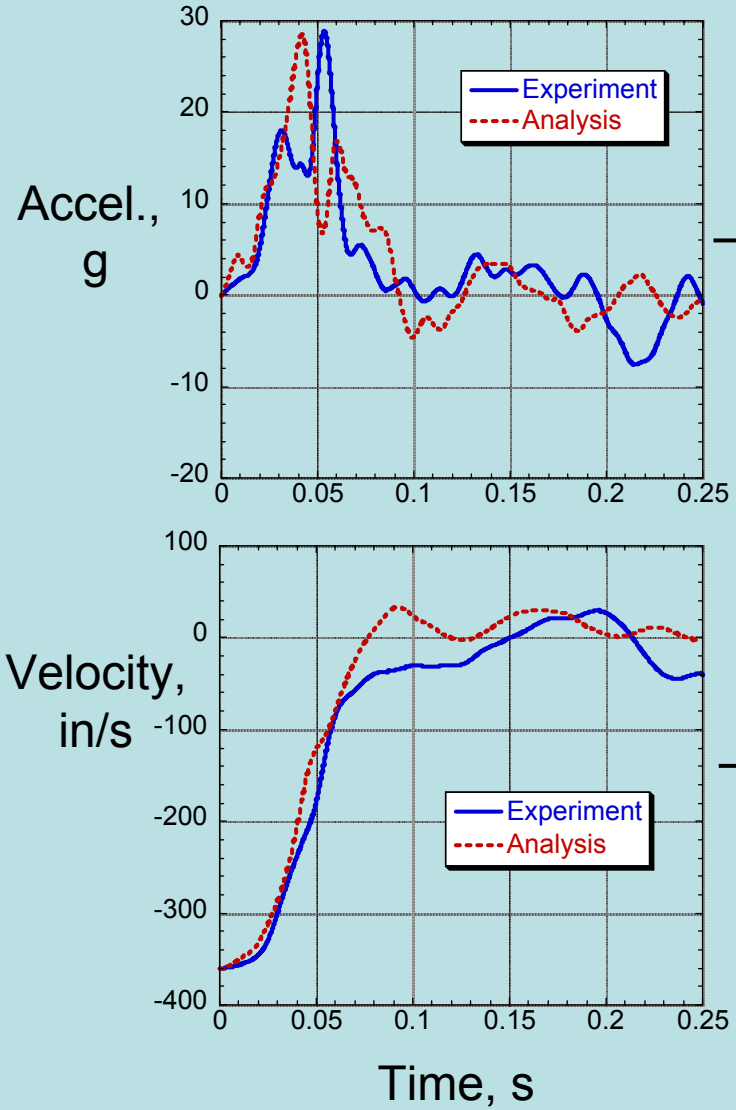
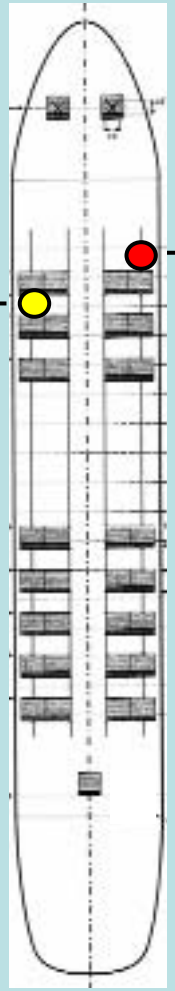
