Chapter 1

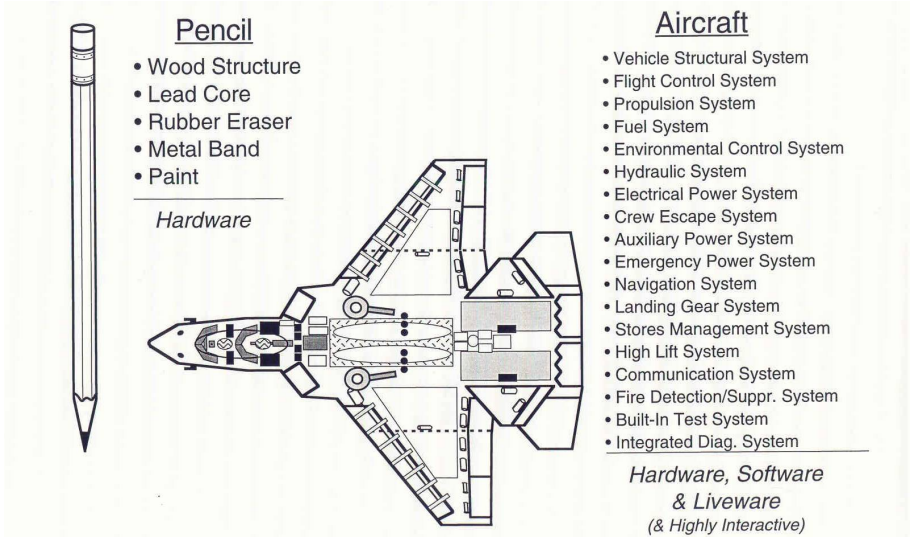
System Science & Engineering

Systems Definitions & Elements

- System classification and a dichotomous contrast of systems similarities and dis-similarities
- Distinction between natural and human-made, or technical systems

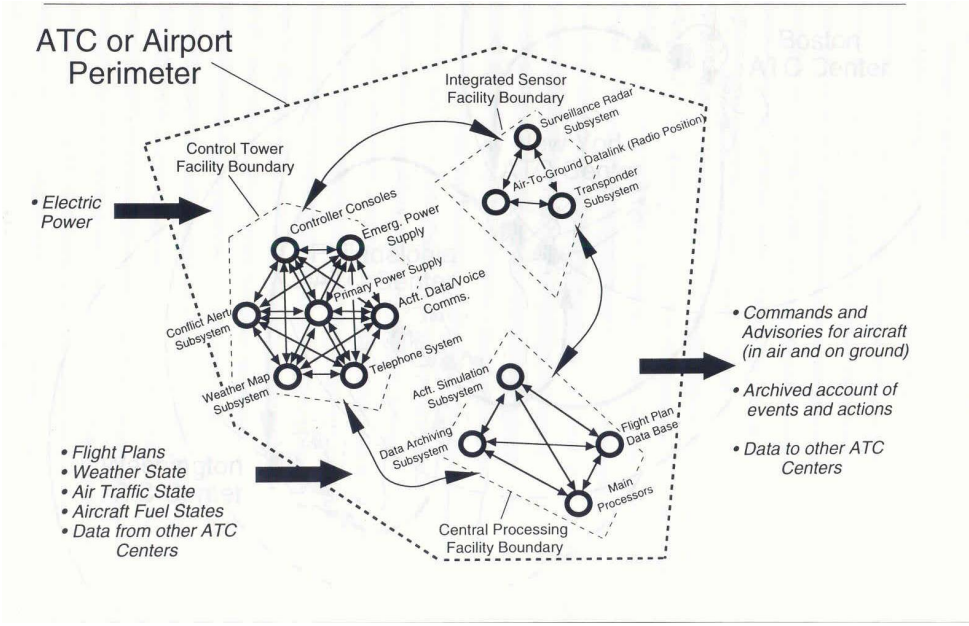
Systems Definitions & Elements
continued

- A *system* is an assemblage or combination of elements or parts forming a complex or unitary whole such as a river or a transportation system, system of currency, or a political system, etc.

