# Transition to the Systems Age

- Beginning ~ 1940 (according to Blanchard & Fabrycky)
- *Rescuing Prometheus*
- Thomas P. Hughes, Prof. of History and Sociology of Technology, U. of Penn.
- Tells the story of four major projects
  - SAGE
  - Atlas
  - CA/T
  - ARPANET

Figure removed for copyright reasons.
Schematic of SAGE Air Defense System.

# Key Aspects of SAGE

- First project to use computers for info processing and process control

- Engineers play a key management role

- Military / Industrial / University Complex
  - MIT Lincoln Labs
  - MITRE Corporation

- Criticized for its technical inadequacies
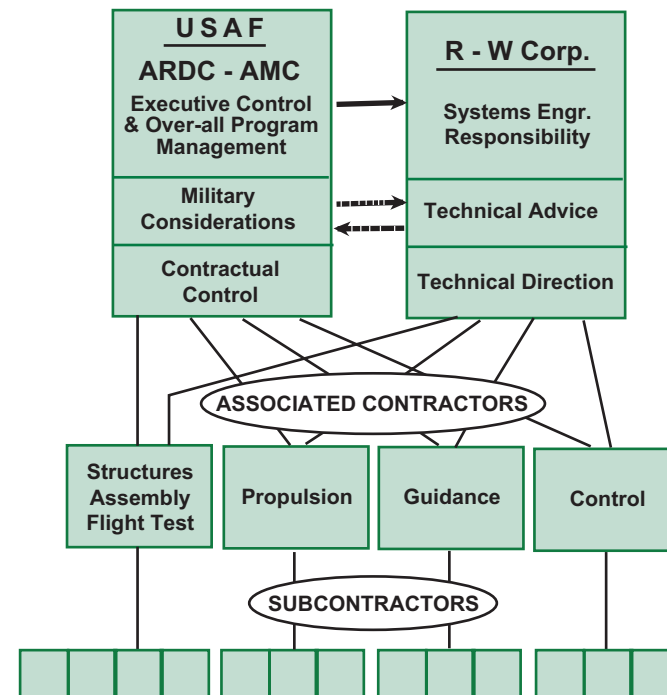
# The Atlas Project

- Produced the first ICBM
- 18,000 scientists and engineers
- 17 contractors
- 200 subcontractors
- 200,000 suppliers
- Coordinated by the Ramo Woodridge Corporation

# Key Aspects of the Atlas Project

- Firmly established the "Systems Engineering" approach to management

- Identified key challenges early (re-entry)
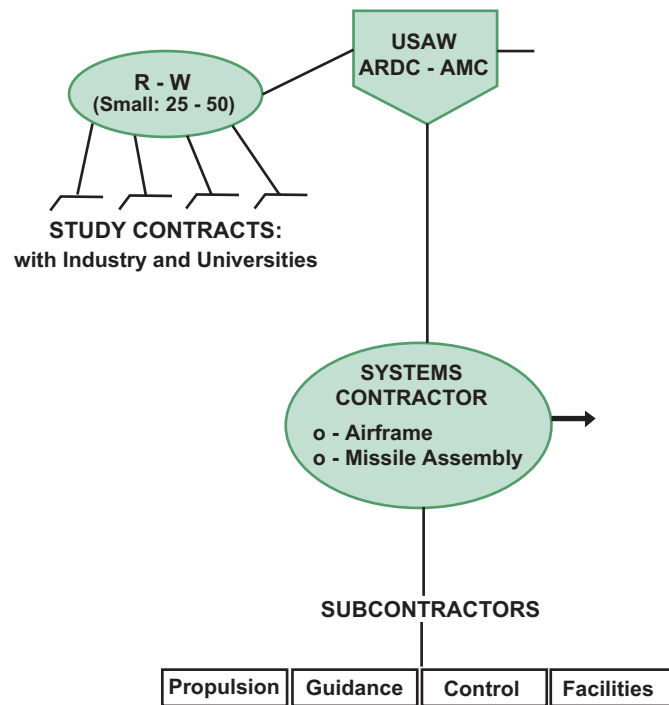


Prime Contractor Approach.



Systems Engineering Approach.