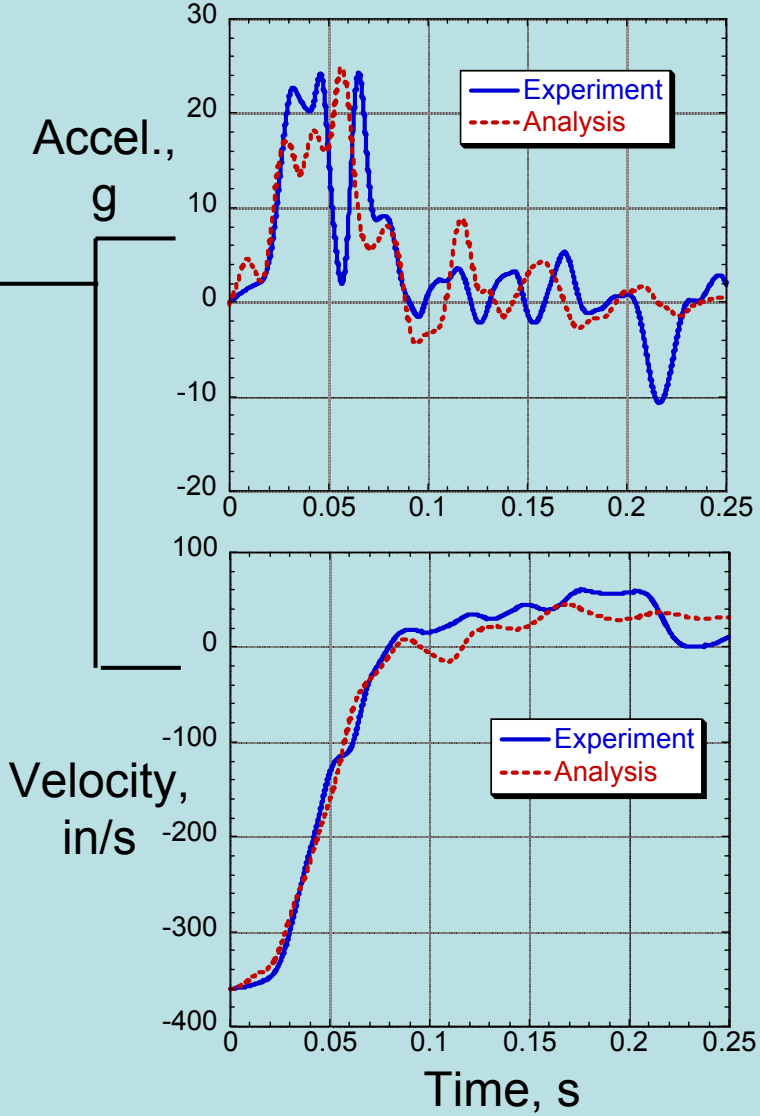
Left Outer Seat Track at FS 20





