Some thoughts on Science and Engineering

(especially Systems Engineering)

AEM 1905: High-Power Rocketry

Science

What fields come to mind?

- Physics
- Biology
- Chemistry
- Zoology
- Ecology

What do scientists do?

- Scientific method
- Hypotheses
- Medical research
- Study the fundamental rules of nature

Engineering

What fields come to mind?

- Civil
- Chemical
- Electrical
- Aerospace
- Mechanical
- Biomedical
- Systems

What do engineers do?

- Applications using science results
- Design things
- Build things
- Test limits things

Scientists look at things as they are and ask “why?”

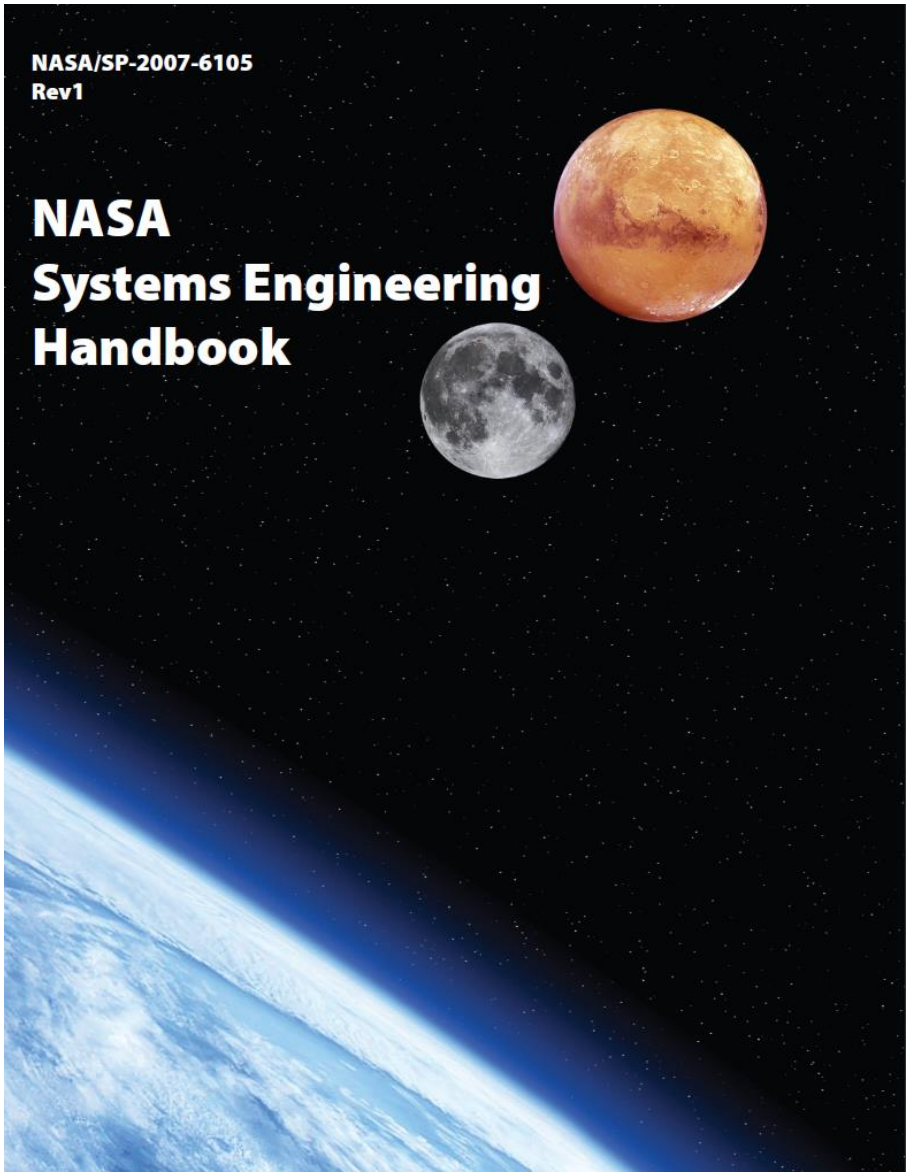
Engineers dream of things that never were and ask “why not?”

Adapted from a quote by George Bernard Shaw

Departments in the U of MN College of Science and Engineering

Aerospace Engineering and Mechanics
Astronomy
Biomedical Engineering
Bioproducts and Biosystems Engineering
Chemical Engineering and Materials Science
Chemistry
Civil Engineering
Computer Science and Engineering
Electrical and Computer Engineering
Geology and Geophysics
Mathematics
Mechanical Engineering
Physics
Statistics
(relatively new) Industrial and Systems Engineering

Central to all – Systems Engineering



From NASA's Systems Engineering Handbook, 2007

Systems engineering is a methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system. A "system" is a construct or collection of different elements that together produce results not obtainable by the elements alone. The elements, or parts, can include people, hardware, software, facilities, policies, and documents; that is, all things required to produce system-level results. The results include system-level qualities, properties, characteristics, functions, behavior, and performance. The value added by the system as a whole, beyond that contributed independently by the parts, is primarily created by the relationship among the parts; that is, how they are interconnected.[1] **It is a way of looking at the "big picture" when making technical decisions.** It is a way of achieving stakeholder functional, physical, and operational performance requirements in the intended use environment over the planned life of the systems. In other words, systems engineering is a logical way of thinking.

