Ingalls Shipbuilding
A Division of Huntington Ingalls Industries

NSRP Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 2

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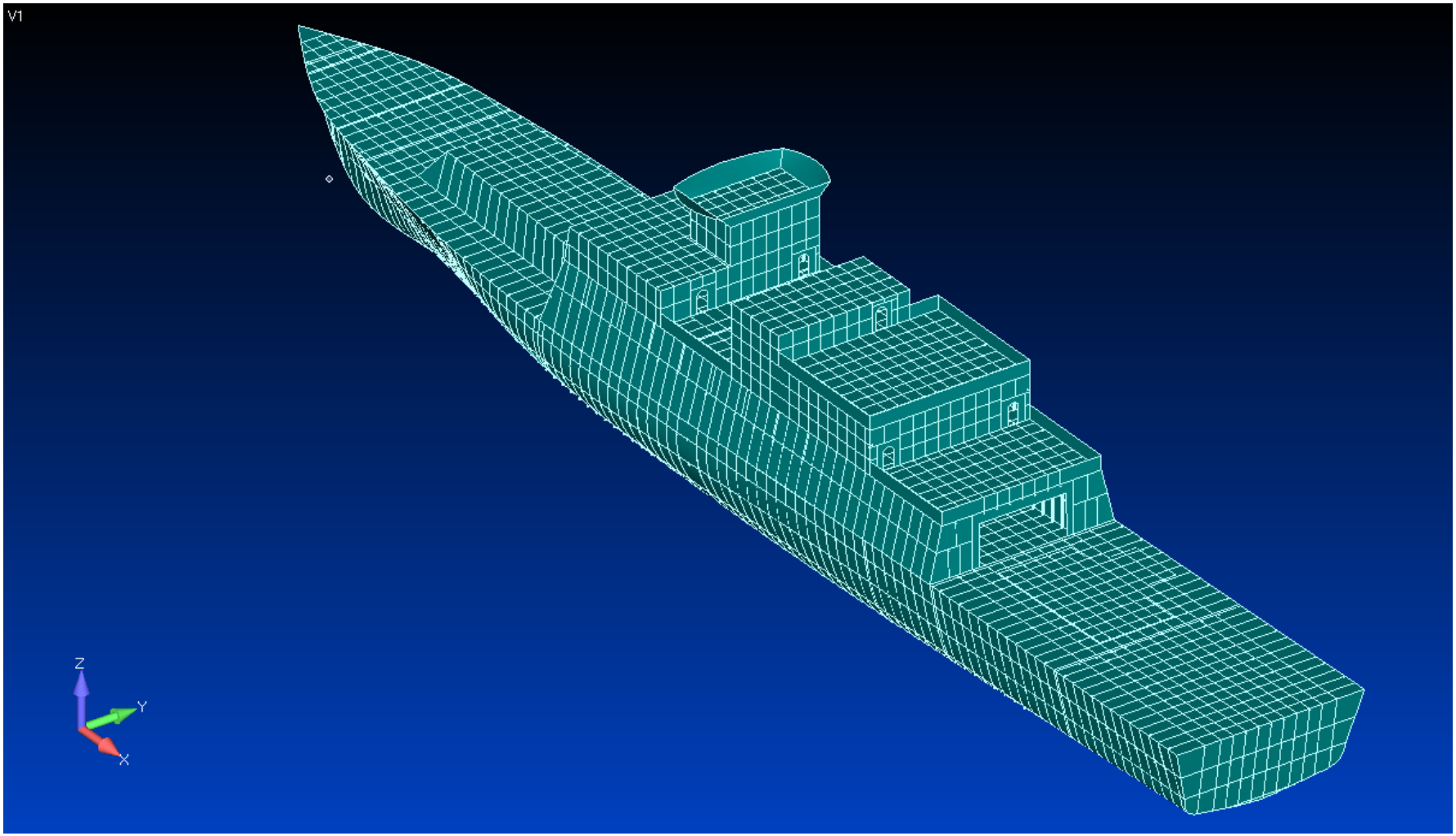
Introduction

- Since 2007, a team of shipbuilders and software vendors have been conducting two **National Shipbuilding Research Program (NSRP)** projects entitled ***Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 1 & 2 (M&S)***

- The objective of the two projects is to reduce the cycle time required to develop large scale, full-ship analysis models for strength, stress, shock, and acoustic simulations and assessment

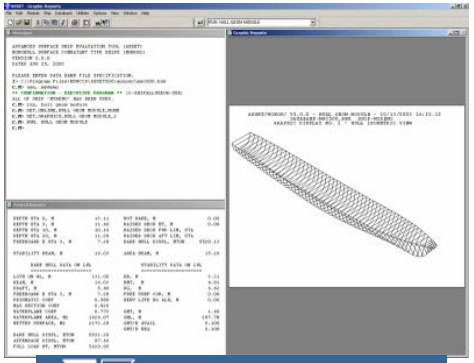
- The team consists of:
  - General Dynamics/Electric Boat Corporation (EB)
  - Huntington Ingalls Industries/Ingalls Shipbuilding (HII)
  - TechnoSoft Inc (TSI)
  - Dassault Systémes Simulia Corporation
  - Product Data Services Corp. (PDSC)

First Type of Full-Ship Simulation/Analysis Model

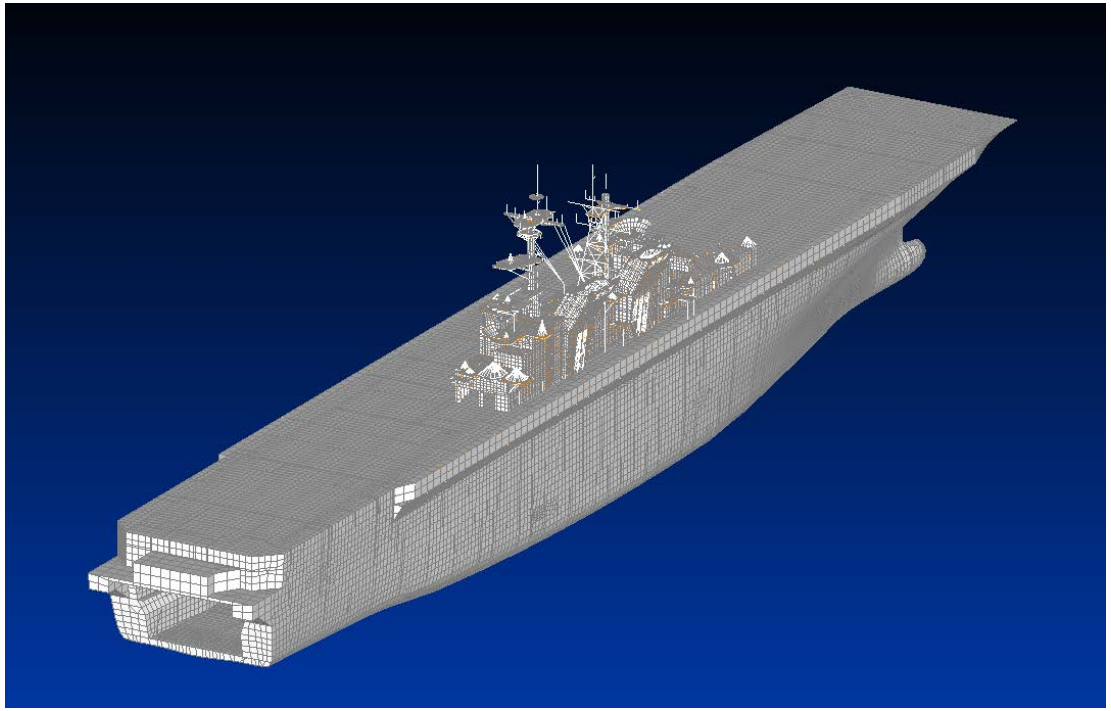


TechnoSoft AMWaves Tool Utilized

- **AMWaves** is a solution that is tailored to the Shipbuilding and Marine industry. It is an object-oriented, knowledge-based engineering modeling framework that enables multidisciplinary modeling and integration of the entire product and process development cycle.