Right Outer Seat Track at FS 18



TEST-ANALYSIS CORRELATION

Comparison of Floor-Level Time-History Responses

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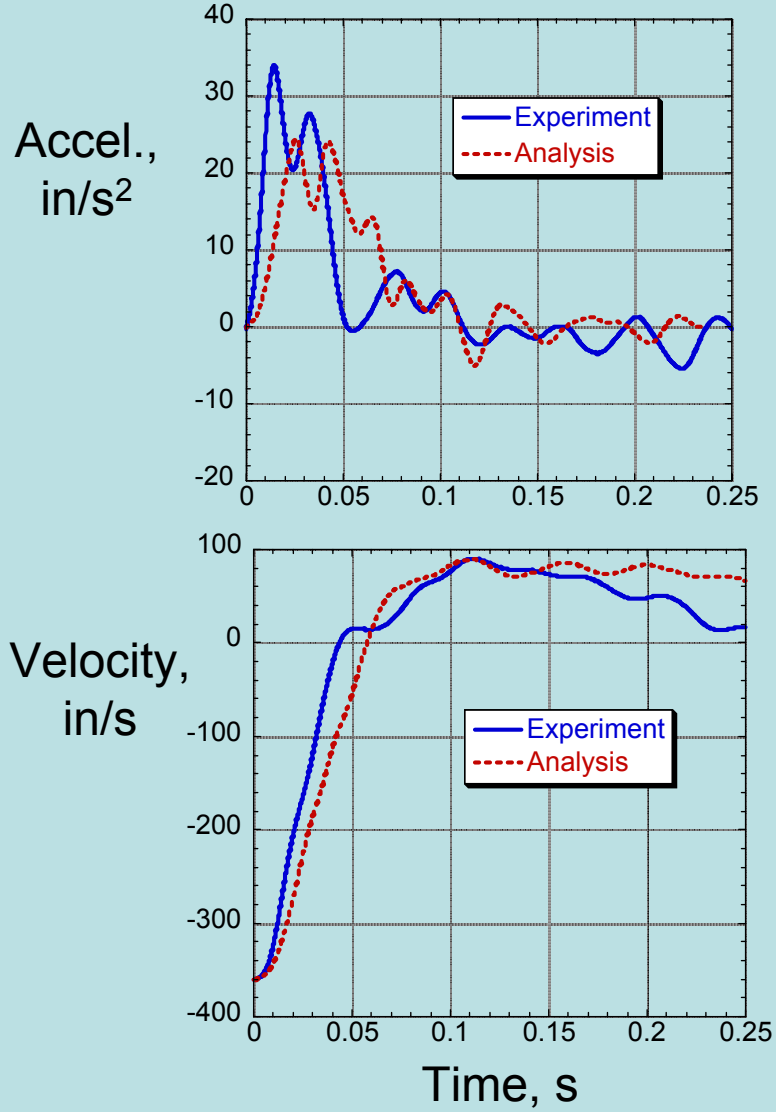
Right Side of the Cockpit Floor



