What is Engineering?

What is Systems Engineering?

Systems engineering is an interdisciplinary approach and process encompassing the entire technical effort to evolve, verify and sustain an integrated and total life cycle balanced set of system, people, and process solutions that satisfy customer needs. Systems engineering is the integrating mechanism for the technical and technical management efforts related to the concept analysis, materiel solution analysis, engineering and manufacturing development, production and deployment, operations and support, disposal of, and user training for systems and their life cycle processes.

For DoD, systems engineering is the set of overarching processes that a program team applies to develop an operationally effective and suitable system from a stated capability need. Systems engineering processes apply across the acquisition life cycle (adapted to each phase) and serve as a mechanism for integrating capability needs, design considerations, design constraints, and risk, as well as limitations imposed by technology, budget, and schedule. The systems engineering processes should be applied during concept definition and then continuously throughout the life cycle.

Systems engineering is a broad topic that includes hardware, software, and human systems. It is an interdisciplinary approach for a structured, disciplined, and documented technical effort to simultaneously design and develop systems products and processes for creating and integrating systems (hardware, software, and human) to satisfy the operational needs of the customer. It transforms needed operational capabilities into an integrated system design through concurrent consideration of all life cycle needs. As systems become larger and more complex, the design, development, and production of such systems or systems of systems (SoS) require the integration of numerous activities and processes. Systems engineering is the approach to coordinating and integrating all these acquisition life cycle activities. It integrates diverse technical management processes to achieve an integrated systems design.

Systems Engineering

a process

Answers!

- What is systems engineering?
- What do engineers do?
- How do I work with engineers?
- What’s happening now?

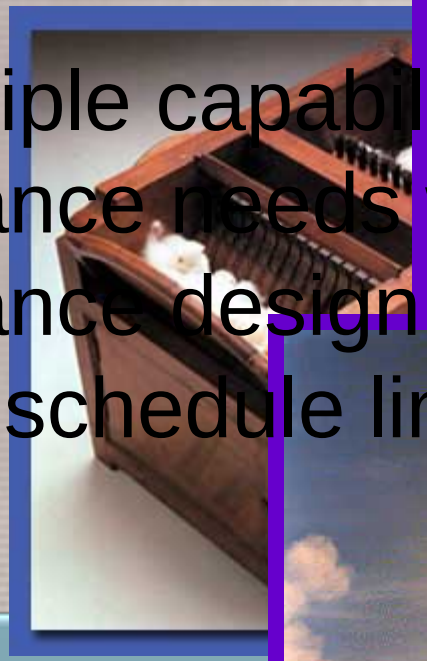
WHAT SYSTEMS ENGINEERING IS

Back to Basics

- Engineering = turning ideas into stuff
- Systems = really complex stuff
- Systems Engineering = turning ideas into really complex stuff

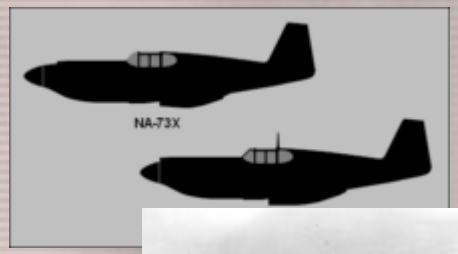
Why complexity matters

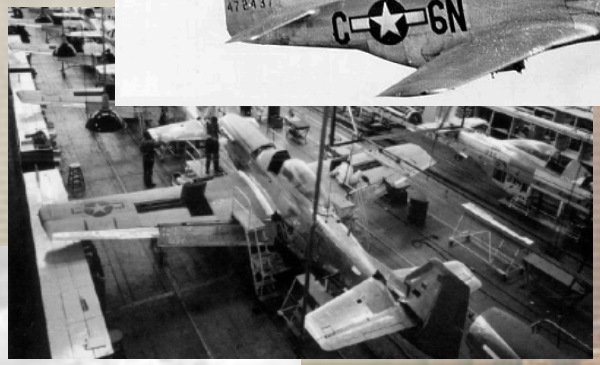
- Multiple capabilities/needs for a system
- Balance needs with design constraints
- Balance design with technology, budget, and schedule limitations



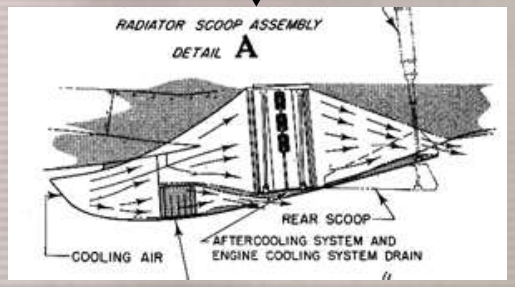
Compl s to use an iterati ve process

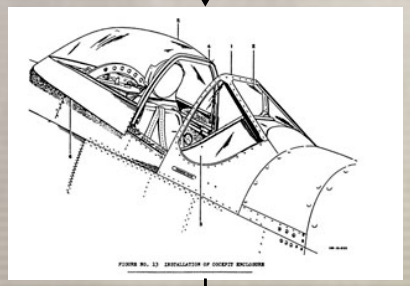
What is Iterative?

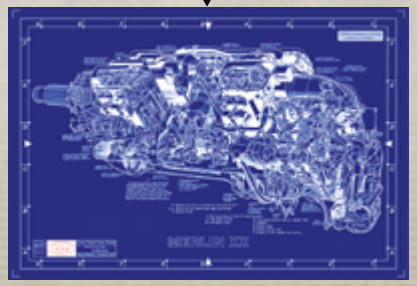


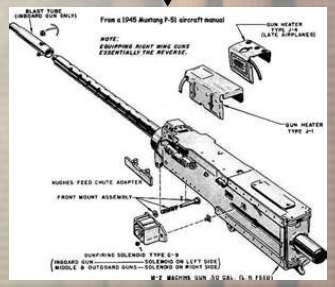


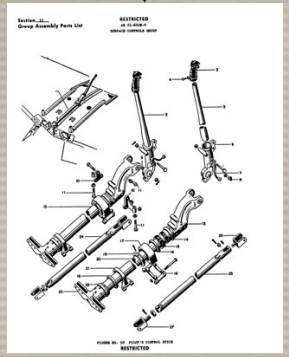
What is Recursive?