[1]Rechtin, *Systems Architecting of Organizations: Why Eagles Can't Swim.*

From NASA's Systems Engineering Handbook, 2007

Systems engineering is the art and science of developing an operable system capable of meeting requirements within often opposed constraints. Systems engineering is a holistic, integrative discipline, wherein the contributions of structural engineers, electrical engineers, mechanism designers, power engineers, human factors engineers, and many more disciplines are evaluated and balanced, one against another, to produce a coherent whole that is not dominated by the perspective of a single discipline.[2]

Systems engineering seeks a safe and balanced design in the face of opposing interests and multiple, sometimes conflicting constraints. The systems engineer must develop the skill and instinct for identifying and focusing efforts on assessments to optimize the overall design and not favor one system/subsystem at the expense of another. The art is in knowing when and where to probe.

[2]Comments on systems engineering throughout Chapter 2.0 are extracted from the speech "System Engineering and the Two Cultures of Engineering" by Michael D. Griffin, NASA Administrator.

Considerations for a spacecraft/spaceflight system:

Communications
Power
Thermal management
Propulsion
Attitude determination and control
Orbit/trajectory
Navigation/guidance
Science
Pre-flight testing
In-flight Ground Operations
Re-entry (depending on the mission)
Life support (sometimes)

Example: the Apollo Lunar Module (LM)

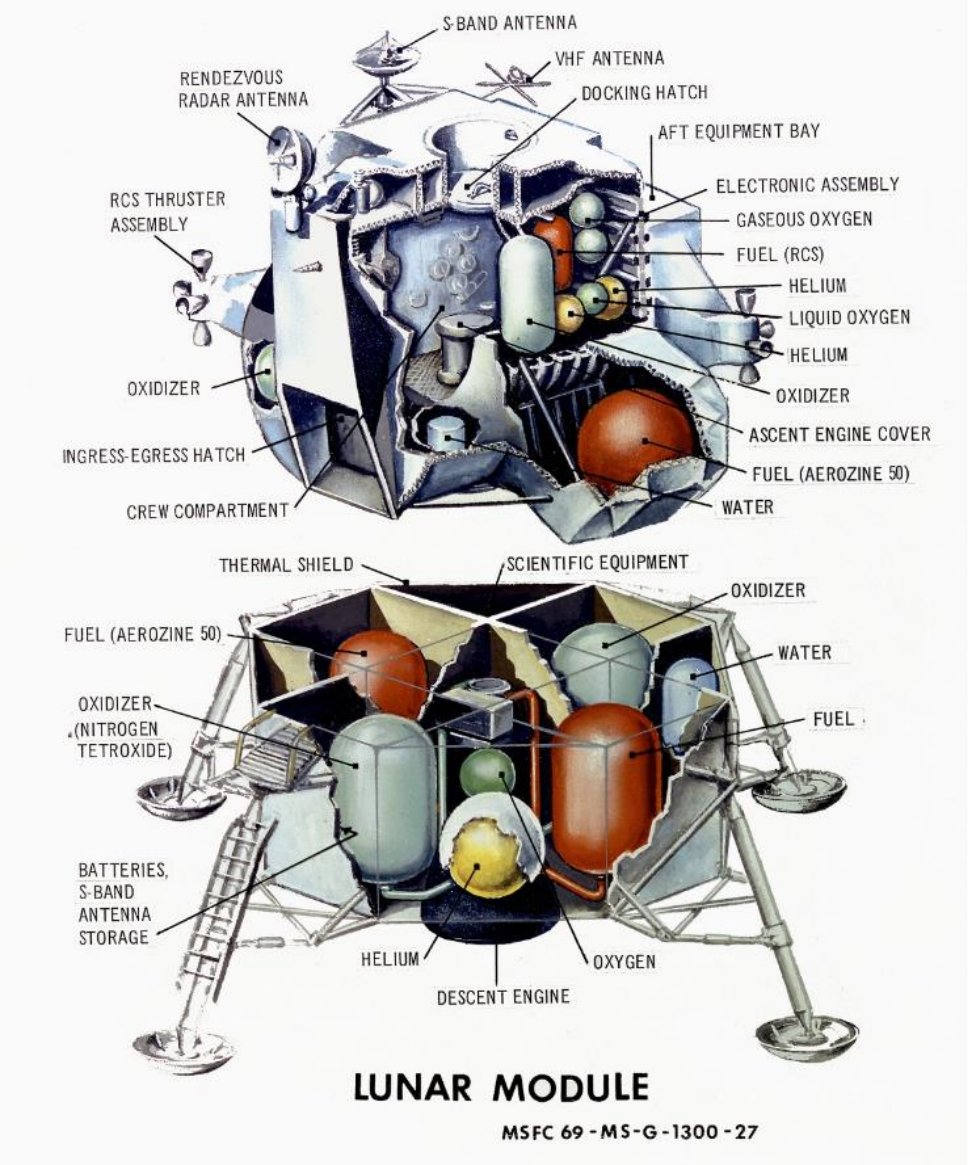


Image posted at http://en.wikipedia.org/wiki/File:LM_illustration_02.jpg