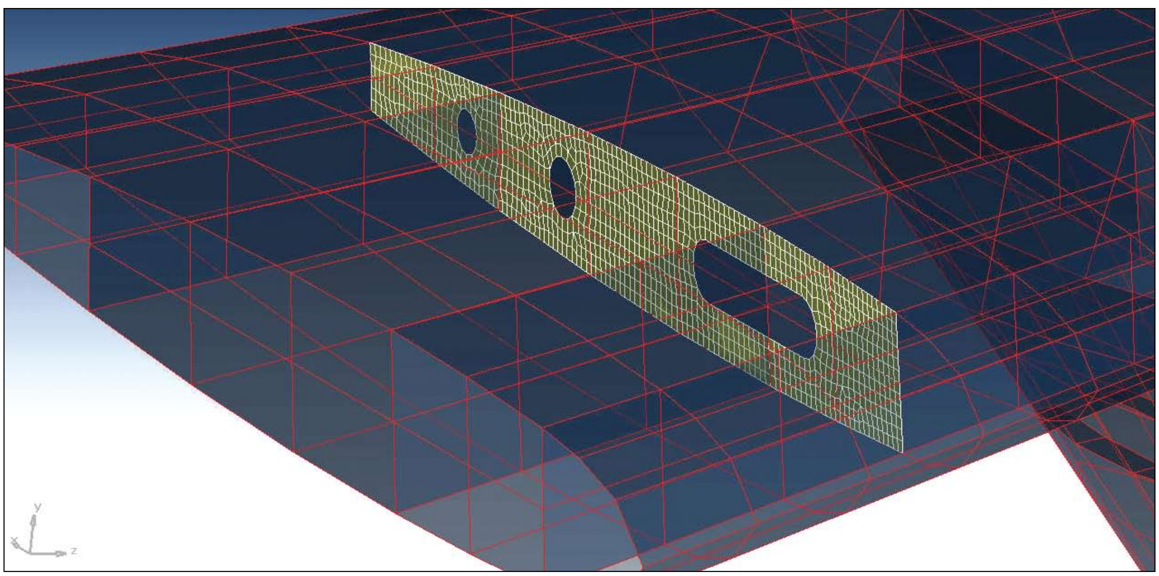
SIMULATE MORE EFFICIENTLY

Automating the Global-Local CAE Modeling Process in Aerospace Applications

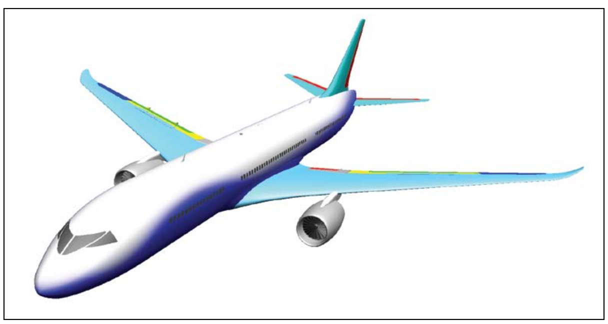
SimXpert Template Automation Improves Speed and Quality When Used to Create Global-Local FE Models

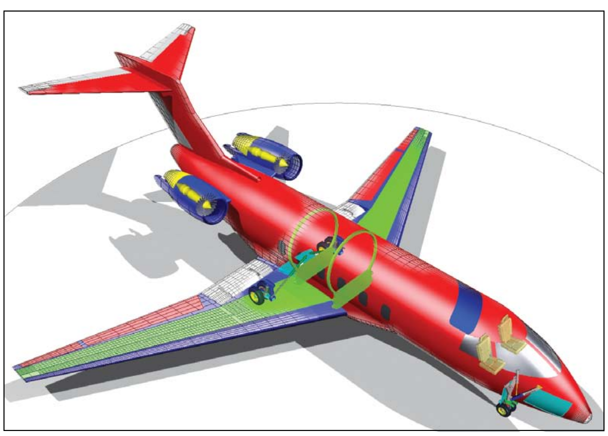


The Challenge of Simulating Large Aerospace Structures

Even at today's state of computation and processing power, creating a complete full-vehicle, detailed CAE model to compute stress, dynamic, and fatigue analyses is extremely difficult, if not practically impossible. The geometric detail and subsequent Finite Element (FE) mesh size required to get accurate results would drive model sizes to tens of millions of degrees of freedom. On its own, solving a model of that size would be challenging, but to try and analyze the results for tens of thousands of load cases, typically applied to aircraft designed to meet the most extreme performance requirements, is monumental.

