SAND2006-6108C

Design Analysis

A Framework for Integrating Analysis and Design in Product Development

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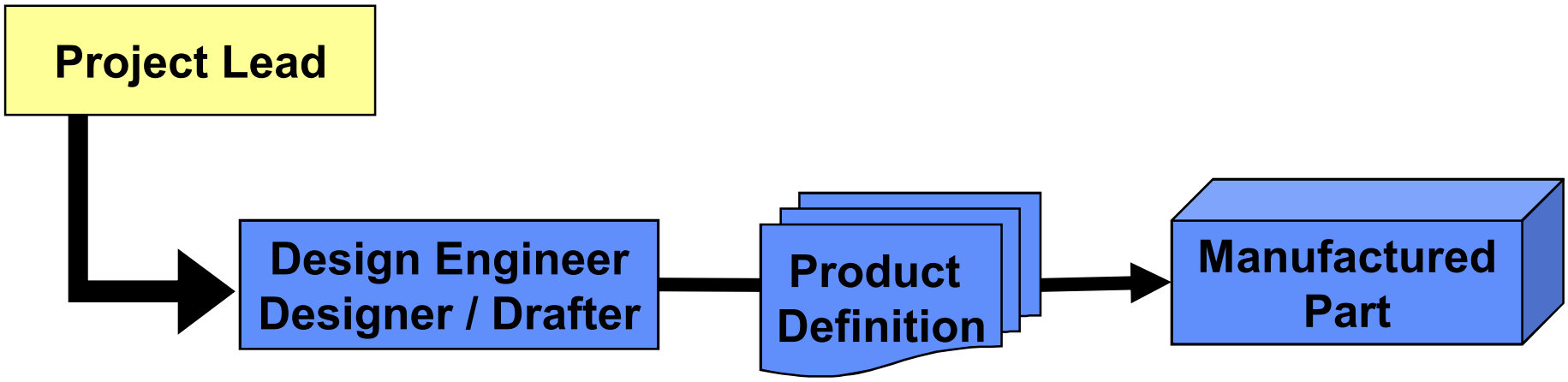
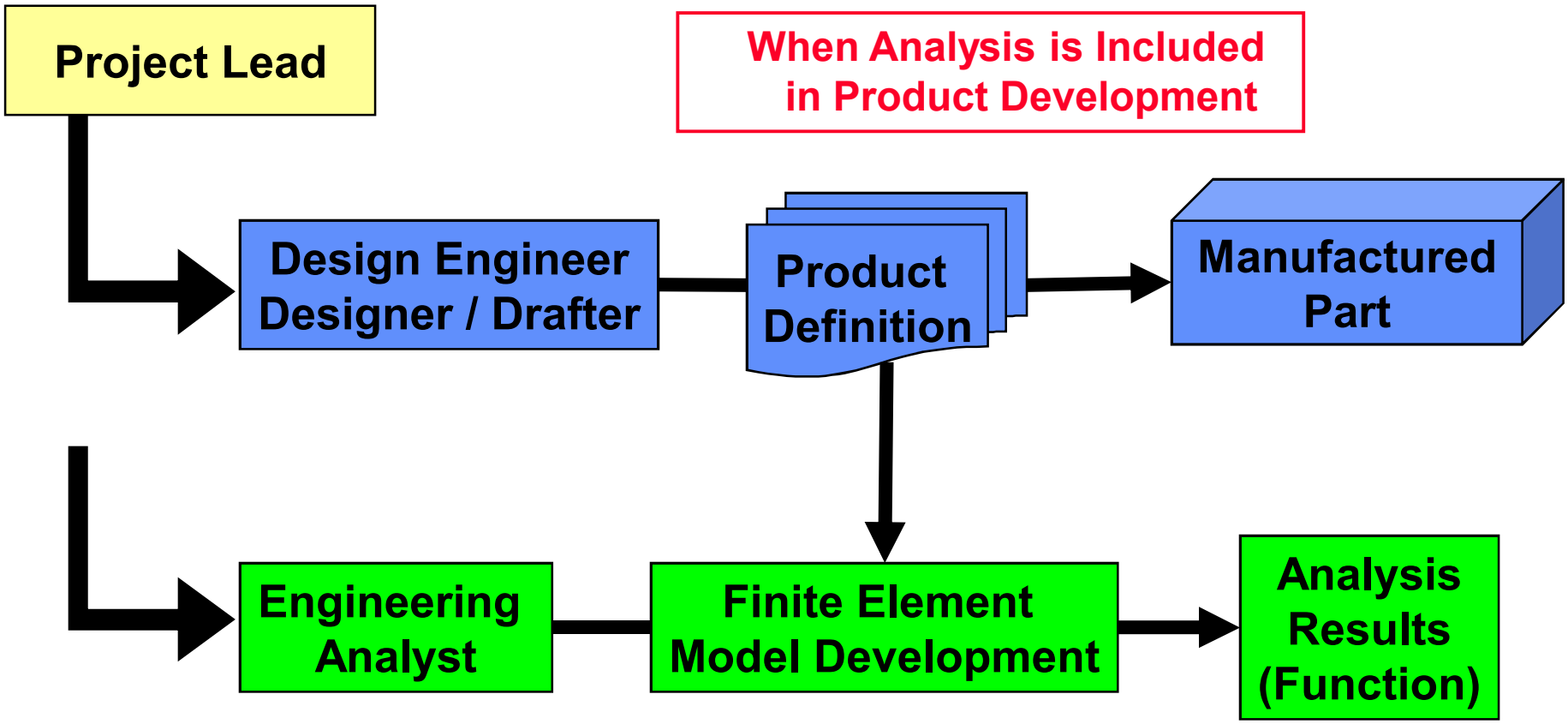
Current State of Practice: Design



