

ADVANCED MANUFACTURING

The 21st Century Materials Design Space

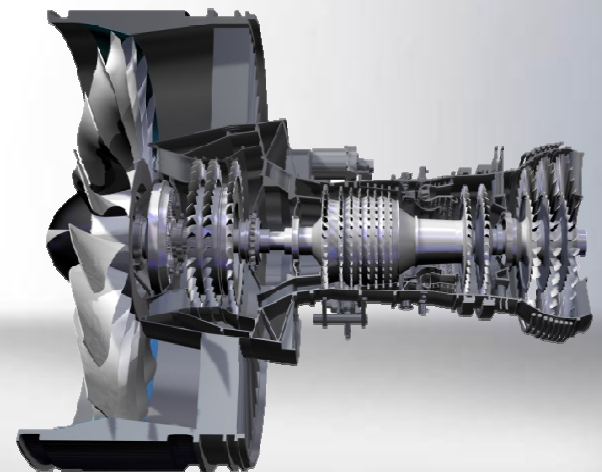
Eric J. Amis, Ph.D.
Director, Physical Sciences
United Technologies Research Center



Increasing Pressure on Manufacturing

Requirements:

- Shorter time to market
- Extreme conditions
- Increased product life
- Reduced weight
- Lower cost
- Higher yield
- Improved energy efficiency
- Less waste and environmentally friendly



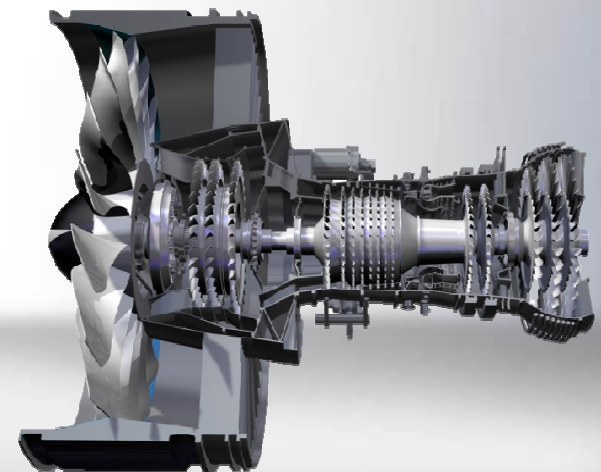
Increasing Pressure on Manufacturing

Requirements:

- Shorter time to market
- Extreme conditions
- Increased product life
- Reduced weight
- Lower cost
- Higher yield
- Improved energy efficiency
- Less waste and environmentally friendly

Additional Challenges:

- Complexity of geometries and systems
- Expanded materials options
- Manufacturability