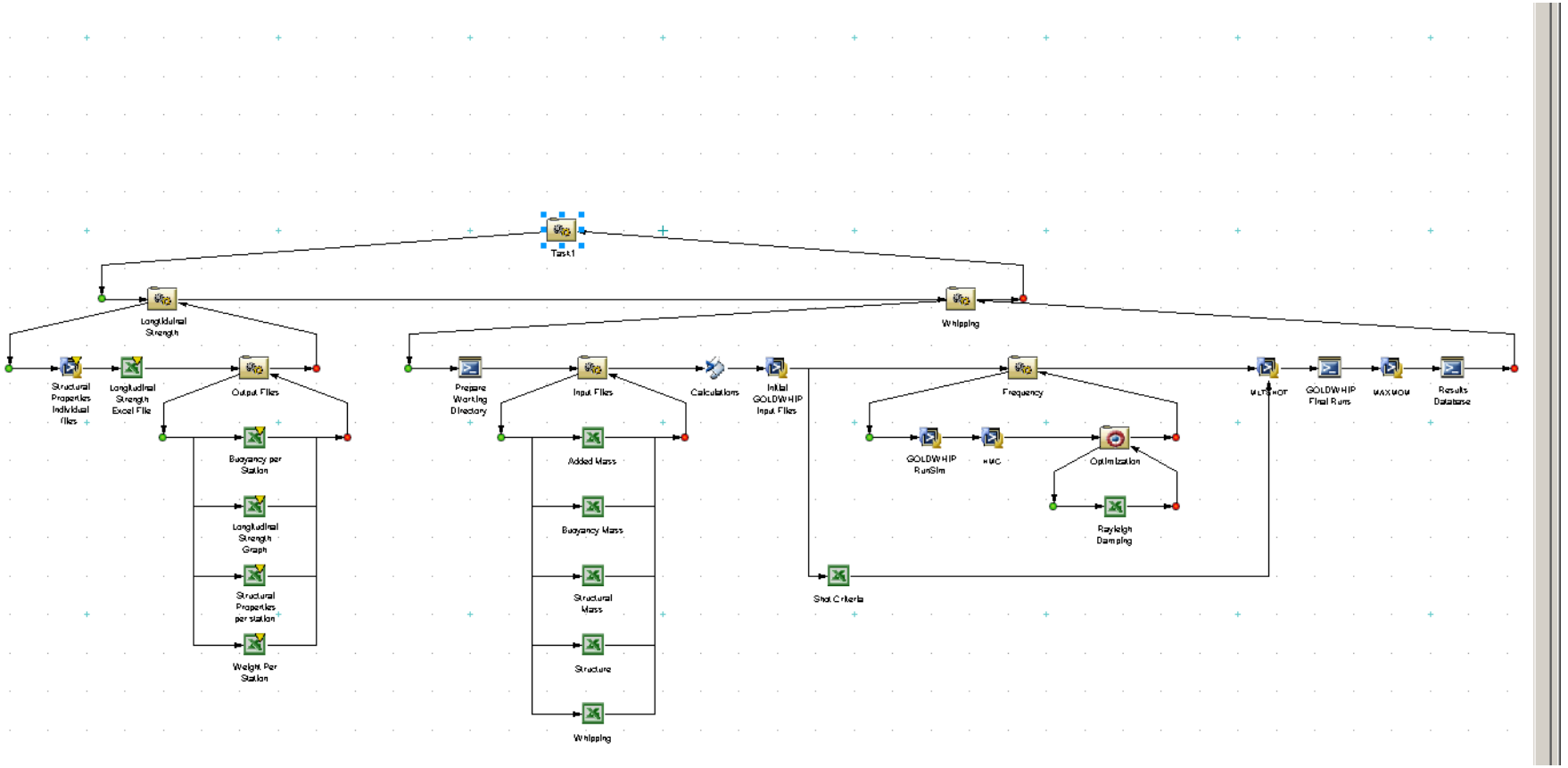


TECHNOSOFT
ADAPTIVE MODELING



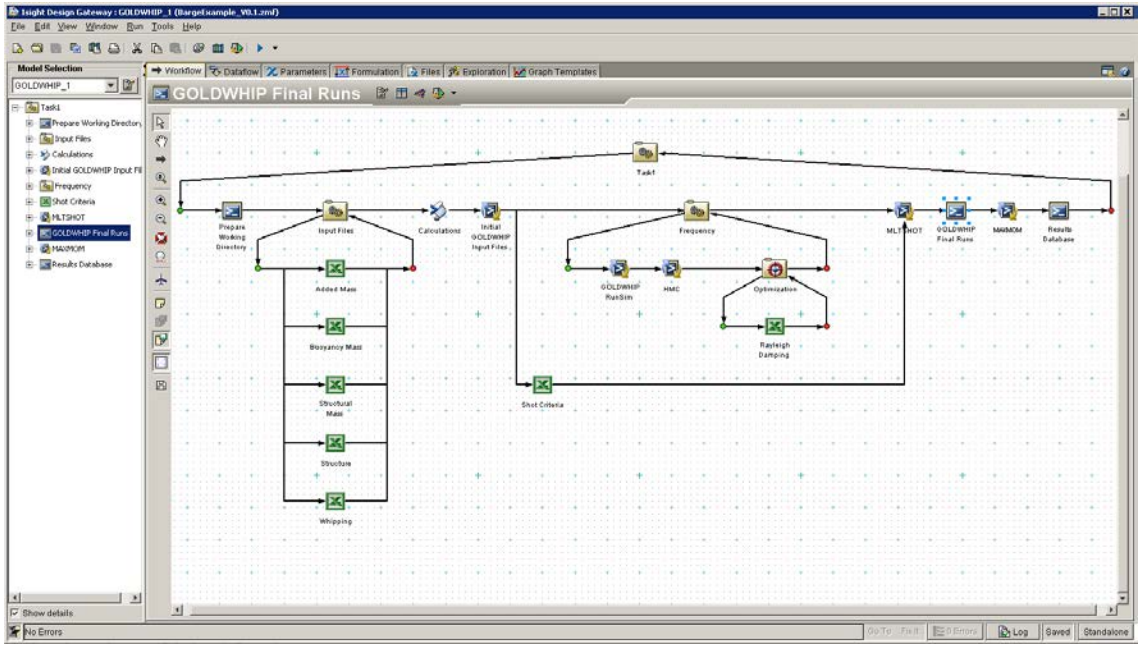
- Full-Ship Modeling from drawings
- LHD8 Full-Ship Benchmark

Second Type of Full-Ship Simulation/Analysis Model



SIMULIA Isight Tool Utilized

- **Isight** is a desktop solution that provides a suite of visual and flexible tools for creating simulation process flows—consisting of a variety of applications, including commercial CAD/CAE software, internally developed programs, and Excel spreadsheets—in order to automate the exploration of design alternatives and identification of optimal performance parameters



HII M&S 2, Phase 1 Project Efforts

- HII emphasized improvement of modeling processes using legacy systems and applications in the M&S 2, Phase 1 project

- 4 analysis data flows were modeled in Isight
    - Beam Model Development and Analysis
    - Whipping Analysis
    - Longitudinal Strength Analysis
    - Post Analysis Processing

- Concentrated on the Noise, Shock, and Vibration analysis business processes

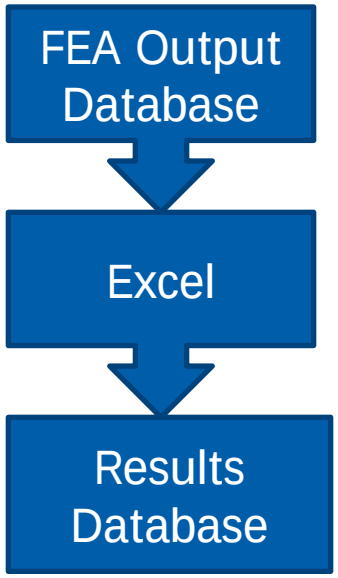
HII M&S 2, Phase 2 Project Efforts

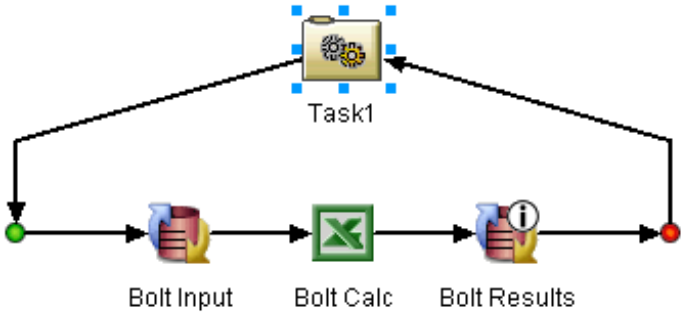
- Originally, 8 simulation data flows (Simflows) were proposed to be developed and evaluated during this phase of the project:
  - Bolt Calculation
  - Foundation Analysis
  - UERD Tools
  - Shipweight
  - Pipe Hanger Support
  - Rafting Foundation
  - Linearized Stress
  - Optimized Linearized Stress
  - 7 Complete, 1 still in development (expected to be complete by June 2011)

- As the project progressed, 3 Additional Simflows added and under development
  - Optimized Foundation Analysis
  - RCS Analysis
  - Full Rafting Analysis

Bolt Calculation Simflow

- This simflow is a Structural Analysis Legacy Process
- The objective of this simflow is to calculate the stress levels in the bolts of equipment based on the loading from the foundation analysis
- This simflow is intended to be a sub task of the overall Foundation Analysis Simflow

