Deep Impact Design for Shock with I-deas Analysis and Test

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Premium Partners:

Agenda

- Background
- The Challenge we faced
- The Solution, or How Integration Helped
- Conclusions

Deep Impact Background

- Mission: Impact a comet in deep space and document the explosion to determine the chemical content of the comet
- Mission was a resounding success!
- *Video Excerpt: Mission Profile*
  - *Source: "Comet Collision", Discovery Channel, 2005*

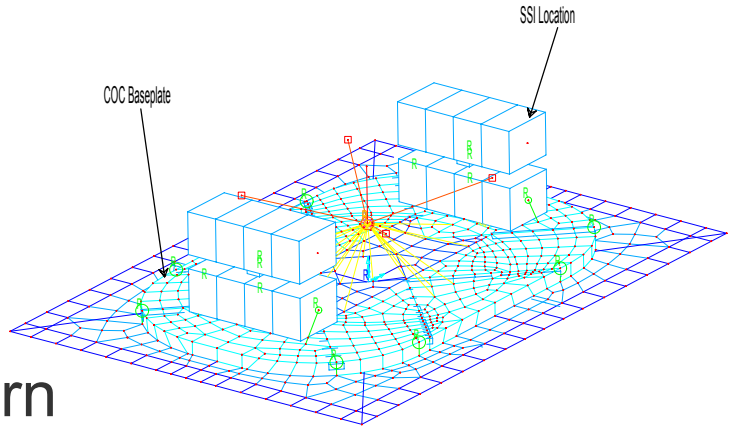
ATA Has Provided High-Value Mechanical Design, Analysis & Test Services Since 1977

- **ATA Engineering's** mission is to provide superior, innovative analysis and test-driven design solutions and exceptional support to our mechanical, structural, and aerospace engineering clients.
- 1977: SDRC opened western region services office in San Diego
- 2000: ATA Engineering, Inc. was formed as an employee-owned company through the purchase of all assets and contractual obligations of the Advanced Test and Analysis group of SDRC

ATA Involvement with Deep Impact

- ATA contracted by BATC to provide analysis support for Deep Impact spacecraft development
- Original paper presented at ATS
  - "Using Transient Analysis To Predict Shock Response for Component Flexure Design", 21st Aerospace Testing Seminar, October 2003

