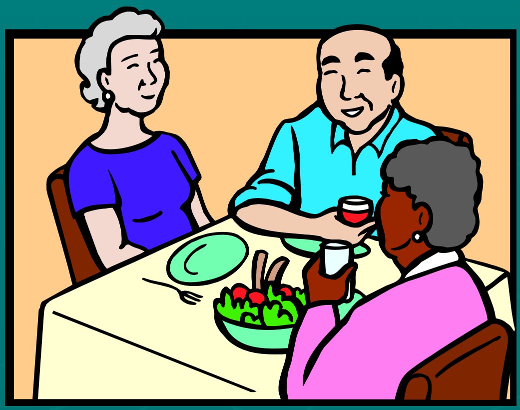
System Engineering

Applying Architectural Principles to Complex System Development

Architect Role/Responsibility Homebuilding

The architect speaks two languages to support the dialog between the homebuyer and the builder



- "Lifestyle" language with the homebuyers

- "Plans/Designs/Specifications" language with the builder

Architect Role/Responsibility Attorney

- “Objectives/Desires” language with client

- “Obligations, Terms and Conditions” language with legal community

Architect Role/Responsibility
System Engineer

- "Needs/expectations" language with user/consumer

- "Specifications" language with engineering

Topics and Threads

- Engineering? System? System Engineering?
- System Engineering Tools
- “Structure” in engineering endeavors
- Program Management & System Engineering
- Why System Engineering
- Example models
- Implementing System Engineering

Simple Invention – Engineering?

Solution of single consequence – not engineering

“Engineering”

- **A**: the application of science and mathematics by which the properties of matter and the sources of energy in nature are made **useful** to people
- **B**: the design and manufacture of **complex products**

[emphasis added]

Merriam-Webster

"System"

An organized integrated whole made up of diverse but interrelated and interdependent parts

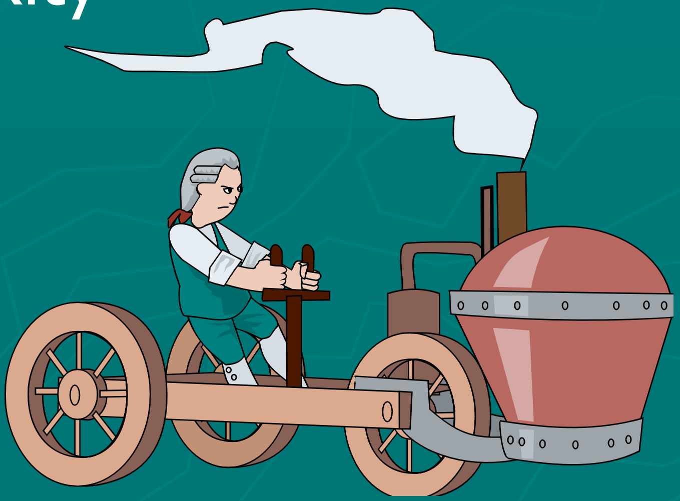
Merriam-Webster

Engineers

- Desire to create useful things – *shared with the aforementioned inventor*
- Complex products – by definition

Engineers and Complexity

- Complexity represents a burden and a fascination
- Fascination with complexity is an affliction



Complexity and Risk

- Complexity increases risk
- Risk potentially impacts usefulness

System Engineers – Mission

- Mitigate complexity (cannot eliminate)
- Maximize usefulness
- Minimize risk

System Engineers - Tools

- Structure, Structure, Structure!
- Clear problem statements – <u>user</u> language
- Architecture - Requirements decomposition
  - Functional allocation – Subsystem identification
  - Interface specs – Detailed engineering requirements
  - Error budgets and tolerances
- Analyses and modeling
- Process design

