National Aeronautics and
Space Administration

Advanced Materials Design Analysis Tools

Designs that are more affordable, lower weight, and efficient

TECHNOLOGY OPPORTUNITY

NASA's Glenn Research Center has developed a suite of software tools that provides accurate, efficient, and effective modeling and design support when using advanced materials, including smart materials and composites. The tool, Integrated multiscale Micromechanics Analysis Code (ImMAC), is a comprehensive, computationally efficient, and user friendly design analysis toolset used for accurately predicting behavior of all continuous- and discontinuous-reinforced composite materials (polymer, ceramic, and metal-matrix) and smart materials (shape memory alloys and piezoelectric). Due to its extreme level of computational efficiency, ImMAC tools are ideally suited for conducting sensitivity/parametric studies, that is, "what-if" scenarios, with a large number of cases.

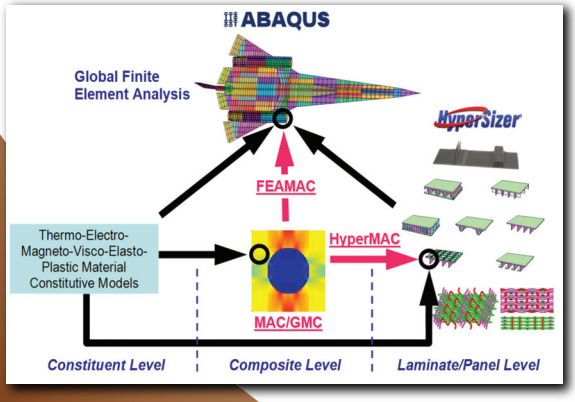
ImMAC is composed of three primary components:

- **Micromechanics Analysis Code (MAC)/Generalized Method of Cells (GMC):** Performs rapid, standalone analysis of composite/smart materials and laminates based on efficient non-Finite Element Analysis (FEA) micromechanics methods
- **FEAMAC:** Couples the efficient micromechanics capabilities of MAC/GMC with the ABAQUS finite element code for nonlinear multiscale analysis of composite structures including damage, failure, and viscoplasticity
- **HyperMAC:** Couples the MAC/GMC micromechanics capabilities with the HyperSizer stiffened structural optimization software

BENEFITS

Through the use of ImMAC and its ability to couple to powerful design and analysis tools, you can achieve

- **Improved material and component reliability** through better design and analysis
- **Conduct design trade studies** optimizing performance versus cost more efficiently
- **Decreased engineering costs** due to decreased need for redesign—get it right faster
- **Quicker adoption of the right materials** with costs savings associated with reducing testing
- **Access to the toolset while maintaining proprietary data** since the analysis tool is secure and will not share your data