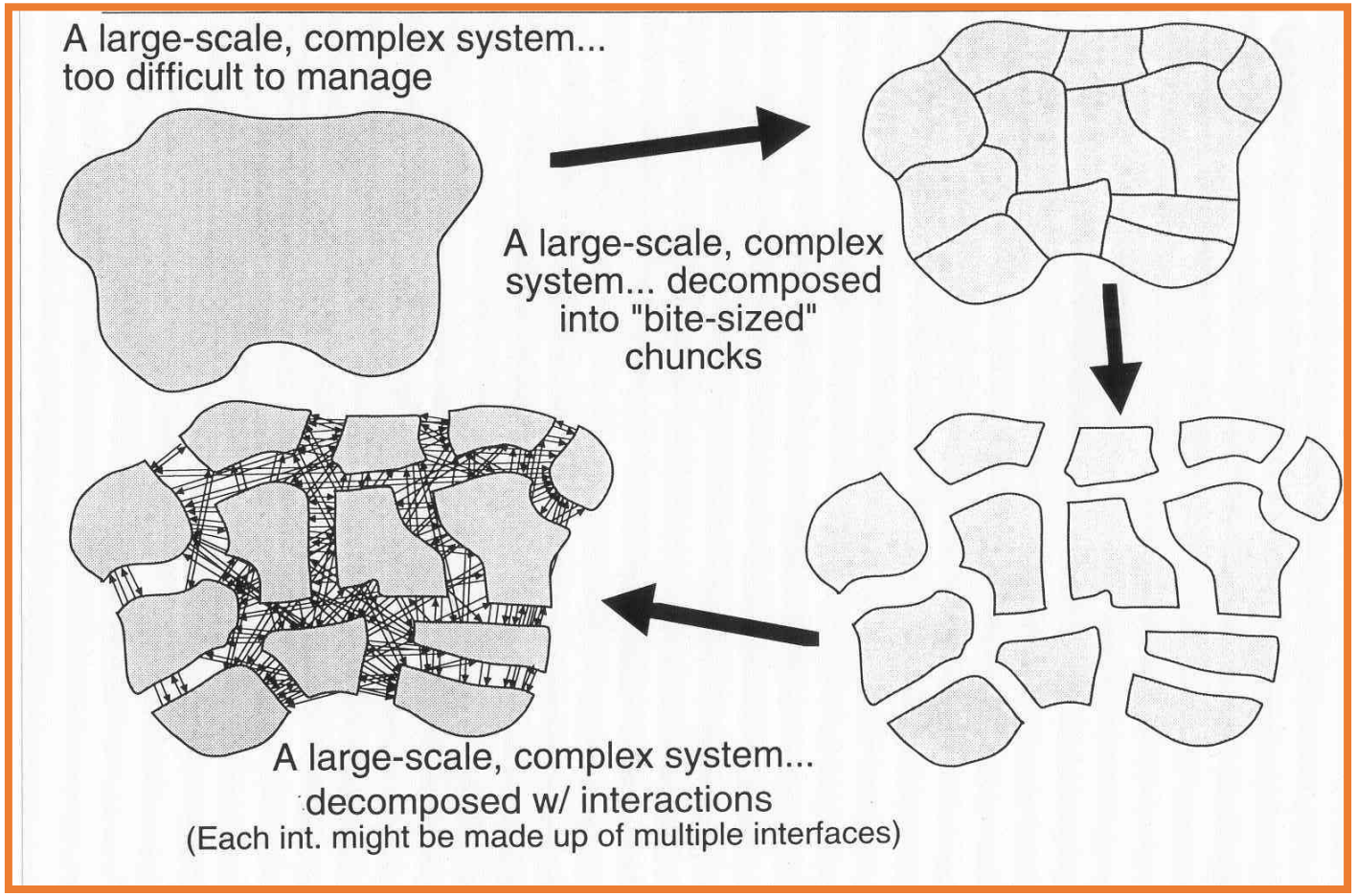


The Elements of a System

- Components are operating parts of a system that have input, process and output
- Attributes are the properties of the components of a system. The attributes characterize the system.
- Relationships are the links between the components and attributes



The Systems approach to problem solving – So simple but so complicated



System Definition continued

- The *state* of a system or system components
- The *behavior* is a connected series of changes in the state over time
- The *process* is of all behaviors with their sequences and timing
- The process of component may control the process of another component

System Definition continued

- The purposeful action performed by a system is its *function*
- A common system function is that of altering material, energy, or information
- This alteration embraces input, process, and output
  - Material processing in manufacturing system
  - Digestive systems
  - The conversion of solar energy to electricity
  - The information processing in computer networks

System Definition continued

- A common system function is that of altering material, energy, or information are composed of:
  - Structural components: Static parts
  - Operating components: parts performing processing
  - Flow components: material, energy, or information being altered
- System components have *attributes*
  - Contribute to the systems' function: configuration, quality, power, constraints, etc..

