



Regional Summit

2008  NAFEMS

2020 Vision of Engineering Analysis and Simulation

October 29 - 31, 2008 | Hampton, Virginia

Abstract Modeling Enables Aerospace Corporation Project to Reap Benefits of Collaborative Engineering Process

October 24th, 2008



Agenda

Abstract Modeling Enables Aerospace Corporation Project to Reap Benefits of Collaborative Engineering Process

October 24th, 2008

9am PDT (Los Angeles) / 12n EDT (New York) / 6pm CET (Paris)

▲ Welcome & Introduction (Overview of NAFEMS Activities)

▲ Mr. Matthew Ladzinski, *NAFEMS North America*

▲ Abstract Modeling Enables Aerospace Corporation Project to Reap Benefits of Collaborative Engineering Process

▲ Dr. David Thomas, *The Aerospace Corporation*

▲ Mr. Malcolm Panthaki, *Comet Solutions*

▲ Q&A Session

▲ Panel

▲ Closing



Ladzinski



Thomas



Panthaki





THE INTERNATIONAL ASSOCIATION
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An Overview of NAFEMS NA Activities



Matthew Ladzinski
NAFEMS
North American Representative





Planned Activities in North America

➤ Webinars

- New topic each month!
 - FAM: Advances in Research and Industrial Application of Experimental Mechanics – November 13th, 2008
- Recent webinars:
 - CCOPPS: Power Generation: Engineering Challenges of a Low Carbon Future
 - Practical CFD Analysis
 - Complexity Management
 - CCOPPS: Creep Loading of Pressurized Components – Phenomena and Evaluation
 - Multiphysics Simulation using Implicit Sequential Coupling
 - CCOPPS: Fatigue of Welded Pressure Vessels
 - Applied Element Method as a Practical Tool for Progressive Collapse Analysis of Structures
 - AUTOSIM: The Future of Simulation in the Automotive Industry
 - A Common Sense Approach to Stress Analysis and Finite Element Modeling
 - The Interfacing of FEA with Pressure Vessel Design Codes (CCOPPS Project)
 - Multiphysics Simulation using Directly Coupled-Field Element Technology
 - Methods and Technology for the Analysis of Composite Materials
 - Simulation Process Management
 - Simulation-supported Decision Making (Stochastics)
 - Simulation Driven Design (SDD) Findings

To register for upcoming webinars, or to view a past webinar, please visit: www.nafems.org/events/webinars



Planned Activities in North America

NAFEMS NA 2008 Regional Summit

NAFEMS 2020 Vision of Engineering Analysis and Simulation

- **NAFEMS 2020** will bring together the leading visionaries, developers, and practitioners of CAE-related technologies and business processes
- **Goal:** Provide attendees with the best “food for thought and action” to deploy CAE over the next several years
- **Location:** Hampton Roads Convention Center, Hampton, Virginia
- **Date:** October 29-31, 2008

Detailed Agenda Now Available

For more information, visit:

www.nafems.org/nafems2020



Keynote Presenters for NAFEMS 2020

- **Prof. Ahmed Noor**, *Old Dominion University*
- **Prof. Thomas J.R. Hughes**, *University of Texas at Austin*
- **Dr. Takeshi Abe**, *Ford Motor Company*
- **Prof. Mary Boyce**, *MIT*
- **Dr. Joel Orr**, *Cyon Research*
- **Dr. Jeffrey Cipolla**, *Weidlinger Associates, Inc.*



2-Day Short Course on V&V for Aerospace, Civil and Mechanical Engineers

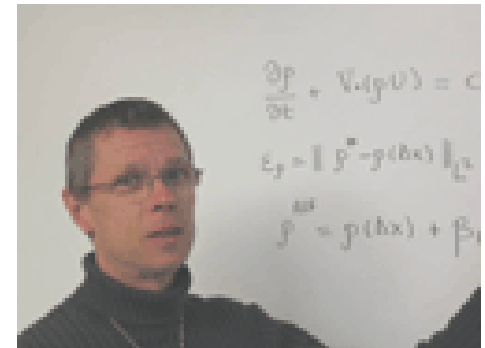
Finite Element Model Validation, Updating, and Uncertainty Quantification for Linear and Non-linear Models

- **Goal:** Attendees will learn the latest techniques for evaluating the accuracy of computational models over a range of parameter values, how to design validation experiments that will determine the simulation range of validity, and how to calibrate model parameters to reflect the measured response from experiments – event for nonlinear Models

- **Location:** Hampton Roads Convention Center
Hampton, Virginia

- **Date:** October 27-28, 2008

Only 3 seats available



For more information, visit: www.nafems.org/nafems2020





▲ **When:** June 16th – 19th, 2009

▲ **Where:** Crete, Greece

▲ **Updates:**

▲ **Nearly 250 abstracts received**

▲ **Keynote Presentations**

▲ **Additional Workshops and Activities:**

▲ **Mini-symposium: Analysis and Simulation of Composite Structures Including Damage and Failure Prediction (Nov. 6)**

▲ **Engineering Analysis Quality, Verification & Validation**





▲ Additional Workshops and Activities (cont.):

- ▲ **Mini-symposium: Analysis and Simulation of Composite Structures Including Damage and Failure Prediction**
- ▲ **Engineering Analysis Quality, Verification & Validation**
- ▲ **High Performance Computing in Engineering Simulation**
- ▲ **Multi-physics Simulation: Advanced Coupling Algorithms and Strategies**
- ▲ **Crash**



▲ Additional Workshops and Activities (cont.):

- ▲ EC AUTOSIM Project – (one year)
- ▲ EC FENet Project – (four years)
- ▲ EC Multi-Scale Analysis of Large Aerostructures Project
- ▲ NAFEMS Skills Management Initiative
- ▲ Simulation Data Management
- ▲ Material Data
- ▲ Optimization/Robustness/Stochastics
- ▲ Round Table Discussion on Business Drivers



For more information about the NWC09, please visit: www.nafems.org/congress.

Sponsorship and Exhibition Opportunities Still Available!

For more information, please visit: www.nafems.org/congress/sponsor.