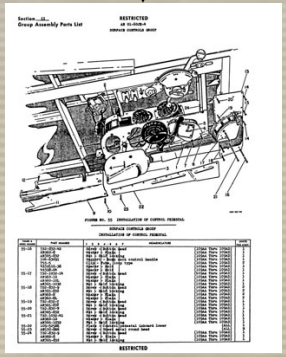




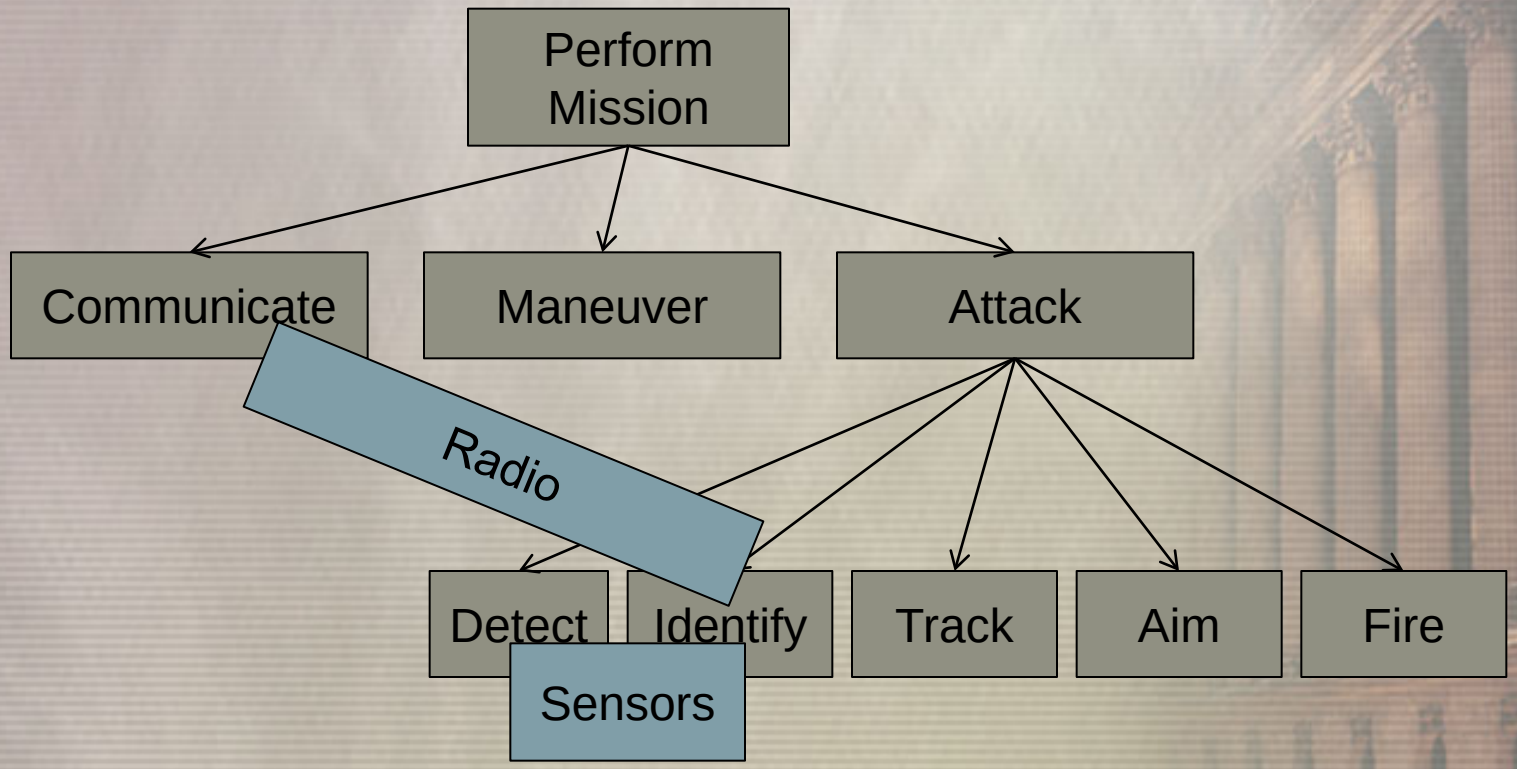








Functional Analysis and Allocation

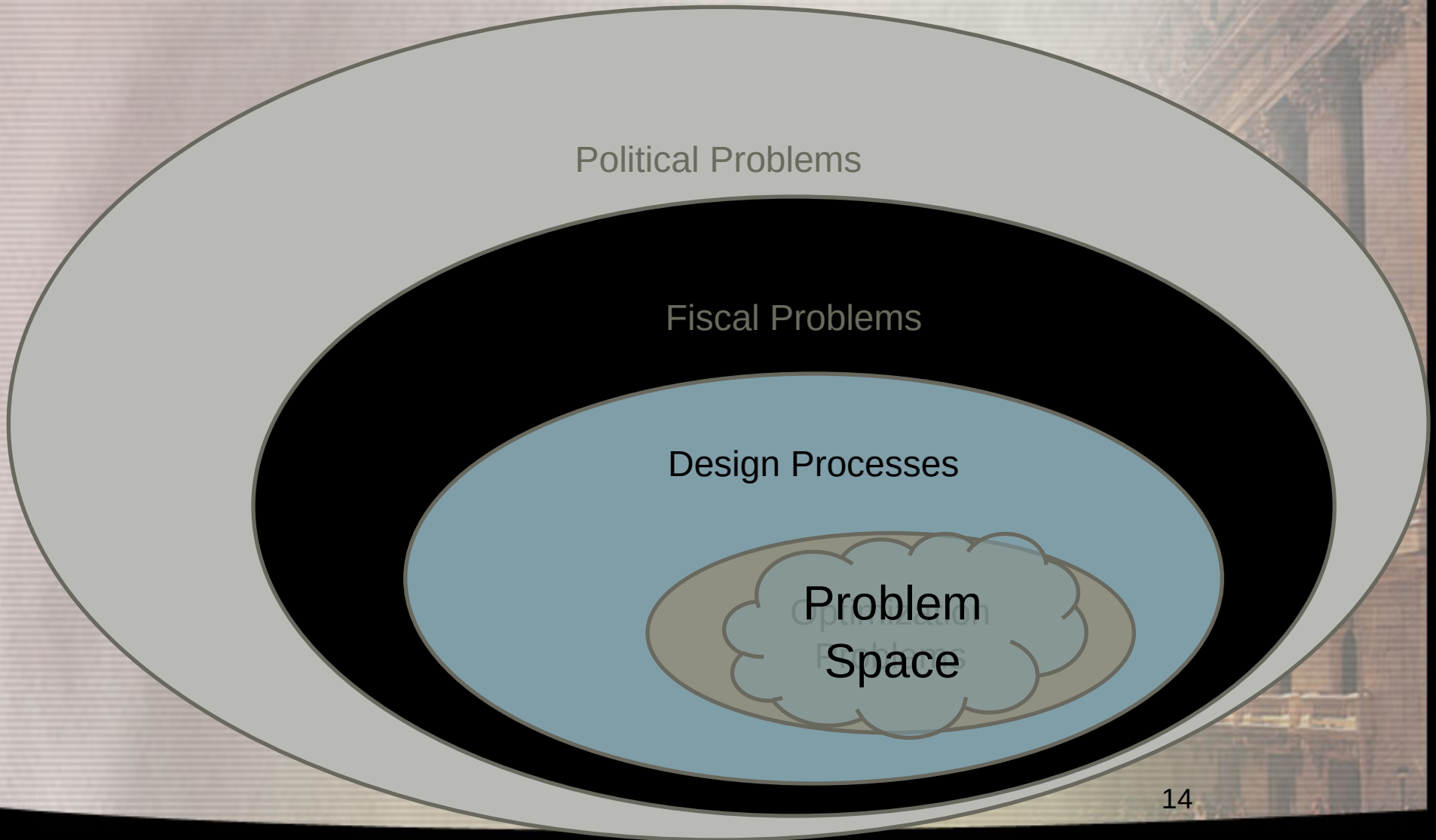


Why we have to keep repeating ourselves

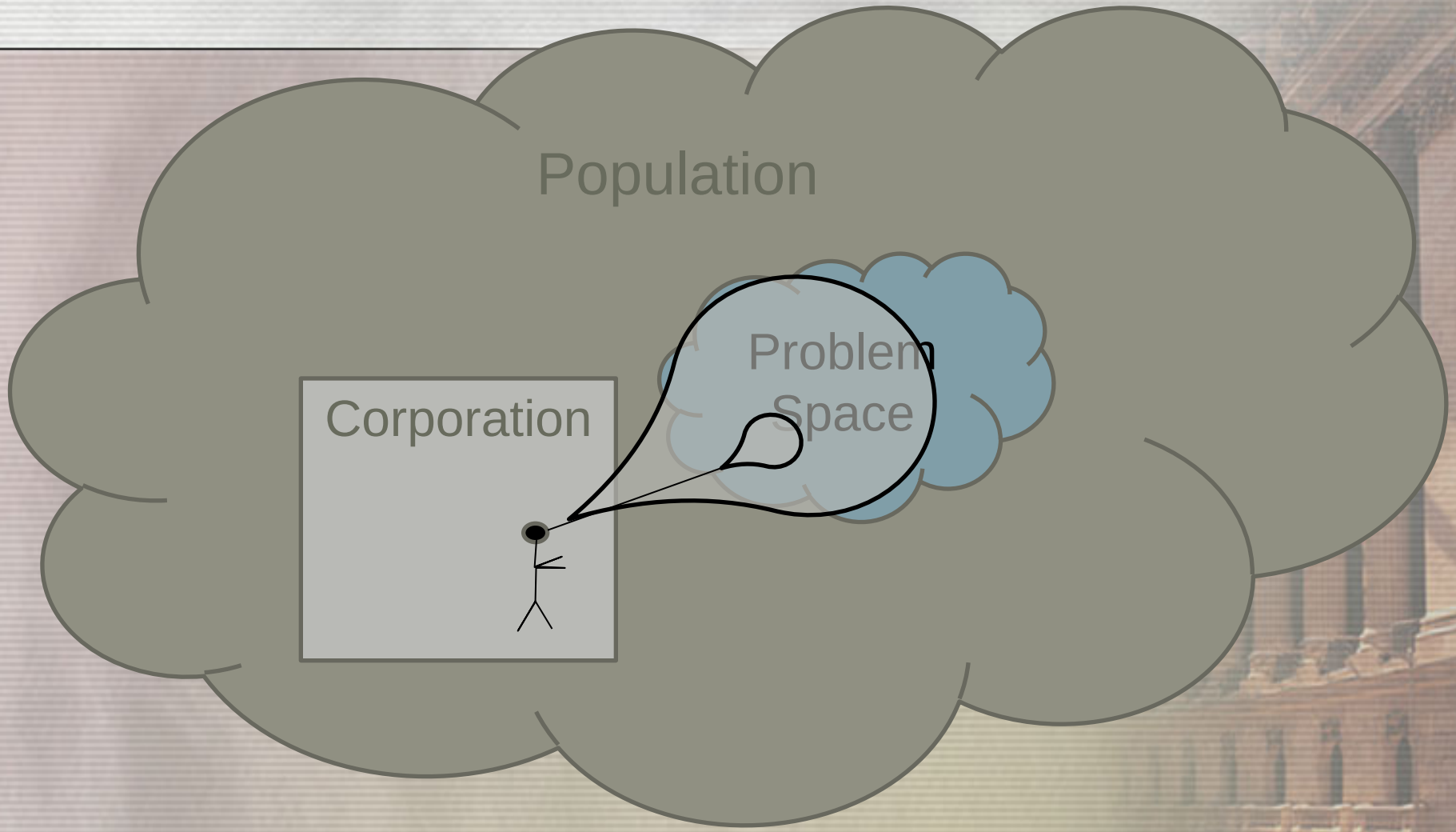
- Iterative with every phase of the life cycle
- Iterative with every schedule change
- Iterative with every budget change
- Iterative at every interface
- Recursive with every anomaly
- Recursive with every subsystem
- Recursive from every “supersystem”

