



# Engineering, invention and innovation

Christopher L. Magee

MIT

Feb. 28, 2008



# Creativity, Invention, and Innovation

- Cognitive science is learning more about the human creative process- it is essentially transgressive.
- We all invent in an incremental way frequently and use the result personally
- However, most inventions are not useful by many people so have small overall impact (but some still may please their inventor/user)
- Innovations are the changes with large impact on society
- With deep knowledge of how things actually work (engineering knowledge) and the laws of nature (science), innovations of importance to all mankind are now occurring quite frequently throughout the world.
- The best of these inventions/innovations build upon one another and use the constantly expanding base of science as well. The marriage of science and engineering is thus known to be essential to economic development and human progress.



# the **SCIENTIST / MATHEMATICIAN** and the **ENGINEER**

## **MANY SIMILIARITIES**

- Engineering requires thorough mathematical & scientific knowledge
- Engineers study science and math extensively
- Engineers may conduct scientific experiments while doing Engineering
- Scientists use engineering methods
- Some great engineers trained as scientists & mathematicians
- Some great scientists trained as engineers
- All require intensity, passion, creativity & intellectual effort

## **BUT, THEY ARE DISTINCT**

*“The scientist seeks to understand what is; the engineer seeks to create what never was”* -Von Karman

***ENGINEERING*** is a human activity aimed at innovating/inventing/creating new artifacts, algorithms, processes and systems that serve humans

## **BROAD HUMAN WANTS**

- **Shelter**
- **Food**
- **Transportation**
- **Communication**
- **Security**
- **Longevity, personal and progeny**
- **Sustainability**
- **Entertainment**
- **Aesthetic pleasure**
- **Social, Emotional, Spiritual & Psychological rewards etc.**



## AN ENGINEER CAN INNOVATE BECAUSE AN ENGINEER IS ABLE TO...

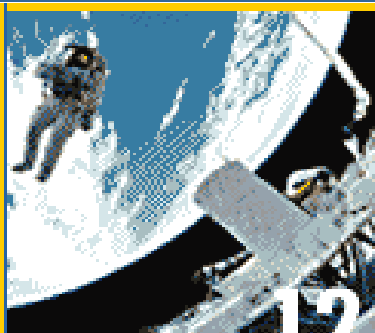
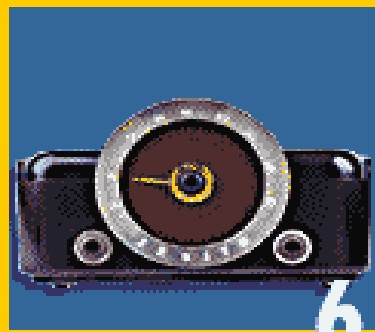
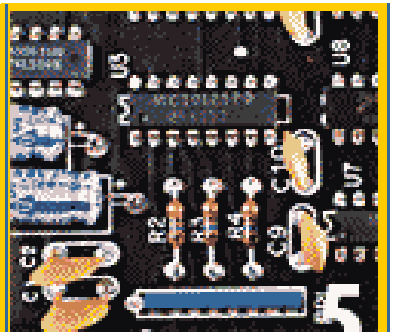
- Determine quickly how things work
- Determine what customers want
- Create a concept
- Use abstractions/math models to improve a concept
- Build or create a prototype version
- Quantitatively and robustly test a prototype to improve concept and to predict
- Determine whether customer value and enterprise value are aligned (business sense)
- Communicate all of the above to various audiences

- Much of this requires “domain-specific knowledge” and experience
- Several require systems thinking and statistical thinking
- All require teamwork, leadership, and societal awareness



# United States National Academy of Engineering

## Greatest Engineering Achievements of the 20<sup>th</sup> Century





# NAE Greatest Engineering Achievements of the 20th Century

- 1. Electrification
- 2. Automobile
- 3. Airplane
- 4. Water Supply and Distribution
- 5. Electronics
- 6. Radio and Television
- 7. Agricultural Mechanization
- 8. Computers
- 9. Telephone
- 10. Air Conditioning and Refrigeration





# NAE Greatest Engineering Achievements of the 20th Century

- 11. Highways
- 12. Spacecraft
- 13. Internet
- 14. Imaging
- 15. Household Appliances
- 16. Health Technologies
- 17. Petroleum and Petrochemical Technologies
- 18. Laser and Fiber Optics
- 19. Nuclear Technologies
- 20. High-performance Materials



# Greatest Engineering Achievements of the 21<sup>st</sup> Century

- What do you think they will be?
- Sustainable air transport? Cheap solar energy, affordable energy from fusion
- Continued improvement in human life but also for other species?
- Human lifespan radical extension?
- Would you like to participate?