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2020 Vision of Engineering Analysis and Simulation
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Abstract Modeling Enables Aerospace Corporation Project to Reap Benefits of Concurrent Engineering

**David A. Thomas (The Aerospace Corporation)
Malcolm Panthaki (Comet Solutions)**





Presentation Agenda

- Space flight Electro-Optical (EO) sensor programs are experiencing large (100%) cost and schedule overruns.
- Simulation Driven Engineering software enables a more effective process – Concurrent Engineering.
- Abstract Modeling – What is it? What are the benefits?
- Aerospace Corporation Project
 - The complex environment and tools we need to use
 - Overview of the Integrated STOP Workspace
 - Overview of the stages of the project
 - How Abstract Modeling and an integrated environment improved our process
 - Project Results
- Q&A

The Aerospace Corporation

- Provides federally funded R&D to U.S. Air Force and technical services to national-security, civil, and commercial space customers.
- Services include:
 - Systems engineering
 - Testing/Analysis/Validation
 - Launch readiness/certification
 - Application of new technologies for existing and next-generation space systems

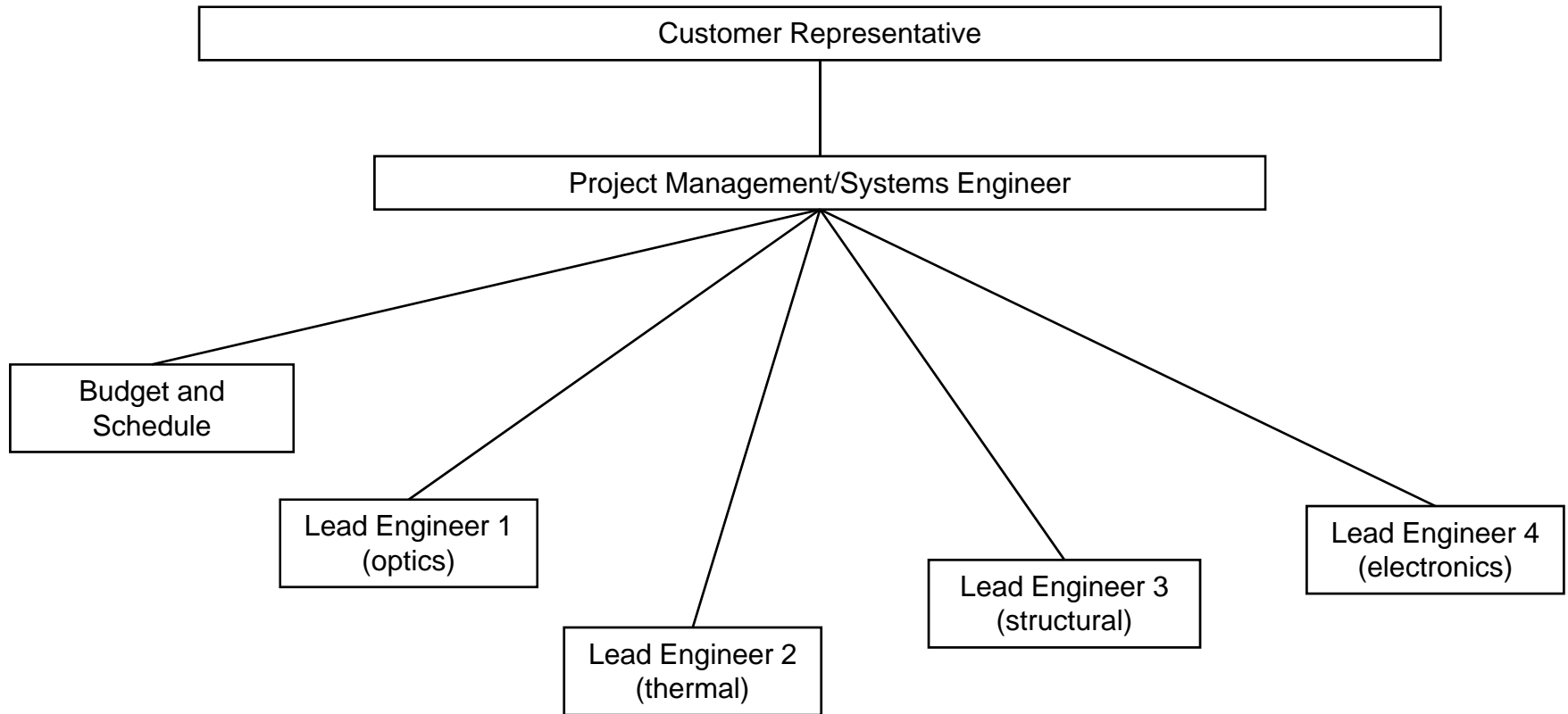




Statement of the Problem

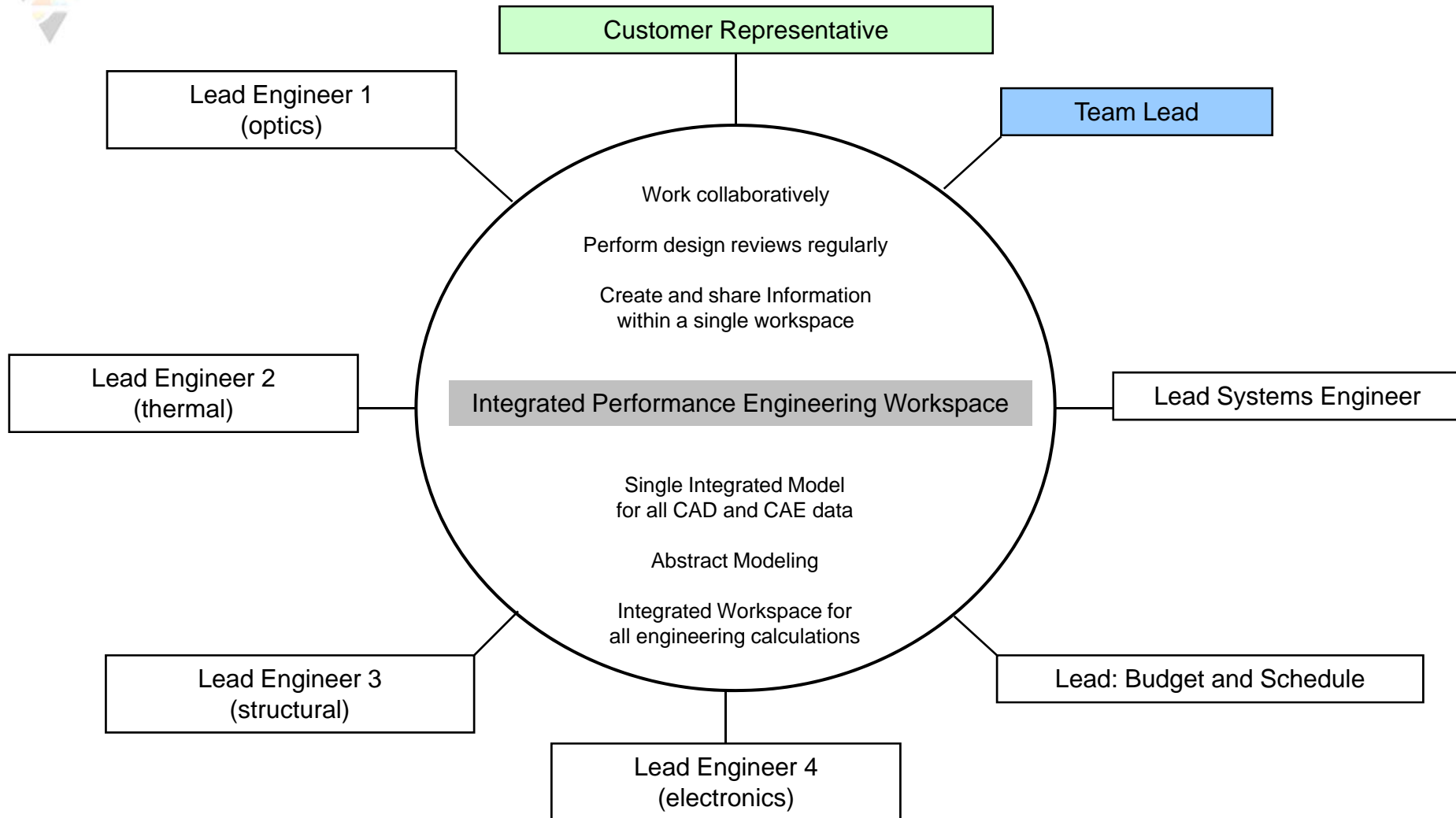
- About 25% of all space-borne EO sensor programs are overrunning budget & schedule allocations by 100% or more.
- Standard program reserves are closer to 20%.
- A 5 times improvement in process cycle time is not likely to result from iterative improvements to existing processes.
- A Concurrent Engineering approach addresses the delays, errors, and late discovery of design problems that underlie our current fragmented process.