WHAT ENGINEERS DO

Technical Problem Solving

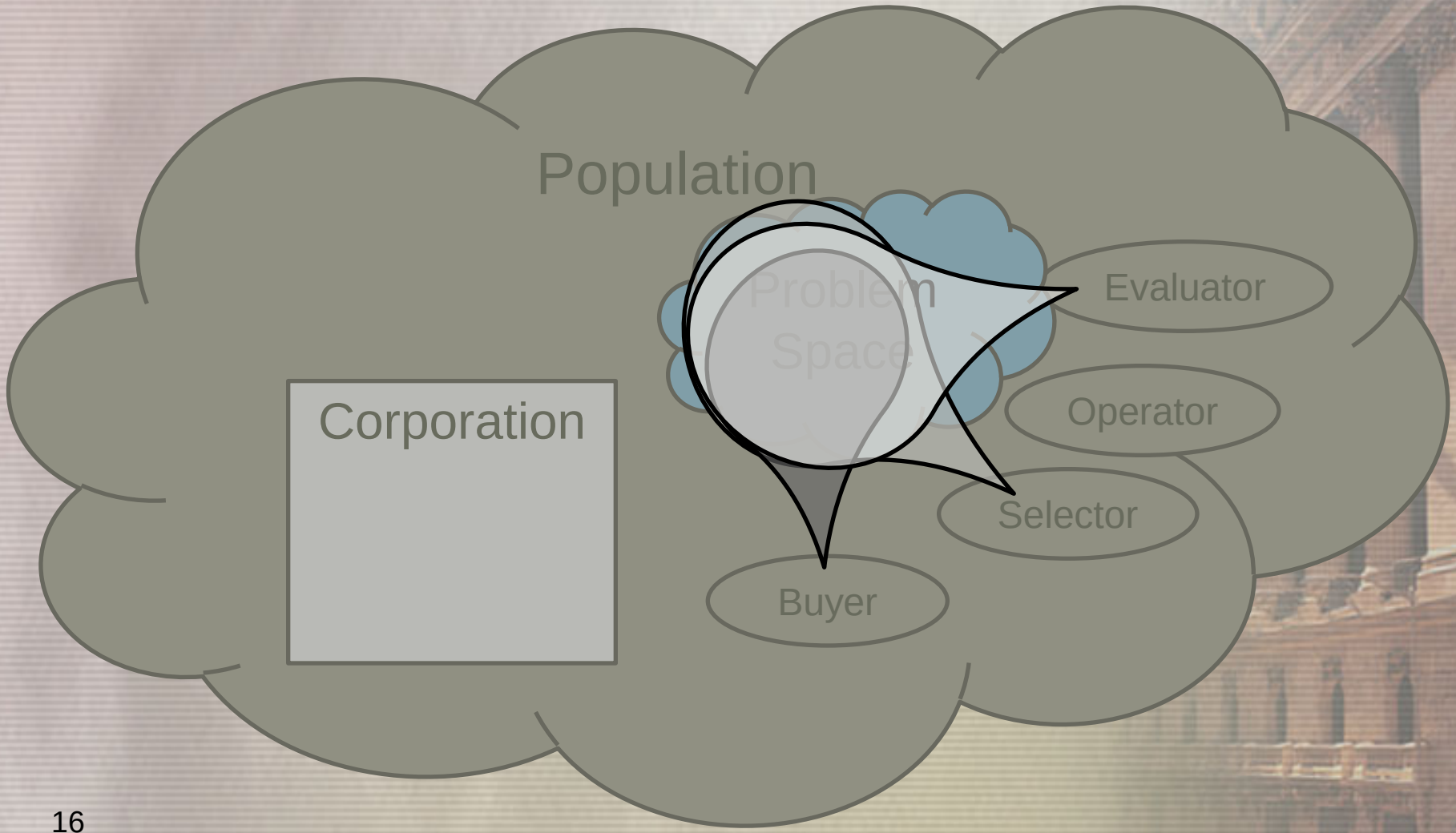


A “for profit” approach



Typical population member is an evaluator/selector/buyer/operator for a solution system

DoD approach



Competition

- Contractual relationships
  - Business to Consumer
  - Business to Business
  - Business to Government
- Imperfect Competition
  - Monopoly
  - Monopsony
  - Bilateral Monopoly

Being honest and Being seen to be honest

- Public stewardship
- Transparency
- Legality
- Ethics

WORKING WITH ENGINEERS

Q: What is the definition of an engineer?

A: Someone who solves a problem you didn't know you had, in a way you don't understand.

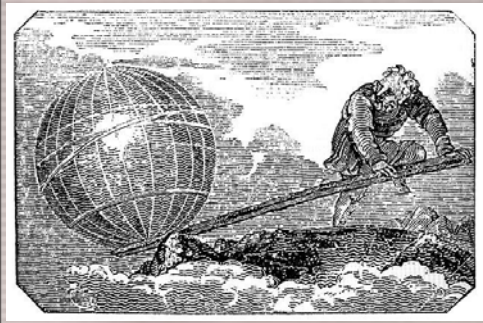
Geek Humor

There are only 10 kinds of people in the world:

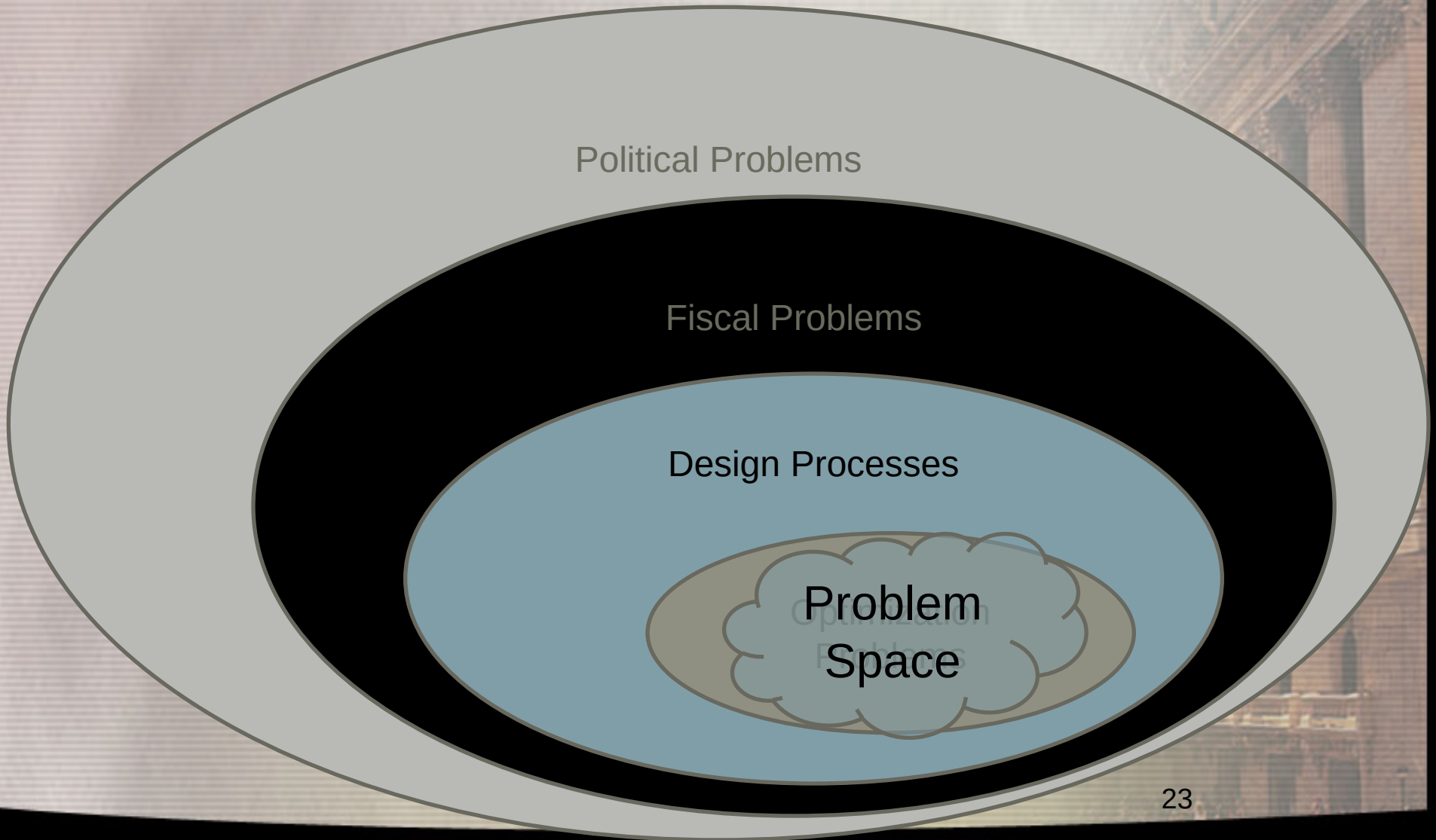
those who understand binary

and those who don't.

Who are they?



How do they see your problems?