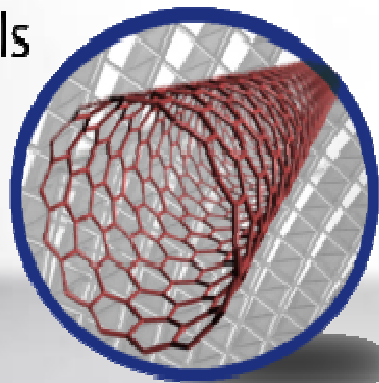


Manufacturing Paradigm

Manufacturing



Materials



Performance

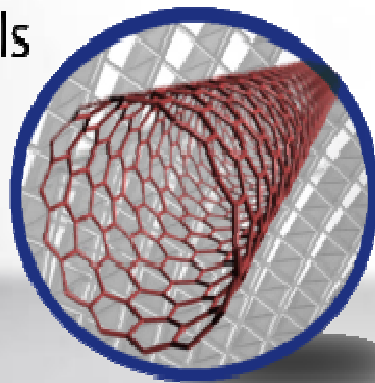


Manufacturing Paradigm

Manufacturing



Materials

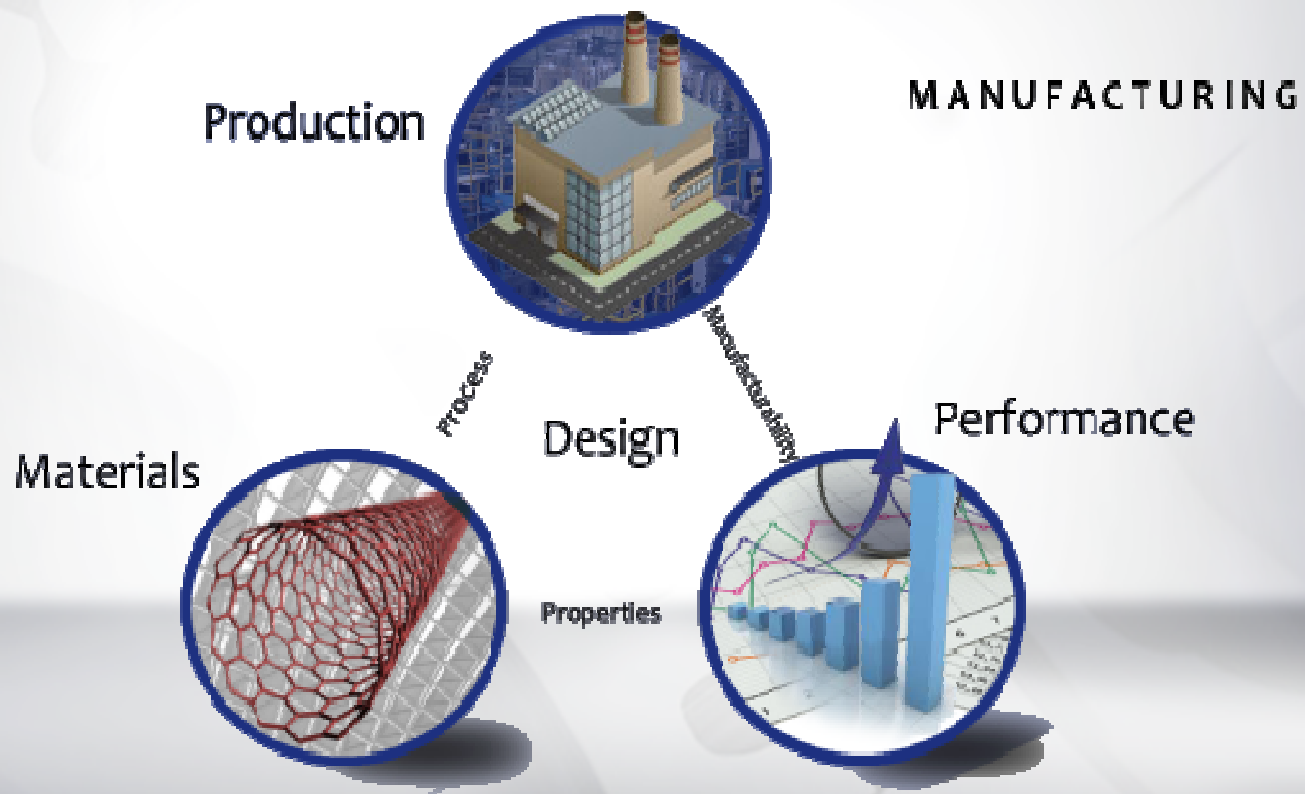


Performance



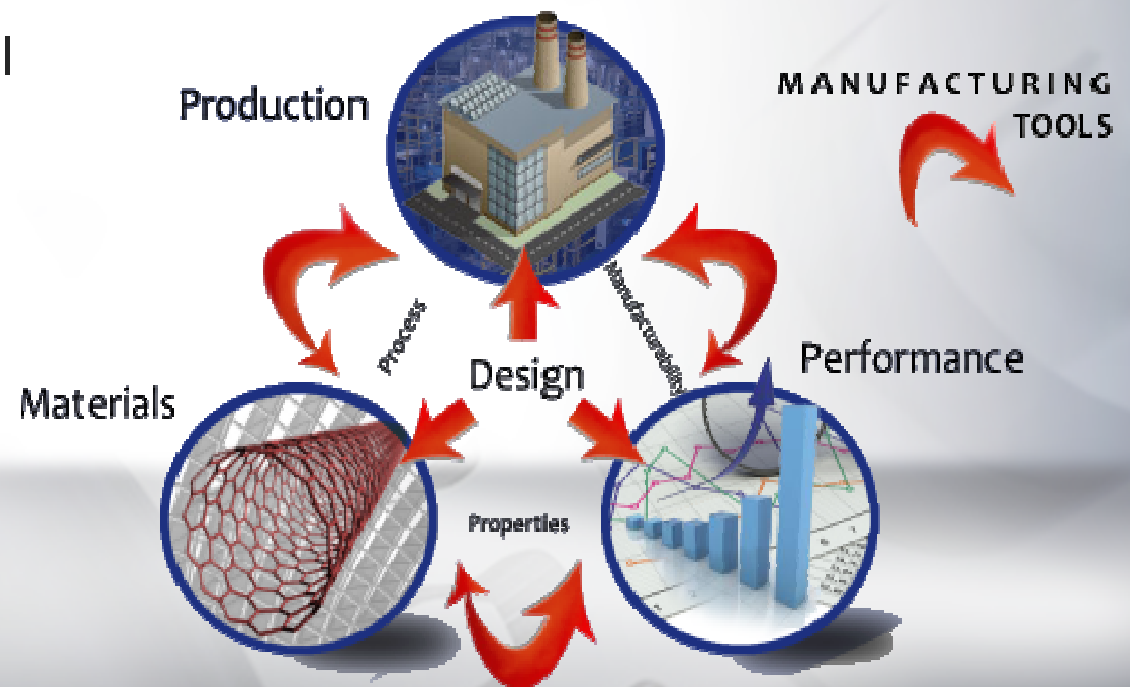
Evolving Manufacturing Paradigm

Design Space to Integrate Properties,