Classic Flight Program Organization



Requirements are handed down to stove-piped engineering functions from a central systems engineering function. Inter-disciplinary interactions are infrequent and often indirect.

Concurrent Engineering Organization



Note: Each lead may in turn be supported by a small team of support engineers or specialists

The Aerospace Corp. STOP Project

- Goal
Higher fidelity STOP analysis of space flight EO sensors in shorter cycle time.
- Pain
Current fragmented approach is slow, inefficient, error-prone.
- Project Team
Team Lead plus optical, mechanical, structural, and thermal engineers.





Requirements to Meet Team's Goals

- Effective and efficient communication and management of *all* project data with *all* team members including managers.
- Single, integrated view of all the model data (*CAD, structural, thermal, optical.*)
- Earlier evaluation of more concepts, and more iterations of a concept at multiple levels of model fidelity.
- “No-wait design reviews” including requirements checking (*no simulation tool expertise needed.*)
- Use of COTS CAD and CAE tools (extensible environment for commercial and in-house tools.)

Performance Engineering Workspace

C:/Documents and Settings/Matt/My Documents/Projects/Welded_Beam/Welded Beam 01.cmtproject (Iteration 1.2/ Leaf Stage)

The interface is divided into several main sections:

- Project Stages:** A tree view on the left showing the project hierarchy, including Root, Abstract Model, and three HF Model iterations (1.1, 1.2, 2.1).
- Project Dashboard:** A central 3D view of the welded beam model, currently in a cutaway state.
- Simulation Process:** A process schematic titled 'FEA Process' showing the workflow from 'Imported Asse...' through 'User Defined' and 'Update Geo' to 'Meshing' and 'Simulation' steps.
- Geometry/Mesh Results Viewers:** A panel on the right displaying various analysis results, including 'Max Stress', 'Field-Viz', and 'Nodal Di'.

Terminal System Console SolarPanel_EnergyGenerated_Constraint

SystemConstant	Value	SystemVariable	Value	SystemRequirement	Value
AppliedOrbit.celestialBodyNa...	EARTH	OrbitParameter.maximumAltitude	500 km	HeatingRates.directError-albedo	4.13051
AppliedOrbit.facingObject	planet	OrbitParameter.minimumAltitude	500 km	HeatingRates.directError-solar	4.47212
Launch_Cost_Budget	1e+07	SolarEnergyPerArea	50 J*m ⁻²	HeatingRates.totalAbsorbed-albedo	101.993 m ² *kg*s ⁻³
Launch_Cost_Per_kg	12000	SolarPanel.Length	2	HeatingRates.totalAbsorbed-solar	369.294 m ² *kg*s ⁻³
Launch_Mass_Budget	1000 kg	SolarPanel.Material	AluminumAlloy,6061T6	Launch_Cost	1.33647e+07
		SolarPanel.Surface_Treatment	KaptonFilm,0.5milAlum	Launch_Mass	1113.73 kg
		SolarPanel.Width	1	SolarPanel_EnergyGenerated	200 m ² *kg*s ⁻²

System Constants

System Variables

System Requirements



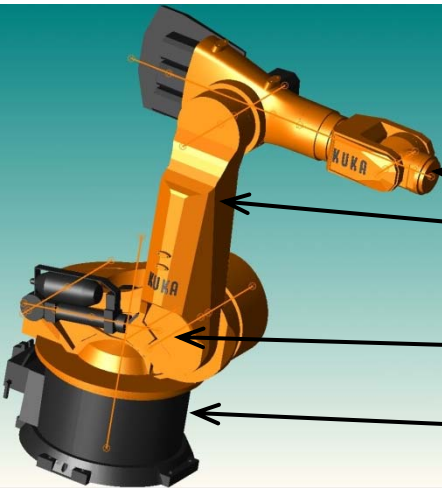


What is an Abstract Model?

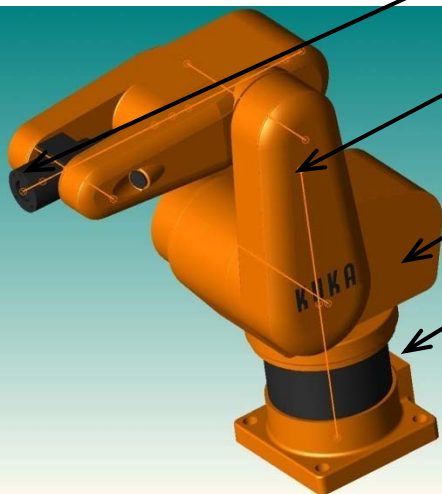
- Models for Performance Simulation – the *Status Quo*
 - Models for simulation are typically geometry-centric – the engineering data is directly attached to the CAD geometry.
 - Changes to the CAD design require large amounts of manual rework to run simulations on the new design.
 - Systems Engineering models are independent of detailed CAD.
- An Abstract Model

“A functional model of a product containing all the engineering data (performance requirements/metrics, materials, environments...) and simulation processes, independent of the CAD geometry or shape characteristics of the product.”