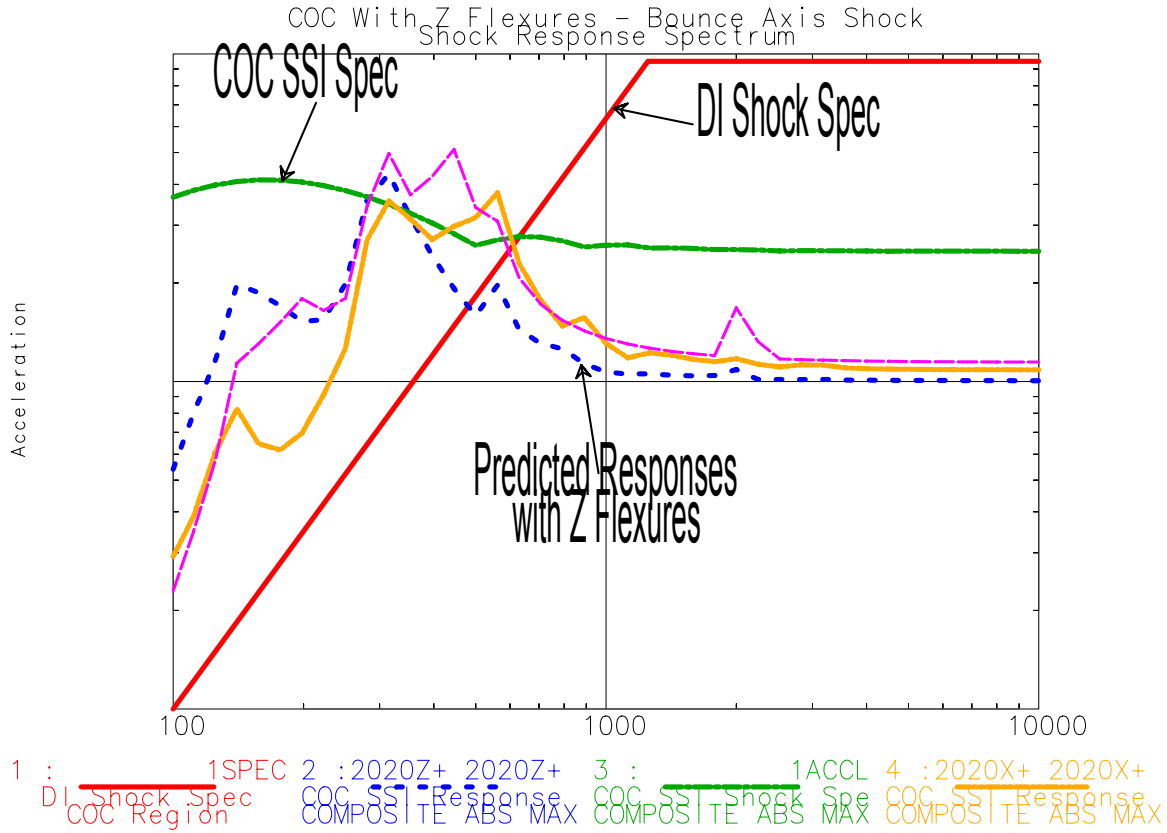
The Challenge



- Several components on DI spacecraft were susceptible to shock
  - COC – Component of Concern
  - SSI – Shock Sensitive Item
- COC mounted with traditional “Z” flexures
  - Flexures did not provide sufficient attenuation
  - Identified by component vendor late in the design process

Initial Predictions of Shock Attenuation Revealed the Concern

- COC tested to DI Shock Input Specification
- SSI response levels (X,Y,Z) with Z flexures exceeded COC SSI Response Specification

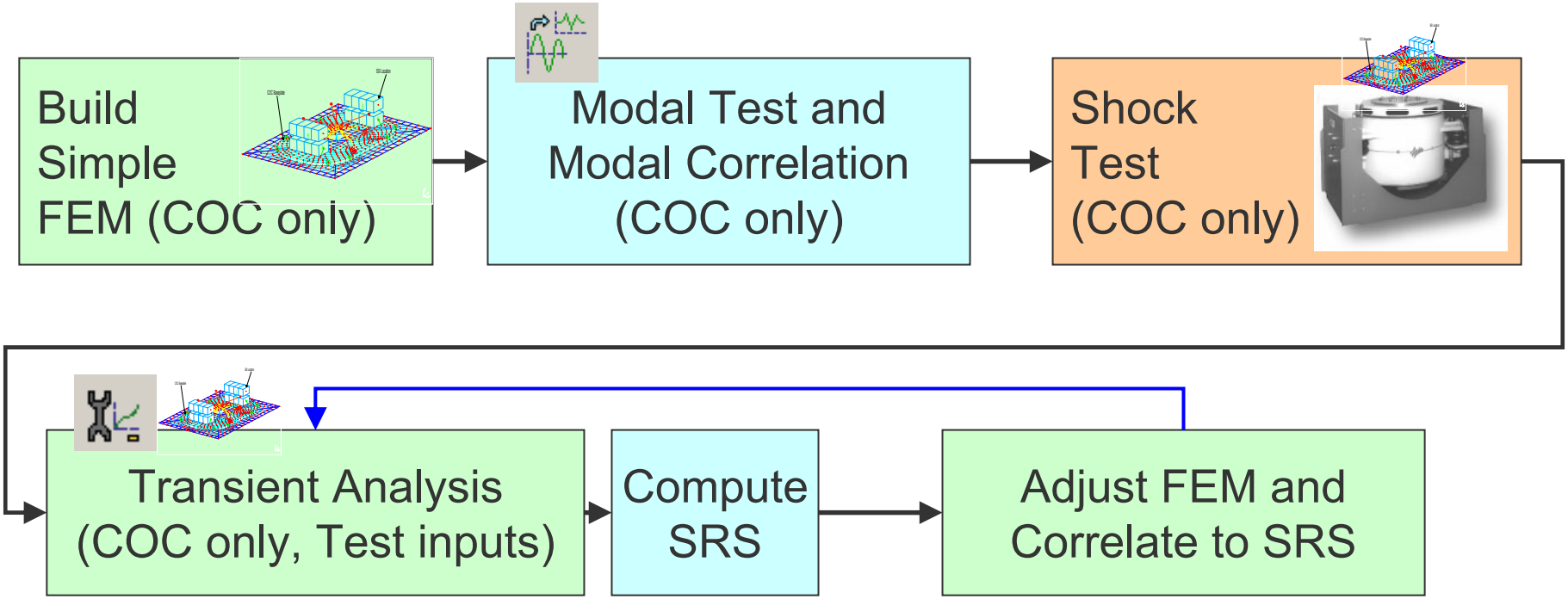


The Challenge: Rapid Redesign Without Prototype Parts

- Late in the design process
- Tight schedule and cost constraints
  - No time or money to build and test prototypes
- Volume and packaging constraints limited solution options
  - No room for taller flexures or active control
- Had to Get It Right the first time, and had to come up with a solution quickly