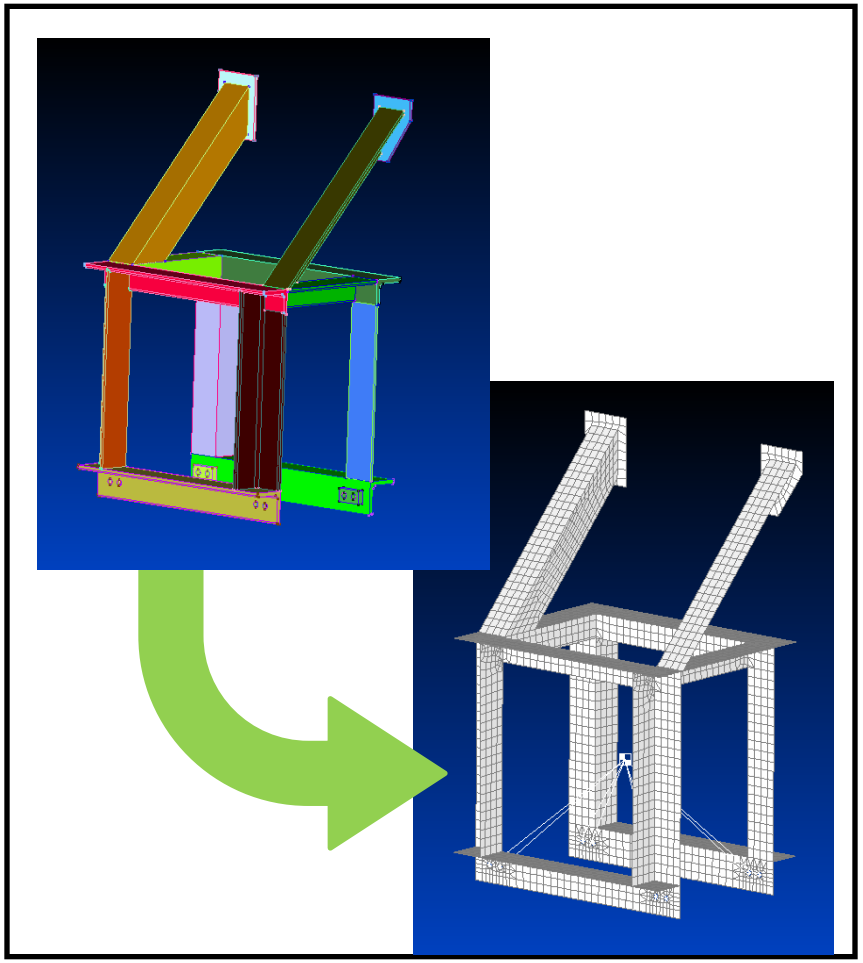




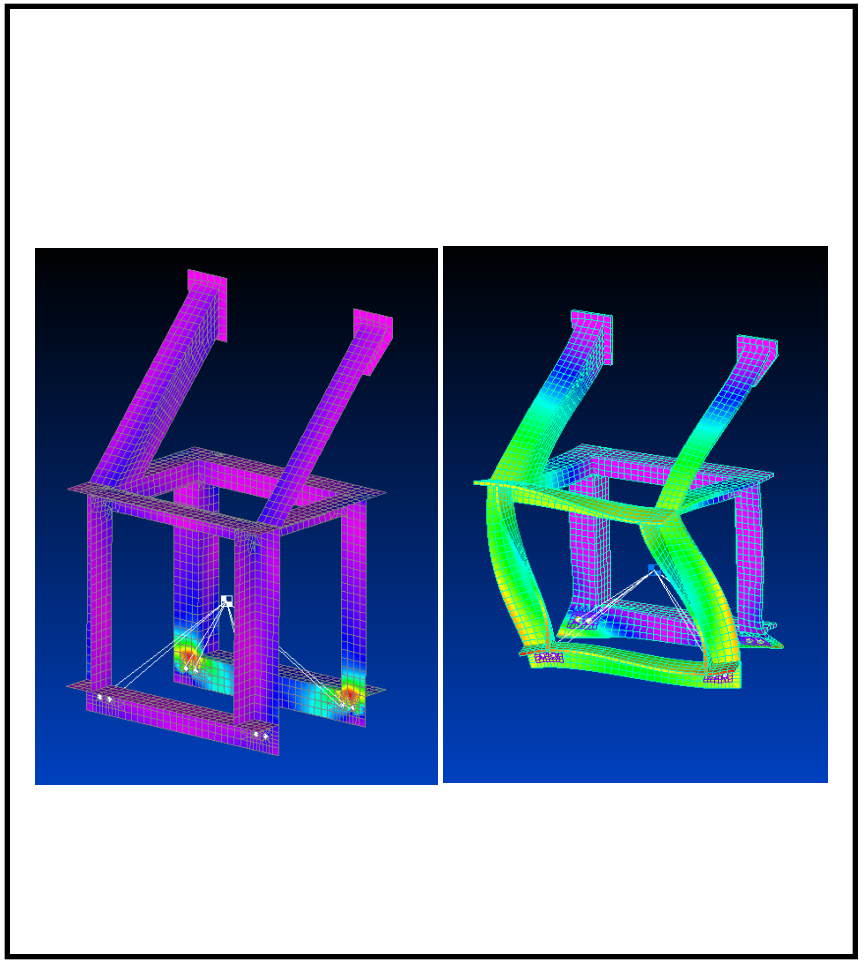
Foundation Analysis, Part 1 and 2

- Significant number of foundation models are built and analyzed for every ship
- Modeling and analysis requires the development of a Finite Element (FE) model from CAD data and then running that model through a series of analyses
- For the purposes of this project, the foundation process was broken into 2 parts
  - Foundation Part 1 – Model Development Improvements
    - Proof of concept being developed by Simulia
  - Foundation Part 2 - Analysis Processing and Results Evaluation
    - Isight Simflows being developed by both Ingalls Shipbuilding and Simulia

Foundation Analysis, Part 1 and 2



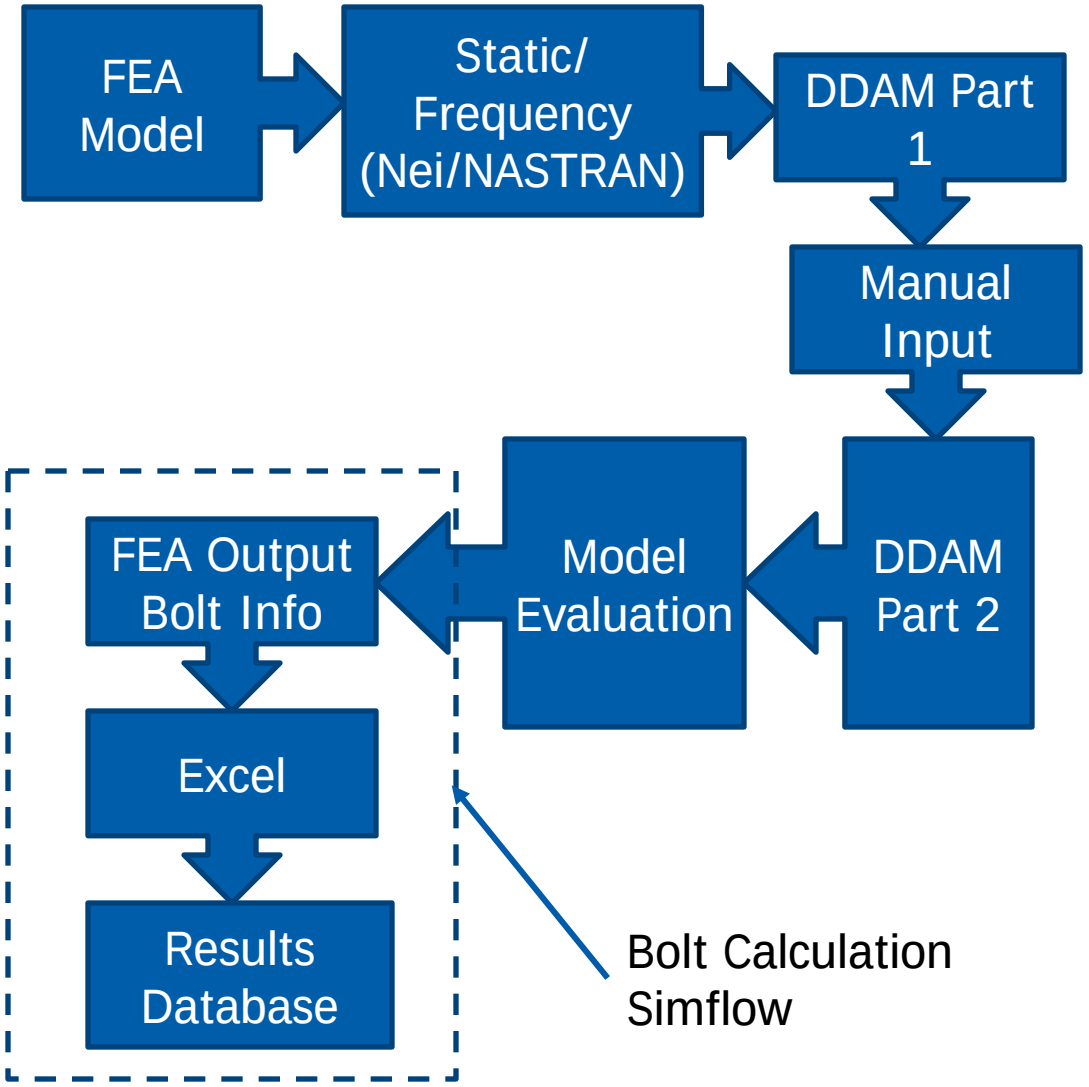
Foundation Part 1



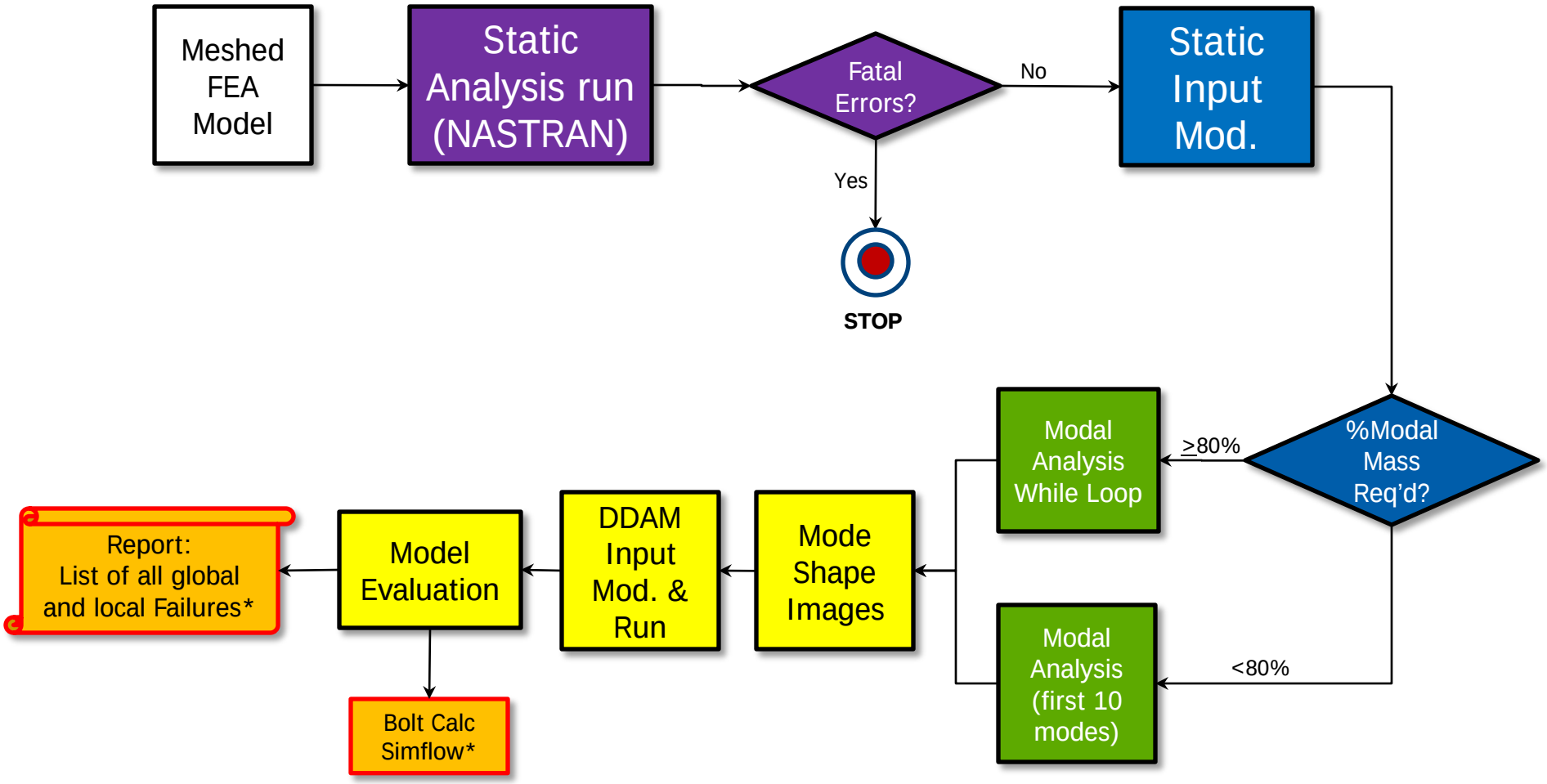
Foundation Part 2

Foundation Analysis Part 2 Simflow: Initial Simflow Layout

- This is a Structural Analysis Legacy Process
- The objective of the simflow is to streamline the foundation analysis process based on an existing FEA foundation model
- This simflow is the most advanced simflow we have worked on. It requires multiple evaluations and multiple analysis runs.

