Getting Useful Ship Design Data for Analysis
Agenda

Introduction to ATA Engineering
Example challenges with getting data for analysis
Five annotated examples for discussion
ATA Has More Than 35 Years Providing High-Value Engineering Services
ATA Has Performed SBIR Projects With Multiple Navy Commands

NAVAIR

N108-025: Strain Sensor Calibration of Fleet Aircraft

NAVSEA

N091-052: Automated Transition Of Product Model Data For Ship Design

MARCORSYSCOM

N142-088: High Efficiency Insulating Barrier for Expeditionary Shelters

SSP

N141-082: Toolset For Nonlinear Prediction Of Woven Ceramic Matrix Composite Material Performance
Post-Damage Kinematic Simulations for Operational Effectiveness Evaluations

Technology Explanation

- Use FE modeling approach to simulate post-damage kinematic response of a complex mechanism (submarine hatch)
- Continued validation of the methods will be accomplished through a series of increasingly complex mechanism tests
- Implementing artificial neural networks (ANNs) as fast-running surrogates for FEA

Product Benefits & Applications

- Reduce reliance on UNDEX testing and allow engineers to evaluate a multitude of postevent mechanical scenarios for hull, equipment, machinery, and platform damage
- Using independent domains for structural and contact regions enable more control of mesh fidelity for each region
- Applicable for wide range of industries/Abaqus users to enable more efficient simulations

Contract Details

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TPOC: Randall Goodnight (NSWCCD)
ATA has worked with Navy and Industry to automate the translation of ship product model data.

- ATA developed ShipPDX™ software under this contract:
  - Flexible framework for mapping data among multiple design systems
  - Expandable methods for data extraction from source, insertion into target
- ATA continues to invest internal research and development into its concepts and capabilities:
  - Read additional data from ShipConstructor
  - Write piping and structure data to ShipConstructor
- Technologies to translate ship design data can also help make useful data available to analysis codes.
Getting Useful Data for Analysis Presents Many Challenges

[1] Cannot get useful geometry for a ship product (deck, bulkhead, foundation, etc.) from design to analysis
[2] Can get geometry, but not attributes / properties
[3] Must identify materials & associate to all analysis items
[4] Hard to get connection details – e.g. welds & bolted joints
[5] Get mass properties into analysis code
[6] Valuable data available in legacy design & solver formats – how to use them?
[7] Software not integrated (design/analysis, vendor/supplier, multiple analysis tools)
[1] Cannot Get Useful Geometry for a Ship Product from Design to Analysis

- Geometry as modeled for design can be hard to use for analysis – parts don’t connect – gaps and overlapping surfaces
- Hard to get connected midsurfaces or connected beam centerlines
- Too many holes or other cut details included in geometry
- Weld locations and connection details undefined in geometry
- Design tool is not set up for easy export of surface or solid geometry to analysis tools
- Geometry is lost in translation – tolerances or other errors
- Curved surfaces don’t transfer properly
- Need to add auxiliary geometry or data for model or boundary conditions – waterlines for example
- Configuration of the ship needed for analysis
Example 1: Get Shell or Beam Model of Complex Foundation – Past NSRP example

Challenge:
Need a useful shell or beam model.
Need to take maximum advantage of work already done by CAD modelers.

Source:
*Improved Methods for the Generation of Full-Ship Simulation Models,*
NSRPComplex_Foundation.stp
Example 1: Geometry Flaws & Design Details Hard To Handle Automatically

Design data translated from STEP
Does not have useful beam centerlines or midsurfaces – lots of abstraction needed.
What are the weld details?
Connection points?
Can be challenging to automate
Example 1: Midsurfaces Generated Automatically Using Femap

- Representative midsurfaces automatically generated
- Still need cleanup to extend and join them for a connected shell model

Femap command: Geometry, Midsurfaces, Automatic
Example 1: Many Possible Methods and Automations Could Improve the Process

- Model or extract useful analysis geometry as part of the design tool process?
- Improved analysis tools for beam center line abstraction?
- Improved analysis automation tools for beam generation from design data?
- Midsurfacing works well for complex foundation example in Femap but some efforts are required to connect and stitch and handle overlapping – tools exist to help the analyst but not automatic – increased automation?
- Check NSRP Panel Project – Femap Shipbuilder Toolbox NSRP Joint Panel Meeting, September 10, 2013
- Check Femap Meshing Toolbox which has picked up several enhancements
Example 1:
Use the Femap Meshing Toolbox to Extend Gaps or Align Midsurfaces.
Example 1: Generate Beam Centerlines

Use the “CG of Surface” method to generate beam centerlines quick on stiffeners… then consolidate the lines

Future automation: Loop over all parts to attempt to identify beam cross sections and extract centerlines.
Example 2: Can Export Geometry from ShipConstructor Drawing to FEMAP...

No direct method known to get identifier & attribute data from ShipConstructor to FEMAP or other analysis tools
Use some existing translation methods to make one?