- Are Basic Design Requirements being met?
  - Fit … Yes – Through the use of ProEngineer CAD Software
  - Form … Yes – ProEngineer
  - Function … Maybe – But Typically Requires Analysis to Verify

- Mechanical Analysis early in the design cycle is not a common feature of Product Development at Sandia Labs.

Current State of Practice: Analysis Follows Design



- Analysis is at the End of the Process
  - Used to verify design requirements are met (Function)
  - Analysis Does Not Typically Drive Design Decisions

Strategies for Implementing Design Analysis in Product Development

Strategies Presented at NWC – MBIT Conference
Santa Fe, NM, October 2005

1. ***Show Value Added by Analysis***
   Convince Design Engineers to integrate Analysis into their product development process.

2. ***Form New Teams***
   Analysts / Designers / Design Engineers

One Example Project – FY06

3. ***Leverage Knowledge and Expertise – R & D Applications***
   Use Research & Development experience as leverage for new products.

4. ***Think Differently***
   File Sharing / Concurrent Design – Analysis / Minimize Tradition

Three Example Projects – FY06

5. ***Find a Pilot Project – or 3 Projects***

Examples Later

Proposed Framework for Implementing Design Analysis – Key Attributes

Desired Attributes for a Design Analysis Framework – October 2006

1. ***CAD File Configuration Management:***
   - **Version Control – Baselining of intermediate stages**
   - **File sharing (Check-out – Check-in) for in-progress work**
   - **Enable Dual Use of CAD Files – Design and Analysis**

2. ***Timely Analysis Methods* – to Drive the Design Decisions**
   - **Analysis models are linked to Design Models – For Design Updating**
   - **Solutions verify Function – Assume Form and Fit are verified by CAD Tool**
   - **Turnaround times must be reasonable**

3. ***Analysis Process Management:***
   - **Dependency Tracking – Results / Models / Design Iteration No.**
   - **Workflow Integration – Enable ALL analysis tools to work together**
   - **Visible Processes and Verifiable Results – for auditing, peer review, and for future product re-development.**

