**What Is ICME?**

Integrated Computational Materials Engineering (ICME) combines bedrock computational physics and informatics with systematic experiments and advanced manufacturing to reduce the cost, risk, and cycle time for new product development. It merges a top-down approach using state-of-the-art informatics tools to mine an extensive database on materials, product properties, and manufacturing process performance with bottom-up multiscale modeling based on first principles.

At Lockheed Martin, ICME is enabling Lockheed Martin engineers to concurrently design materials, components, and flexible manufacturing processes to reduce technology insertion risks for major programs. Potential savings from ICME will come at every step of the design and manufacturing process:

- Conceptual design
- Material selection and qualification
- Component design trades
- Process selection, development and optimization
- Device design and integration
- Process verification
- Assembly and testing
- Part certification
- Low rate initial production
- Repair, maintenance, and sustainment.

**ICME Application Benefits**

- Risk reduction
- Cost savings
- Novel fit-for-purposes materials
- Integrated design, certification, and flexible manufacturing

ICME has already benefited several programs at Lockheed Martin.

**Materials Design**

During the development of the APEX family of multiscale reinforced nanocomposites, the ICME team modeled the unique behavior of the nano- and microscale constituents that make up these materials. Through a multiscale modeling approach combining computational fluid dynamics, anisotropic laminate analysis, and continuum mechanics, changes in APEX constituents and thermal process conditions, can be translated into predictions of part performance at the design stage.

**New Tools for Solving Problems with ICME**

Lockheed Martin's ICME efforts go beyond modeling activities. Lockheed Martin engineers are developing a suite of informatics tools and rapid characterization tools that will speed the calibration of empirical models that is needed to fill gaps in our theoretical understanding. Working with colleagues at the Air Force Research Laboratory, the ICME team is integrating this suite of tools into a high-throughput carbon nanotube materials discovery platform in order optimize the growth conditions for single-walled carbon nanotubes with specific electronic configurations. This work aims to enable device designers to tailor the bandgap of electro-optical devices such as infrared sensors.

The ICME team is also creating a new open and interoperable device modeling and design tool. The ultimate payoff will be the ability to design products from the top down and enable the digital factory that will provide flexible materials and manufacturing solutions—and a 3- to 9-fold return on investment from such ICME efforts.