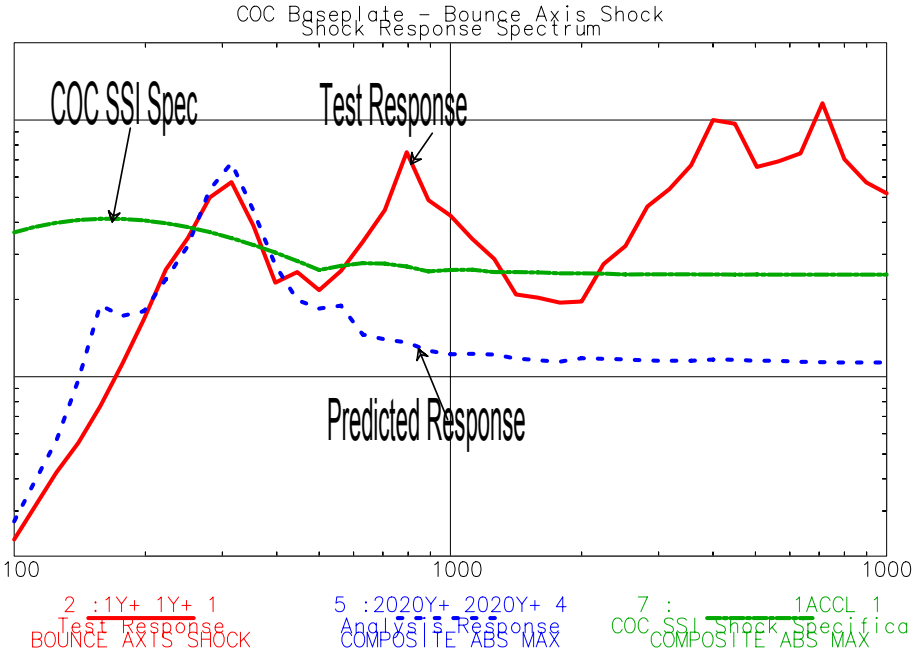
The Solution: Test-Driven Design and Analysis in I-deas (Part 1 of 2)

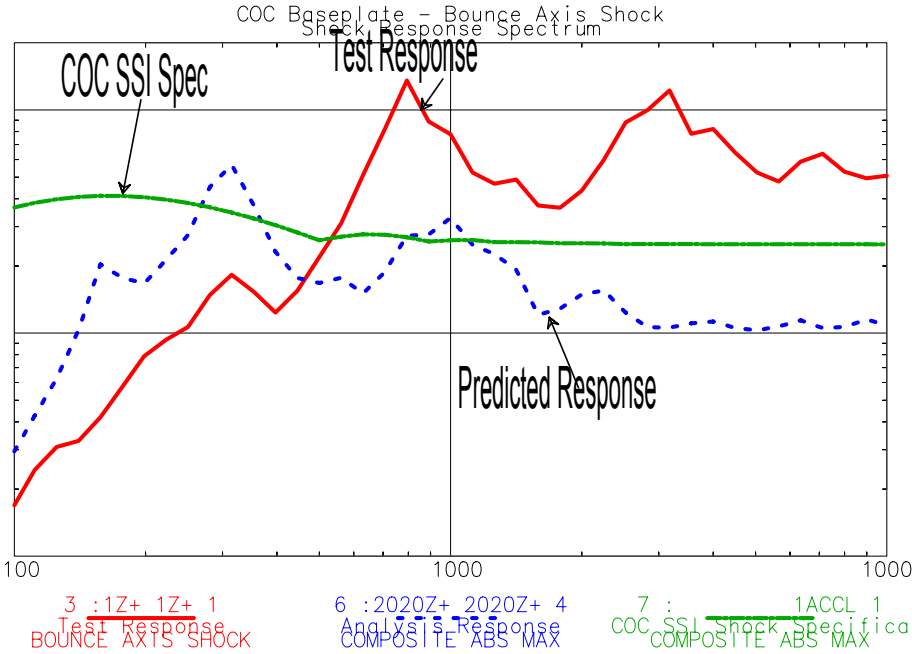
- Only COC baseplate available when problem was identified
- Test and correlate baseplate FEM
- Use transient analysis to predict SRS