The Status Quo: Geometry-Centric Modeling in Silos



Geometry



Rework
Wasted Time
Manual Errors
Data Silos

- Mesher 1
- Mesher 2
- Abaqus
- ANSYS
- Nastran
- Excel
- MATLAB
- Adams
- Thermal-Desktop
- CODE V
- SigFit
- In-House Codes

Engineering Data Silos

- Materials
- Surface Treatments
- Environments (Loads/BCs/...)
- Joints
- Contact and other Interactions
- Springs/dashpots/bushings/...
- Meshing rules
- Analysis rules
- Subsets of the assembly

Processes

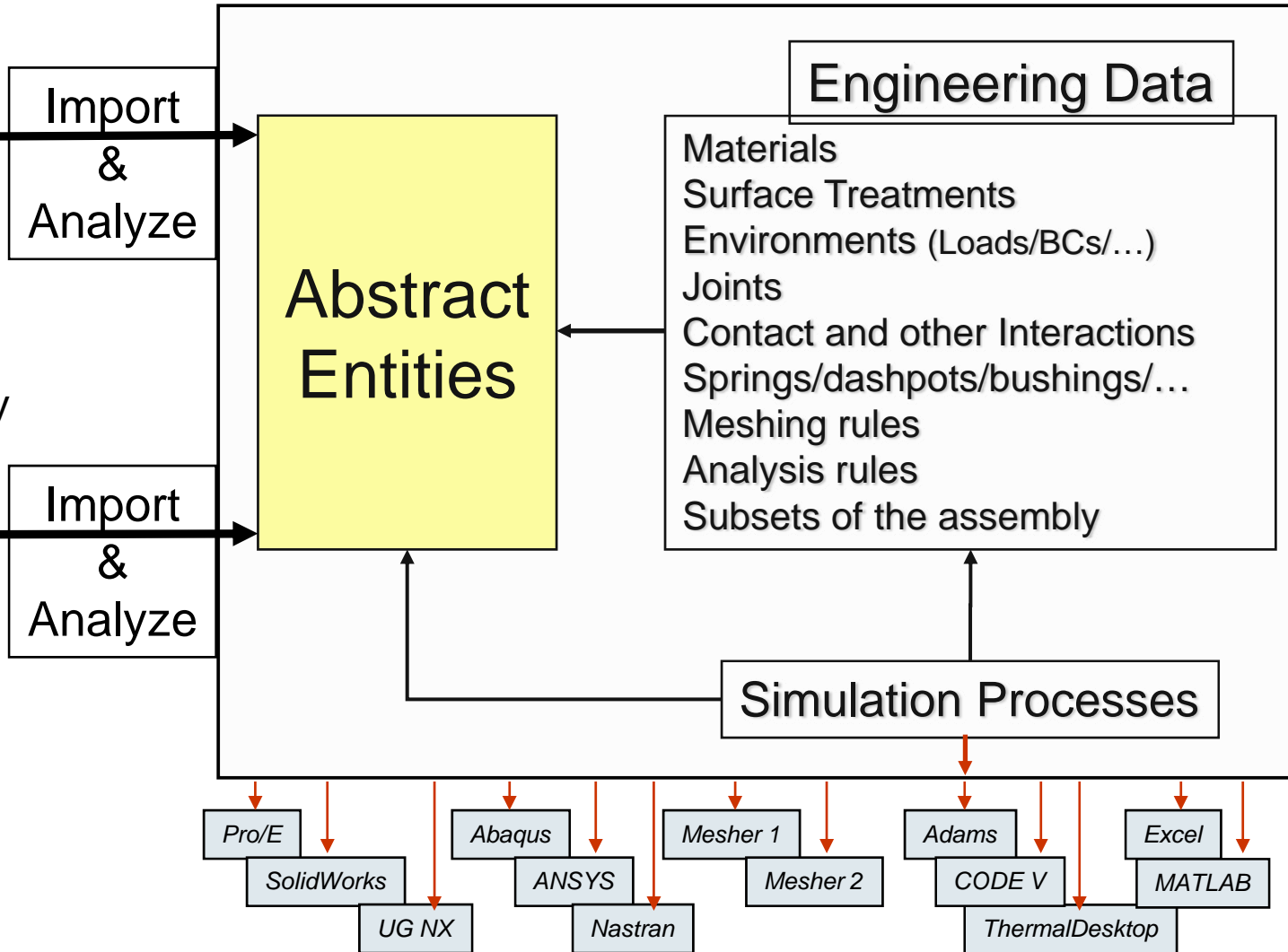
The Future: Integrated Abstract Modeling



Tagged Geometry



Abstract Model





Why Abstract Modeling?

- Automatically generate the analysis model across multiple disciplines – minimize/eliminate data reentry and manual errors.
- Capture engineering “best practice” workflows abstractly, independent of the *design geometry*.
- Set up performance requirements abstractly, independent of the *design geometry*.