Process, and Manufacturability



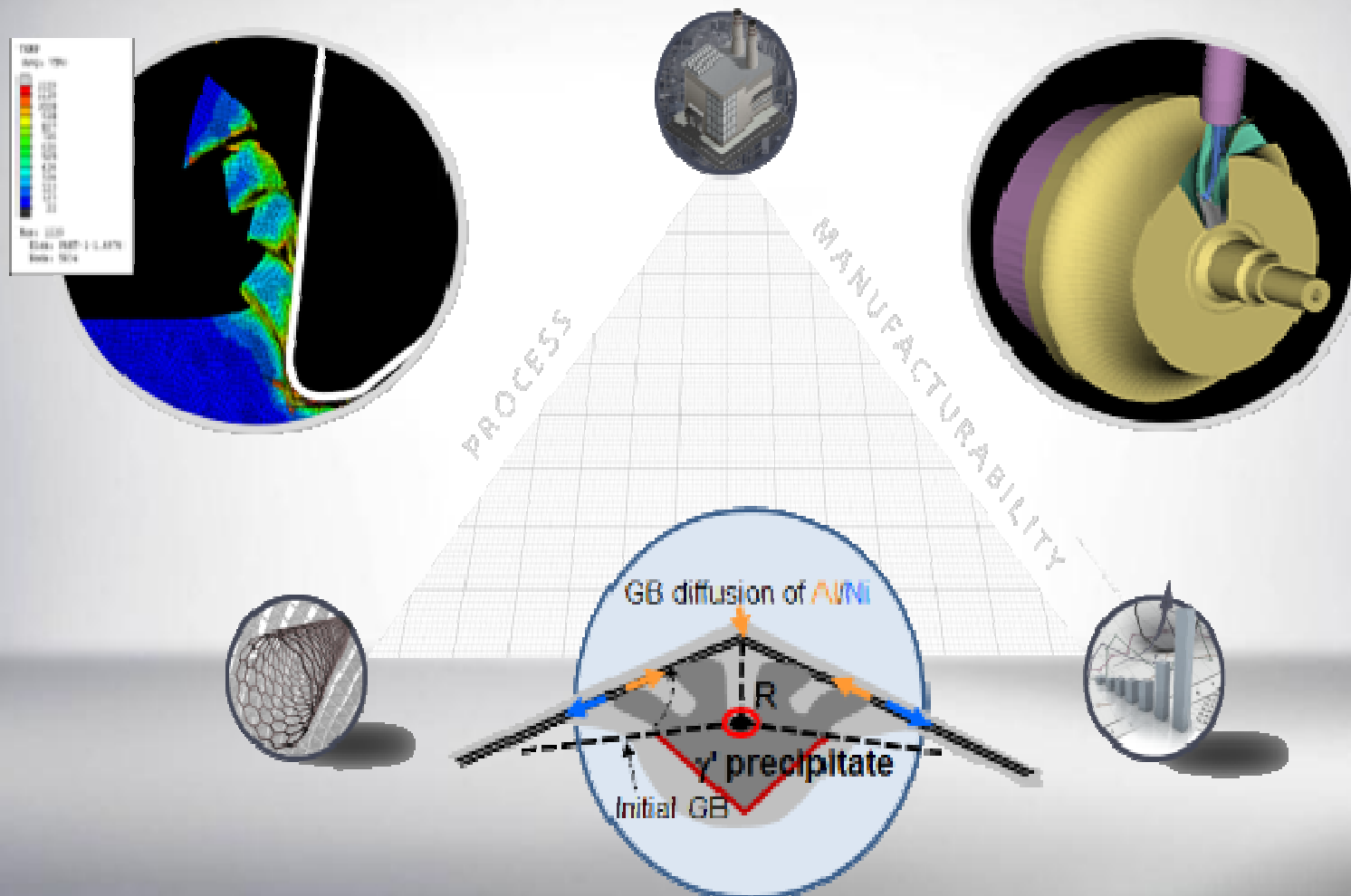
Components of Integrated Approach

- Integrate computational materials engineering
- Optimize with physics-based models
- Enable agility by additive manufacturing
- Implement concurrent hybrid processes
- Process monitoring, online inspection, feedback control
- Virtual manufacturing optimization