“Structure” – System Engineering

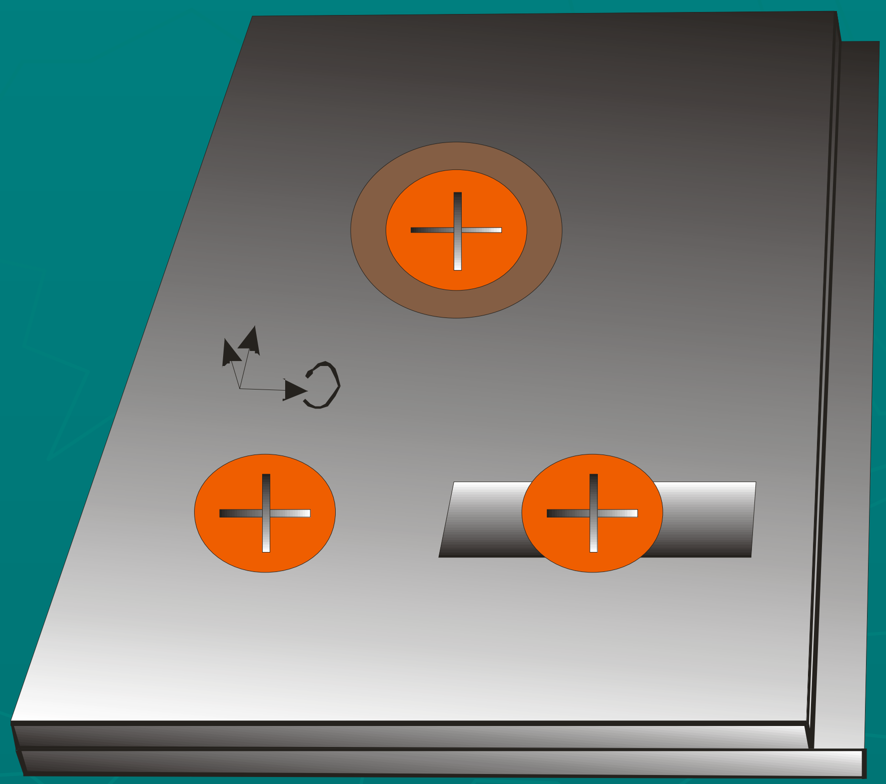
- Requirements
- Architectural definitions – subsystems
- Engineering specifications
  - Mechanical, electrical, thermal, optical
  - Only at the subsystem boundaries!!

    i.e. Interface specifications
- Process
  - Phases and milestones

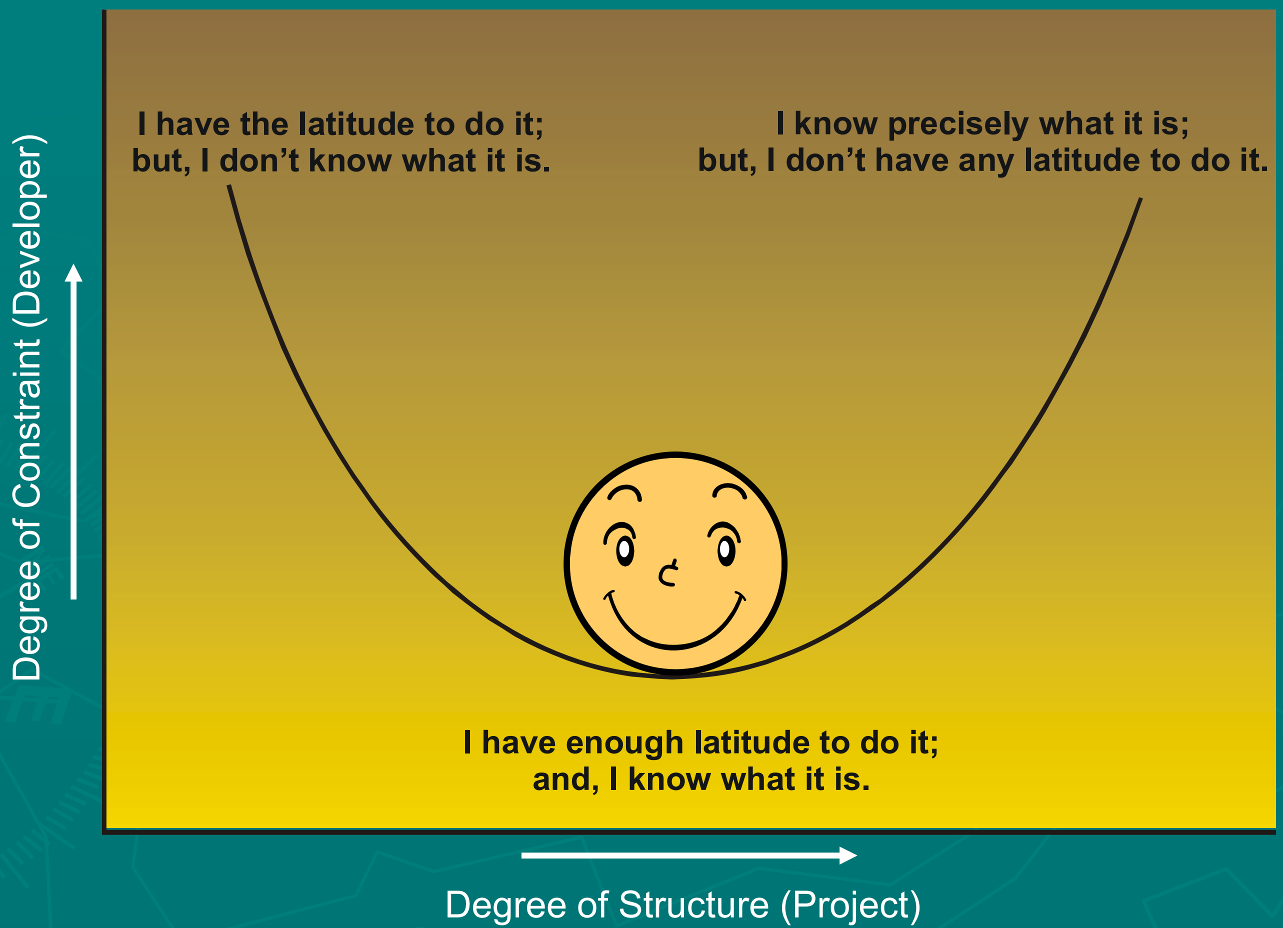
Structure – an aside

Mechanical systems – "exact constraint"