***Bottom Line:* High-fidelity, accurate simulations in a fraction of the time.**

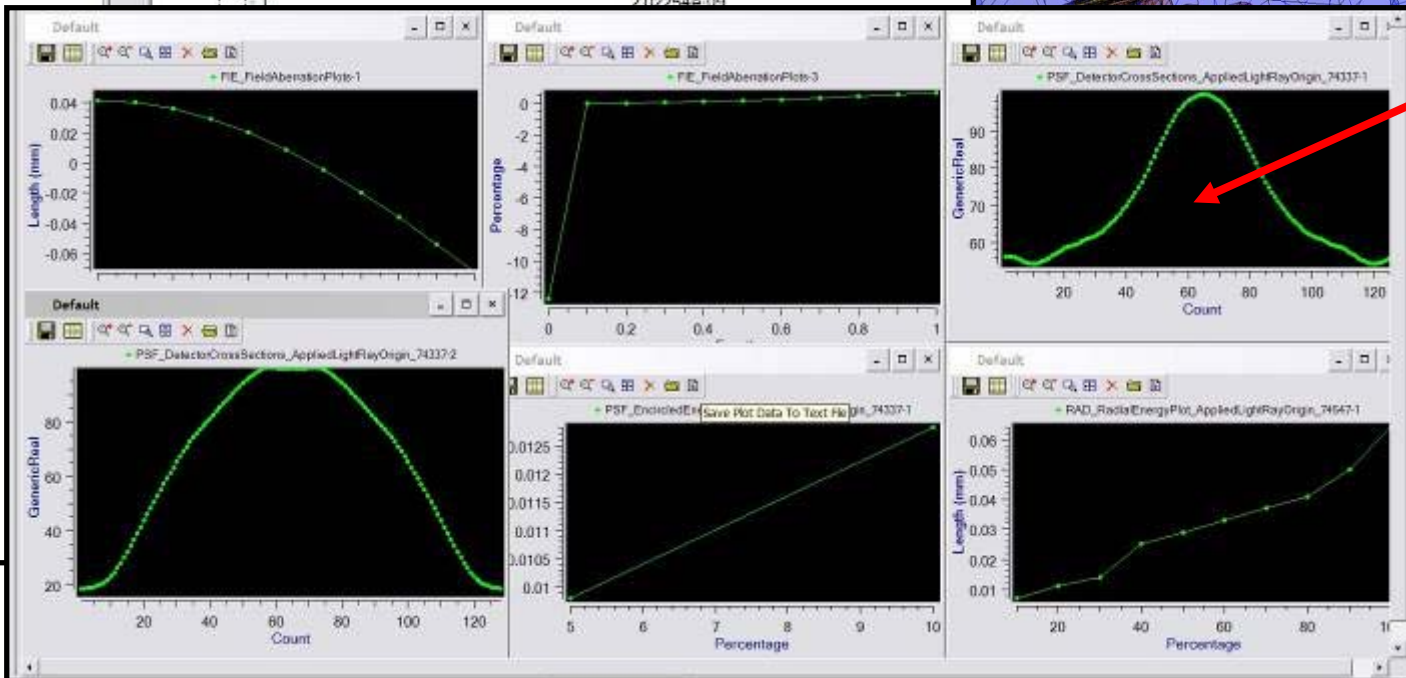
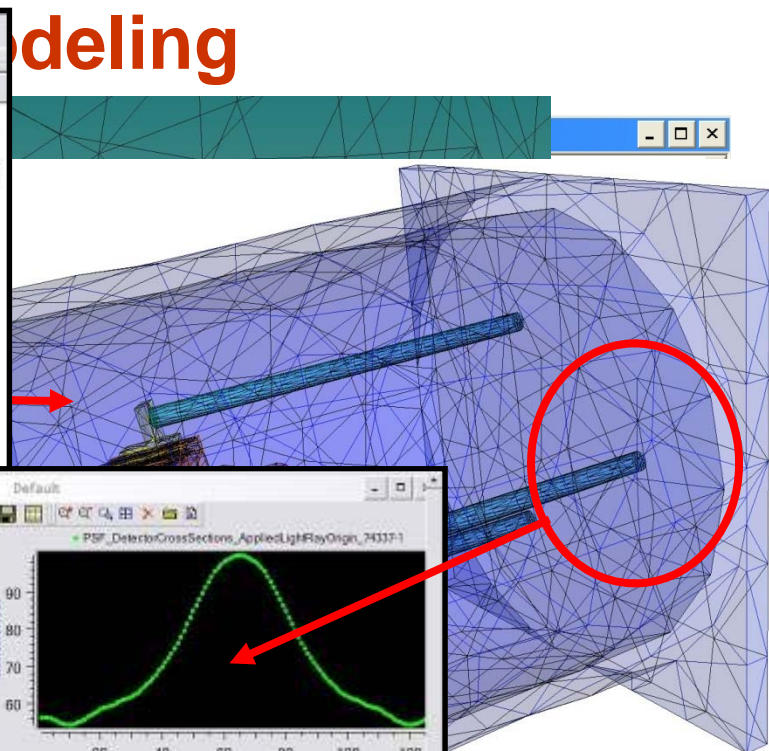
Structural/Thermal/Optical Performance Modeling

System Console [CompositeOpticalEntityDisturbance 280522 6]

CompositeOpticalEntityDisturbance
MirrorDisturbance 281500 6
R07: PrimaryMirror

MirrorDisturbance Properties

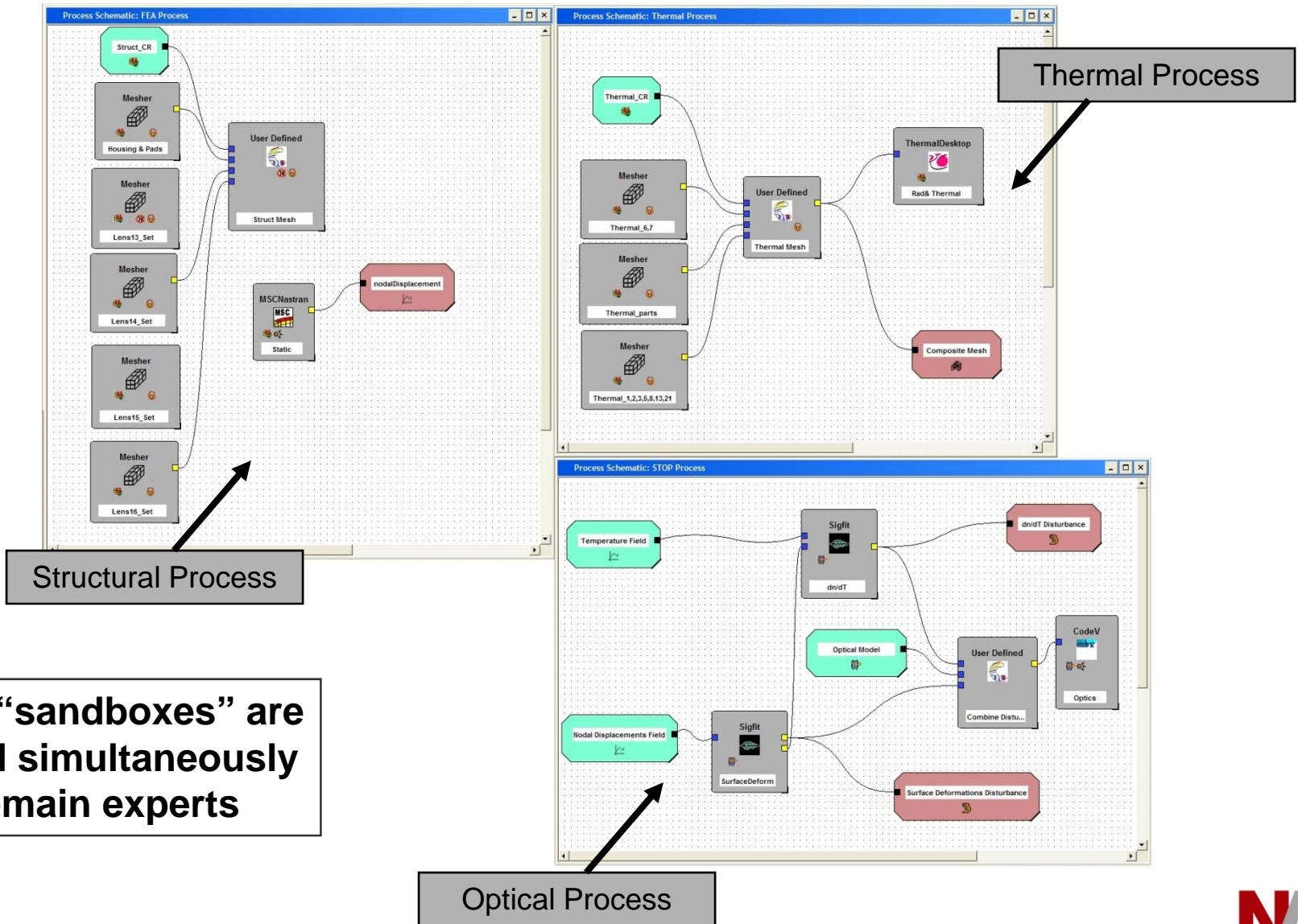
Key	Value
surfaceDisturbanceSpecification	OpticalSurfaceDisturbanceSpecification
Optional Member(s)	
<input checked="" type="checkbox"/> surfaceDisplacementSpecification	OpticalSurfaceDisplacementSpecification
-x	1.60672e-08 m
-y	1.65955e-08 m
-z	-3.35259e-07 m
<input checked="" type="checkbox"/> surfaceTiltSpecification	OpticalSurfaceTiltSpecification
alpha	-7.74712e-06 degree
beta	-2.6697e-06 degree
gamma	-2.54115e-06 degree
zernikePolynomialSpecification	ZernikePolynomialSpecification
coefficients	List(Coefficient)
-0	-1.88836e-09
1	2.02254e-09