Aerospace companies have circumvented these limitations by following and taking advantage of the systems engineering approach to product development where performance requirements are developed at the full vehicle level and then cascaded down to the system, subsystem, and component level. Once the detailed part performance objective is met, the component behavior is then cascaded back up to validate the system and vehicle level performance, using the more accurate information. One of the key ways that the systems engineering approach is supported using CAE is through using a Global-Local modeling and analysis methodology.





This methodology also works well in the aerospace industry, because it supports having distributed engineering teams responsible for specific engineering of subsystems, and it supports the extended enterprise where suppliers are responsible for subsystems and component engineering. It ensures that performance requirements are properly cascaded down, and that detailed component performance is easily plugged into the larger subsystem, system, and vehicle level models.

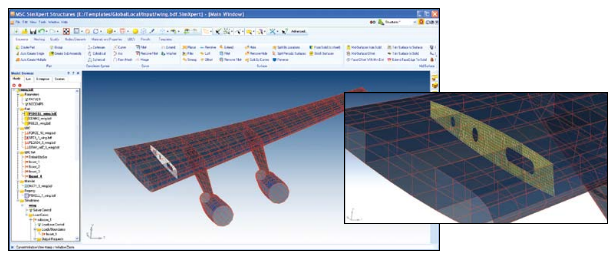
Global-Local CAE Methodology

As the name indicates, the Global-Local modeling methodology uses two types of models:

- Global – to capture overall vehicle or system behaviors such as displacements and forces, under defined loading conditions, using simplified or coarse FE meshing techniques.
- Local – to obtain accurate stress states of a design by modeling the geometry, boundary conditions, and loads using detailed or fine FE modeling techniques.

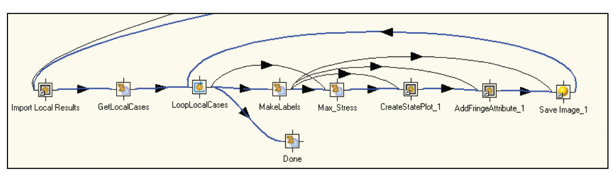
There are some key challenges to this methodology:

Creating global models can be a very tedious and time consuming modeling effort. After importing the required CAD geometry there is a lot of manual work required to clean and prepare the geometry, and then to properly create the beam elements representing all of the stiffening components and to create the shell elements for the large surface patches. This process can take a few calendar days as well as up to a couple of man weeks to complete, depending on the stage in the development process and complexity of the vehicle system. Even minor changes can require this entire process to be repeated in order to update the CAE model.



Local modeling requires the ability to extract the forces or displacements and boundary conditions from the locations where the detailed part connects to the global structure. These loads and boundary conditions then need to be properly modified in order to be assigned or mapped to the more detailed geometric FE representation of the part. The modeling time is not necessarily the key issue here, but it's the manual process of interpreting the global loads and understanding how to apply them on the local model that can be the biggest headache. In addition, with every iteration of the global model, this process must be repeated again.

Automating the Process Using SimXpert Templates



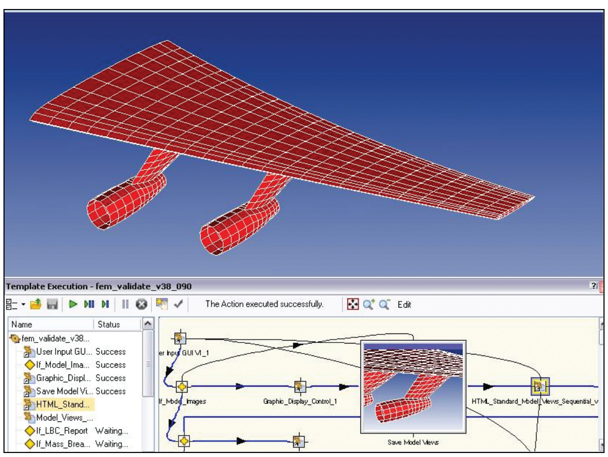
MSC's SimXpert and SimXpert Template Builder were specifically designed and developed to enable CAE analysts and experts to capture, standardize and deploy CAE best practices and processes. Based on Actions, SimXpert Templates are the most flexible and reusable process automation tools available. And the Template Builder provides an advanced environment to build templates using a 2D graphical drag-and-drop workspace which is very convenient for both non-programming CAE experts and advanced programmers.