TEST-ANALYSIS CORRELATION

Comparison of Floor-Level Time-History Responses

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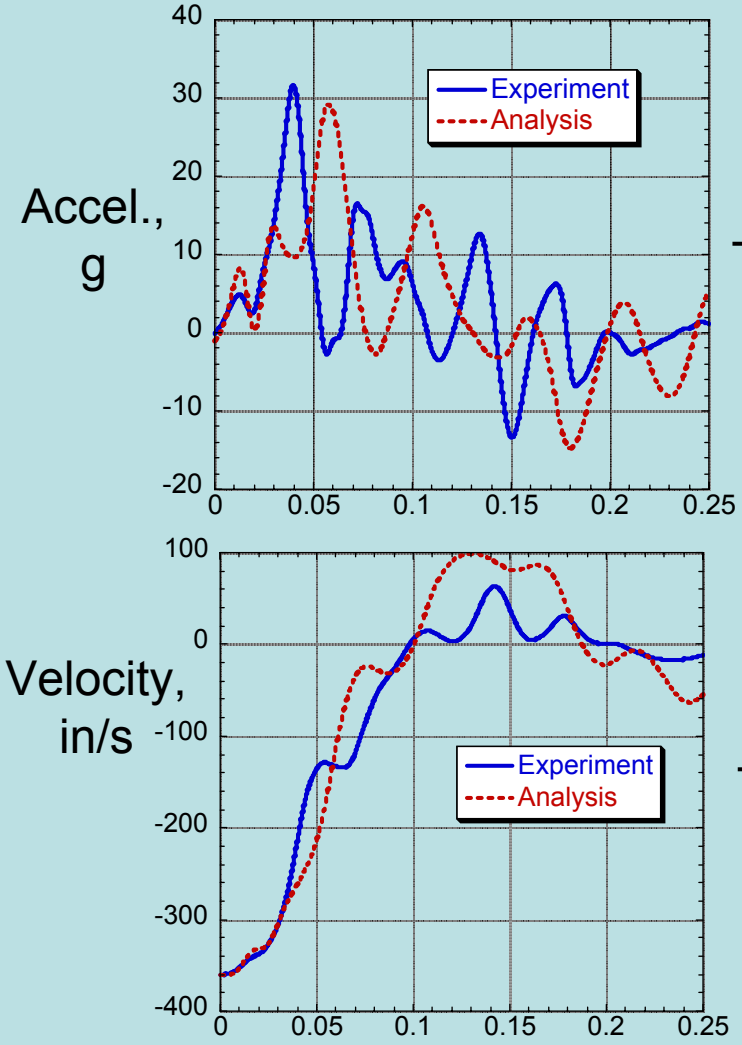
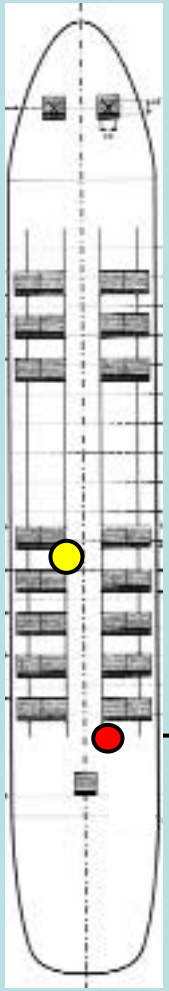
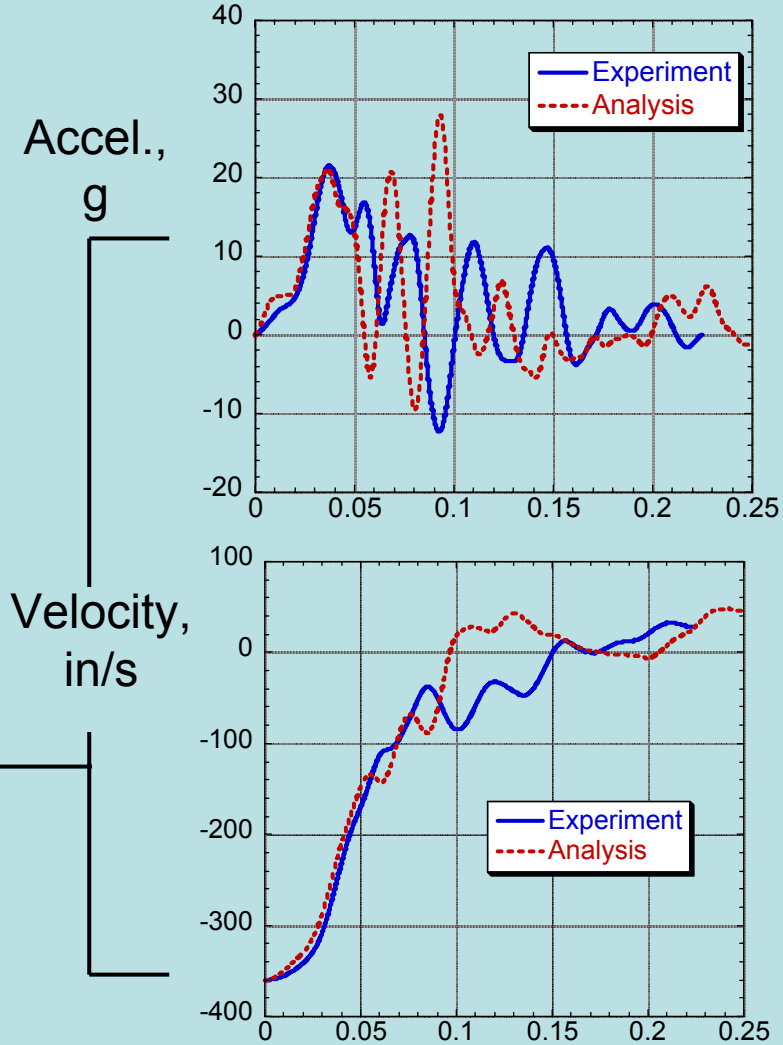
Left Inner Seat Track at FS 29