3 Example Projects – FY 2006

To Illustrate a Design Analysis Framework

Design Analysis Framework Attribute	Pilot Project Name
1. CAD File Configuration Management	PDM Link Investigation
2. Timely Analysis Methods	Actuator Product Development
3. Analysis Process Management	Random Vibration Simulations using Nastran within the Analysis Process Controller – DART Toolset

Disclaimers:

- **The example projects were conducted as part of ongoing efforts and were not created specifically to illustrate Design Analysis Strategies.**
- **It would be ideal to describe the synthesis of all three aspects of the proposed Design Analysis Framework within a single project, but this has not been accomplished.**

PDM Link Investigation Project

1. CAD File Configuration Management

January – April 2006

- A Designer and Analyst Team was asked to investigate the "out-of-the-box" capabilities of the PTC Software Product, PDM Link, for managing ProEngineer CAD files.

Summary Highlights – Comments from the Investigators

- PDM Link does an excellent job of tracking ProEngineer files.
- Easy to check-in, check-out, or look for updated files.
- The tool mimics the usual way of sharing folders (but with PDM Link the design team is now following CM practices).
- File Version can have many states (In Work, Released, Cancelled) upon check-out of the ProEngineer CAD files.
- A baseline is created for every file version.

PDM Link Investigation Project

1. CAD File Configuration Management

PDM Link creates automatic baselines of entire ProEngineer structure upon check-in (SOLVES HUGE PAIN FOR DESIGNERS)

Baseline structure includes all subordinate files with their version ID's

Model Structure Report (15 of 15 items)

Expand One | Expand All | Collapse | Show Parts | Hide Parts | Save | Add to Workspace | Promote | Move | Configuration | Refresh | Single Level Report | Multi Level Report

Model Tree	Number	Version	Suppressed	Dependency Type	Placed	State
ans1-a05-sh28-00-unc.asm	ANS1-A05-SH28-00-UNC.ASM	A.4				In Work
ans1-a05-sh3-00-unc.asm	ANS1-A05-SH3-00-UNC.ASM	A.1	false	Membership	true	In Work
ans1-a05-sh6-00-unc.asm	ANS1-A05-SH6-00-UNC.ASM	A.1	false	Membership	true	In Work
ans1-a05-sh5-00-unc.asm	ANS1-A05-SH5-00-UNC.ASM	A.1	false	Membership	true	In Work
ans1-a05-sh12-00-unc.asm	ANS1-A05-SH12-00-UNC.ASM	A.10	false	Membership	true	Released
ans1-a05-sh23-00-unc.prt	ANS1-A05-SH23-00-UNC.PRT	A.2	false	Membership	true	In Work
ans1-a05-sh24-00-unc.prt	ANS1-A05-SH24-00-UNC.PRT	A.1	false	Membership	true	In Work
ans1-a05-sh25-00-unc.prt	ANS1-A05-SH25-00-UNC.PRT	A.1	false	Membership	true	In Work
ans1-a05-sh27-00-unc.asm	ANS1-A05-SH27-00-UNC.ASM	A.1	false	Membership	true	In Work
ans1-a05-sh30-00-unc.asm	ANS1-A05-SH30-00-UNC.ASM	A.4	false	Membership	true	In Work

Each file has unique version

File State is not uniform

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Actuator Product Development

2. Timely Analysis Methods

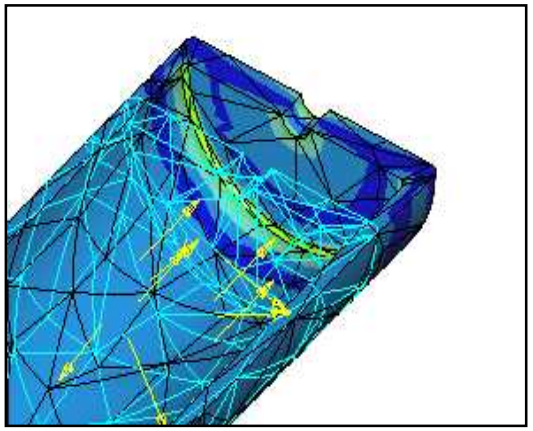
July – August 2006 – Actuator Product Development Analysis:

WHAT	*WHY*	*HOW*
1. Linear Stress Analysis of Individual Parts	To verify functional requirements	Mechanica – Integrated with ProEngineer
2. Optimize using stress as objective function	To reduce the mass	Mechanica – to find optimal configuration
3. Create high fidelity solid mechanics FE model.	To perform integrated assembly analysis using Abaqus.	Analysis model created from ProEngineer files within Patran.
4. Evaluate design through a transient dynamic simulation.	To confirm functional requirements on final configuration. To optimize parts that behave non-linearly.	Transient dynamics analysis with Abaqus-Explicit.

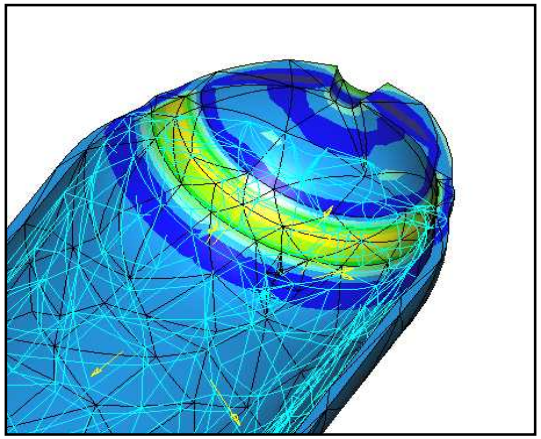
Actuator Product Development

2. Timely Analysis Methods

Static Stress Analysis – Mechanica



Original design



New Design

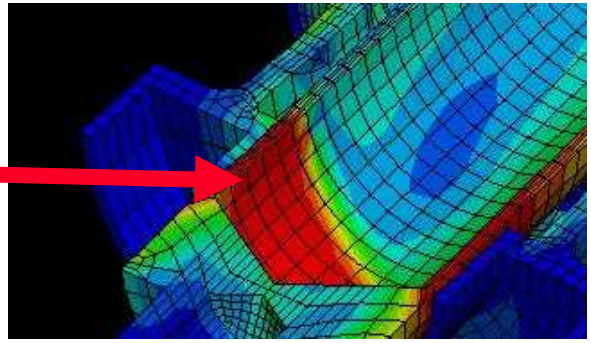
- **Linear Stress Analysis and Mass Optimization – Mechanica**
  - **3 Design Iterations**
  - **Approximately 1-week turnaround per iteration, including automatic updating of the ProEngineer CAD files**
- **Actuator Assembly Mass Optimization:**
  - **Original = 2.25 lbs**
  - **New = 0.99 lbs**

Actuator Product Development

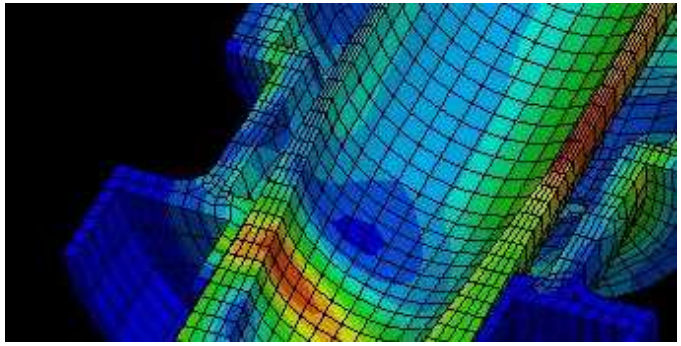
2. Timely Analysis Methods

Dynamic Simulation – Abaqus-Explicit

Local region of in-elastic strain.