Initial Test and Analysis Comparisons Showed A Workable Approach

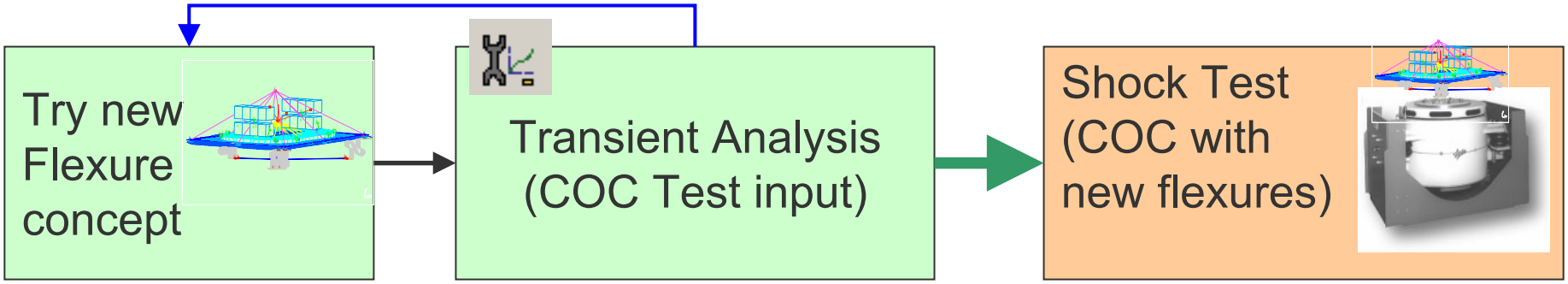
- Calculate SRS from COC baseplate (no flexures) analysis using test inputs
- Predictions match test data close enough for redesign effort, which involved adding flexures to the FEM and analyzing again





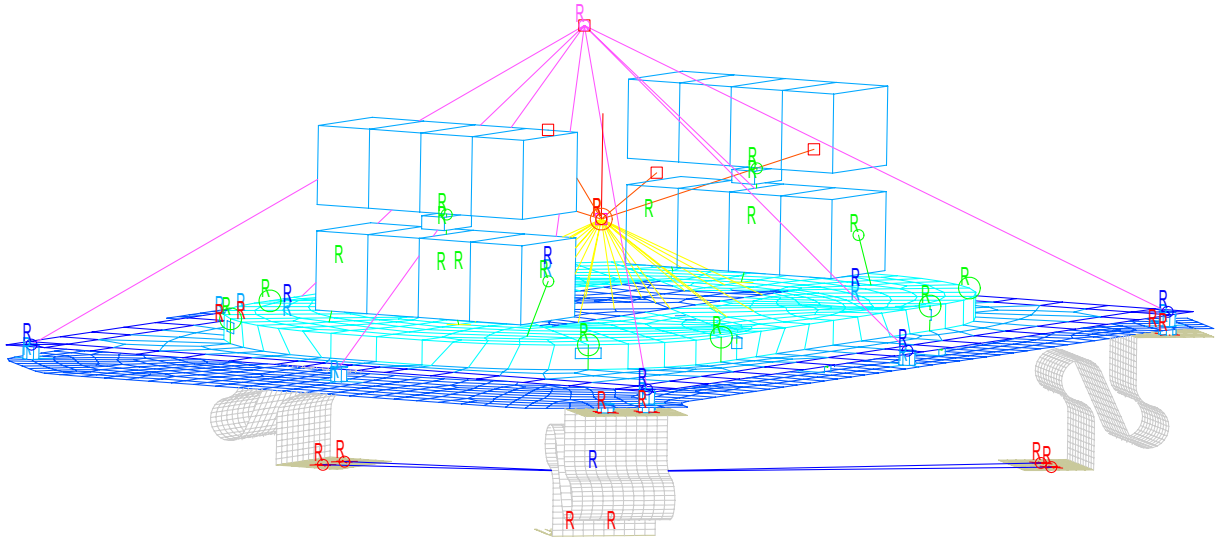
The Solution: Test-Driven Design and Analysis in I-deas (Part 2 of 2)