Here are some of the unique capabilities and advantages to using SimXpert Templates and the Template Builder workspace:

- Use Macro Record to capture and string together a series of modeling actions and build basic starting templates which can be directly loaded into the Template Builder workspace.
- Use the Template Builder workspace to create, edit, and publish CAE process templates.
- Drag-and-Drop Actions from an extensive library of CAE modeling actions.
- Nesting of sub-templates – reuse existing templates as components of new templates.
- Looping of actions to process a list of parts or multiple load cases, for example.
- Create actions from Python scripts.
- Access to SimXpert API layer.
- Automatic creation of template dialogs.
- 3D graphical snapshots of the CAE model at different stages of the process for progress checks.
- Create interactive or fully automatic CAE processes.

Once the template is complete, the user can publish it to SimManager for enterprise simulation deployment or it can be maintained on a local or served file system for local and remote access.

The template can then be run within the SimXpert Workspace, using the Template Runner. Or, if the template is intended to be run by the Design Engineer, it can be run from SimDesigner through SimManager using a managed template user interface.



Global-Local Modeling of an Aircraft Wing Rib

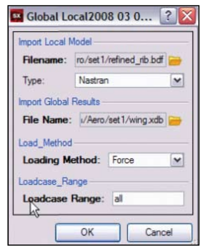
Here is an MSC-developed example that demonstrates how a company may use SimXpert Templates to automate a particular local modeling activity. In this example, SimXpert was used to capture the complete process of extracting loads and boundary conditions from the global model of an aircraft wing and then mapping them to the detailed rib model. This is done for each of the available load cases from the global model. Each load case on the local model is then setup, the job is submitted to MSC Nastran, and stress results are retrieved and plotted automatically.

Here's an overview of the process implementation:

Template Inputs

Upon loading the GlobalLocal Template, a start dialogue is displayed. This dialogue asks the user for four pieces of information, from which the entire process will run automatically. The data required is:

- Location of the local (refined) model
- Location of the global results, .xdb file
- Which loading method to use, Force or Displacement
- Which load cases to use from the global model. The user can select all, discrete load cases, or ranges of load cases



Template Outputs

For each selected and processed load case, the following outputs are available:

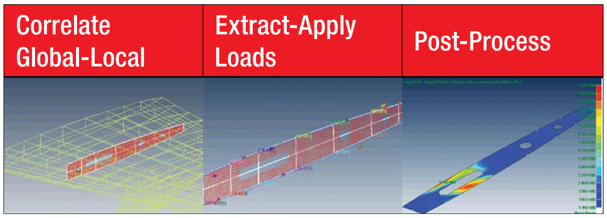
- Maximum Stress at Element
- Stress Fringe Plot

Key Process Steps and Actions

The Global-Local Template automates several of the key process steps that normally take significant time and become sources of error when creating local models by hand. These include:

Key Local (Global) Modeling Process Steps		
✓	Find Global Parts	Automatically finds the parts in the global model, from which the correct loads and boundary conditions will be extracted.
✓	Correlate Edges	Find the outer boundary of the detailed model and geometrically search for a matching element edge in the global model
✓	Create Loadcases and Subcases Element Quality Checks	Using Force Method: • Create RBE3 for each global interface grid • Create forces by summing grid point forces • Create inertia relief objects
		Using Displacement Method: • Interpolate displacements (translation and rotation) • Create SPCDs
✓	Export and Run Nastran	
✓	Post-Process	Retrieve results for each Loadcase: • Extract maximum stress and at which element • Create stress fringe plot

As an example, this methodology takes advantage of some readily available modeling objects; in this case, RBE3s, to help transfer forces to the local model nodes. Depending on any particular customer methodology, it is also possible to apply loads using spline-based methods or techniques based on St. Venant's Principle to achieve higher accuracy.



