Systems Philosophy

Derek Hitchins

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

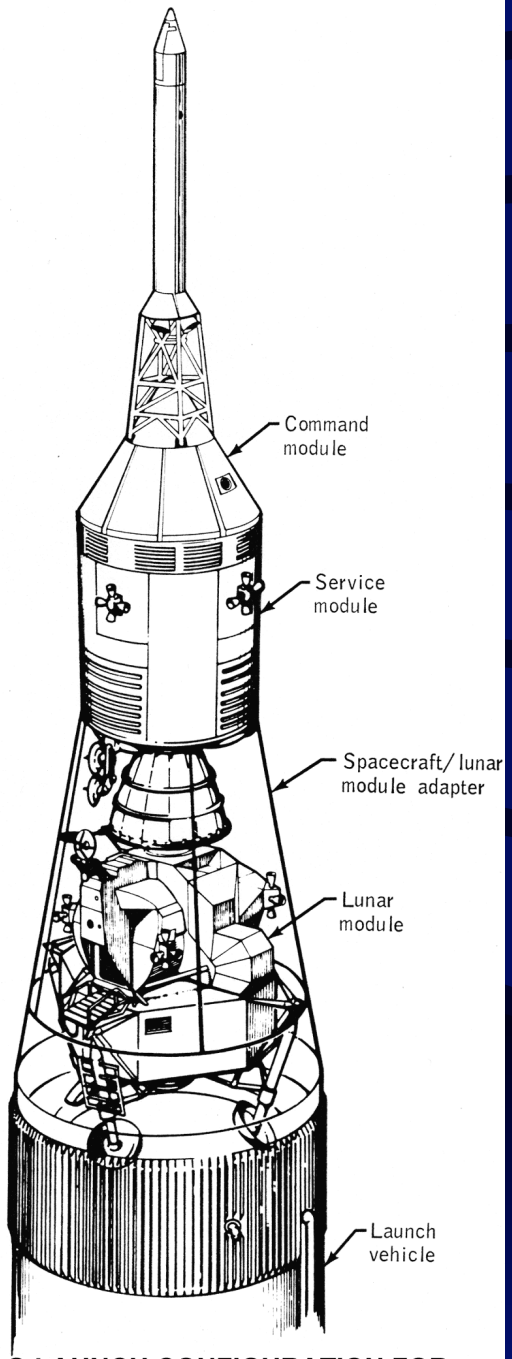
- 1954: Ludwig von Bertalanffy, Kenneth Boulding, Ralph Gerard, A. Rapoport
- GST postulated as a "science of wholeness"
- Embraced the Life Sciences as well as physics, chemistry, etc. Very mathematical
- Models from GST, and ideas of Open Systems and the Organismic Analogy greatly influenced the fledgling 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 jig-saw 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

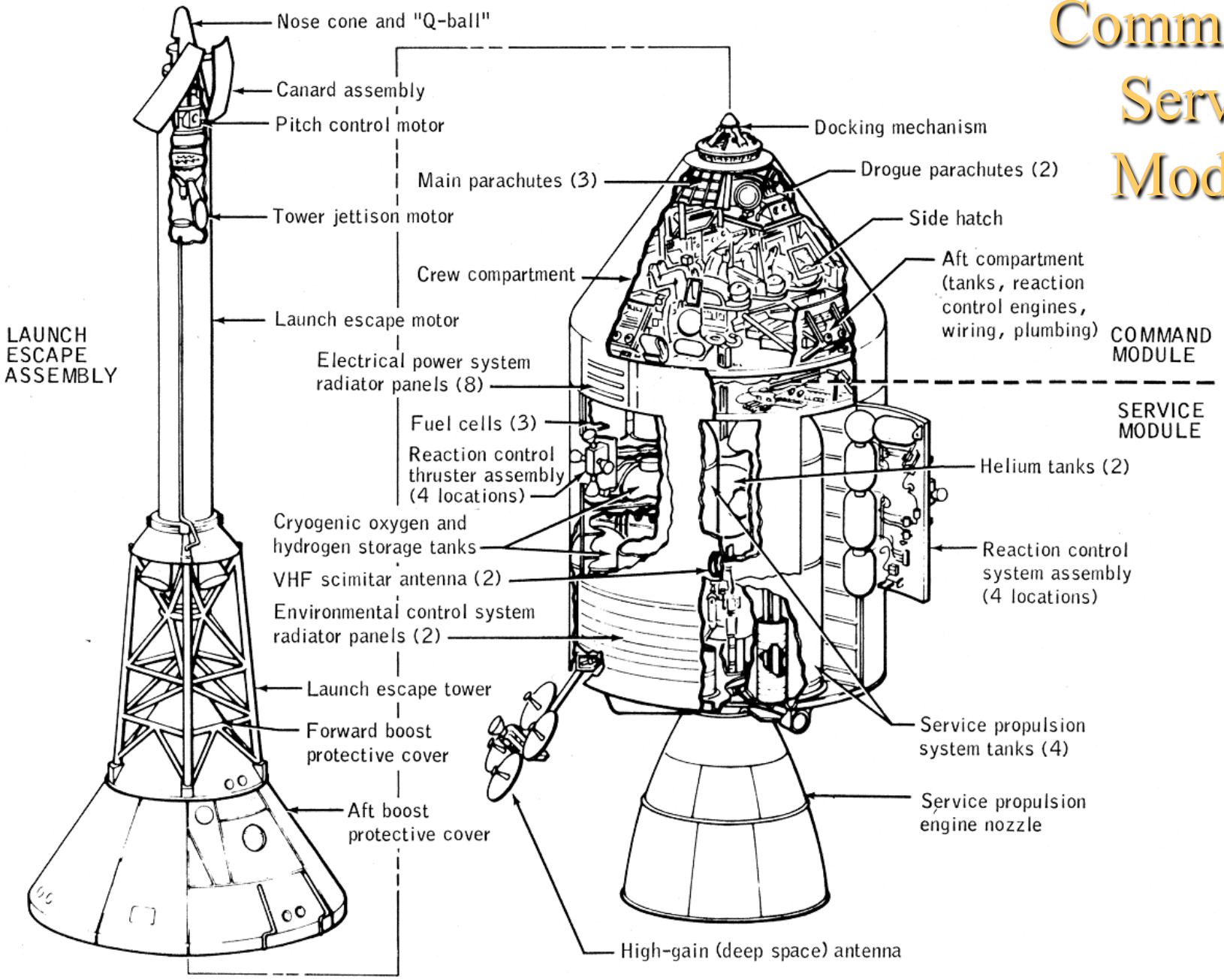


APOLLO LAUNCH CONFIGURATION FOR LUNAR LANDING MISSION

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

Command & Service Modules



APOLLO COMMAND AND SERVICE MODULES AND LAUNCH ESCAPE SYSTEM

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