# Boston's Central Artery Tunnel

- "The largest, most complex, and technically challenging highway project…"
  - www.bigdig.com/
- >7 Miles of tunnels
- Projected to cost $14.6B
- 87% Complete

# Key Aspects of the CA/T

- Greater "messy complexity" than either SAGE or Atlas (T. Hughes)
- Bechtel / Parsons Brinkerhoff coordinates
- ~1/3 of budget spent on remediation
- Highly publicized mistakes
  - Voids in concrete of Zakim Bridge
  - Planning maps missing the Fleet Center
  - "Based on anecdotal evidence, I believe that there is a genuine potential for monetary recovery. " -  MA State Inspector General
- How was the CA/T project similar to/different from from the building of the Great Pyramid?
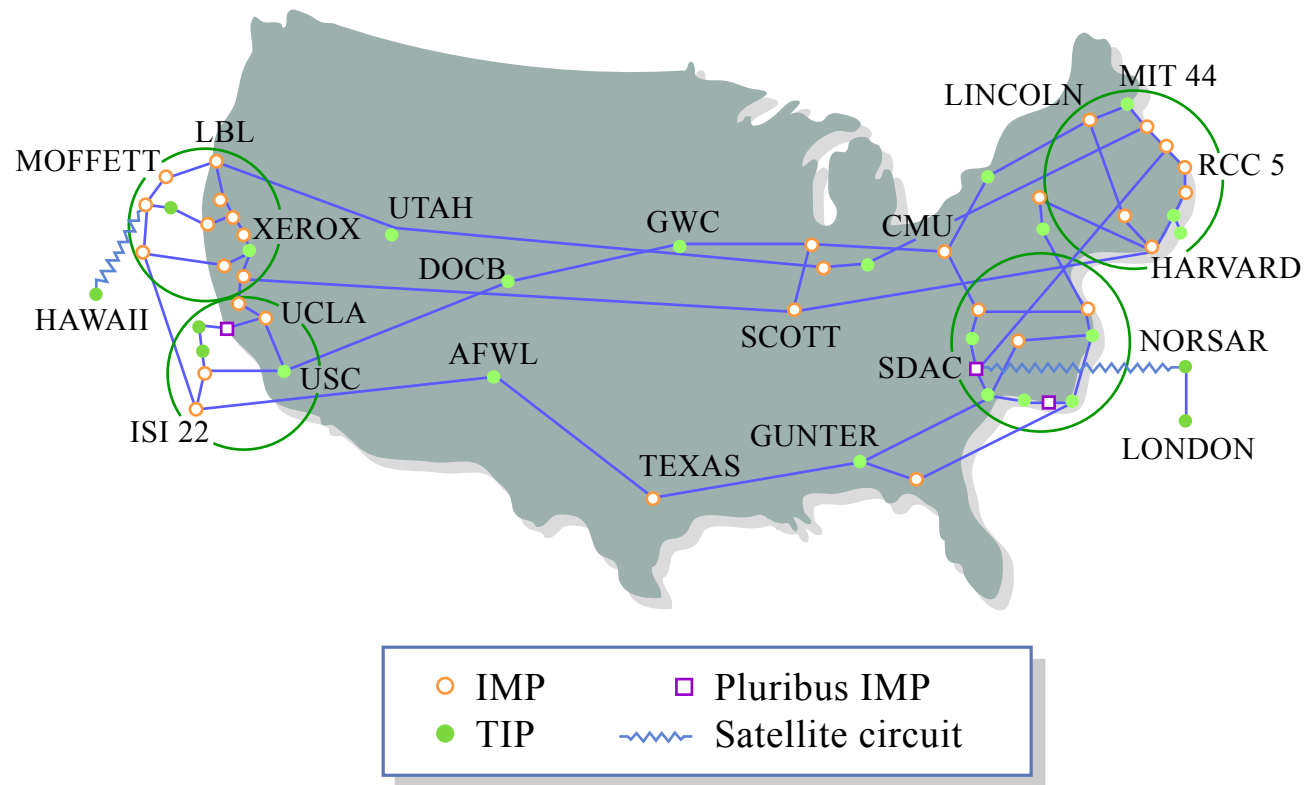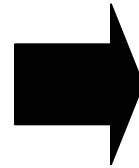- Is the CA/T project successful so far?

# ARPANET
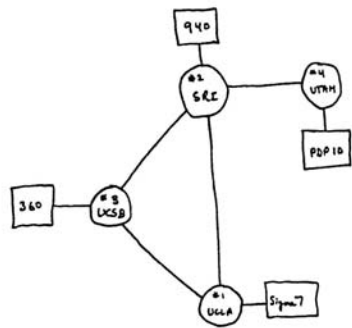


Figure by MIT OCW.

- A prime example of scalable architecture
- New trends in management of big projects
  - Flatter    - Less centralized  - Meritocratic
- Do these trends work for other systems?

# Discussion Points

- Do the systems engineering practices of big programs like Atlas work for simpler systems?

- Is there a major difference between the engineering process of the "machine age" and the "systems age" even for the same basic function?

# History of Systems Engineering Summary

- Engineering has a long history
- Systems Engineering seems to be a more recent phenomenon
- Strongly related to management
- Post WWII government-funded projects played a major role in defining SE
  - NOTE:  Clausing, Axelband, Campbell article explores commercial SE and contrasts in with government SE