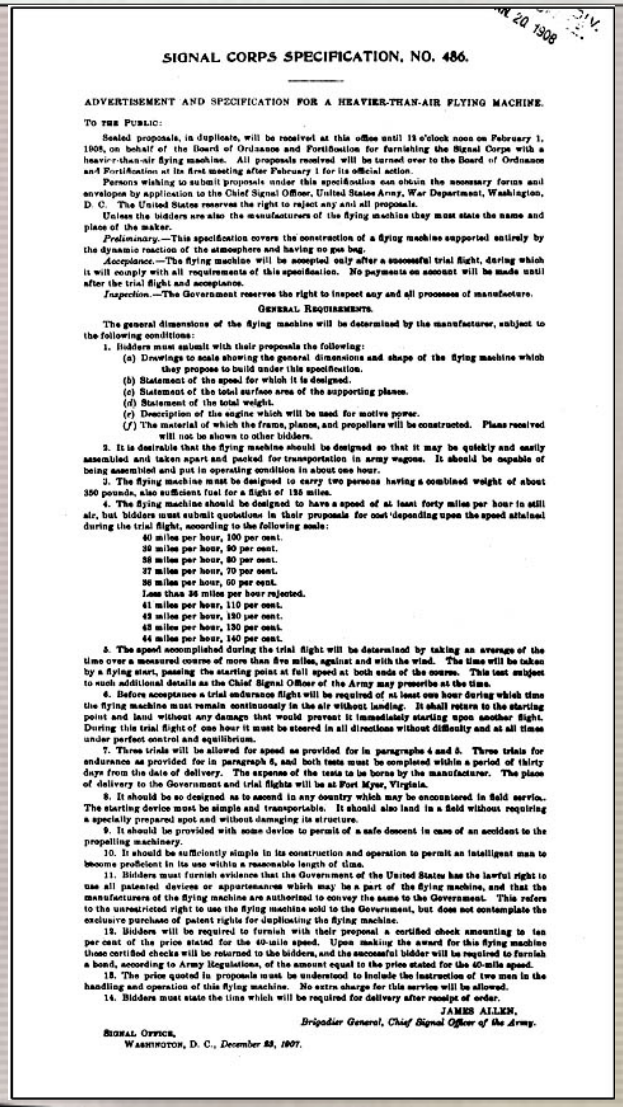


SE as a coordinating function

- Program management
- Finance
- Contracting
- Test
- Manufacturing
- Logistics

SYSTEMS ENGINEERING POLICY

A certain engineering task



SIGNAL CORPS SPECIFICATION, NO. 486.

ADVERTISEMENT AND SPECIFICATION FOR A HEAVIER-THAN-AIR FLYING MACHINE.

TO THE PUBLIC:

Sealed proposals, in duplicate, will be received at this office until 12 o'clock noon on February 1, 1908, on behalf of the Board of Ordnance and Fortification for furnishing the Signal Corps with a heavier-than-air flying machine. All proposals received will be turned over to the Board of Ordnance and Fortification at its first meeting after February 1 for its official action.

Persons wishing to submit proposals under this specification can obtain the necessary forms and envelopes by application to the Chief Signal Officer, United States Army, War Department, Washington, D. C. The United States reserves the right to reject any and all proposals.

Unless the bidders are also the manufacturers of the flying machine they must state the name and place of the maker.

Preliminary.—This specification covers the construction of a flying machine supported entirely by the dynamic reaction of the atmosphere and having no gas bag.

Acceptance.—The flying machine will be accepted only after a successful trial flight, during which it will comply with all requirements of this specification. No payments on account will be made until after the trial flight and acceptance.

Inspection.—The Government reserves the right to inspect any and all processes of manufacture.

GENERAL REQUIREMENTS.

The general dimensions of the flying machine will be determined by the manufacturer, subject to the following conditions:

1. Bidders must submit with their proposals the following:
   (a) Drawings to scale showing the general dimensions and shape of the flying machine which they propose to build under this specification.
   (b) Statement of the speed for which it is designed.
   (c) Statement of the total surface area of the supporting planes.
   (d) Statement of the total weight.
   (e) Description of the engine which will be used for motive power.
   (f) The material of which the frame, planes, and propellers will be constructed. Plans received will not be shown to other bidders.

2. It is desirable that the flying machine should be designed so that it may be quickly and easily assembled and taken apart and packed for transportation in army wagons. It should be capable of being assembled and put in operating condition in about one hour.

3. The flying machine must be designed to carry two persons having a combined weight of about 350 pounds, also sufficient fuel for a flight of 125 miles.

4. The flying machine should be designed to have a speed of at least forty miles per hour in still air, but bidders must submit quotations in their proposals for cost depending upon the speed attained during the trial flight, according to the following scale:

   40 miles per hour, 100 per cent.
   39 miles per hour, 90 per cent.
   38 miles per hour, 80 per cent.
   37 miles per hour, 70 per cent.
   36 miles per hour, 60 per cent.
   Less than 36 miles per hour rejected.
   41 miles per hour, 110 per cent.
   42 miles per hour, 120 per cent.
   43 miles per hour, 130 per cent.
   44 miles per hour, 140 per cent.

5. The speed accomplished during the trial flight will be determined by taking an average of the time over a measured course of more than five miles, against and with the wind. The time will be taken by a flying start, passing the starting point at full speed at both ends of the course. This test subject to such additional details as the Chief Signal Officer of the Army may prescribe at the time.

6. Before acceptance a trial endurance flight will be required of at least one hour during which time the flying machine must remain continuously in the air without landing. It shall return to the starting point and land without any damage that would prevent it immediately starting upon another flight. During this trial flight of one hour it must be steered in all directions without difficulty and at all times under perfect control and equilibrium.

7. Three trials will be allowed for speed as provided for in paragraphs 4 and 5. Three trials for endurance as provided for in paragraph 6, and both tests must be completed within a period of thirty days from the date of delivery. The expense of the tests to be borne by the manufacturer. The place of delivery to the Government and trial flights will be at Fort Myer, Virginia.

8. It should be so designed as to ascend in any country which may be encountered in field service. The starting device must be simple and transportable. It should also land in a field without requiring a specially prepared spot and without damaging its structure.

9. It should be provided with some device to permit of a safe descent in case of an accident to the propelling machinery.

10. It should be sufficiently simple in its construction and operation to permit an intelligent man to become proficient in its use within a reasonable length of time.

11. Bidders must furnish evidence that the Government of the United States has the lawful right to use all patented devices or appurtenances which may be a part of the flying machine, and that the manufacturers of the flying machine are authorized to convey the same to the Government. This refers to the unrestricted right to use the flying machine sold to the Government, but does not contemplate the exclusive purchase of patent rights for duplicating the flying machine.

12. Bidders will be required to furnish with their proposal a certified check amounting to ten per cent of the price stated for the 40-mile speed. Upon making the award for this flying machine those certified checks will be returned to the bidders, and the successful bidder will be required to furnish a bond, according to Army Regulations, of the amount equal to the price stated for the 40-mile speed.

13. The price quoted in proposals must be understood to include the instruction of two men in the handling and operation of this flying machine. No extra charge for this service will be allowed.