OBA_Tempe

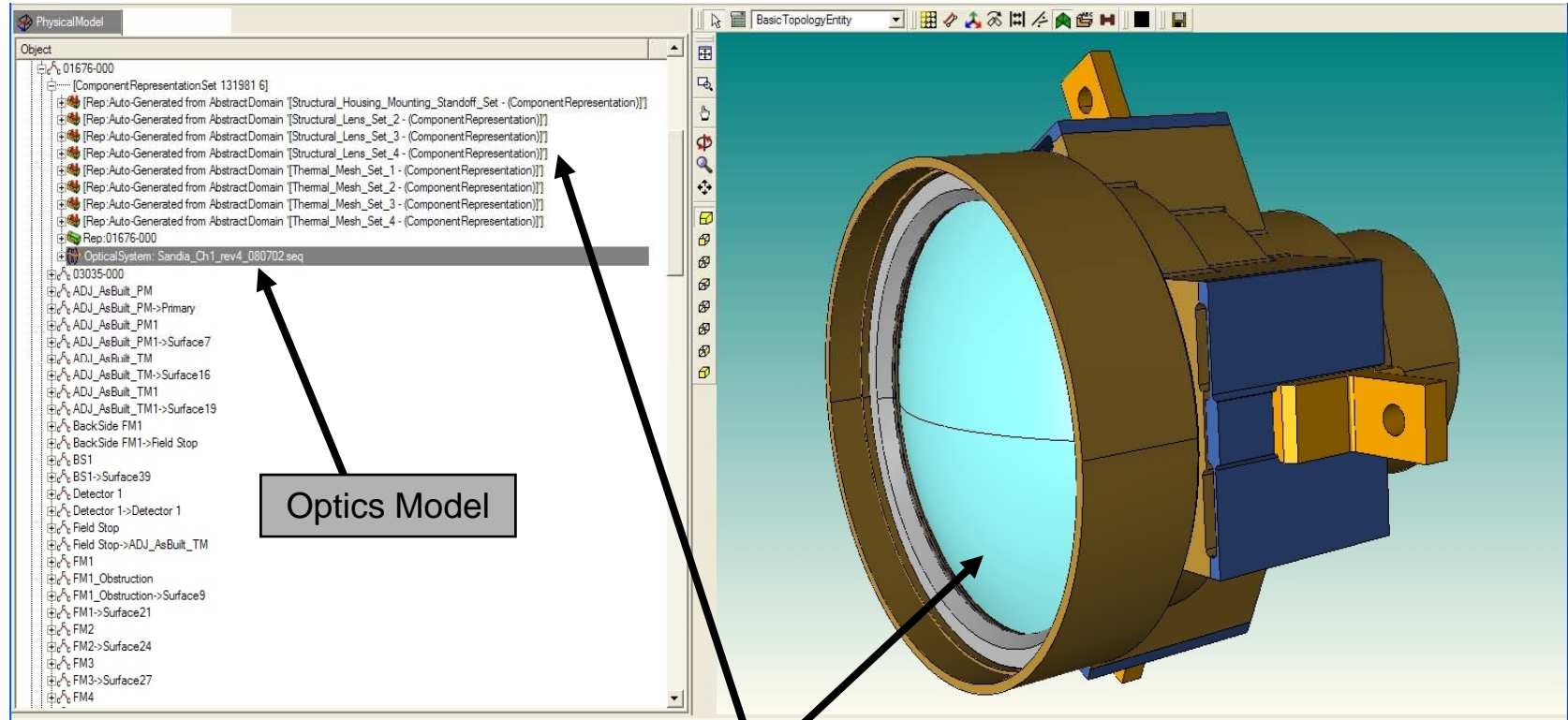
Name: + - Name: + - Name:

Reusable Simulation Templates: Capture/Reuse Multi-Disciplinary Processes



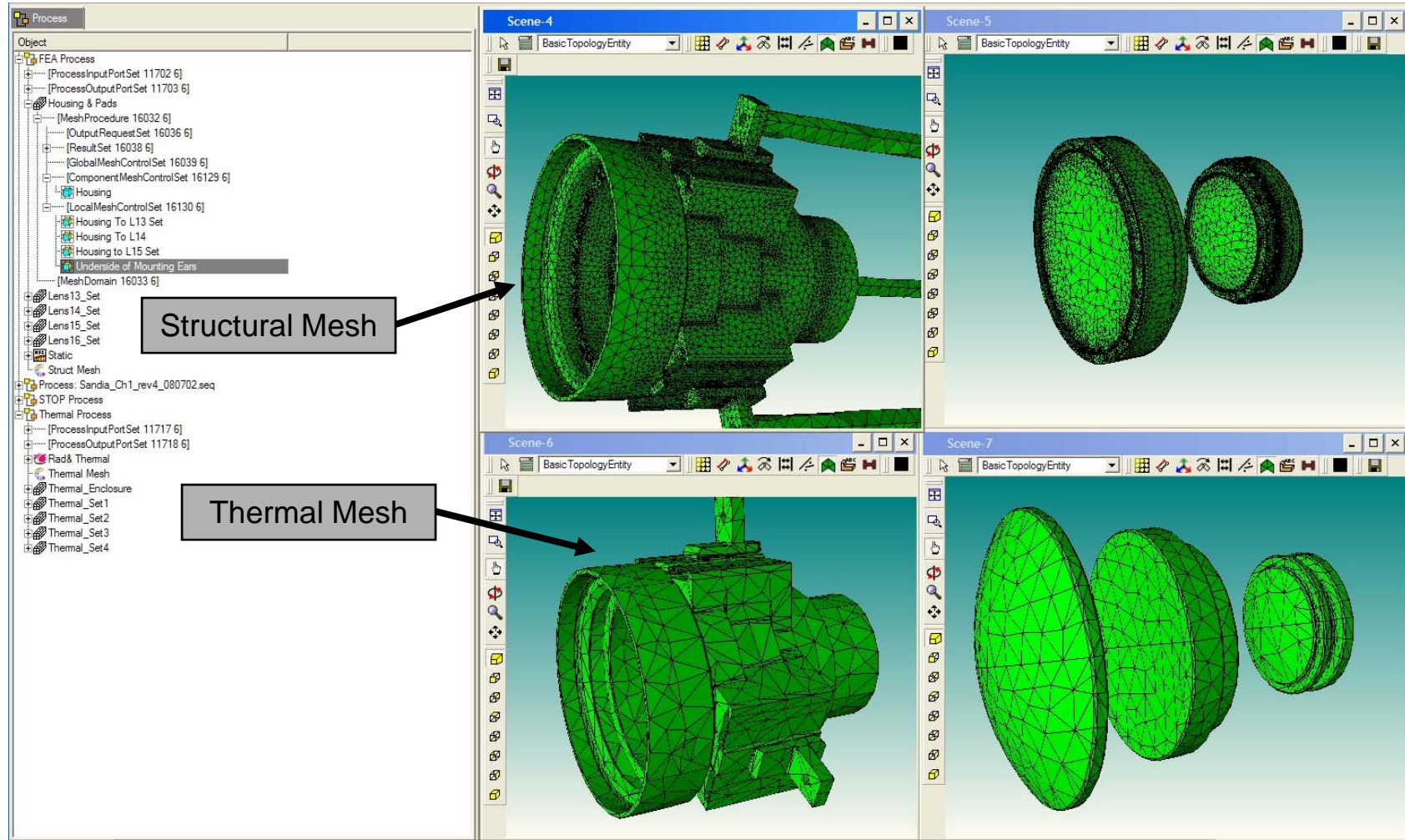
Process “sandboxes” are executed simultaneously by domain experts