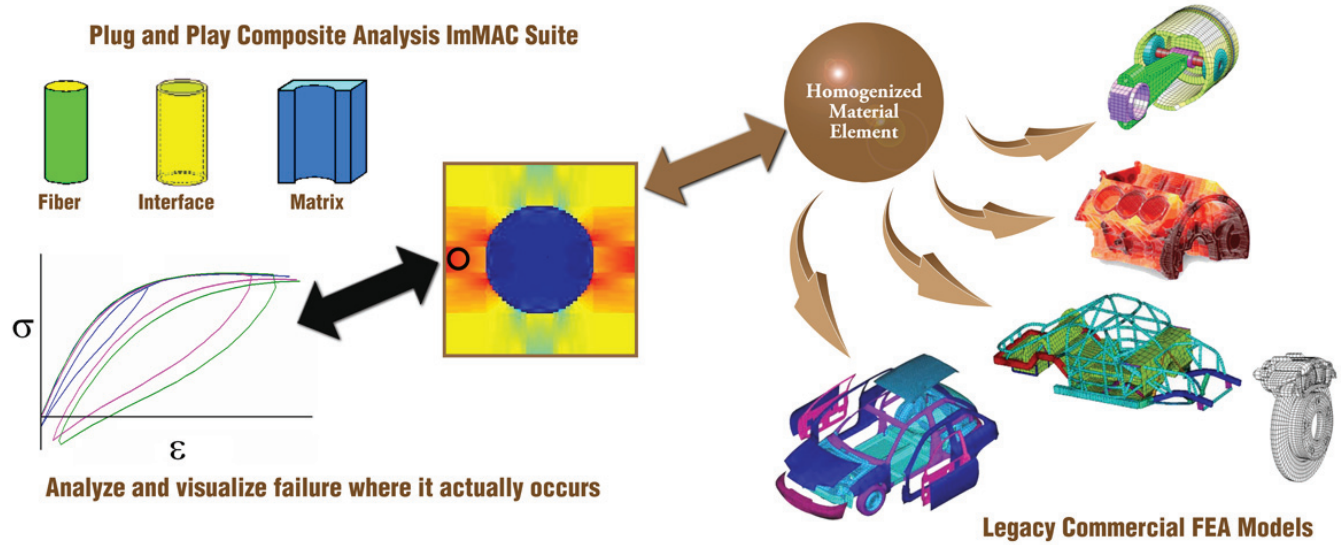
APPLICATIONS

ImMAC can be applied in numerous automotive applications that require design and analysis of components using advanced materials and composites. This includes

- Body
- Suspension/chassis
- Closures/fenders
- Multifunctional panels and frames wherein stress, thermal, acoustic, and vibration load management is achieved within a monocoque material system

HOW IT WORKS

The ImMAC toolset is fully maintained and distributed to over 90 customers in industry, government, and academia, with extensive user manuals and published test cases. The power of ImMAC has been validated through aerospace research use for over 15 years. ImMAC was successfully used to optimize the belt angle and develop a new tire (resulting in two patents) design with 28 to 50 percent improvement in durability at various speeds. Results were also obtained in a fraction of the time it normally took; for example, a two-ply composite analysis task that took more than 3 days to complete (preprocessing, analysis, and post-processing) using the traditional FEA approach (with submodeling instead of rebars so that local fields could be obtained) was accomplished in a matter of minutes (typically 45) using FEAMAC. The ImMAC infrastructure takes advantage of modern programming languages for storing and accessing data and employs dynamic memory allocation. The modular construction of ImMAC enables collaborative development of capabilities across users as selected limited source code can be exposed to outside developers while keeping the bulk of the source protected in compiled libraries. ImMAC was designed to support user-defined proprietary constitutive and damage/failure models/rules and to protect the company's proprietary data.



WHY IT IS BETTER

ImMAC allows for much more effective and efficient design of components and systems that utilize advanced materials and composites, as well as providing an excellent means of assessing damage. Material/component damage, for example, fiber failures, matrix damage, and interface debonding, can be modeled based on the local stress fields throughout the structure, and the effects of this damage progression on the global structural response can be simulated. This higher level design and analysis design toolset provides for a more proactive and effective approach to incorporating advanced materials and composites into your product lines. Through use of ImMAC, you can now capitalize on the great benefits that use of these materials can bring including

- Weight reduction due to higher structural integrity per unit mass
- Lower costs from lower part count and near net-shape manufacturing capability
- Structural versatility based on the highly tailorable properties of composites

LICENSING AND PARTNERING OPPORTUNITIES

Glenn's Office of Technology Partnerships and Planning seeks to transfer technology to and from NASA to benefit the space program and U.S. industry. NASA invites companies to consider utilizing the ImMAC toolset (LEW–16,487–1; LEW–17495–1; LEW–17818–1; LEW–17819–1; and LEW–18544–1).

FOR MORE INFORMATION

For more information about this and other technology licensing opportunities, please contact

Office of Technology Partnerships and Planning
NASA Glenn Research Center
Email: otpp@grc.nasa.gov
Phone: 216–433–9701