Right Inner Seat Track at FS 35



TEST-ANALYSIS CORRELATION

Comparison of Structural Time-History Responses

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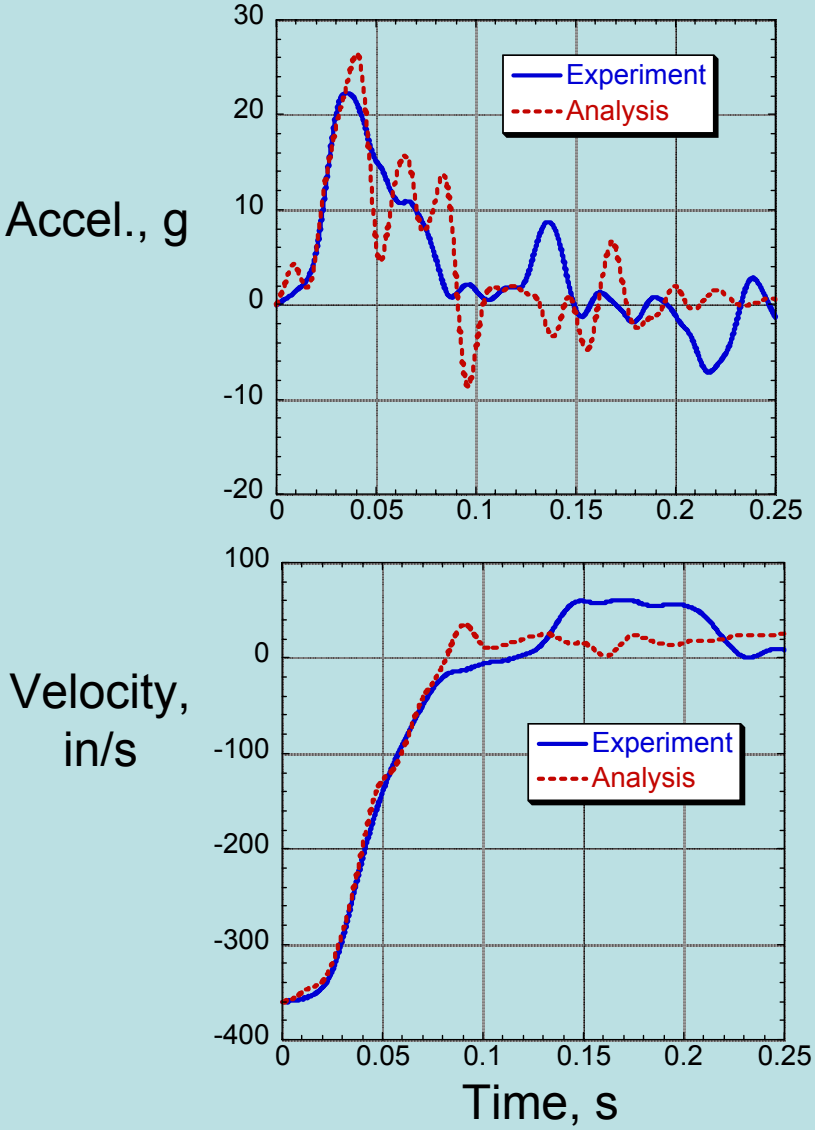
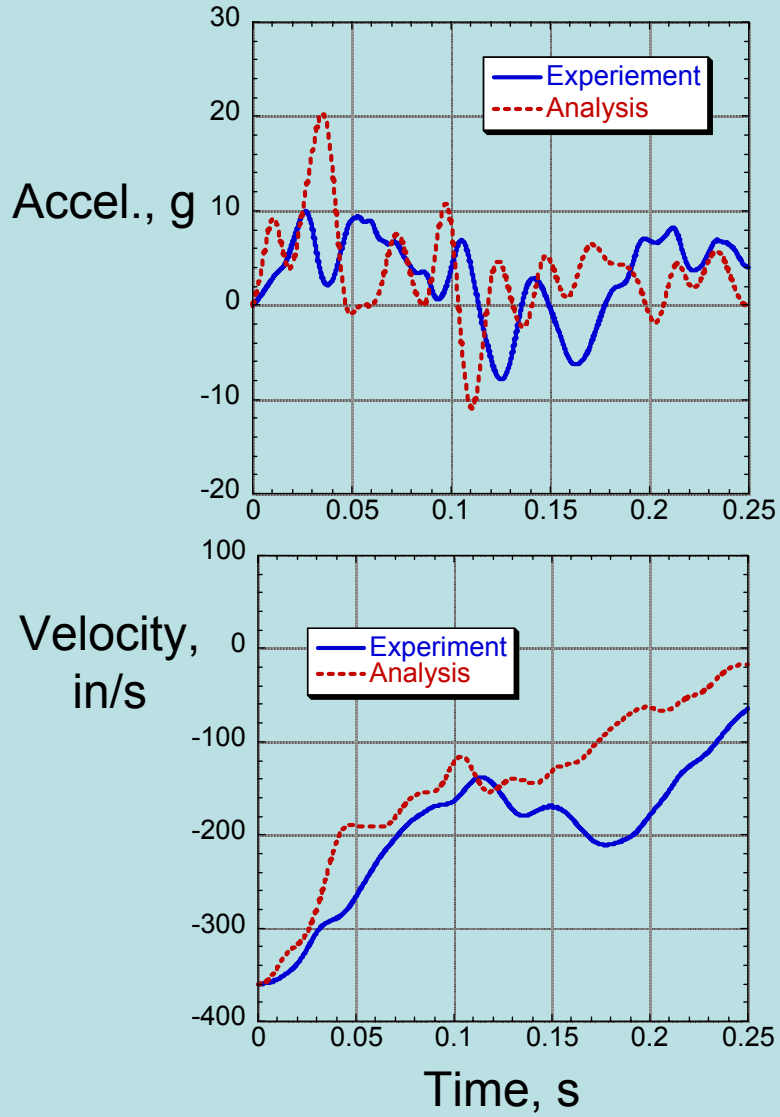
Left Sidewall at FS 18



