

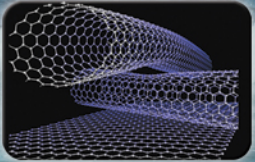
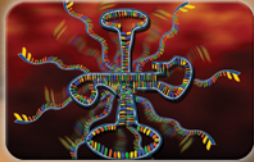
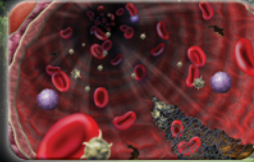


Celebrating
60 *years*
of Discovery

2012 Cyber Physical Systems PI Meeting

CPS in Design & Manufacturing

Bruce M. Kramer, Senior Advisor



October 4, 2012
Gaylord National Hotel



A Short 'History' of Manufacturing

- **Materials- and Process-Driven Manufacturing**
 - New materials demand process innovations
 - Stone-chipping to semiconductor fabrication
- **Metrology-Driven Manufacturing**
 - Precision of parts made > that of machine parts
 - A cycle of ever-increasing precision
 - Interchangeable parts to LIGO
- **Logistics-Driven Manufacturing**
 - Electric motors provided distributed power
 - Layout for material flow, not power access
- **Computer-Driven Manufacturing**
 - NC Machining (1952), CAD/CAM
 - Modeling and Simulation, MRP, Synthetic Biology



Current Role of the Internet in Manufacturing

- **The CAD terminal is pervasive**
 - Modern gateway to manufacturing
 - 100,000 CAD/CAM seats in US High Schools
- **Manufacturing enterprises use internet communications**
 - data transmission, collaborative design, ordering
- **Improved web services promise reduced wait time**
 - Estimated > 95% of part time in organizational handoffs
- **Some manufacturing services available, within process**
 - Rapid prototyping, NC machining, VLSI, PCBs...
- **No analog to explosive expansion of web commerce**
- **Retailing, music, publishing have been transformed**
 - Widely accessed by a creative public



The Manufacturing Mindset

- Highly skilled and experienced specialists
- Product must be 100% reliable, on-time and in-spec
 - A deciding factor for critical applications
 - Systems must respond predictably to every need
- Requires ‘command and control’ systems
- Top-down, expensive, complex, difficult to change
- The opposite of the web

But...



The 'Internet Manufacturing' Mindset

- System capabilities will evolve and increase with time
 - If some entrepreneurs can make money using them
 - Only a tiny fraction of apps will survive
- Small scale users exploit incremental capabilities
 - Key element is better tools than they have
 - They' ll make what the system can produce
 - Access increased by reduced cost of entry
 - Long odds of success for millions of ideas
- Large-scale users exploit proven capabilities
 - Adopt as the reliability threshold is crossed
 - Fortune 100 were not early web adopters