14. Bidders must state the time which will be required for delivery after receipt of order.

JAMES AILLEN,
Brigadier General, Chief Signal Officer of the Army.

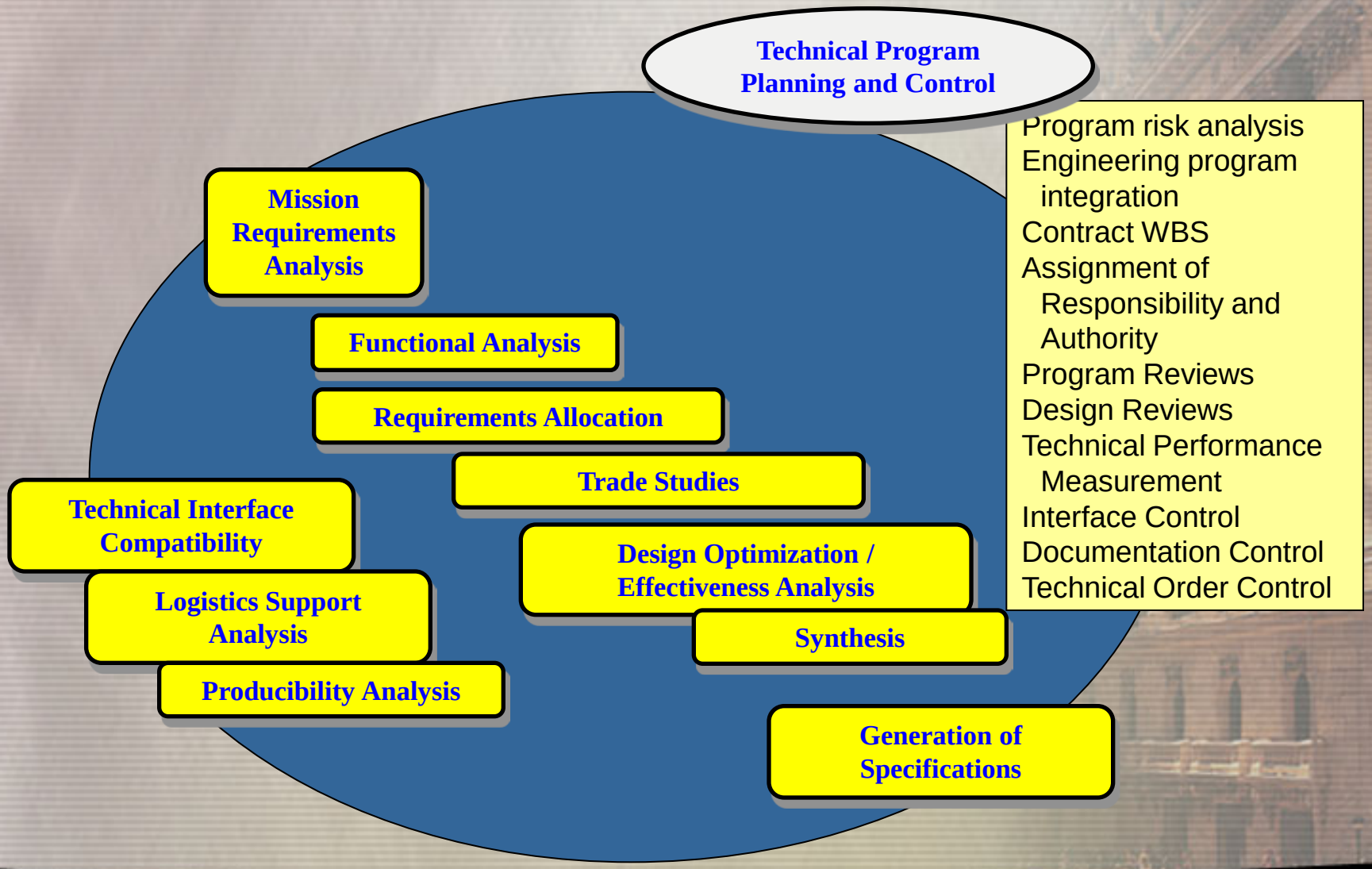
SIGNAL OFFICE,
WASHINGTON, D. C., *December 23, 1907.*

- US Army Signal Corps Specification No. 486
  - Primarily a functional specification
  - Political and competition issues
  - Data rights
  - Process inspection
  - Test conditions
  - Logistics/Training