Center Ceiling at FS 26



TEST-ANALYSIS CORRELATION

Comparison of Structural Time-History Responses

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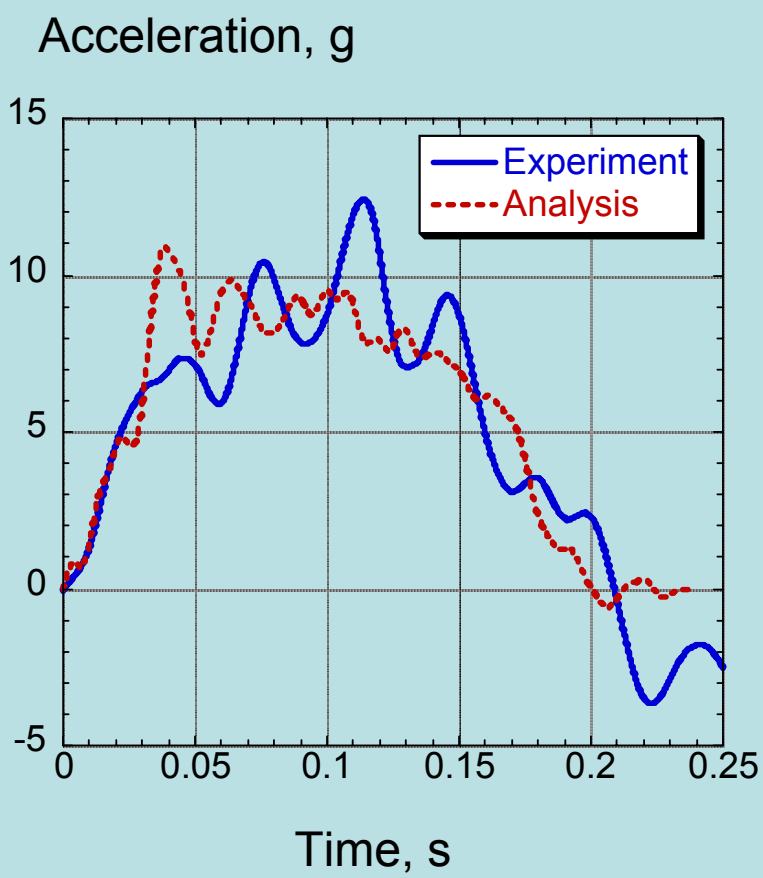
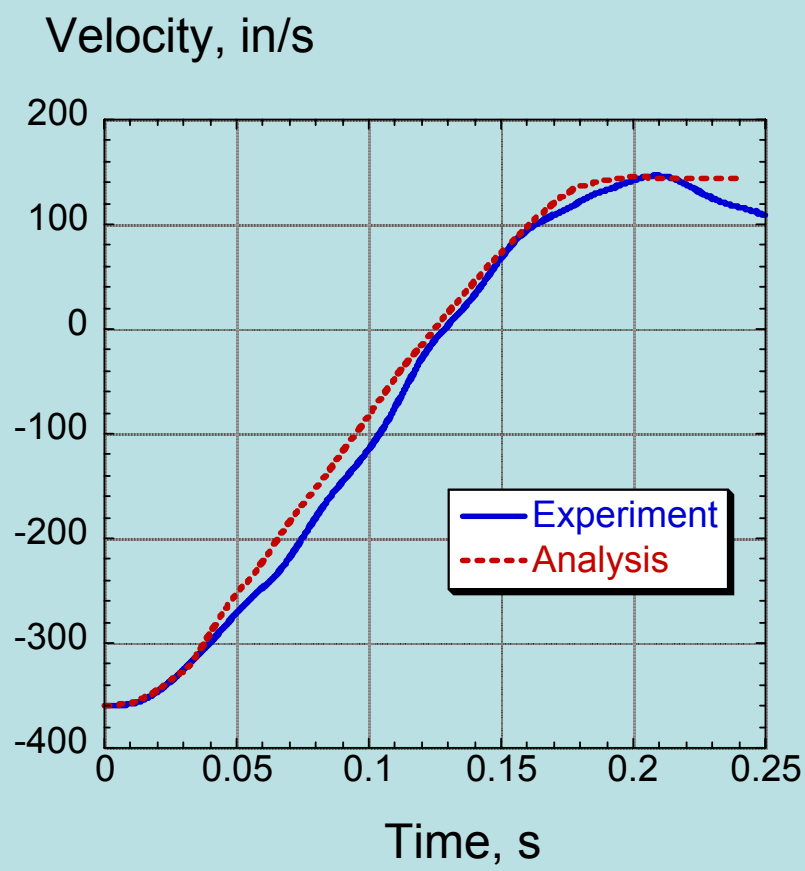
Center Tail Section at FS 47





CONCLUDING REMARKS

- A finite element model of the ATR42-300 aircraft was developed from direct measurements of airframe geometry.
- The model was executed in LS-DYNA (v. 970) for 0.25 s of simulation time to predict the structural response of the airframe during a 30-ft/s vertical drop test.
- The simulation correctly predicted the major damage mode (collapse and failure of the wing support structure).
- Good correlation was achieved between test and analysis when comparing the overall shape, magnitude, and duration of the acceleration, velocity, and resultant dog bone force responses.
- Accurate prediction of the floor-level responses are needed to evaluate the FAA's proposed seat requirements for commuter-category aircraft.