- Added flexures to baseplate FEM and used baseplate test input transient to predict SRS
- When acceptable SRS response was demonstrated, fabricated flexures and repeated shock test to validate analysis



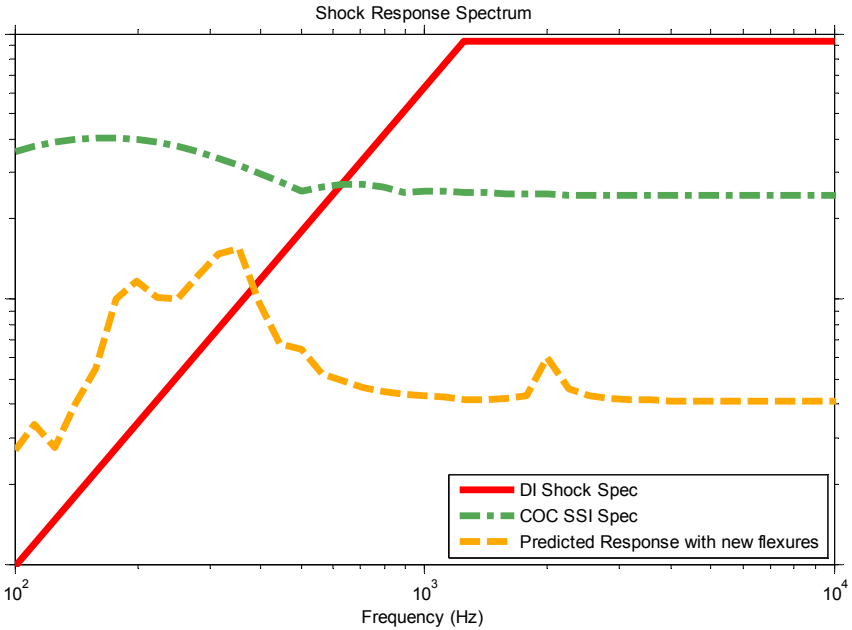
The New Flexure Design Was Realized Quickly

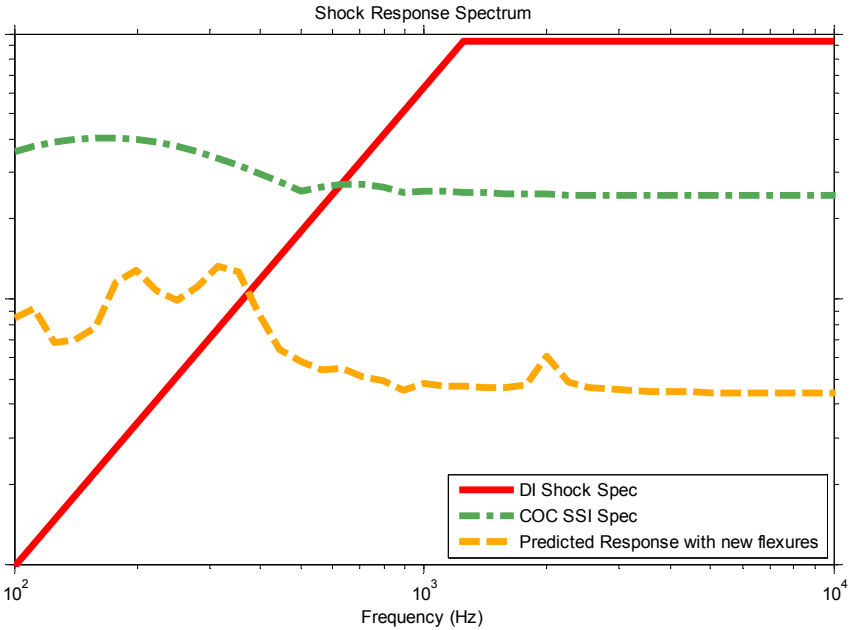
- Redesign effort completed in two days
- Small model size allowed for many quick iterations
- Redesigned flexures had minimal impact to the system
  - No overall dimension changes so no repackaging required



