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## **"Made in the USA" can be Revitalized**

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It's no accident that Apple's iPhone and Boeing's 787 are receiving global applause. Both are highly engineered products manufactured by experts who use advanced technologies and high-volume, cost-effective production methods. This is the kind of know-how that once established "Made in the USA" as the global standard to beat.

The iPhone, however, is manufactured in Taiwan. The Boeing 787 is assembled in Japan. America, birthplace of the modern assembly line, is losing ground when it comes to putting things together. Driven by short-term savings and ignoring the close relationship between innovation and manufacturing, America has relinquished this responsibility to ambitious foreign competition, who are investing in fundamental research that improves manufacturing processes and luring our finest researchers overseas. America produces roughly 75,000 engineers per year. China graduates ten times that number. India produces close to a million.

But quality control weaknesses in overseas manufacturing of toys, tires, and toothpaste have resulted in huge losses in reputation and value, environmental repercussions, and employee layoffs. Our overseas competitors are learning from these lessons and developing advanced automation to ensure consistent product quality. The next wave of high-value products will require assembly at the micro and nano scales, where manual labor is no longer an option. These trends suggest enormous opportunities.

US manufacturing is not a lost cause: the production of goods from consumer electronics to industrial equipment accounts for 14 percent of the U.S. GDP and 11 percent of U.S. employment. But U.S. manufacturing today is where database technology was in the early 1960's, a patchwork of ad hoc solutions that lacked the rigorous methodology that leads to scientific innovation. That all changed in 1970 when Ted Codd, an IBM mathematician, invented relational algebra, an elegant mathematical database model that galvanized federally funded research leading to today's \$14 billion database industry.

Manufacturing needs the same treatment. Just as the method to add two numbers together doesn't depend on what kind of pencil you use, manufacturing abstractions can be wholly independent of the product one is making or the assembly line

systems used to assemble it. Another precedent is the Turing Machine, an elegant abstract model invented by Alan Turing in the 1930s, which established the mathematical and scientific foundations for our now-successful high-tech industries. Without Turing's theoretical work, the system that typeset this line wouldn't exist.

What's needed today is an analogy to the Turing Machine for design, automation and manufacturing. Recent developments in computing and information science have now made it possible to model and reason about physical manufacturing processes, setting the stage for us to "put the Turing into Manufacturing". The result, as was the case with databases and computers, would be higher quality, more reliable products, reduced costs, and faster delivery.

With the signing of the America Competes Act on August 9, 2007, Congress is authorized to appropriate \$33.6 billion into new science and technology programs. Let's use this opportunity to revitalize America's attitude toward manufacturing. Investing a small portion of our national resources into a science of cost-effective, resource-efficient manufacturing would benefit American consumers and support millions of workers in this vital sector of the US economy. Such a research program would benefit health care, agriculture, and transportation, and strengthen our national resources in defense, energy, and security. The resulting flurry of research activity would invigorate the quality and productivity of "Made in the USA" for the next fifty years.

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