Can get volume geometry from STEP data but not body or part identifiers or attributes to relate to design data
Example 3: Revisiting Legacy Model – Existing Sub Analysis

Reuse data from an existing analysis model for a new design or analysis interest

Image shows results from .odb file in Abaqus CAE

Simulation_Models.zip
Example 3: Legacy FEM Found – No CAD, Incomplete, but Shell Elements Exist

- Abaqus model is undex_driver_xpl.inp
- Beam Section properties are missing from input files – appear to have been in “include” files whose type (.bsp) was not included in project archive
- Shell regions are available (shown) – how can we use them?
Example 3: Generate Geometry From Legacy FEM in FEMAP – Process

1. Obtained the **surface elements** from the Abaqus .odb file and exported those to Nastran

2. Automatically generated **groups** using FEMAP commands for grouping elements – utilized the option to break on > 20 degrees to insure that separate groups are obtained for different plate parts

3. For large angle curved surfaces and cylinders, further manually broke up the groups to get <90-degree arcs

4. Wrote a macro to generate surfaces for each of the groups using “Geometry, surface, face from mesh”
Example 3, Step 2: Auto-Generate Groups in Femap

Select Entire Mesh

- Entity Selection - Enter Element(s) to Select
  - ID
  - Group

- Model Segments
  - Element Types
    - Planar
    - Solid

- Attribute Breaks
  - None
  - Property ID
  - Material ID

- Geometric Breaks
  - None
  - Angle Between
  - Maximum: 20

- Group Expansion
  - Elements Only
  - Elements and Nodes
  - All

- NonManifold Edges
Example 3, Step 4: Run Femap Macro to Generate Surfaces from Element Groups

First make sure surfaces are <90-degree arcs and are not non-manifold
Example 3: Generate CAD Geometry From Legacy FEM Shell Elements
Example 3: Generated Nose Dome Geometry Can Be Used for New Mesh

- Geometry generated from legacy FEM is quite accurate. Could be re-meshed for new FEM.

- Technique may be especially useful for getting geometry from design codes that don’t export CAD surfaces, but do export surface meshes.
Example 4: Get Auxiliary Data to Analysis Codes – Ideas

1) Get mass and other property data from components to analysis codes for comparison to modeled regions

2) Get geometry with unique identifiers to analysis code for comparisons
   - Use the unique identifiers to verify or check material or other data useful for analysis
   - See Example 2

3) Get weld connection details to the analyst
   - Analysts really need it
   - Currently really hard for them to get it
Example 5: Get FE Data to Exodus II for Advanced Solvers

• Get advanced solver input and data from commercial tools to Exodus:
  ▪ Navy Enhanced Sierra Mechanics tool suite (NESM) uses Exodus II for input
  ▪ Cubit (for example) can read some element types from Nastran or Abaqus and write Exodus

• Is there current interest in getting FE data more directly to Exodus for ship analysis?
Example 5: Generation of Exodus File

Cubit can import some mesh types from Nastran and Abaqus and can export Exodus files....
Conclusions

There are lots of challenges to get useful ship design data for analysis. Some annotated examples have been discussed for further possible exploration or development.

In addition to automation of the transition of product model data, ATA is interested in helping with methods, software, and skills that could help our maritime customers use valuable design and legacy model data to perform simulation early in design cycles.

Future Work Ideas: Acquiring useful design data for analysis
Translate geometry and data from ShipConstructor to Femap
Methods of modeling midsurfaces and beam centerlines as part of the design for ease of use
Further automation to help with shell and beam modeling
Getting advanced solver specific FE format - Translate to Exodus
High-Value Test- and Analysis-Driven Mechanical Engineering Design Solutions

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Visit us at www.ata-plmsoftware.com to see how we can help you meet your software needs.

And connect with us on LinkedIn.
Autonomating the Transition of Product Model Data

**CONCEPT**

PLM Systems, Ship Design Tools, Databases, Text Files

ShipPDX™ software: Ship Product Data Exchange

Modular Architecture. Incrementally create/read LEAPS database.

**DESCRIPTION/REQUIREMENT**

**Requirement/CAPABILITY GAP:** Navy needs access to ship design data to allow analysis of conceptual and preliminary design and for logistical support of as-built designs. To date Navy has had limited success getting as-designed ship configuration into LEAPS. Current methods are manual, extremely time consuming and error prone.

**DELIVERABLE:** Specification of required data entity support (to/from LEAPS); prototype translator software “ShipPDX™”; validated test database; business plan for implementation, support, and maintenance.

**TRANSITION(S):** Following successful demonstration of prototype ShipPDX software, transition to licensed software and implementation of business plan for support, maintenance and customized implementation services.

**OBJECTIVE:** Near term: develop methods and tools to enable delivery of ship product model data to the Navy. Long term: enable sharing of product model data among shipyards and with Navy during all phases of ship’s life cycle.

**CONTACTS**

**Tech Sponsor:** NSWC – CD (Elizabeth Madden)

**Tech Transition POR/Path:** DON must specify

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**TWH:** none

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**Contractor POC:** Mr. Gregory W. Antal

**Contractor email:** greg.antal@ata-e.com

**FUNDING SUMMARY ($K)**

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