Outcomes* for Undergraduate Systems Engineering

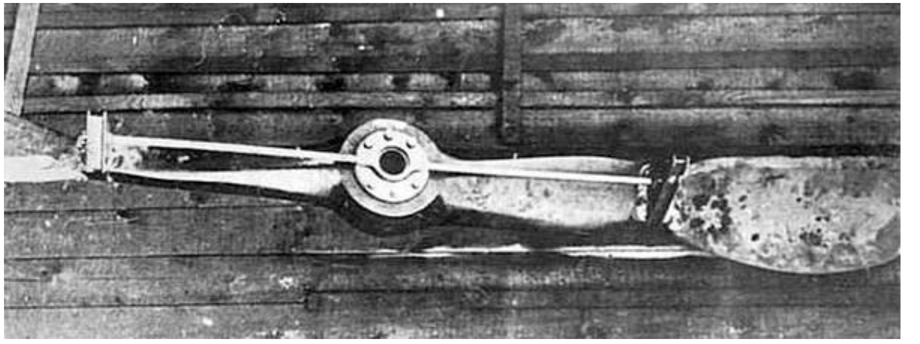
Ron Carson, PhD

Fellow, International Council on Systems Engineering

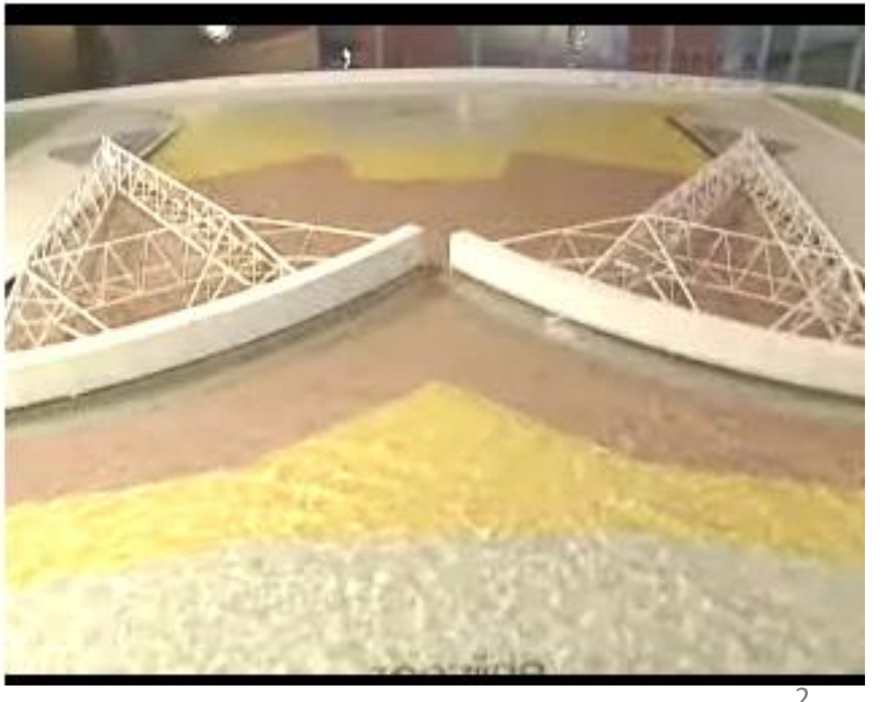
*Covey: “Begin with the end in mind”

Observations

- Industry SEs characterized by ability to accommodate competing technical and programmatic criteria (Chief Engineer role)
- Bias exists regarding having >10 years experience in engineering prior to becoming an "SE"
- Key question: How to replace ">10 years experience" during undergraduate curriculum?



WWI fighter propeller



Model of Rotterdam barrier

What “Experiences”?

- Design –
  - Using different engineering domains (ME, EE, SWE, etc.)
  - Interacting with other people and systems
    - Interfaces, organizations (supplier/acquirer/associate)
  - Balancing competing factors
    - Performance, cost, producibility, reliability, human factors
- Lifecycle – design, test, production, operations, support (maintenance, logistics, training), upgrades, disposal
  - Project execution, planning, management
  - New technology, and constraints of old technology – interfaces and allocations of functionality
  - Documentation/reporting/configuration management

Valuable Characteristics

- Technical credibility
  - Technical depth in selected engineering areas
  - Knowledge of vast technical areas (physics)
- "Heads up" personality – Expansive view of problems and stakeholders
  - Focus on problem definition and solution outcomes, not just the solution
  - Ability to work in and lead teams
- Consideration of *more* than the technical elements

University of Arizona*

Freshman Year
(Common to all Engineers)

- Introduction to Engineering I
- Calculus I
- Chemistry I, with Laboratory
- English I
- Humanities or Social Science Elective

- Introduction to Engineering II
- Calculus II
- Chemistry II, with Laboratory
- English II
- Physics I

Sophomore Year

- Introduction to Systems Engineering
- Calculus III
- Physics II
- Numerical Methods
- Economics

- Probability and Statistics
- Differential Equations
- Physics III
- Economic Analysis
- Engineering Science Elective
- Psychology

- Most valuable?
- More?

Junior Year

- Human Factors
- Engineering Statistics, with Laboratory
- Deterministic Operations Research
- Electrical Engineering I
- Mathematics Elective

- Stochastic Operations Research
- Linear Systems Theory
- Microcomputer Systems, with Laboratory
- Electrical Engineering II
- Technical Writing

Senior Year

- Simulation Methods
- Control Systems
- Departmental Elective
- Technical Elective
- Humanities or Social Science Elective

- Human-Computer Interaction
- Senior Design Projects
- Technical Elective
- Free Elective
- Humanities or Social Science Elective

* Bahill, et al., "**30 Years of Systems Engineering at the University of Arizona**,"
Proceedings of the National Council on Systems Engineering, 1992 (Seattle, WA)

"computers, modeling, and project courses"

More "communications, labs"

SIMILAR* – What SEs do!

The SIMILAR Process
State the Problem
Investigate Alternatives
Model the System
Integrate
Launch the System
Assess Performance
Reengineer the System

Systems Engineering Consensus
Understanding customer needs, Stating the problem, Discovering system requirements
Validating requirements
Defining quantitative measures
Exploring alternative concepts, Sensitivity analyses
Designing and managing interfaces, System integration
Functional decomposition, System modeling, System design, Configuration management, Risk management, Reliability analysis, Total quality management, Project management, Documentation
Prescribing tests, Conducting design reviews, Total system test

Special emphasis in SE

* Bahill and Gissing, "**No Matter What The Application, It Is Still Systems Engineering**," *Proceedings of the International Council on Systems Engineering*, 1997 (Los Angeles)

Career Risks

- Failure to identify the unique *technical* contribution of SE
  - Counter: technical excellence in at least one area
- “Process” focus – become technically irrelevant
  - Counter: emphasis on “xx systems engineer”, e.g., “RF Systems Engineer”
- “Management” focus – become sidelined into “xxx management” tasks
    - Interface management
    - Requirements management
    - Risk and Issue management
  - Counter: emphasis on design, verification, and other “technical” process areas (ISO/IEC 15288, INCOSE SE Hdbk)

Discussion

- Is it possible to instill SE capability in an undergraduate?

- What characteristics are most valuable for
  - Immediate hiring
  - Career progression
    - Technical
    - Management