- Dr. Jack McLeod and Dr. Jack Morse
- Eastman Kodak Co. 1960's
- 6 degrees of freedom – controlled appropriately

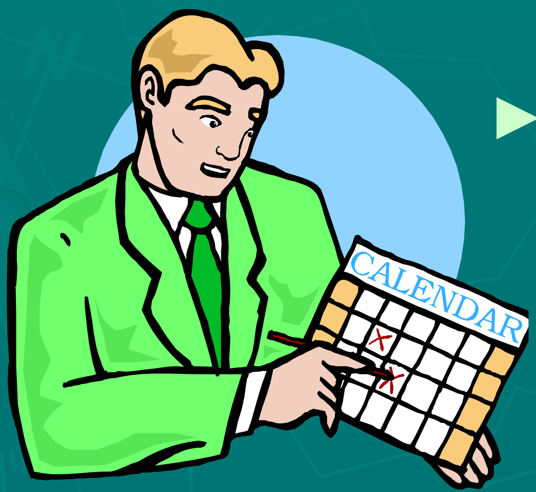


System Engineering – Sweet Spot



System Engineering –
Relationship to Program Management

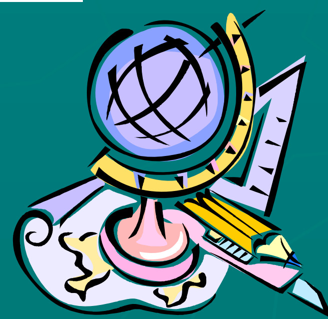
- System Engineering - <u>Structure</u>
  - Specifications
  - Process
  - Analyses

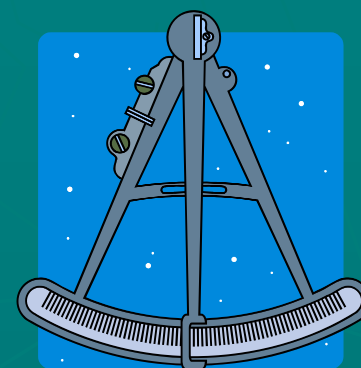


- Program Management - <u>Discipline</u>
  - Responsibility
  - Monitoring
  - Control

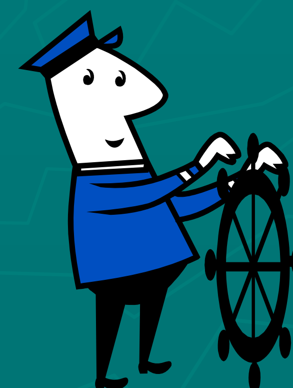
System Engineering – Relationship to Program Management

- System Engineering - Navigation
  Charting the course





- Program Management - Command
  Sailing the ship



Heard in Troubled-Program Hallways

"We need more conference rooms!"

Heard in Troubled-Program Hallways

"We need more
conference rooms."

It is the responsibility of System Engineers to establish the vehicle for communications among the program participants.

System Engineers accomplish this by providing structure in both product and process definition.

Heard in Troubled-Program Hallways

"Are you working through the holiday?"

Good System Engineering manages risk, thereby relieving stress on schedule, cost, and performance.