Original Design



New Design

Transient Dynamic Impact Simulation in Abaqus

- To Confirm Functional Requirements of Assembly.
- To Optimize certain parts that were not optimized through linear stress analysis.
- Approximately 4-hour simulation time pre run. Several runs were required to understand parameter sensitivity. 2 Week Turnaround.

Peak Stress Fringe Plots

- Original Design – Von-Mises Stresses were above yield – locally.
- New Design – Von-Mises Stresses well below yield.

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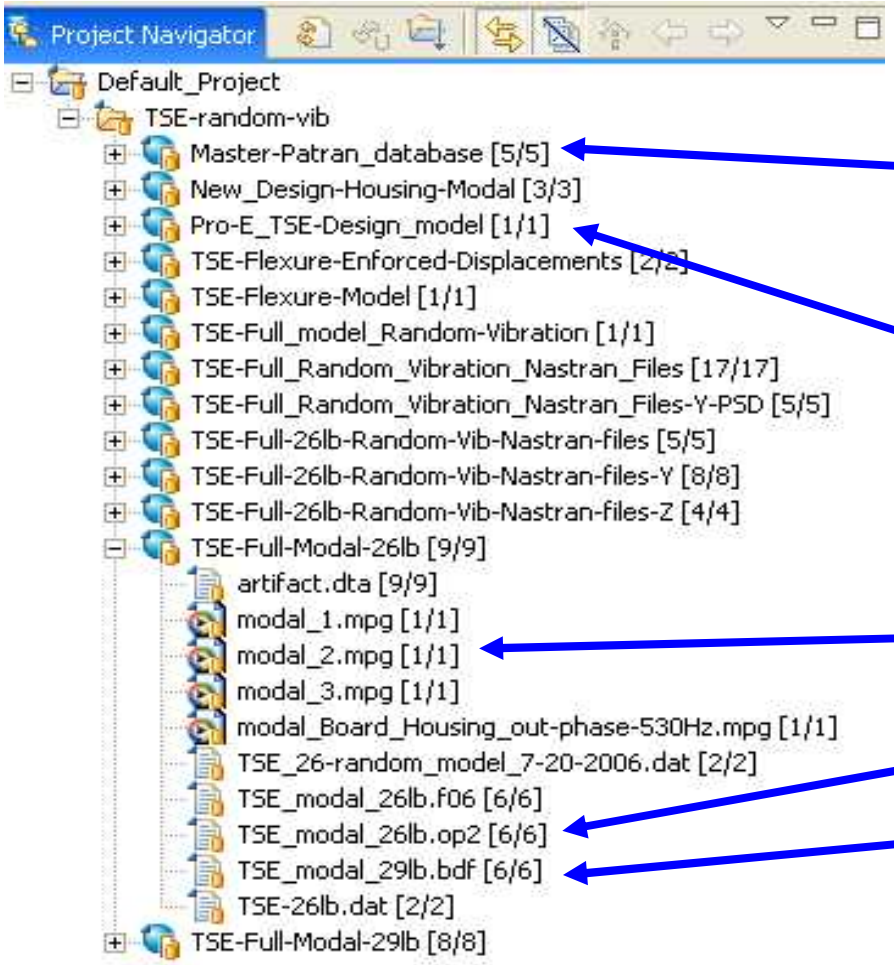
Nastran Simulations within the APC

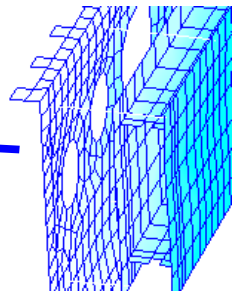
3. Analysis Process Management

July – August 2006 – Random Vibration Simulations

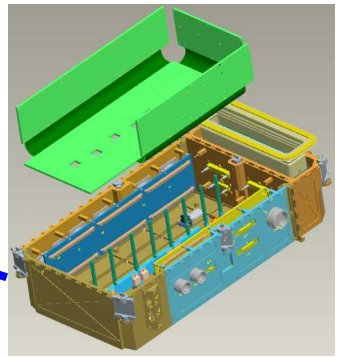
DART – Analysis Process Controller – Folder / Artifact Structure