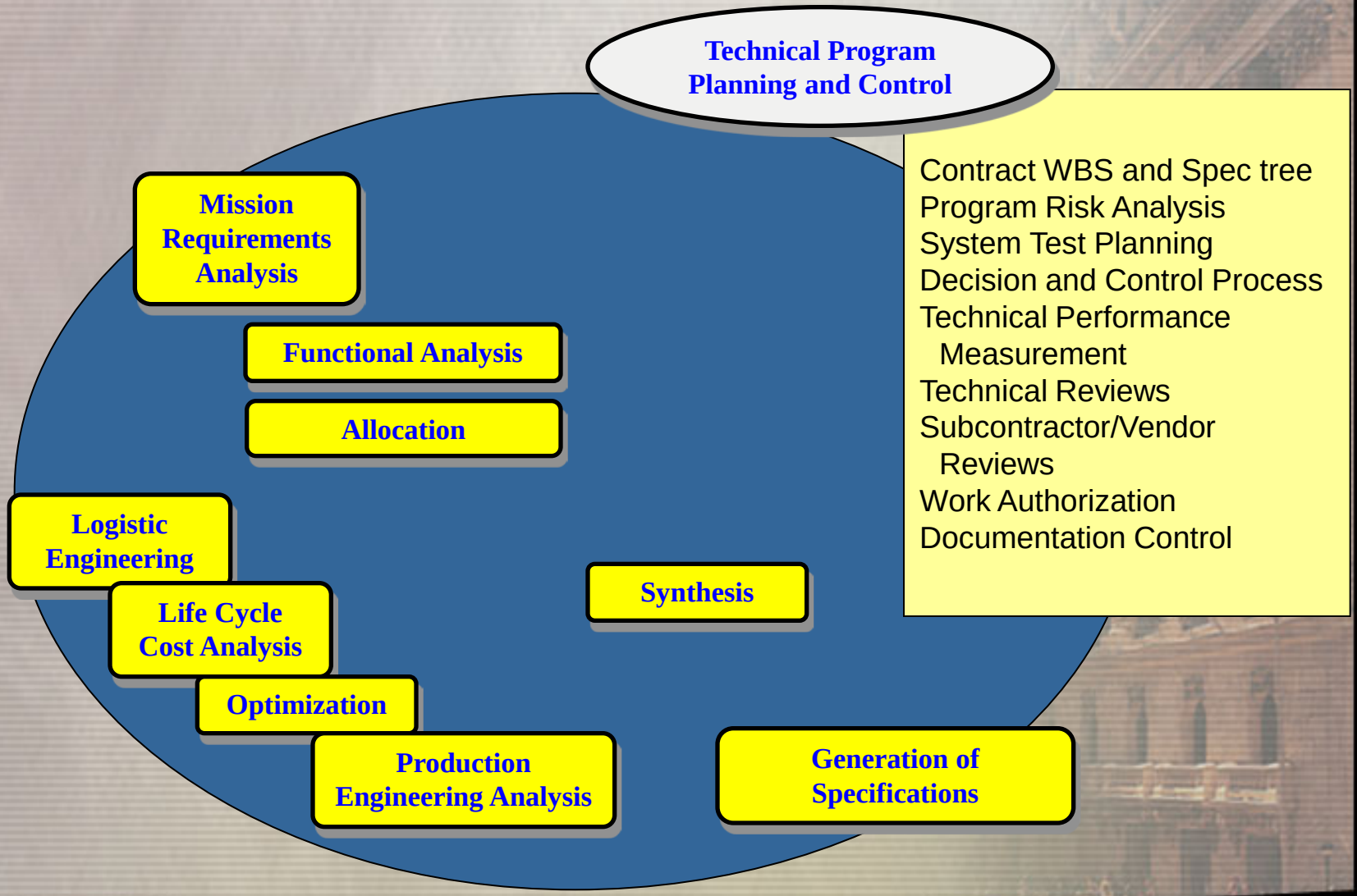
Growth of DoD SE

- WW II operations analysis
- PERT
- WBS
- FFBD
- AFSCM 375
- MIL-STD-499
- The “Perry Memo”
- “Systems Engineering Fundamentals”

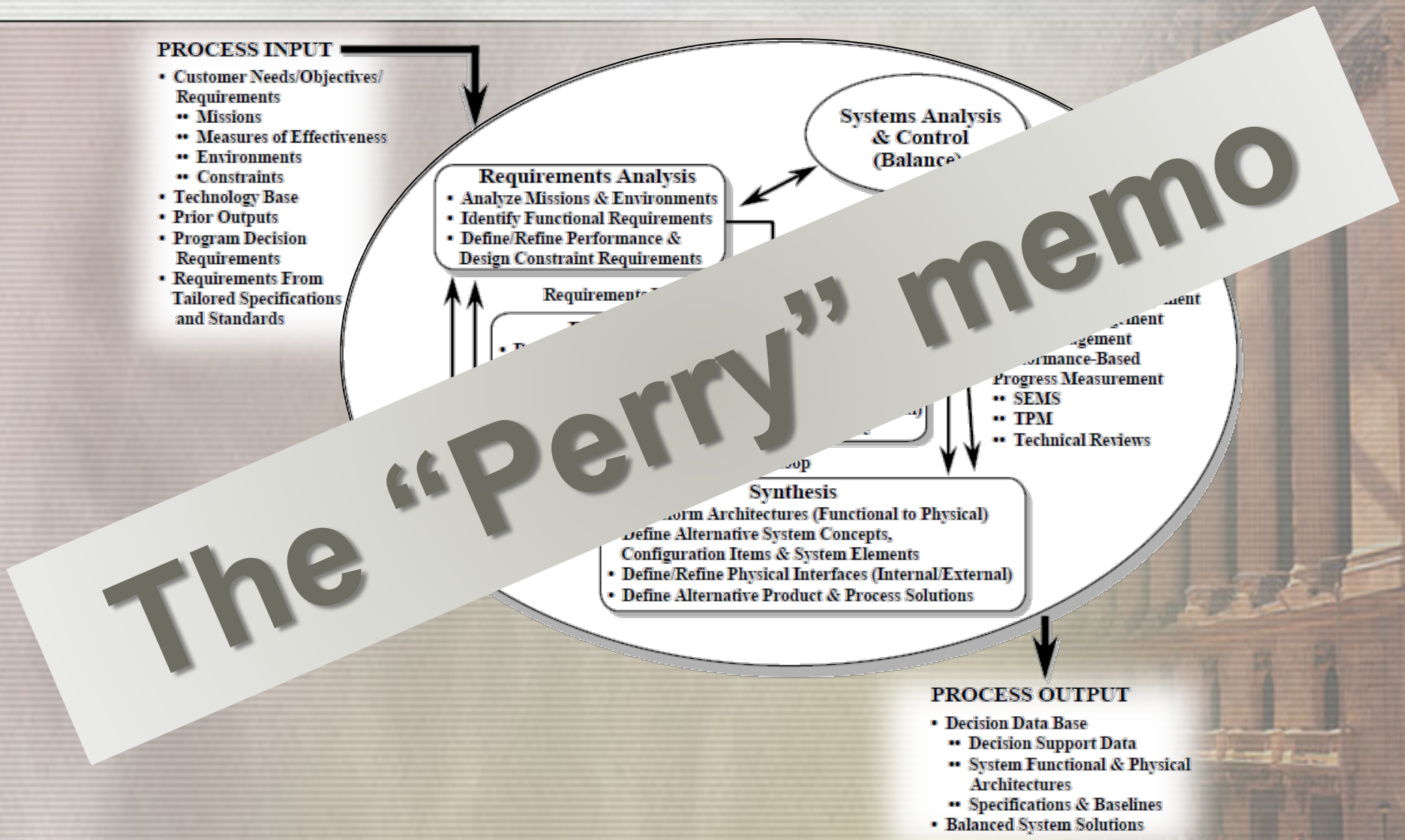
MIL-STD-499 (1969)



MIL-STD-499A (1974)