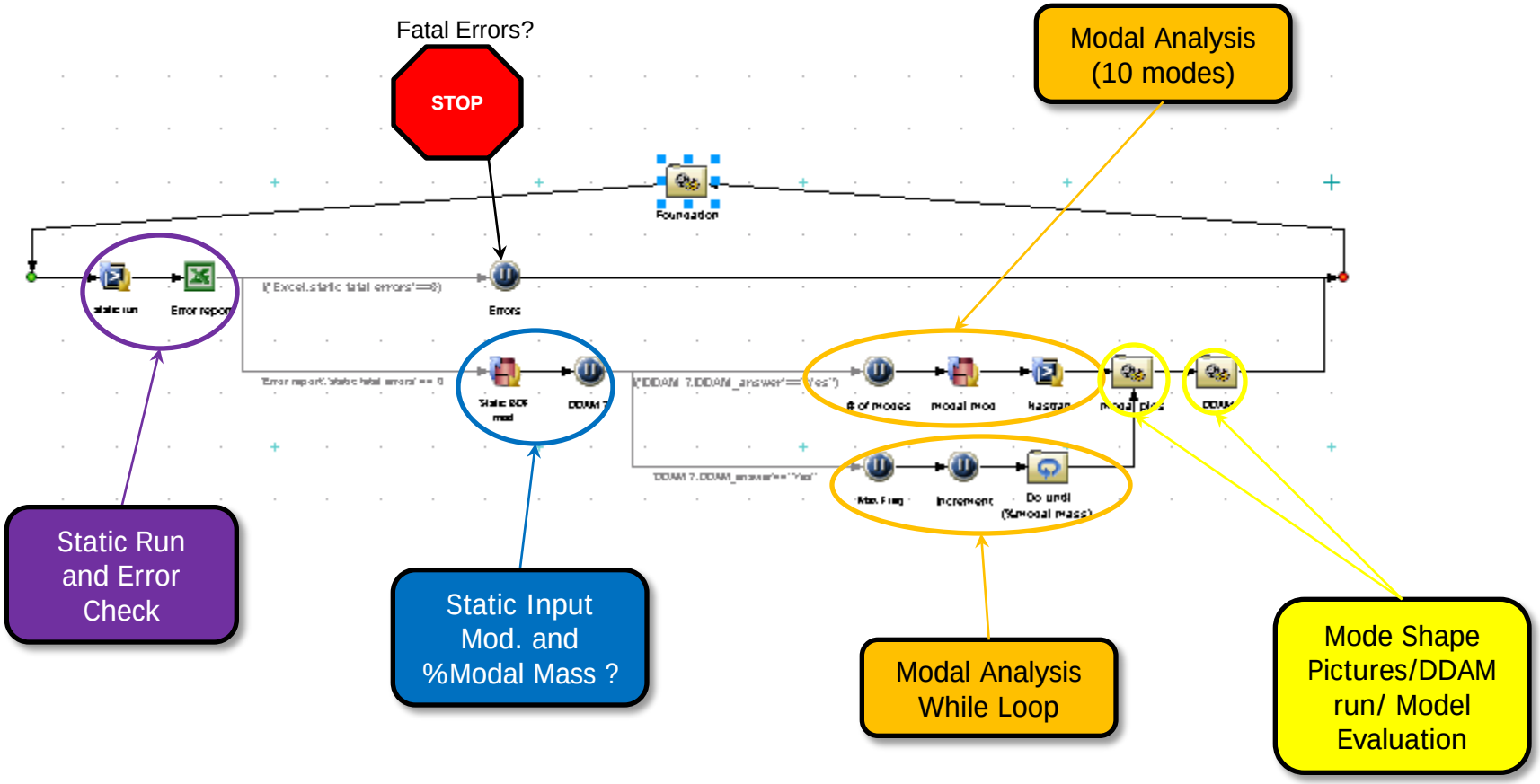


Foundation Analysis Part 2: Simflow Design



*These steps have yet to be fully incorporated

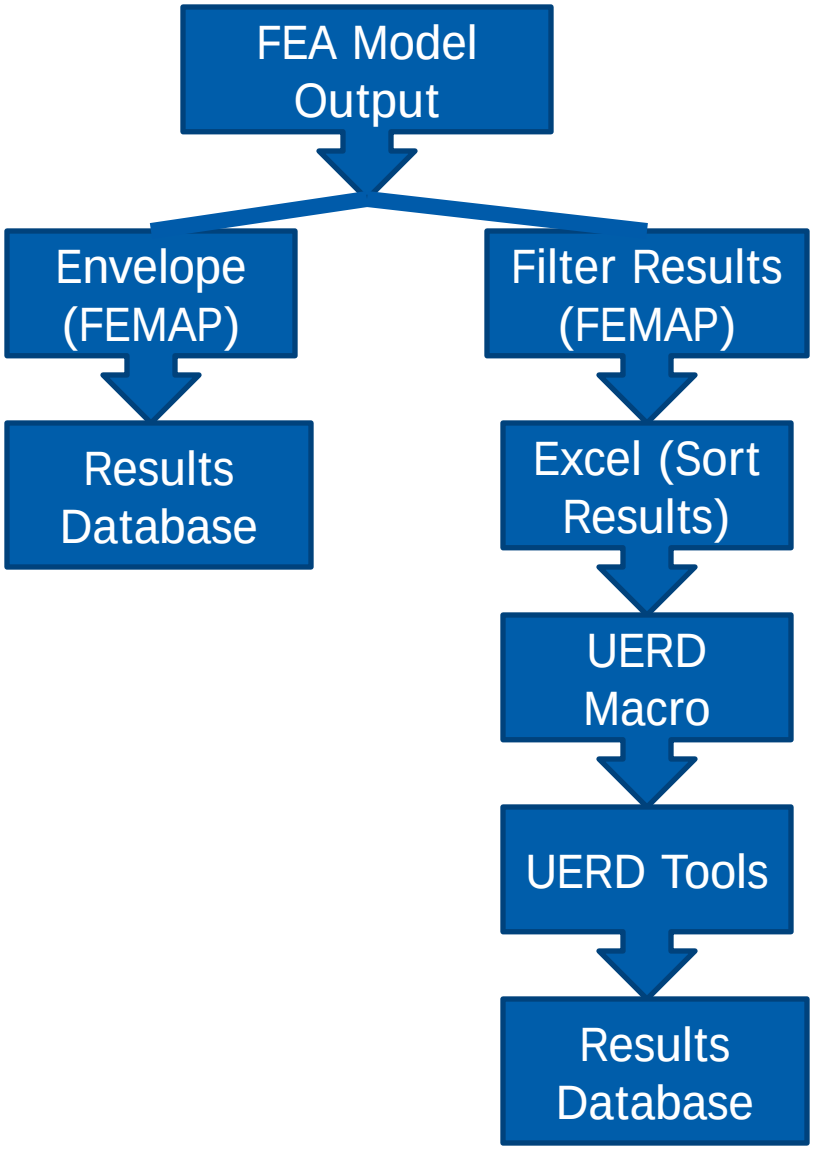
Foundation Analysis Part 2 Simflow: Model to Date



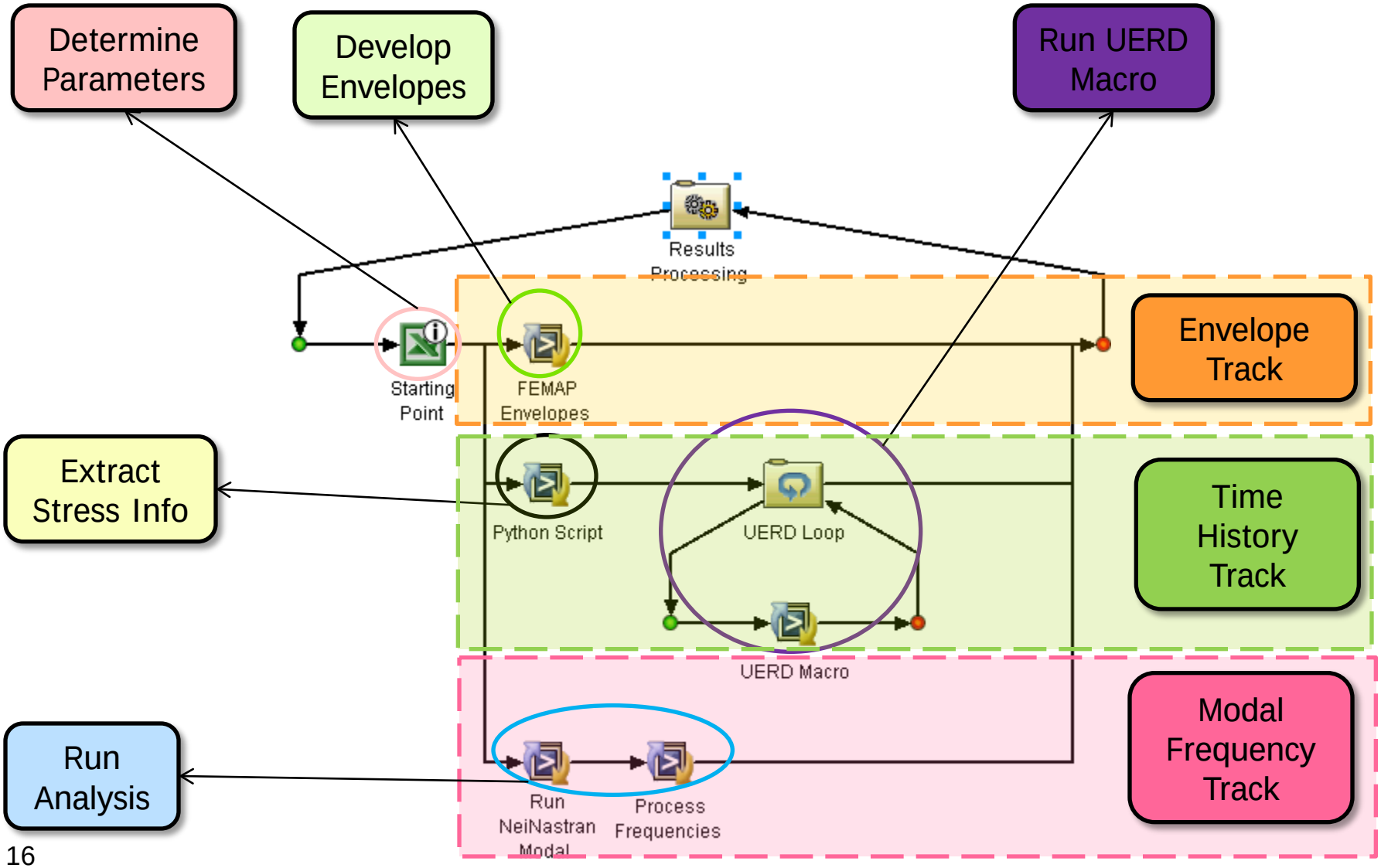
Current setup simply checks the maximum Von Mises stresses against the general global membrane allowable

Results Evaluation with UERD Tools Simflow

- This is a Shock and Vibration Analysis legacy process
- The objective of this process is to streamline the post processing effort of a transient analysis model and results