Analysis Model



Design Model



Animations

Results Files

Input Deck

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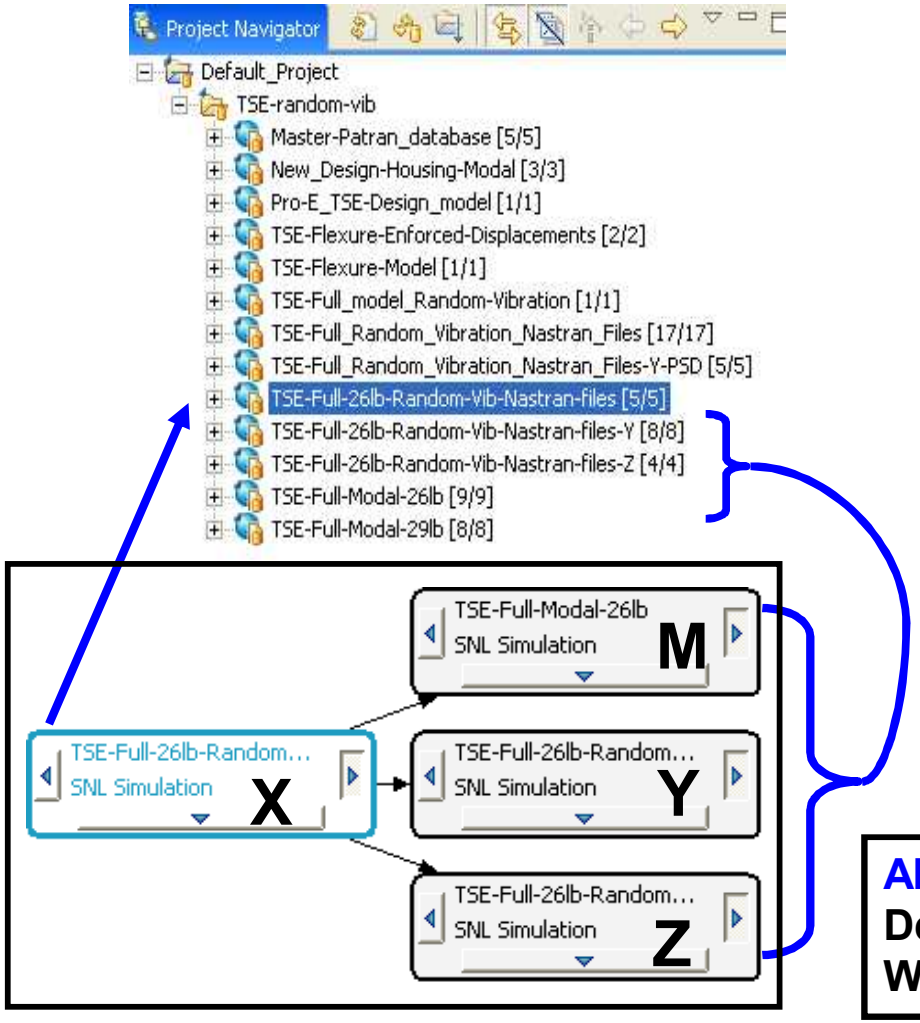
Nastran Simulations within the APC

3. Analysis Process Management

DART – APC – Dependency Tracking



- **Initial Simulation Artifact:** Random Vibration Analysis Input Deck for X-Direction.
- **Derived from Initial Artifact:** Analysis Input Decks for
  - Y direction Random Vibe.
  - Z direction Random Vibe.
  - Modal Analysis

APC Artifact Dependency Window

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Nastran Simulations within the APC