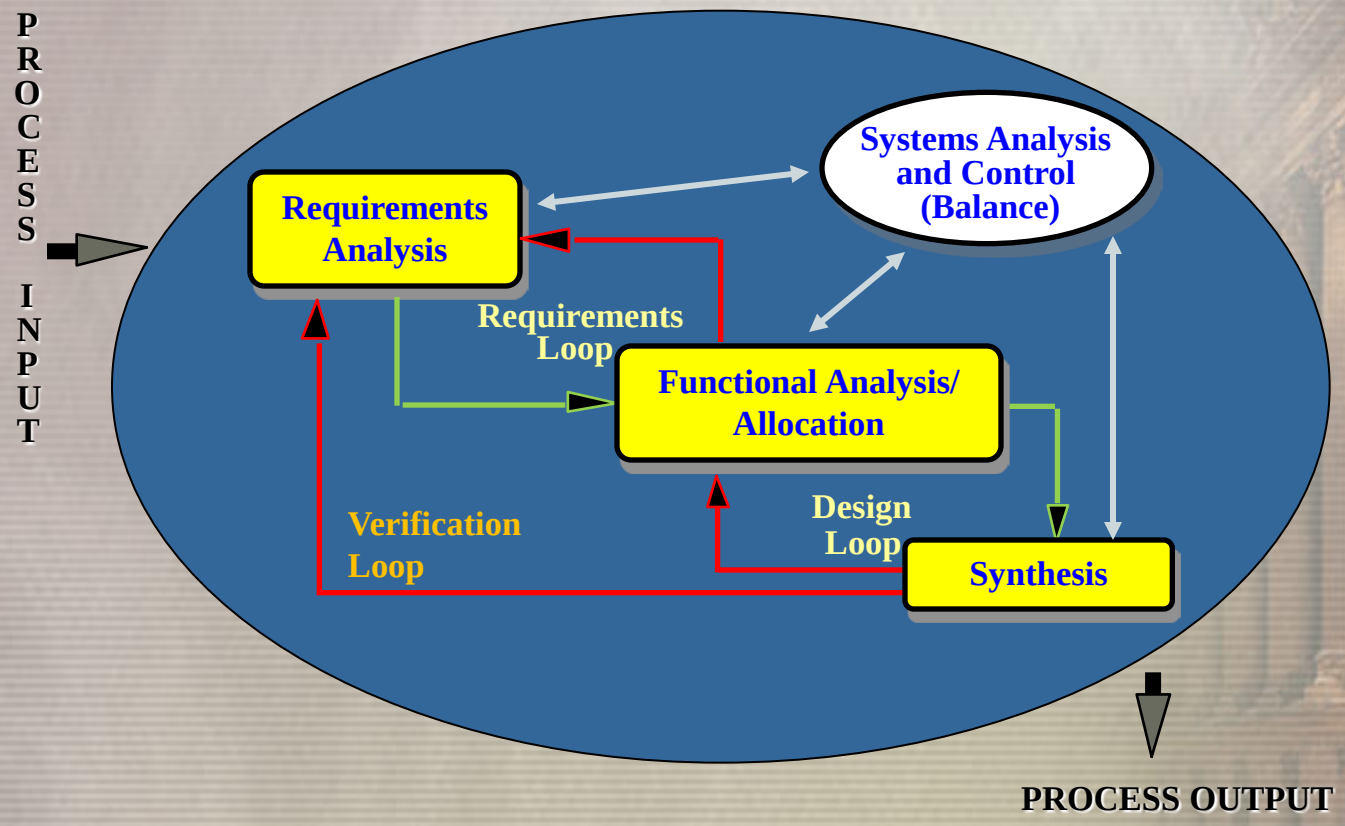


499B (Draft) Early 90s

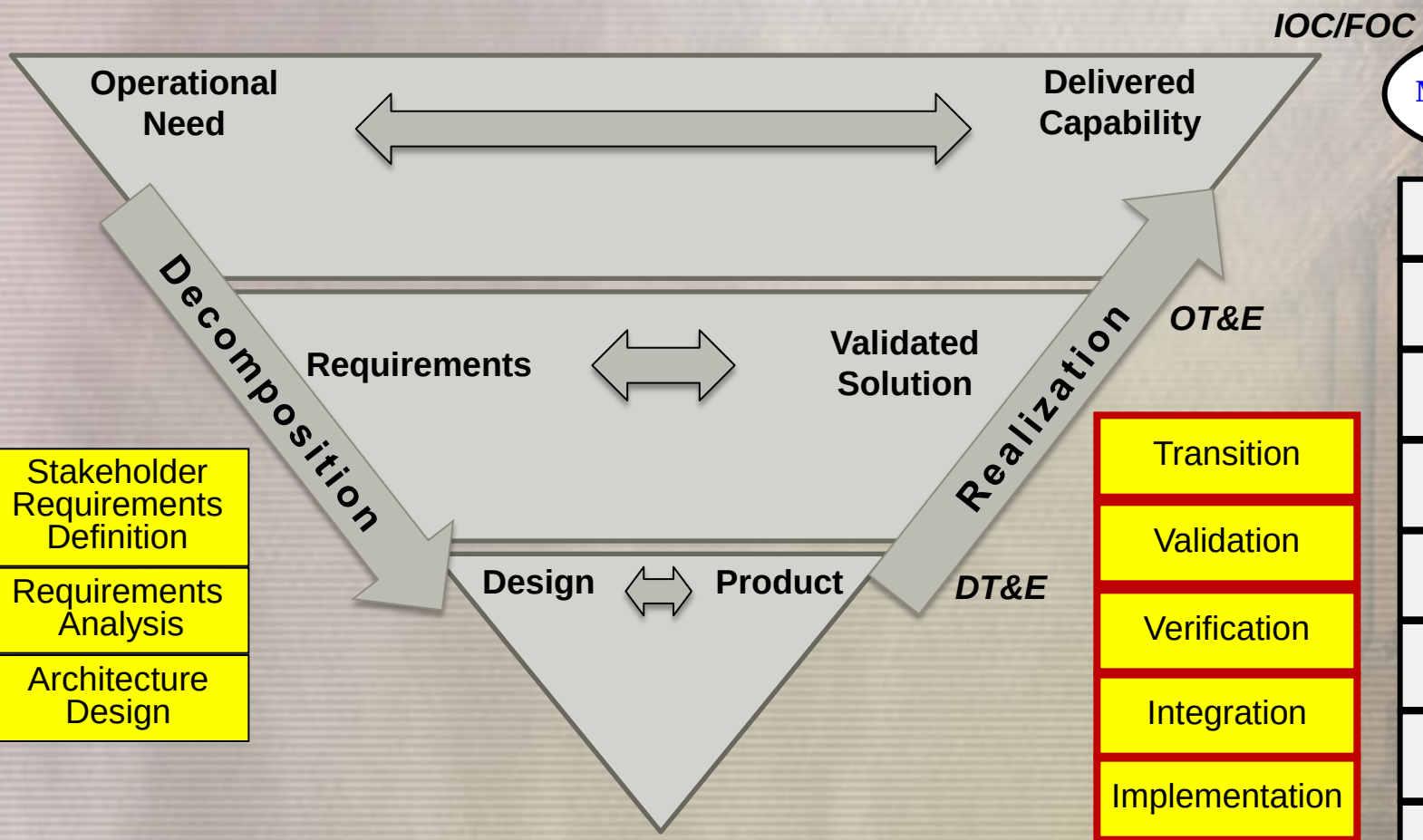


The "Perry" memo

Systems Engineering Fundamentals



Systems Engineering Today



Stakeholder Requirements Definition
Requirements Analysis
Architecture Design

Transition
Validation
Verification
Integration
Implementation

TECHNICAL MANAGEMENT PROCESSES

- Decision Analysis
- Technical Planning
- Technical Assessment
- Requirements Management
- Risk Management
- Configuration Management
- Technical Data Management
- Interface Management

SE Lately

- Director of Systems Engineering
  - Joint report with Director of Developmental Test and Evaluation
  - Reports to USD (AT&L)
- Focus Areas
  - Systems Engineering Plan
  - Mandated preliminary design review and critical design review
  - Program Protection
  - Reliability and Maintainability (R&M)

Issues

- Historical “stickiness” of DoD approach
- Fad Fatigue
- Establishing and maintaining relationship with industrial base
- Stakeholder proliferation

No Magic

Systems engineering is simply (and complexly) an iterative and recursive process for designing solutions to meet needs

Define your needs, divide them into manageable chunks, design chunk solutions, and integrate…