Import initial CAD and Optics Models



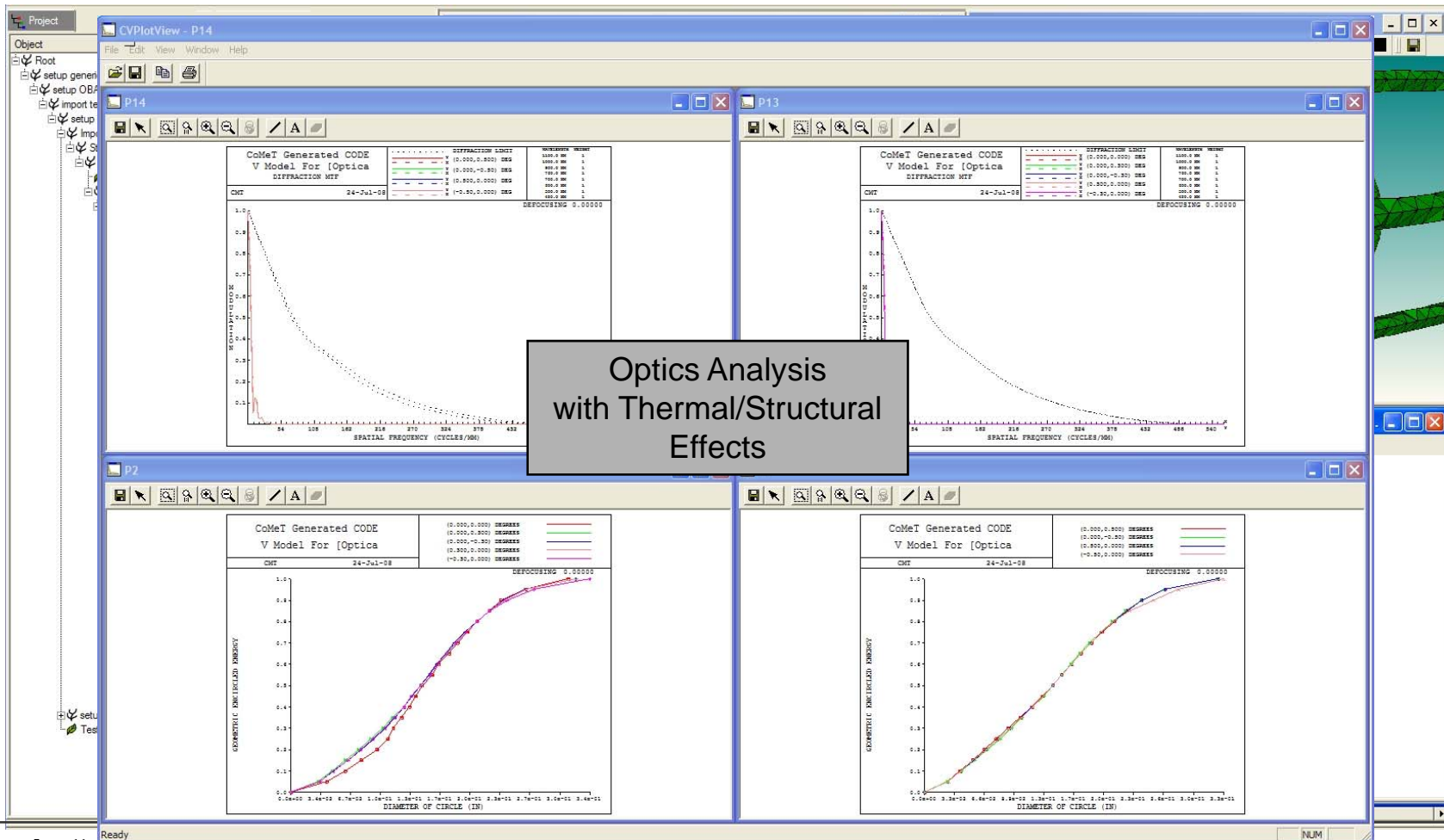
Optics and CAD models are “synchronized” when imported

Mesh the CAD Model



Automatic meshing “rules” set up in the Abstract Model resulted in significant efficiency gains during iterations

Get Optics Performance Results



Analysis “rules” (BC’s, analysis controls, environments...) for each engineering domain are captured in the template

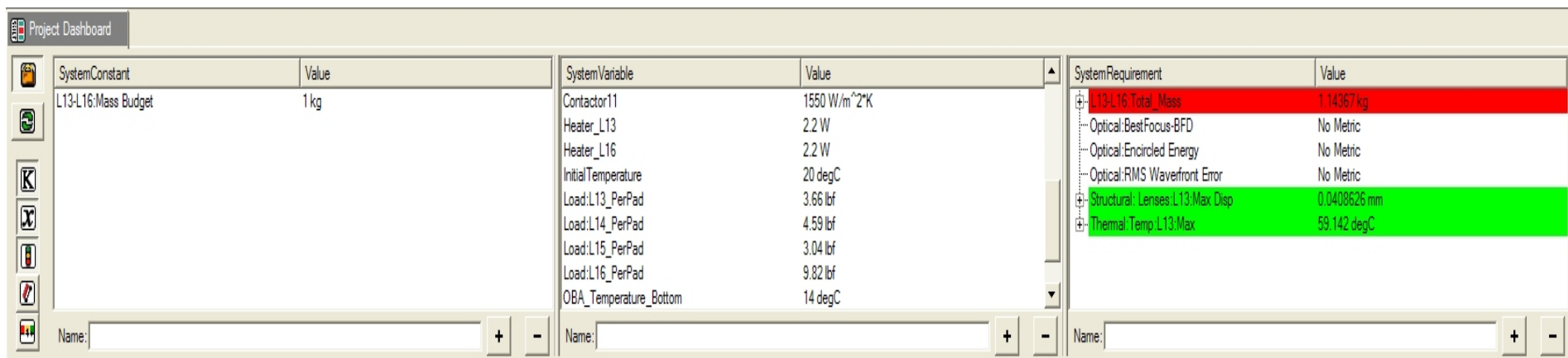
Analysis “rules” for SigFit and CODE V are captured in the template