3. Analysis Process Management

DART – APC – Engineering Notebook

Engineering Notebook | Progress | Dependency Viewer | File Locations | Machines | Resource History

TSE_modal_29lb.bdf

Revision	Date	Author	Comment
***6**	**9/13/06 10:15 AM**	**sdbrook**	**Orginal design with the corrected ribs in the housing**
5	8/16/06 9:06 AM	sdbrook	Changed the number of modes to 200 going over 1700 Hz
4	8/4/06 1:48 PM	sdbrook	same changes as 29 lb modal
3	7/26/06 1:45 PM	sdbrook	Changed to 123456 DOF fixed
2	7/26/06 9:35 AM	sdbrook	changed the include statement to point to the 26lb model dat file
1	7/26/06 9:34 AM	sdbrook	copy from 29lb modal model

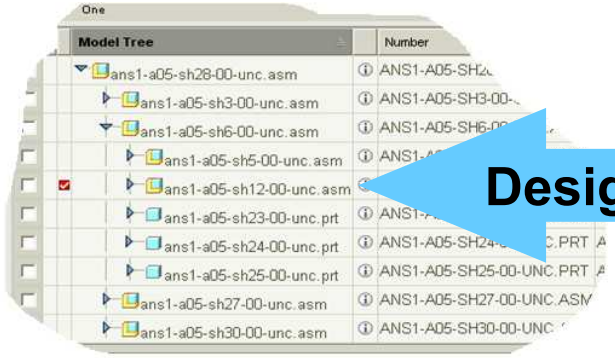
Typical "Note to Self" in Engineering Notebook

Comments to Justify Revisions

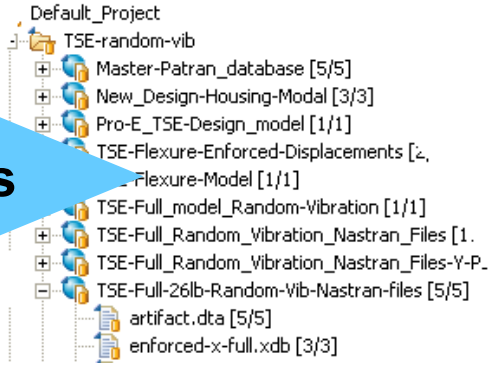
apc29677

```
This is the full model ran on Tesla
to run on Tesla type nastran <filename> memory=4Gb
```

Design Analysis Framework Synthesis



Design Baseline used for analysis

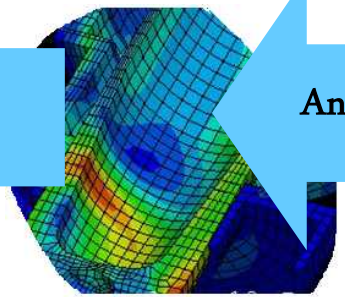


Design Data Management

Analysis Data Management

Design Change

Analysis Results



Design Tools & Process

PDM-Link

Analysis Tools & Process

DART – APC

Design Impacting Analysis & Analysis Impacting Design

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Summary
To Implement Design Analysis …

We Need Guiding Strategies – Presented 2005

- ***Show Value Added by Analysis – Design Engineer & Analyst Roles***
- ***Form New Teams – Design Engineer / Designer / Analyst***
- ***Leverage Knowledge and Expertise – R & D Applications***
- ***Think Differently – File Sharing / Design + Analysis / Minimize Tradition***
- ***Find a Pilot Project***

We Need a Framework – Proposed 2006

- ***CAD File Configuration Management – for baselining, file sharing, etc.***
- ***Timely Analysis Methods – to guide the designs***
- ***Analysis Process Management – for tracking, verification, etc.***

We Need Integration Tools

- ***PDM Link – for Design Data Management***
- ***Timely Analysis Methods Linked to Design Data***
- ***DART - APC – for Analysis Data Management***