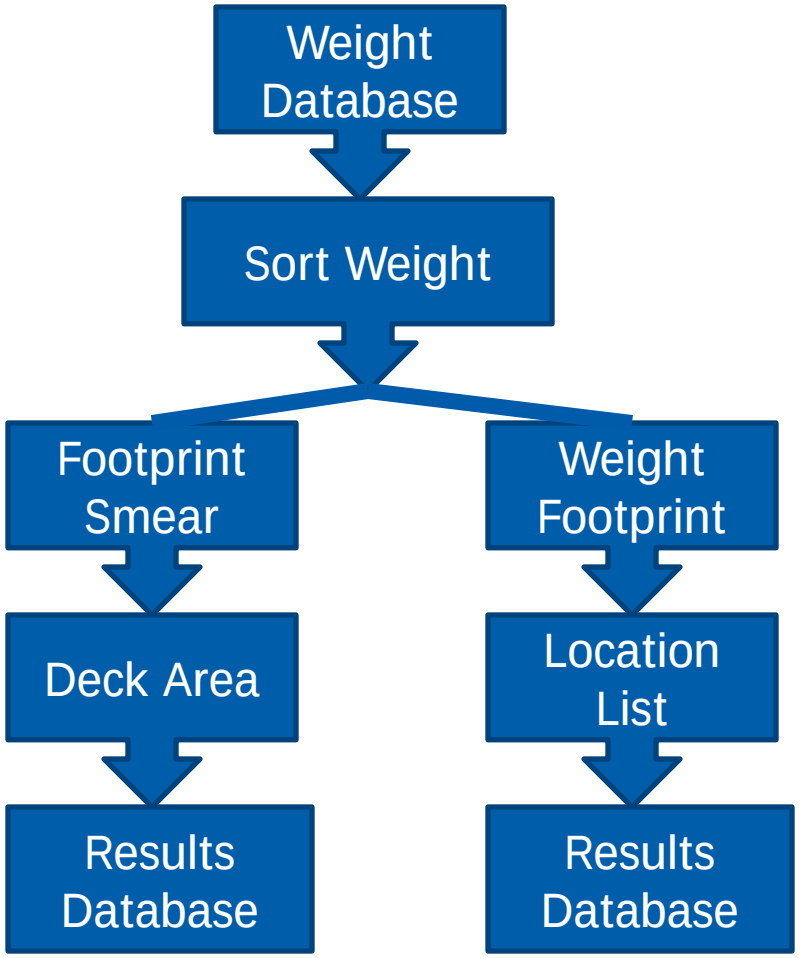


Results Post Processing



Full Shipweight Simflow

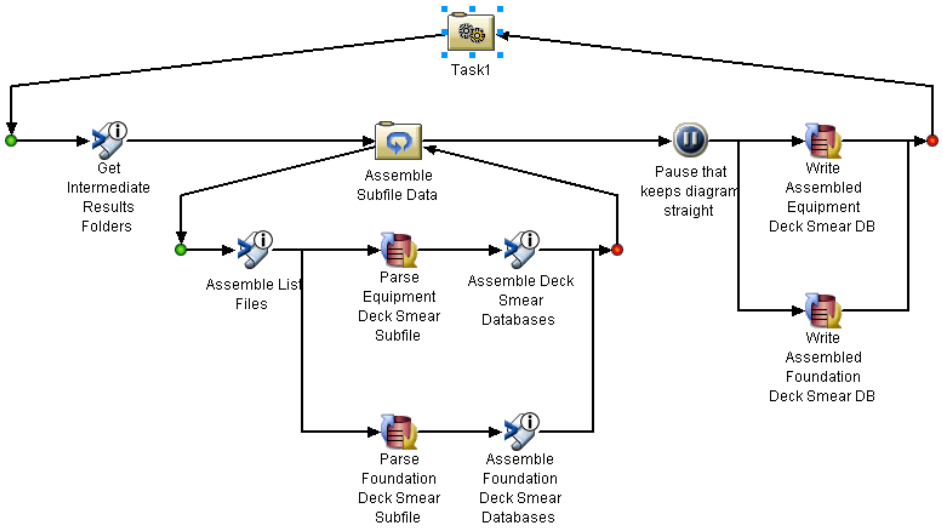
- This is a Weight Control legacy process
- The objective of this Simflow is to streamline the manipulation of the Ship Weight Database for Naval Architecture, Structural, and Shock and Vibration Analyses



Full Shipweight Analysis: Simflows

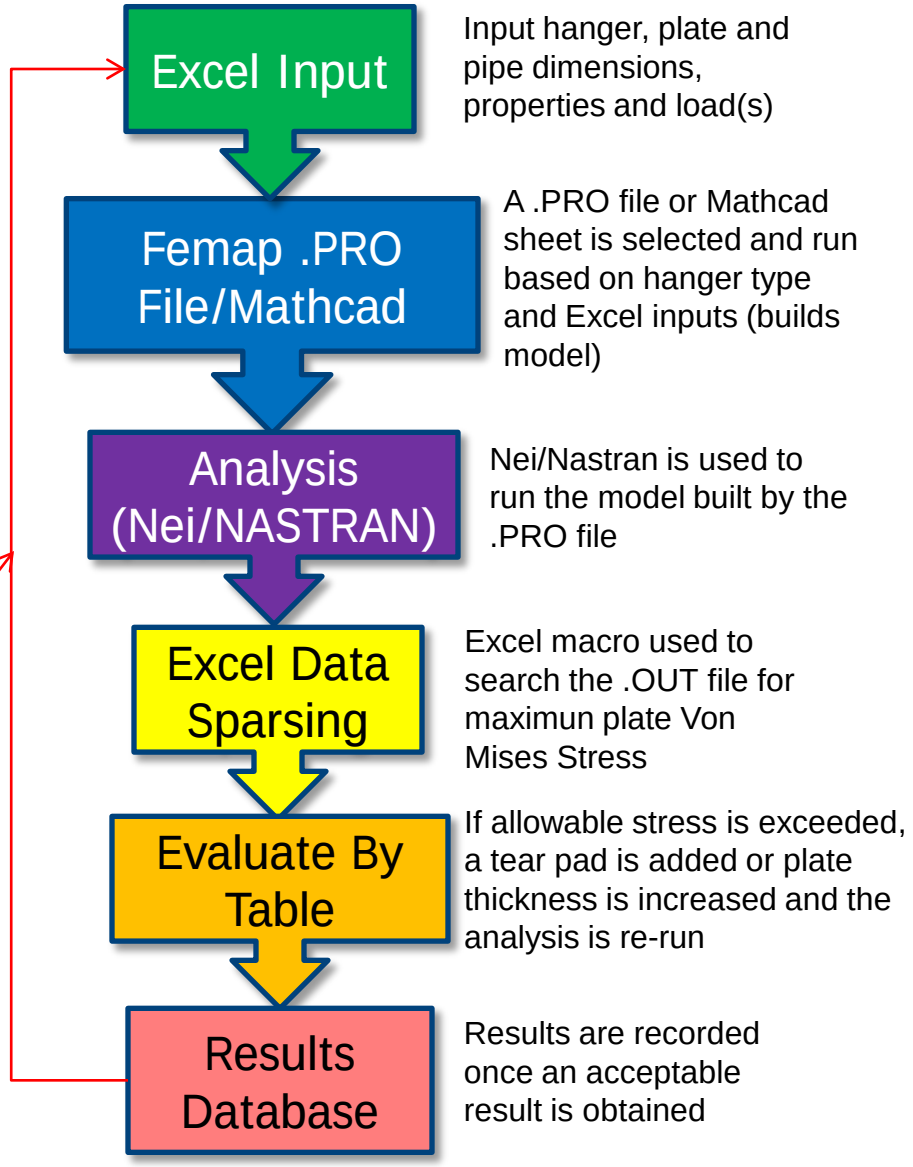
- Process broken up into 3 simflows
  - Required due to size of the weight database
  - First simflow splits database into multiple files
  - Second simflow parses database based on the parameters defined (Deck location, Foundations, and Weight Limit)
  - Third Simflow combines the results into 3 Databases.

- Resultant Databses:
  - **Deck Level Smear -** This process locates all ship elements that are not foundations and calculates the ship element footprint, and creates the **Deck Smear database**.
  - **Large Weights -** This process locates all large ship weights and then creates the **Large Weight database**.
  - **Foundations -** This process locates all ship elements that are foundations, calculates the ship element footprint, and creates the **Foundation database**.

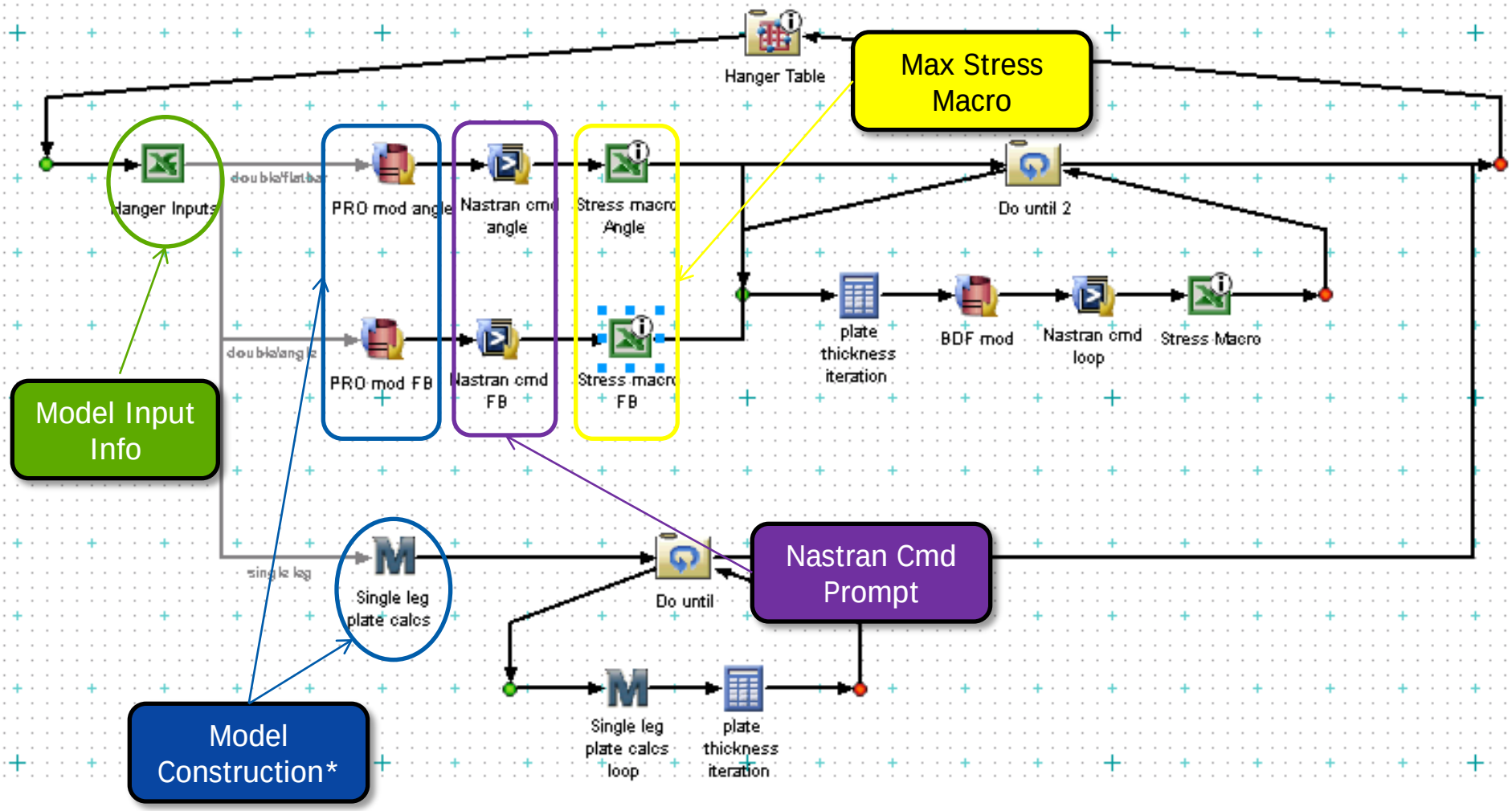


Pipe Hanger Support Structure Simflow

- This is a Marine Technical, Shock, Noise and Vibration, and Field Engineering legacy Process
- The objective of this Simflow is to evaluate the need for support structure when pipe hangers are attached directly to plate as opposed to more substantial structure (e.g. stiffener)
- A table can be generated which provides the plate thickness needed to prevent “punch through” of the hanger legs under shock for various pipe diameters