Results are immediately available for review and downstream inputs



Use Project Dashboard for Reviews: A Single Summary View of Product Performance

- Change system variables.
- Run simulation processes.
- Immediately review key performance data regardless of the underlying CAD and CAE tools used.
- Facilitate the concurrent engineering process and customer briefings.



The screenshot displays the Project Dashboard interface with three data tables. The first table, SystemConstant, shows a single entry for L13-L16:Mass Budget with a value of 1 kg. The second table, SystemVariable, lists various parameters such as Contactor11 (1550 W/m^2K), Heater_L13 (2.2 W), and Initial Temperature (20 degC). The third table, SystemRequirement, lists requirements like L13-L16:Total_Mass (1.14367 kg), Optical:BestFocus-BFD (No Metric), and Thermal:Temp:L13:Max (59.142 degC).

SystemConstant	Value
L13-L16:Mass Budget	1 kg

SystemVariable	Value
Contactor11	1550 W/m ² K
Heater_L13	2.2 W
Heater_L16	2.2 W
Initial Temperature	20 degC
Load:L13_PerPad	3.66 lbf
Load:L14_PerPad	4.59 lbf
Load:L15_PerPad	3.04 lbf
Load:L16_PerPad	9.82 lbf
OBA_Temperature_Bottom	14 degC

SystemRequirement	Value
L13-L16:Total_Mass	1.14367 kg
Optical:BestFocus-BFD	No Metric
Optical:Encircled Energy	No Metric
Optical:RMS Waverfront Error	No Metric
Structural: Lenses:L13:Max Disp	0.0408626 mm
Thermal:Temp:L13:Max	59.142 degC



STOP Project Results and Conclusions

- Performance Engineering Workspace with Abstract Modeling is enabling our team to meet its goals:
 - We developed a higher fidelity STOP model *in less than half the time compared to standard processes.*
 - The abstract modeling technique allowed us to *perform more simulations effectively*, reducing manual data entry and errors.
 - Quantitative visualization of CAD/CAE results across discipline boundaries and in one view is key to *identifying and troubleshooting interdisciplinary design issues.*
 - The integrated project environment allowed us to *capture and track all analysis data and design variations.*
 - We conducted *effective and efficient design reviews* with customers from within the software environment with no need for PP slides!



Q&A

- Any Questions?
- A detailed white paper is available on this subject.
- Please see me or a Comet representative following this presentation or during the conference to request a copy.



Webinar Q&A

- Any Questions?
- A detailed white paper is available on this subject.
- Please visit www.cometsolutions.com for more information about our performance engineering workspace and abstract modeling. Or email – malcolm.panthaki@cometsolutions.com.

Managing Multiple CAD/CAE Representations

The screenshot shows a software interface with a project tree on the left, a central 3D model of a spacecraft, and a right-hand panel with a hierarchical object tree. The project tree includes stages like 'Import CAD Model', 'Run STOP Analysis', 'Iteration 1', 'Iteration 2', 'Parameter Study', 'Import CAD Model with Thermal Shields', 'Structural Study - Aug 5', 'Telescope', 'Gimbal Yoke', 'Iteration 1 - Default', 'Iteration 1.1 - Reduced Thickness', 'Thermal Study - Aug 1', 'Vary Shield', 'Add Overhang and Reduce Height', 'Increase Thickness and specificHeat', 'Thermal Shield Design', 'Design 2 with Thermal Shield', and 'Iteration 2.1'. The 3D model shows a spacecraft with a gimbal yoke and thermal shields. A color-coded displacement magnitude scale is visible at the bottom of the model. The right-hand panel shows a hierarchical tree with nodes like 'PhysicalModel', 'UserDefinedComponentRepresentationSet 186 [6]', 'GlobalCoordinatesSystem', 'AuxiliaryGeometry 199 [6]', 'Spacecraft', 'ComponentRepresentationSet 750617 [6]', 'Rep:Auto-Generated from AbstractDomain [Radi', 'Rep:Spacecraft', 'Bus-1', 'GimbalYoke-1', 'S.P1 Bus-1 To Sales Area-1', 'OpticalSystem: schmidt4.seq', 'CR01: object', 'CR02: object->Lens1', 'CR03: Lens1', 'CR04: Lens1Subobject1', 'Mirror', 'CR09: Lens2', 'CR10: Lens2->image_plane', 'CR11: image_plane', 'CR12: image_plane->image_plane'. A 'System Console' window at the bottom left shows 'SystemConstant' with values for 'AppliedOrbit:celestialBodyName', 'AppliedOrbit:fac', 'Launch_Cost_E', 'Launch_Cost_P', and 'Launch_Mass'. A 'Terminal' window shows '[SigfitTask-2007 174176]'. A 'Value' window at the bottom right shows 'sorbad-abebo' with a value of '184.053 m^2*kg*s^-3'. A large text box at the bottom contains the text: 'Work with multiple, closely associated, automatically created, CAD/CAE models and meshes'. The IVA logo is in the bottom right corner.

Thermal Analysis of Spacecraft

Component-Centric Model, not geometry-centric

Single Master CAD Representation per Stage in the Project

Optical System

Multiple Component Representations per Component

Modal Analysis of Gimbal Yoke

Deformation of Optical Element

Working with Subsets of the CAD Model

Working with Relevant Subsets of the Model

Work with multiple, closely associated, automatically created, CAD/CAE models and meshes

Space Borne Sensor Design: Tools Environment



Structural FEA



Optical Disturbances



Thermal/Radiation Simulation



CAD



Optics Simulation



General Calculations



Comet Solutions, Inc.

Comet Solutions, Inc.



Software Approaches were Limited

- Current Choices
 - Single-vendor, integrated suites of CAE tools
 - CAE point tools with bi-directional connection to CAD models
 - CAD-embedded “light” tools
- Limitations
 - Lack of integrated environment with access to all data & tools from multiple vendors
 - Lack of ready access to data for decision-making
 - Highly inefficient process when dealing with design changes



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Q&A Session

Using the Q&A tool, please submit any questions you may have for our panel.



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Thank you!

matthew.ladzinski@nafems.org