Gains

For this specific wing-rib example, **the process takes about one minute to complete** in its entirety, including running the MD Nastran simulation of the local model. This was done on a fairly well configured laptop, in standard use by MSC's application engineers and consulting staff. **Users can expect 4X to 10X improvement** in overall time to complete this type of process.

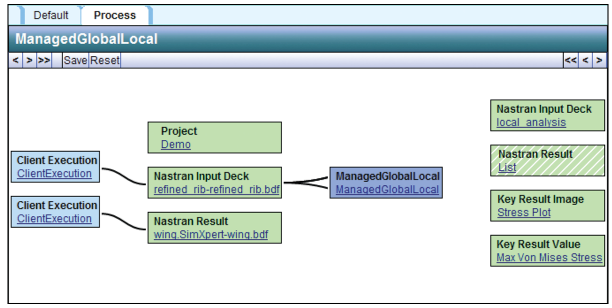
In addition, there is now a best practice that can be distributed to the rest of the CAE team, ensuring that:

- Best practices and knowledge are captured and followed.
- New engineers are trained in the best modeling practices.
- Re-work and delays are avoided by removing user errors introduced during a manual process.
- High confidence CAE results are delivered.

Where to Next?

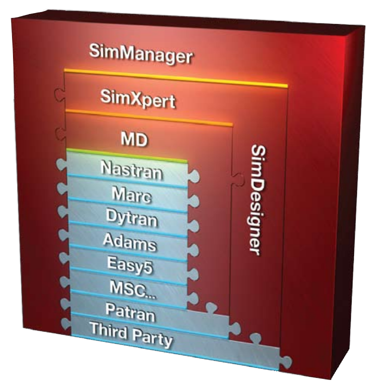
By developing and implementing a CAE Best Practice solution based on SimEnterprise, including SimManager, SimXpert, and MD Nastran, users can expect a significant impact on overall process speed and quality of work. For this particular example, utilizing SimManager enables:

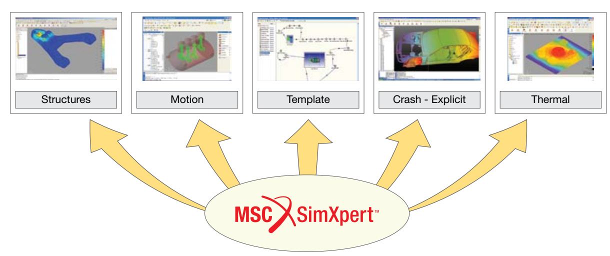
- Control and distribution of CAE Best Practice templates and versions ensuring that the best practice is always used.
- The template can be run in batch mode on the complete list local rib models, significantly improving overall modeling and analysis efficiency.
- SimManager can deploy simulations to existing HPC (High Performance Computing) centers, ensuring maximum resource utilization and process turnaround.
- Processes are audited, providing full documentation of design data, CAE method, and results.
- This template can be utilized as a sub process in a larger series of MD templates which may include other simulation types such as thermal or flexible body motion analysis, enabling a complete systems engineering approach to designing and validating vehicle performance.



In conclusion, MSC's Enterprise Simulation strategy based on SimXpert, SimDesigner and SimManager provides an all encompassing platform for maximizing simulation efficiency and quality. From this platform, a comprehensive set of multi-discipline simulation processes can be developed, deployed and managed. And, based on industry standard and leading multi-discipline CAE solution foundation, a path forward to high confidence and advanced simulation capabilities is ensured.

MSC's Solution Stack Portfolio provides a complete path forward from industry standard and multi-discipline CAE analysis foundations to a complete end-to-end simulation process and content management platform for Enterprise Simulation.





MSC's SimXpert provides a multi-discipline, multi-workspace platform for maximized CAE productivity utilizing a common framework for capturing, authoring, and publishing CAE best practices and processes.

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