Systems Philosophy

• Problems evident with mechanistic and reductionist view, post Industrial Revolution

• Unable to accommodate “life.”
  – Physics: “entropy increases in a closed system”
    • Second Law of Thermodynamics
  – Life: “obvious example of order increasing”
  – Civilization: ditto
  – Organizations, industries and enterprises: ditto

• Stability in physics—low energy
• Stability in life, etc., above—*high* energy
Systems Philosophy

• It is not that the Second Law is wrong
• It is because the Second Law applies only to closed systems
• Are there any closed systems in the real world?
• If there were, would we know of their existence?
• So, the idea of “open systems” emerged…
Systems Philosophy—Organismic Analogy

• Analogies were drawn between man-made systems and organisms
• The “Organismic Analogy”
• Not to say that enterprises, industries, civilizations, etc., were organisms
• More to say that, like organisms, they “behaved as a unified whole”
• Each had a life cycle, each exhibited growth, stability, and finally death - often sudden, collapsing death.
Systems Philosophy—Holism

• Besides the Organismic Analogy, two other tenets emerged

• Holism:
  – everything within a system is connected/related to—and affects—everything else
  – viewing or considering parts on their own is irrational

• Systems and their problems have to be viewed as a whole
Systems Philosophy—Synthesis

• Synthesis: systems created by bringing other systems together in some special way
• Not possible to employ reductionism
• Why? Not possible for a surgeon to dissect a patient into many, various organs, treat the organs, reassemble, and expect life
• Various parts cannot exist/survive/operate/behave/even be considered in mutual isolation
  – they depend for their very existence on interchanges with the other parts
Systems Philosophy—Emergence

• The notion that, in behaving as a whole, a system may exhibit properties that are not exclusively attributable to any of its parts
  – E.g., self-awareness from the human brain
  – Perception of motion from film and TV

• Commonly referred to as: the whole is greater than than the sum of the parts

• More appropriate—the whole is different from the sum of the parts

• Caused by mutual interaction between the parts, each affecting the other—and the whole
General Systems Theory

- 1954: Ludwig von Bertalanffy, Kenneth Boulding, Ralph Gerard, A. Rapoport
- GST postulated as a “science of wholeness”
- Embraced the Life Sciences as well as physics, chemistry, etc. Very mathematical
- Models from GST, and ideas of Open Systems and the Organismic Analogy greatly influenced the fledgling discipline of systems engineering
...and so to Apollo

- Astounding early NASA success
- Conception, design, development consistent with Open Systems and Organismic Analogy
- Spacecraft made from many interconnected, interlocking parts
- These parts could separate and operate independently, yet...
- Behave as a unified whole
Apollo

• The various parts had to exist within a single limit of overall weight/mass
  – Increase any one, others had to reduce

• Ditto for shape/form

• Design became something like creating a 3-D jigsaw puzzle

• Moreover, the function, fit, form and mass of the various parts had to be “fluid” during design

• Designers abstracted, working with the emergent properties of the various parts, rather than technologies
Apollo—Major Parts

- Apollo missions carried complex, highly integrated, yet potentially independent, parts
  - Command module
    - Crew positions
      - Re-entry vehicle
  - Service module
    - main propulsion system
    - stowage for most consumable supplies.
  - Lunar module
    - Descend, roam, return
      - Modularised Equipment Stowage Assembly (TV equipment, lunar sample containers, and portable life support systems), the Lunar Roving Vehicle (LRV), and the Apollo Lunar Surface Experiment Package (ALSEP)
  - Saturn V launch vehicle

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Concept of Operations

- NASA employed systems people at the top level to design and synthesise the whole from the parts.
- Each of the parts also had systems people, similarly designing and synthesizing their part from sub-parts.
  - And so *ad infinitum*
- The whole design was tested using step-by-step run-throughs of “how things would work”.
  - When things went right, *and* when they went wrong.
- Result was a Concept of Operations (CONOPS).
- Competing CONOPS eliminated to leave only one.
  - The preferred CONOPS - identified the preferred design.
Where was the Technology?

- Note the absence of technology in any of the descriptions of Apollo. Also absent from the CONOPS.
- Technology in background during top level design
  - to avoid unrealistic designs
- Technology and engineering came to the fore once the various systems had been designed.
- Technology’s role: to instantiate the system, once designed, i.e. to make it happen.