System Definition continued

- System is a set of interrelated components working together toward some common objective or purpose
- Components have the following properties:
  - The properties of each component has an effect on the overall performance of the system
  - The properties and behavior of each component depends on the property and behavior of at least one other component

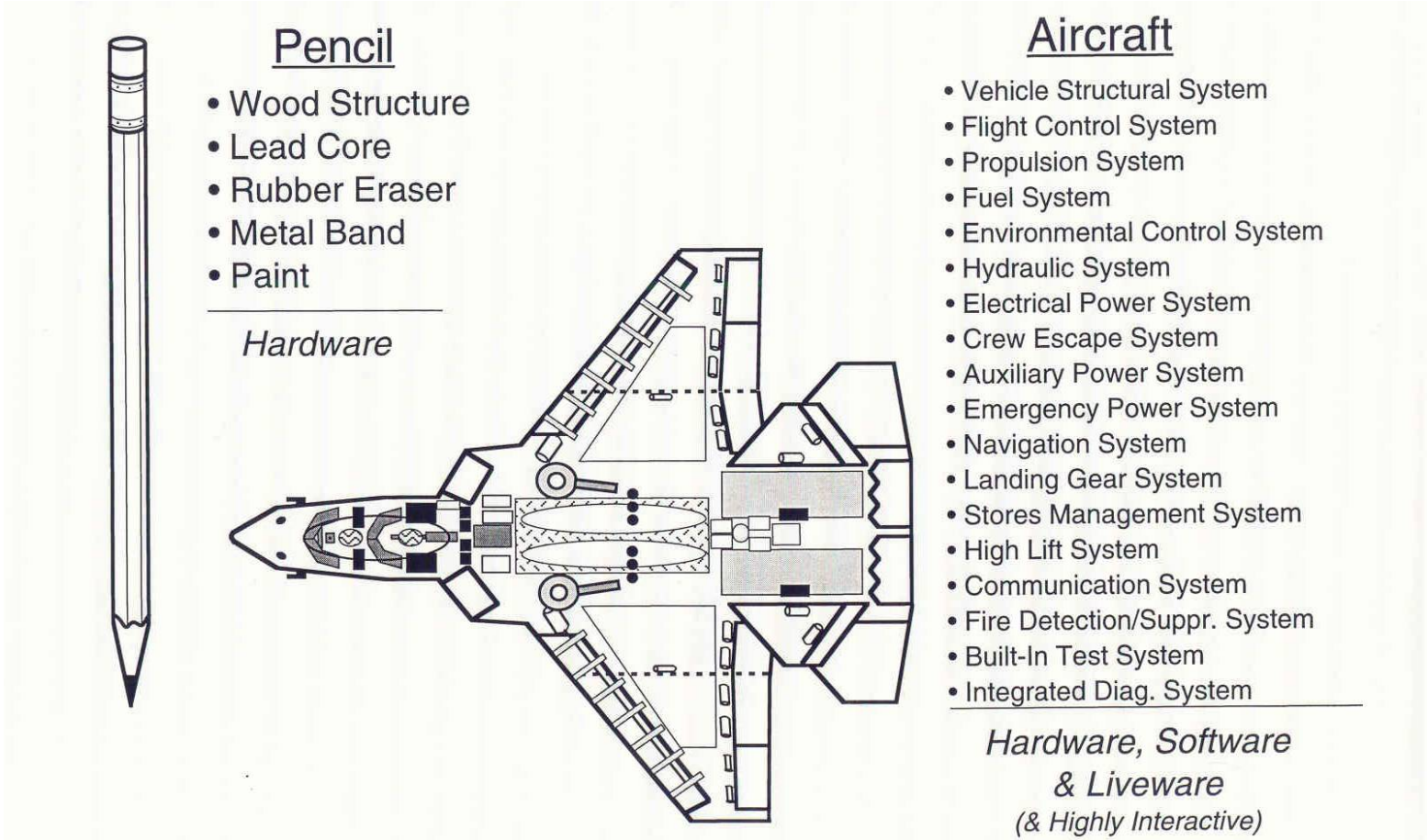
Systems & Subsystems