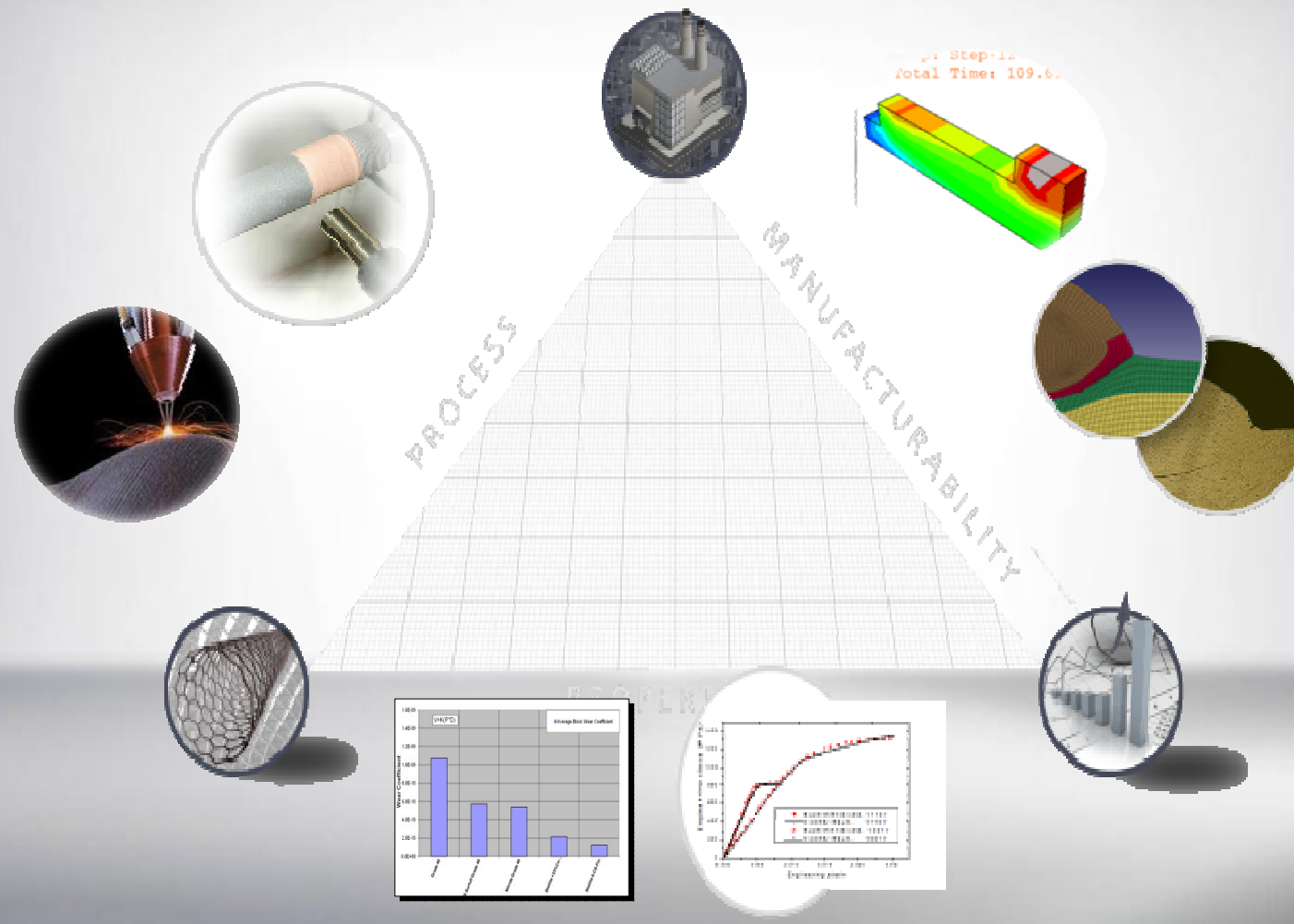
Integrated Computational Models

Quality, Speed, and Cost



Additive Hybrid Optimization

Complexity, Agility, Efficiency



Invention and Innovation

Invention and innovation are complements.

In the short run, this complementarity is not perfect; it is possible to have one without the other.

But in the long run, technologically creative societies must be both inventive and innovative.

Without invention, innovation will eventually slow down and grind to a halt, and the stationary state will obtain.

Without innovation, inventors will lack focus and have little economic incentive to pursue new ideas.

“The Lever of Riches: Technological Creativity and Economic Progress” John Mokyr, Oxford, 1990.