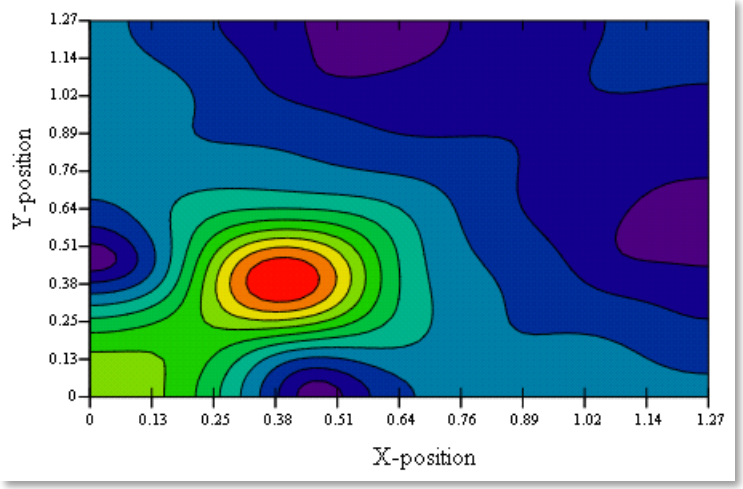
Pipe Hanger Support: Simflow



* If the MathCad worksheet is chosen, this component builds the model, runs the analysis and post-processes the stress results

Products of Hanger Support Simflow

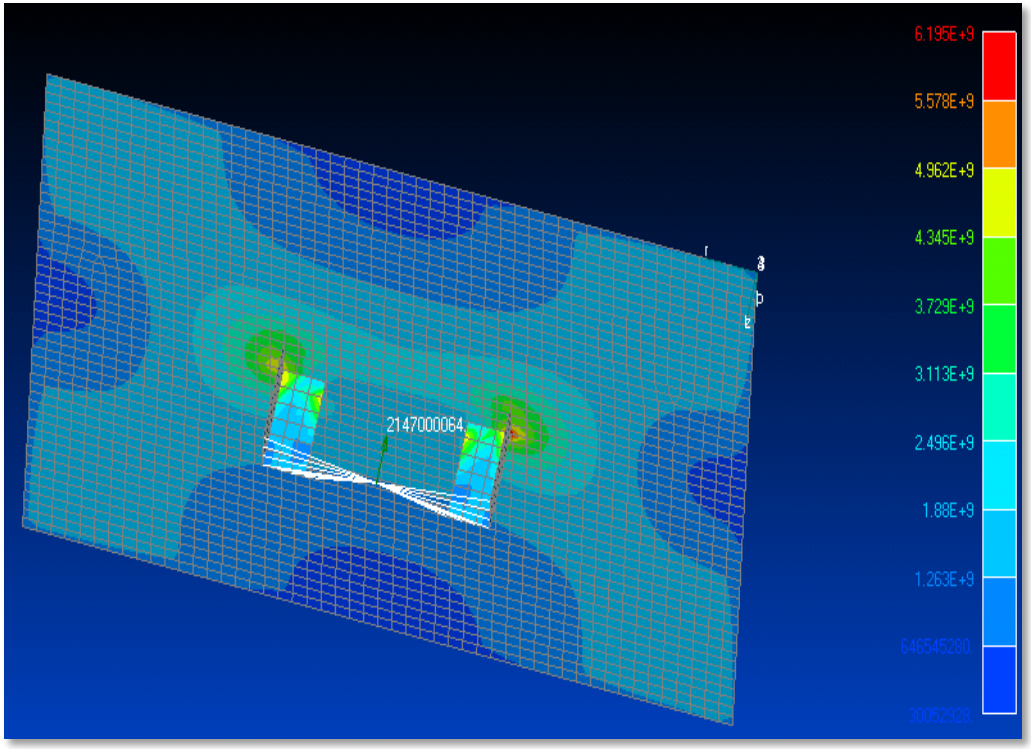
Stress Contour for Single Leg Hanger (MathCad)



Hanger Tear Pad Table

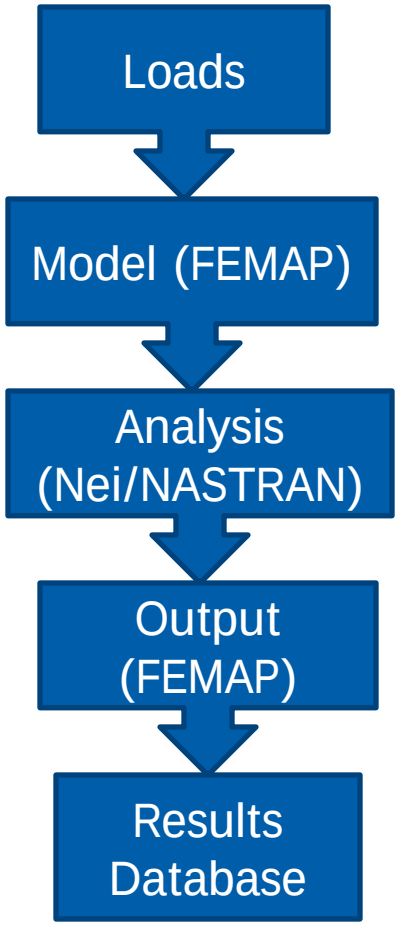
H-04 Pipe Hanger											
IPS Pipe Diameter / Plate Thickness	2”	2-1/2”	3”	3-1/2”	4”	5”	6”	8”	10”	12”	14”
3/16”	P	P	P	P	P	P	P	P	P	P	P
1/4"	P	P	P	P	P	P	P	P	P	P	P
5/16”			P	P	P	P	P	P	P	P	P
3/8”					P	P	P	P	P	P	P
7/16”						P	P	P	P	P	P
1/2"							P	P	P	P	P
9/16”							P	P	P	P	P
5/8”								P	P	P	P
11/16”								P	P	P	P
3/4"									P	P	P
13/16”									P	P	P
7/8”										P	P
15/16”										P	P
1”											P

FEM of Double Leg Hanger



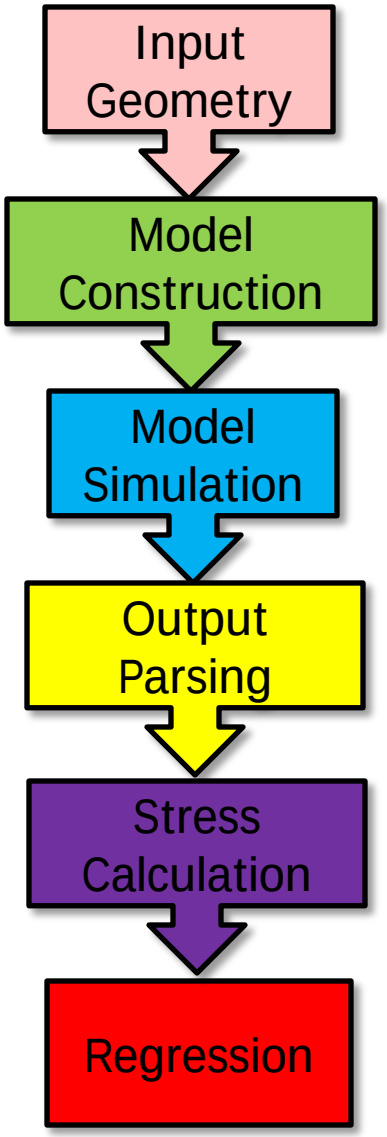
Rafting Foundation Simflow

- This is a Structural Analysis legacy process
- The objective of this simflow is to calculate the required support structure for a raft or isolated foundation



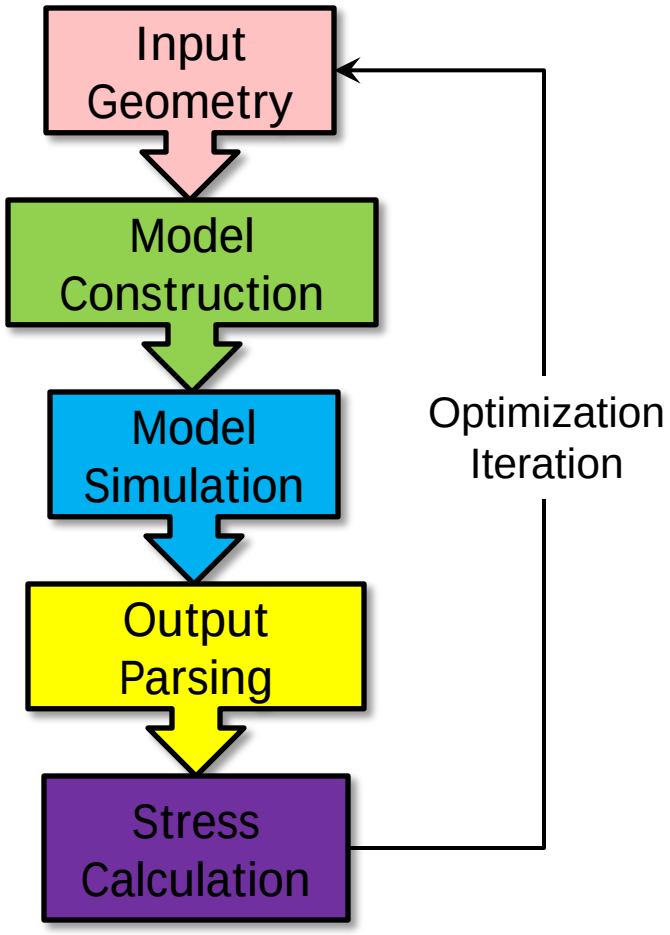
Linearized Stress Analysis Simflow

- This is a Marine Technical and Shock and Vibration legacy process
- The objective of this simflow is to evaluate the fatigue capability of a piping system component and generate a response surface as a function of several variables (e.g. weld size, pipe insertion depth, Pipe NPS)