- System’s position in the hierarchy of the systems must be considered
- A system usually is made of components or subsystems
- Subsystems may have subsystem(s) of their own
- Systems boundaries must be known. Anything outside the boundaries is called environment

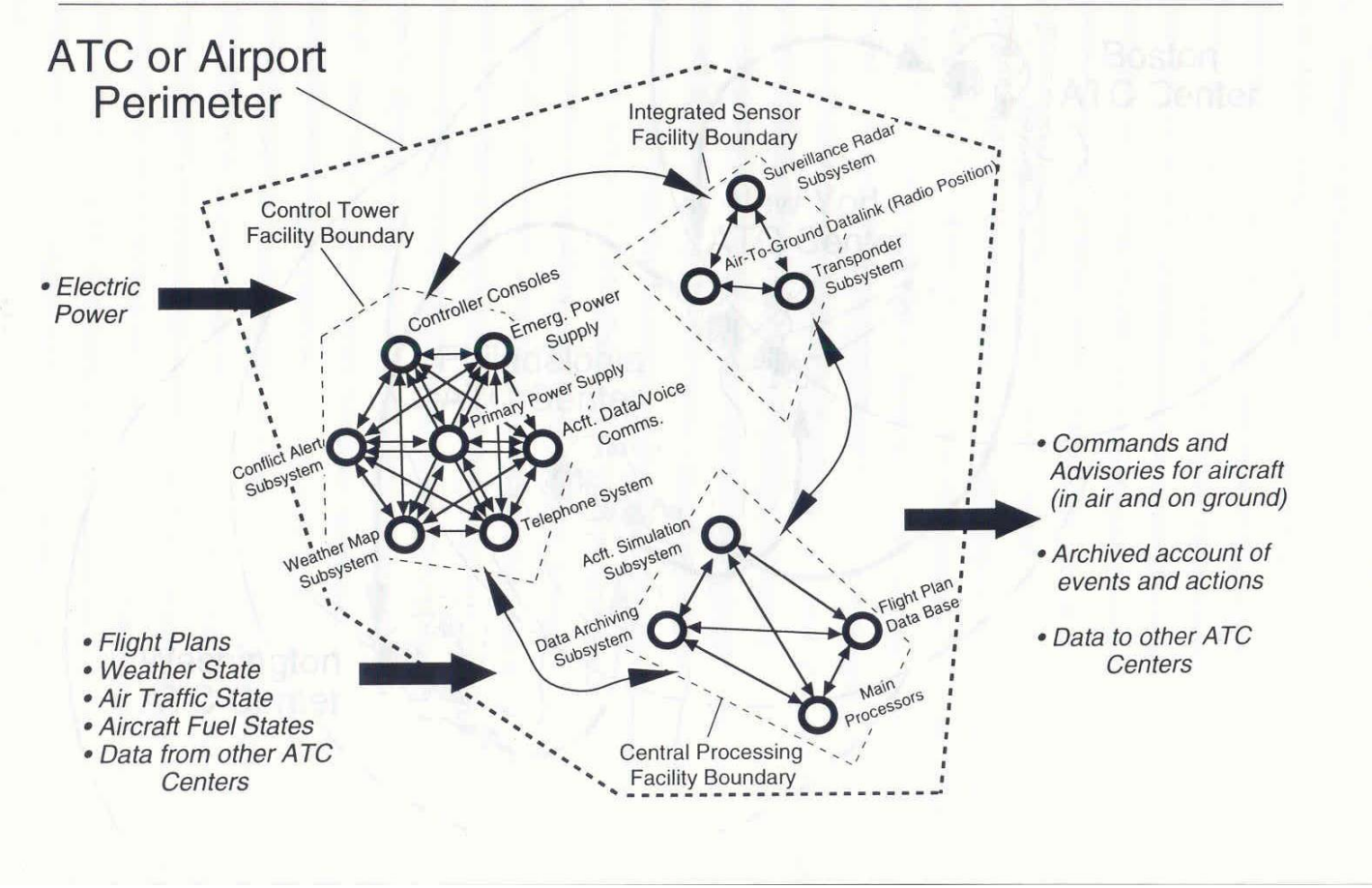
Classification of Systems

- Natural Systems come to being by natural processes
- Human-made systems are the one that human being has intervened
- Each of the above has an effect on the other

