Systems Engineering

The Key to Successful Outcomes
What is a Systems Engineer?

- Anyone can print a business card with “Systems Engineer” in the title.

- Lots of schools offer “systems engineering” courses.

- …But what does it mean to be a systems engineer?
Maybe some people just have the *SE Knack*?

- See everything as a system
- Strive to understand “context”
- Apply systems engineering principles and practices – without thinking – in all facets of life
Do successful SE’s have a unique talent for “Systems Thinking”? 

Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static “snapshots.”

Peter Senge

Systems Engineering is more than just process!
Typical SE Behaviors

- Always trying to understand the “Big Picture”
  - Context and CONOPS

- Analyzing “expectations” to separate “needs” from “wants”
  - Requirements

- Obsessive about determining root causes
  - Root cause analysis

- Frequently making check lists
  - Verification
The Big Picture

Afghanistan Stability / COIN Dynamics

Fig. 6

WORKING DRAFT – V3
Separating Needs and Wants

- **Wants**
- **Needs**
Obsessive About Root Causes

- Environment
- Machines
- Manpower
- Methods
- Materials

Effect
## Frequently Making Check Lists

### Table

<table>
<thead>
<tr>
<th>Level</th>
<th>Rev</th>
<th>ID</th>
<th>Name</th>
<th>Make or Buy</th>
<th>Requirement</th>
<th>Predecessor</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>Bicycle System</td>
<td>M</td>
<td>&quot;Light Wt&quot; - &lt;105% of Competitor</td>
<td>User Need&quot; Doc ¶ 1</td>
<td>0.0.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>Bicycle System</td>
<td>M</td>
<td>&quot;Fast&quot; - Faster than any other bike</td>
<td>&quot;User Need&quot; Doc ¶ 2</td>
<td>0.0.2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>8.0 KG max weight</td>
<td>0.0.1. Marketing</td>
<td>1.1.1 Test (Weigh bike)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>85 cm high at seat</td>
<td>Racing rules ¶ 3.1</td>
<td>1.1.2 Test (Measure bike)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>68 cm wheel dia</td>
<td>Racing rules ¶ 4.2</td>
<td>1.1.3 Verif at ass'y level</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>Carry one 90 KG rider</td>
<td>Racing rules ¶ 2.2</td>
<td>1.1.4 Demonstration</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>Use advanced materials</td>
<td>Corporate strategy ¶ 6a</td>
<td>1.1.5 Verif at ass'y level</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>Survive FIVE seasons</td>
<td>Corporate strategy ¶ 6b</td>
<td>1.1.6 Accelerated life test</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>Go VERY fast (&gt;130 km)</td>
<td>0.0.2</td>
<td>1.1.7 Test against benchmark</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.1</td>
<td>Bicycle</td>
<td>M</td>
<td>Frame is to be Red, shade 123</td>
<td>Marketing</td>
<td>1.1.8 Inspection</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1.2</td>
<td>Packaging</td>
<td>B</td>
<td>Packaged for Shipment</td>
<td>0.0.4, Marketing</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.2</td>
<td>Packaging</td>
<td>B</td>
<td>Photo of &quot;Hi Tech&quot; Wheel on Box</td>
<td>0.0.4, Marketing</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.2</td>
<td>Packaging</td>
<td>B</td>
<td>Survive 2 m drop</td>
<td>Industry std</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.3</td>
<td>Documentation</td>
<td>M</td>
<td>Assembly Instructions</td>
<td>0.0.4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.3</td>
<td>Documentation</td>
<td>M</td>
<td>Owner's Manual</td>
<td>0.0.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2.1</td>
<td>Frame Assembly</td>
<td>B</td>
<td>Welded Titanium Tubing</td>
<td>1.1.5, 1.1.6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2.1</td>
<td>Frame Assembly</td>
<td>B</td>
<td>Maximum weight 2.5 KG</td>
<td>1.1.1 allocation</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2.1</td>
<td>Frame Assembly</td>
<td>B</td>
<td>Demo 100 K cycle fatigue life</td>
<td>1.1.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2.1</td>
<td>Frame Assembly</td>
<td>B</td>
<td>Support 2 x 90 KG</td>
<td>1.1.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2.1</td>
<td>Frame Assembly</td>
<td>B</td>
<td>Powder-coat frame Red, shade 123</td>
<td>1.1.4</td>
<td></td>
</tr>
</tbody>
</table>

©2011 Strategy Bridge International Inc.
Applying SE to Every Day Life

- Clearly defining objectives (requirements), while staying focused on outcomes
- Decomposing problems and issues into component pieces
- Structured decision-making (trade studies)
- Focusing on accuracy (verification) and appropriateness (validation) of outcomes
- Being sensitive to risk
- Taking the long view (supportability)

Fig. 10
Clearly defining objectives - focused on the outcomes

- MOE (outcome): score
- New clubs may be a “want” but probably won’t impact MOE
- Considers enabling systems
  - System for maintenance of greens will impact MOE
Decomposing Problems and Issues

How would you approach the project for installing a new flower garden?

Do you see everything as a WBS?
Structured Decision Making

- Makes rational decisions
- Evaluates alternatives based on merit
- Identifies the important considerations

1. Identify the decision situation—understand the objectives “Framing”
   - Identify Alternatives
   - Model-Evaluate the Decision
   - Choose an Alternative
   - Conduct Sensitivity Analysis

   Analyze Further?

   - Yes
   - No
     - Implement the Selected Alternative
Accuracy versus Appropriateness

- **Accurate (Verification)**
  - Verification: relates back to the approved requirements set and can be performed at different stages in the life cycle

- **Appropriate (Validation)**
  - Validation: relates back to the Concept of Operations
Sensitivity to Risk

- Understands the risk philosophy appropriate to the project
- Adjusts rigors of the process to the need
- Considers the effort to make it work (cost and schedule)
Taking the Long View

- Sees things that might go wrong in the future
- Avoids, prevents, and prepares to be successful
- Considers Reliability, Maintainability, and Supportability aspects of all decisions.
Case: Applying SE to Organizations

# Summary

## A Way of Thinking
- Recognize the need
- Understand the problem
- Think about potential solutions
- Define the problem
- Make rational decisions
- Implement and prove the solution
- Usability

## A Formal Process
- Requirements definition
- Concept of Operations
- Concept and Architecture Development
- Functional Analysis
- Trade-off Analysis
- Integration, Verification, and Validation
- RAM and ILS
So What?

- Great processes do not replace great insight (talent versus dedication)
- Knowing when (and what) to compromise is the part of the *art* in Systems Engineering
- People with “the knack” are valuable assets to any project