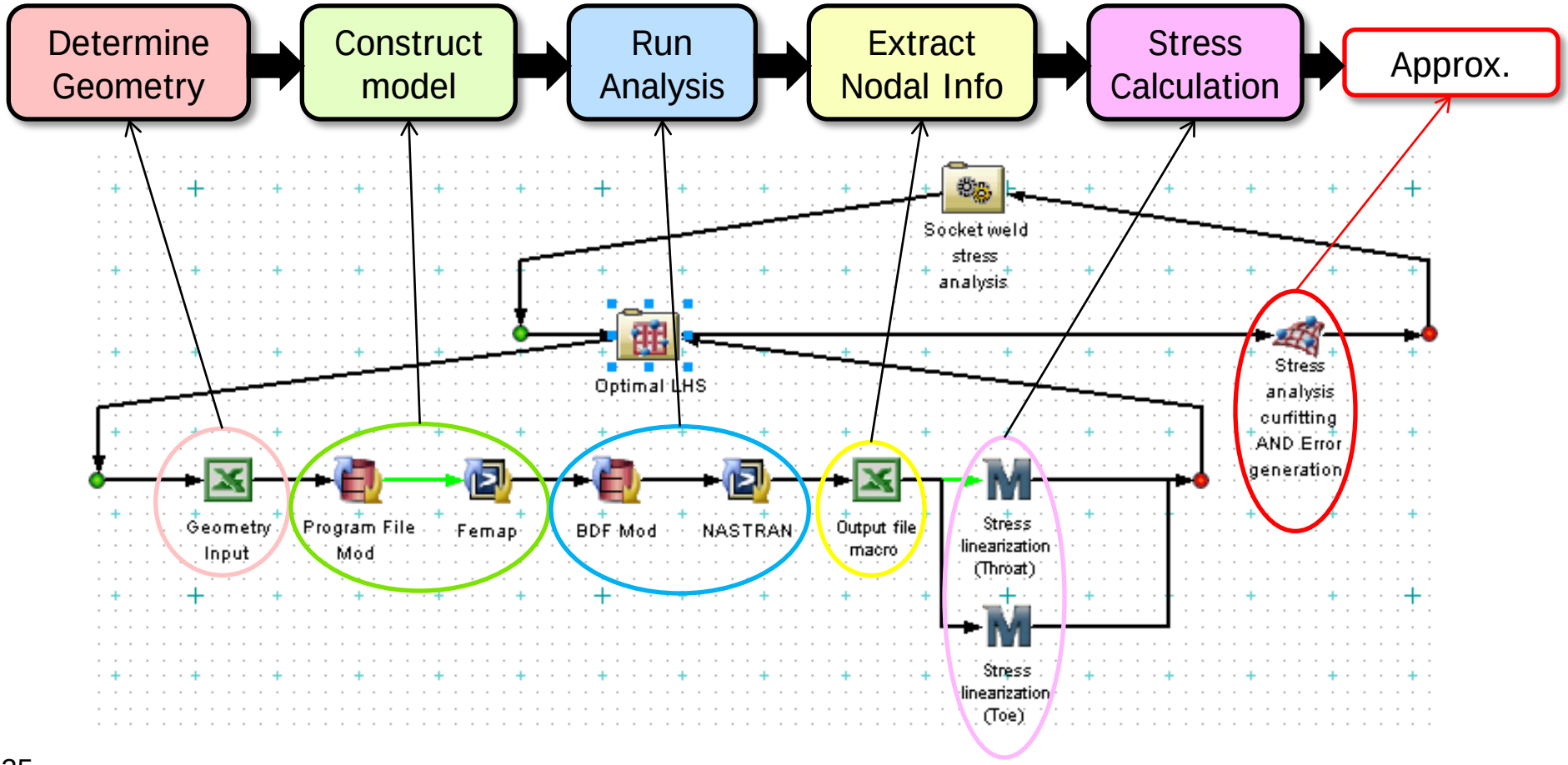
Optimized Linearized Stress Analysis Simflow

- This is a Marine Technical and Shock and Vibration legacy process
- The objective of this simflow is to evaluate the fatigue capability of a piping system component
- The optimization routine varies particular variables under realistic constraints to obtain the best solution in terms of fatigue performance
- This simflow can be set up for advance modeling by taking many variables into consideration simultaneously using one of many algorithms



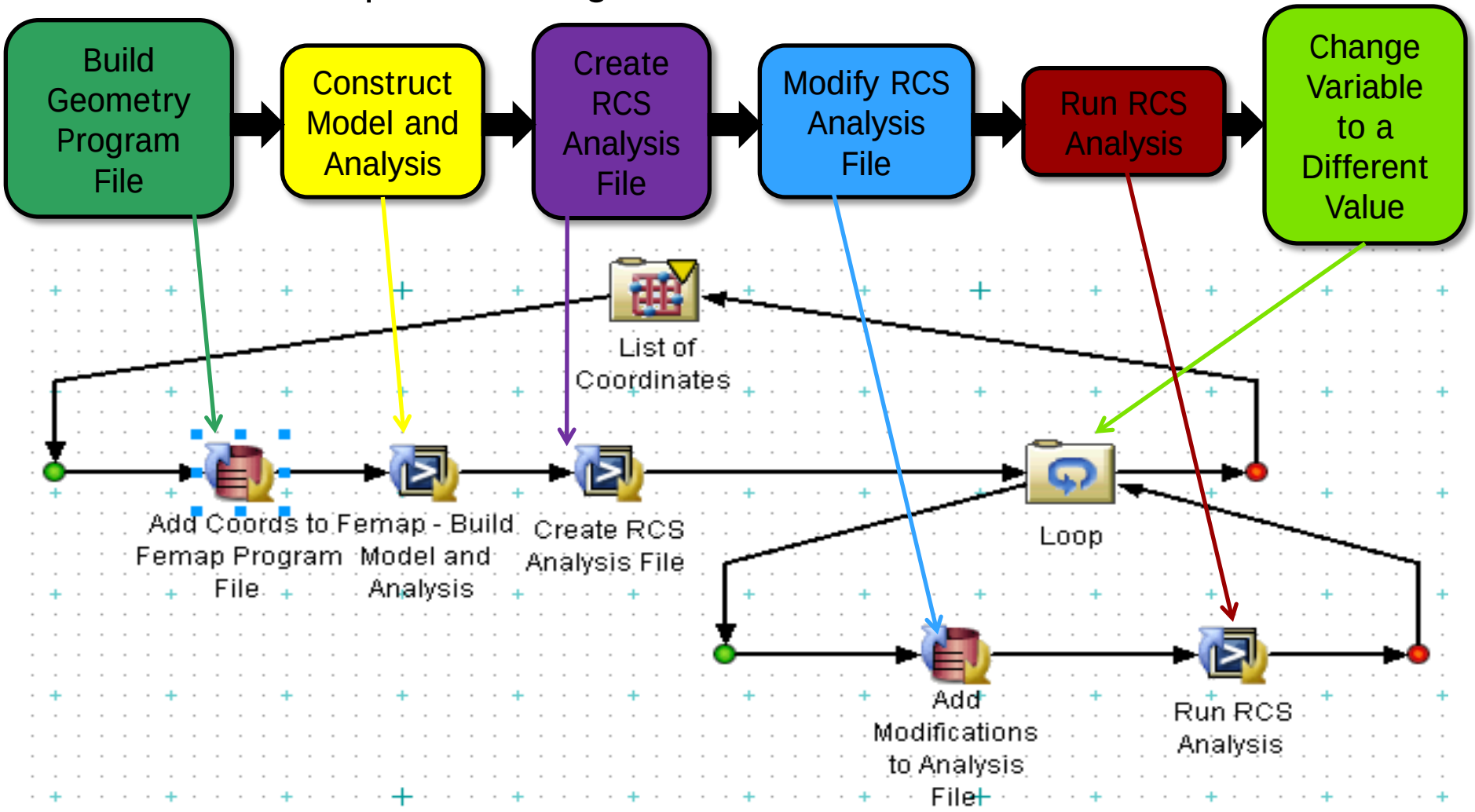
Linearized Stress Simflow (socket weld fitting)

- Tasked to calculate linearized stresses across stress classification lines (SCL's) for fillet welds on socket weld joints using FEA



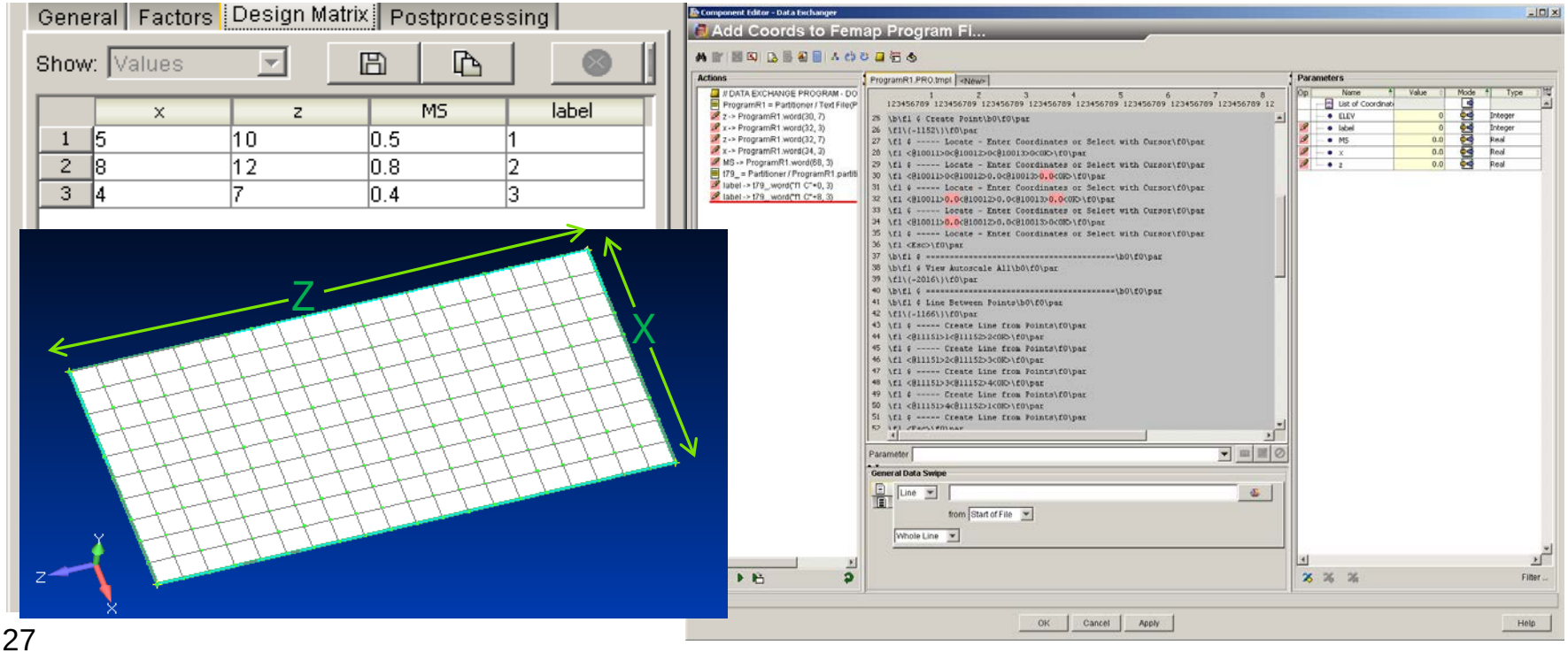
RCS (Radar Cross Section) Component Analysis Simflow

- Analyze RCS signature of many different sizes of a component with the same basic shape, a rectangle in this case.