Heard in Troubled-Program Hallways

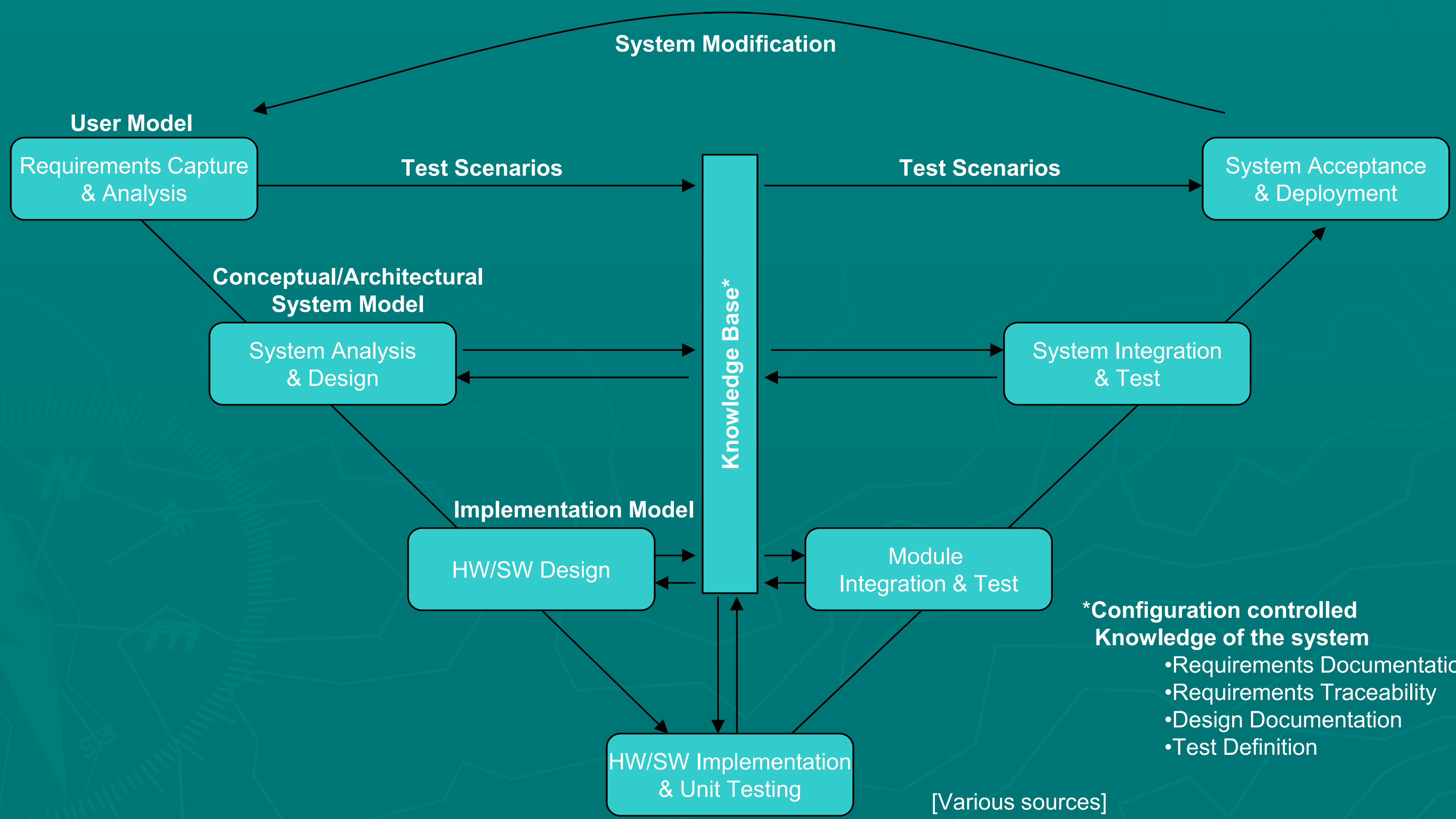
"What Tiger-team are you on?"

Good System Engineering obviates the need for the best people to salvage programs in later phases.

System Engineering Models

- Waterfall (problematic)
- V-Diagram
  - Waterfall with feedback
  - Easily understood
- Architecture Based Development
  - Manage to the interfaces
  - Easy technology insertion
- Model Based Development
  - Applying math is cheaper than bending metal

V-Diagram SE Model



*Configuration controlled Knowledge of the system
- Requirements Documentation
- Requirements Traceability
- Design Documentation
- Test Definition

[Various sources]

Common Elements – all models

- Phases
  - Requirements
  - Definition (Design)
  - Implementation
  - Test
  - Deployment
  - Retirement
- Phase products
  - Documents
  - Increasing detail
  - Process definition
  - Components
  - The Product

Companion Activities

- Configuration management
  - Document control, versioning, release, etc.
  - Vault/librarian activity
  - Component compatibility/interchangeability
- Analyses
  - Risk analysis/management
  - -ilities (see next slide)
  - Performance analyses/improvement
  - Error budgeting
- Contingency planning

Companion Activities, cont.

- Important Analyses – the "-ilities"
  - Usability
  - Reliability
  - Manufacturability
  - Serviceability
  - Maintainability
  - Supportability
  - …

System Engineering – Effects

- Strong Architecture
  Mitigates complexity
- Solid Requirements Statements
  Maximizes usefulness
- Robust Process
  Minimizes risk

McClure Precepts

- Requirements statements **- User Language**
- Best minds application – *still an art*
  - Conceptual models
  - Technology selection
  - Architecture

- Discipline
  - Stick to the **Process**!!
  - Steps may be postponed to a more **expensive** phase – but they cannot be eliminated!
  - Assess and improve the process

SE Implementation

- Establish executive sponsorship
- Pick an SE model
- Adapt to your need
- Acquire, develop, assign staff
- Select a pilot program
- Monitor progress
- Roll-out to new/existing programs

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