Simple systems vs. complex systems



At the airport – The air traffic control system with components



Physical & Conceptual Systems

- Physical systems manifest themselves in physical form
- Conceptual systems are represented by symbols, hypothesis, ideas, etc.

Static and Dynamic Systems

- A static system has structure but no activities, such as a bridge or a building
- A dynamic system has structure and activity, such as a school that is made of students, building, & equipment

Closed & Open Systems

- Closed system does not interact significantly with its environment
- Open system allows information, energy, and matter to cross its boundaries and interacts with its environment

- Video

https://www.youtube.com/watch?v=BErtl_ZcGpw

https://www.youtube.com/watch?v=m3L9bEAha1I

An Introduction to Systems Engineering

The Art of Managing Complexity

- Systems Engineering has emerged as a distinct professional discipline in direct response to the increasing complexity of new development projects.

- We will review some of the reasons for the emergence of this discipline and discuss the tools and methodologies that have been established as a means for dealing with increasing system complexity.

Outline

- What is Systems Engineering?
- Emergence of the Discipline
- Role of the Systems Engineer
- The SE Process, Methodologies, and tools
- Setting standards
- SE, the ultimate solution?
- References

What is Systems Engineering?

- It *is not* fundamental mathematics or strict laboratory science
- It *is* a mix of HR, project management, business, rational decomposition, trade studies, requirements traceability, integration, testing, verification and validation, operations, and end of life cycle disposal of systems
- Standardizes the ***flow-down and traceability*** of specifications for complex products from customer requirements through production, operation , and disposal

What is Systems Engineering?

- Systems Engineering is an ***interdisciplinary approach*** and means to enable the realization of successful systems.
- It focuses on defining ***customer needs*** and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem:
    - Operations
    - Performance
    - Test
    - Manufacturing
    - Cost & Schedule
    - Training & Support
    - Disposal

What is Systems Engineering?

- Systems Engineering ***integrates*** all of the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation.
- Systems Engineering considers both the business and the technical needs of all customers with the goal of ***providing a quality product*** that meets the user needs

Emergence of Systems Engineering Issues

- “The Mythical Man-month”, written by Fred Brooks, who was the first manager of the OS/360 development team at IBM in the 1960's:
  - People seem to think that people and time are interchangeable and substitutable resources in projects
  - Face it, the addition of people to a late project will only make it later
  - In computer systems, the issue of decomposition and system management reared its ugly head with optimistic programmers saying "This time it will surely run," or " I just found the last bug."
  - The false assumption is that things will take as long as they “ought to take” and things will work as planned.
  - Nothing works out as planned the first time - Systems Engineering attempts to mitigate this issue

The Role of the System Engineer

- Any engineer acts as a systems engineer when responsible for the design and implementation of a total system.
- The difference with “traditional engineering” lies primarily in the greater emphasis on defining goals, the creative generation of alternative designs, the evaluation of alternative designs, and the coordination and control of the diverse tasks that are necessary to create a complex system.
- The role of Systems Engineer is one of ***Manager*** that utilizes a structured value delivery process

Assignment

1) Choose one engineering system from among the following:
   a) Digital Manufacturing
   b) Virtual Reality
   c) Intelligent Systems
   d) Other - Define
2) Define – in as few words as possible - the purpose or mission of your system – what does it do?
3) List your system stakeholders
4) Use slides as templates and do the following
   a) Identify the System of Systems that your system belongs to
   b) Define your system inputs (including environment) and outputs
   c) Identify at least five subsystems required by your system and indicate how these sub-systems interact or communicate with each other
5) Prepare a Powerpoint presentation with as few slides as possible to illustrate your answers
6) Print the presentation and hand in at the beginning of class.