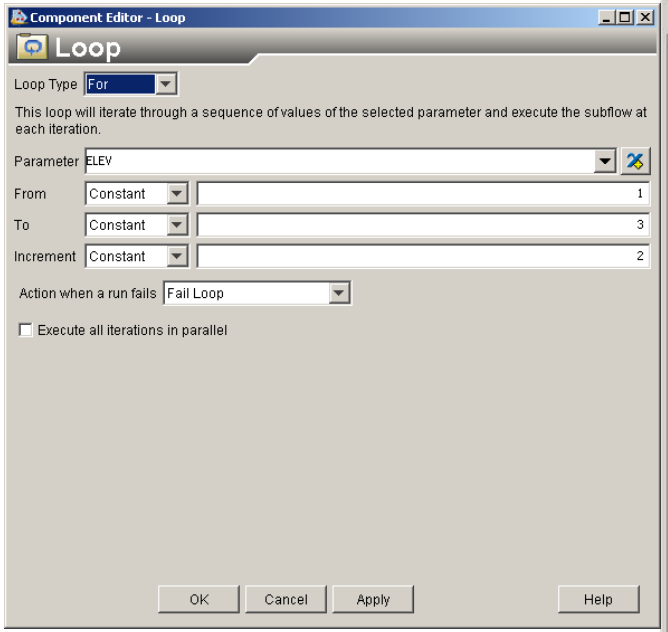
DRIVER and Model Construction

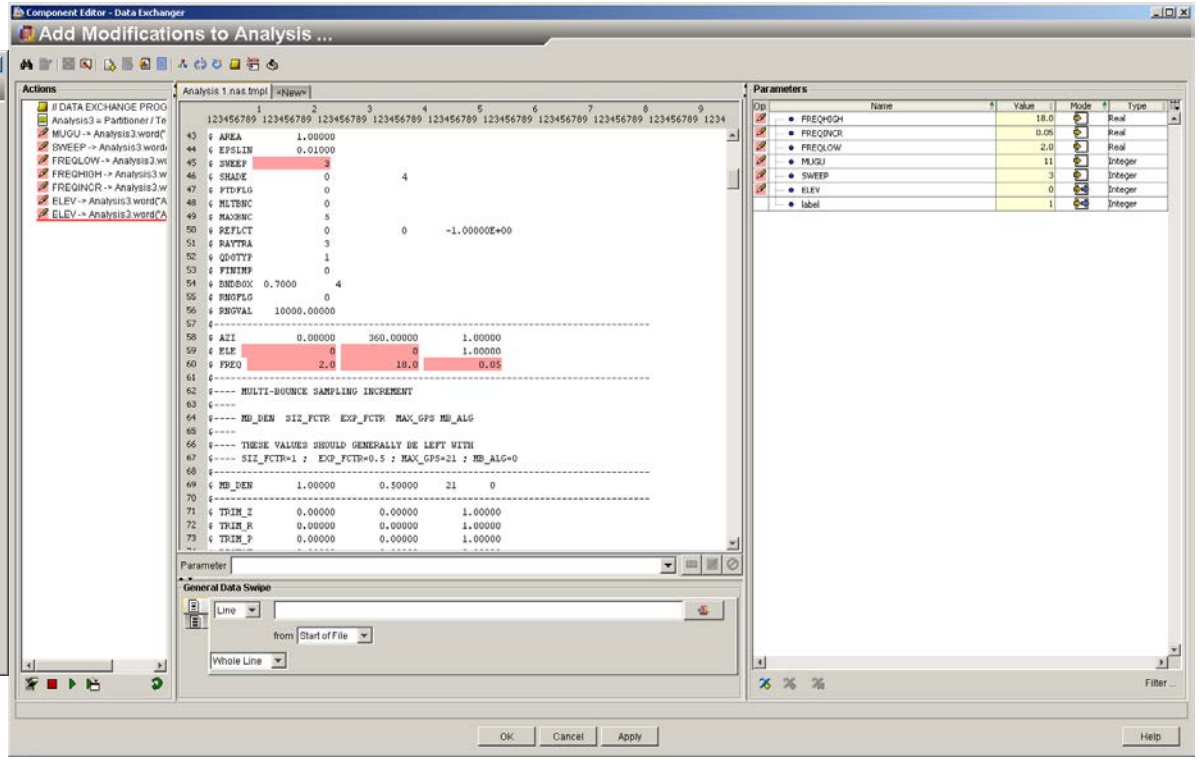
- **Design of Experiments (DOE) – Data File**
  - *Uses a tab delimited text file created in Microsoft Excel*
  - *Variables from data file – X and Z coordinates (x, z), Mesh Size (MS), and a variable to keep track of the data used for file naming purposes (label).*
- **Data Exchanger/Simcode –**
  - *Data file information plugged into FEMAP .PRO file through the Data Exchanger.*
  - *Simcode uses the .PRO file in FEMAP to create the model file and the .NAS (Nastran) analysis file.*



Analysis

- Another Simcode component is used to convert the .NAS file into an RCS analysis
- A loop is used to first change a variable, in this case it is an angle used in the analysis, that angle is inputted into the analysis through the use of the Data Exchanger
- The actual RCS analysis is then run through the use of another Simcode
- After the analysis, the next angle is produced from the loop and the process is repeated until all angles are finished
- Then the next set of Coordinates is produced from the DOE and the entire Simflow is executed until all Coordinates are finished

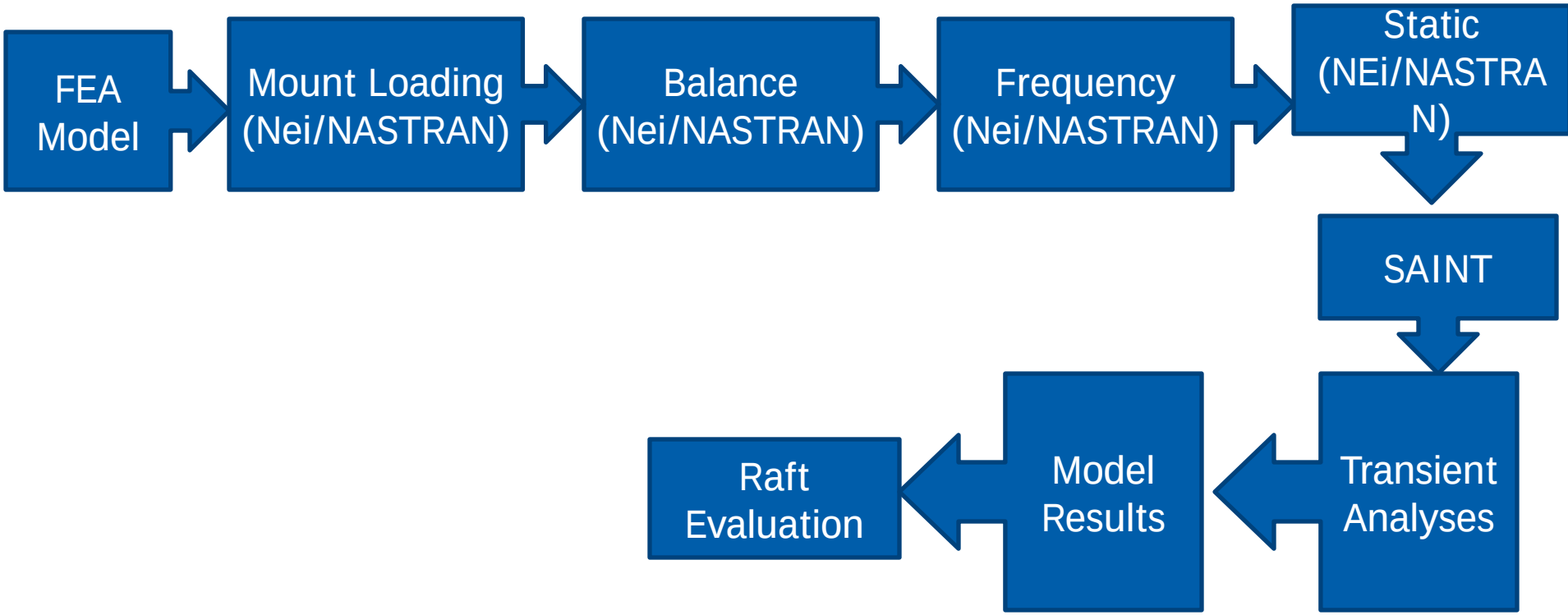




Full Rafting Analysis

- Legacy Process

- Changes to accommodate Isight better



Summary

- HII is leveraging previous experience with Isight to evaluate the tool's usage in technical areas of shipbuilding other than Noise, Shock, and Vibration

- The presented series of M&S 2 project HII simflows is expanding into the following other technical areas:
    - Structural Analysis
    - Weight Control
    - Marine Technical
    - Field Engineering

- As previously shown, the Isight application's flexibility improves the users' abilities to meet analysis requirements in areas such as:
    - Flexibility to incorporate multiple applications into one process flow
    - Automatically reading input files in Isight vs. manually transferring data into applicable data formats
    - Increases capability of configuration management and collection and storage of data
    - Removes the opportunity to make manual data errors
    - Processes documented in Isight give the added benefits of a good communication and training device for process owners