The New Flexure Design Shows Sufficiently Attenuated Response

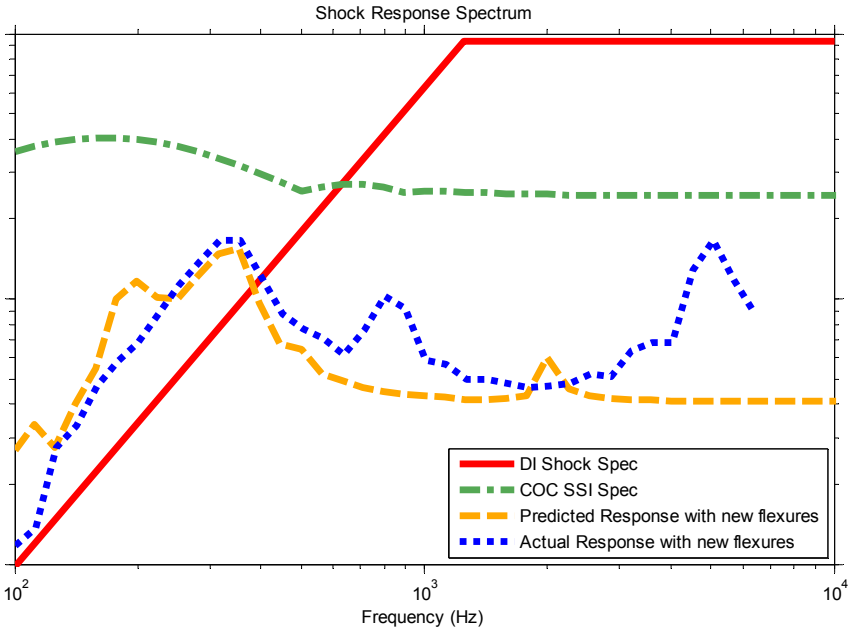
- Predicted responses due to DI Shock Spec input was sufficiently below COC SSI spec

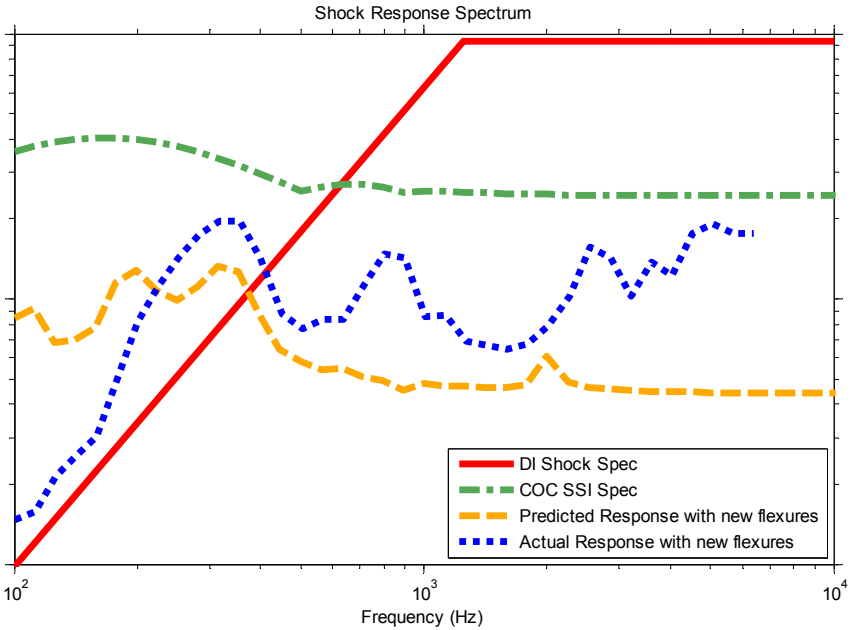




The New Flexure Design Was Validated After Building Hardware and Re-Testing

- Actual responses compared fairly well with predicted responses





Flexures “Make the News”

- *Video Excerpt: Flexures In Flight*
  - *Source: “Comet Collision”, Discovery Channel, 2005*

The Benefits of Integrated Design, Analysis, and Test software

- Software integration was extremely helpful in this process
  - No data translation between processes
    - I-deas Response Analysis understood test data formats natively
    - Used analysis results (mode shapes) from I-deas Model Solution directly
    - Use I-deas Test to generate SRS from Response Analysis Transients
    - Use plotting capabilities to overlay and compare results
  - Easily switch between tasks
- Lack of integration for parts of the process caused some delays
  - Difficult to transfer shock transients from shock test system over to I-deas

Conclusions

- Combination of Test and Analysis worked well for the flexure redesign
  - Rapid redesign validated after new hardware built
  - Hardware fabricated with confidence
  - Minimum cost and schedule impact
- Integrated software key to success
- Project was a success