Systems Engineering through a Systems Lens

Dr. Michael Pennotti

Prof. William Robinson

School of Systems and Enterprises

Let's begin with our roots.

Mervin J. Kelly, President, Bell Telephone Laboratories

"Systems engineering's major responsibility is the determination of the new specific systems and facilities development projects….The projects that are activated are those that give greatest promise for user benefit."

Address to the Royal Society of London, March 23, 1950

E. W. Engstrom, Senior Executive Vice President, RCA

"Systems engineering…is best defined by stating the two major requirements for its success: first, a determination of the objective that is to be reached; second, a thorough consideration of all factors that bear upon the possibility of reaching the objective, and the relationships among these factors."

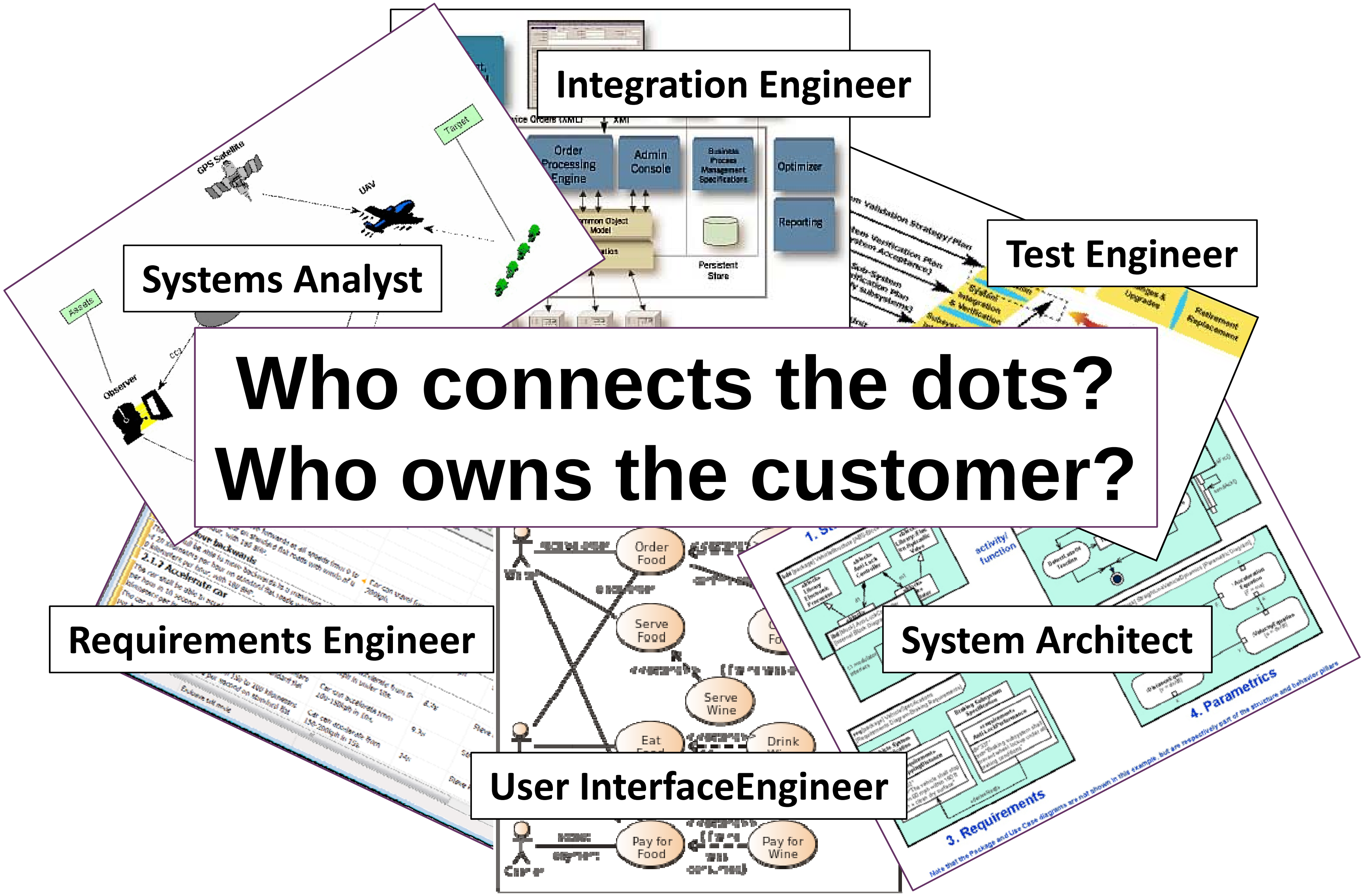
"Systems Engineering: A Growing Concept,"
Electrical Engineering, February 1957

Hendrick Bode, VP of Military Development and Systems Engineering, Bell Labs

"Systems engineering is distinguished by the persistence with which it turns to the needs of the ultimate user as the final criterion for planning."

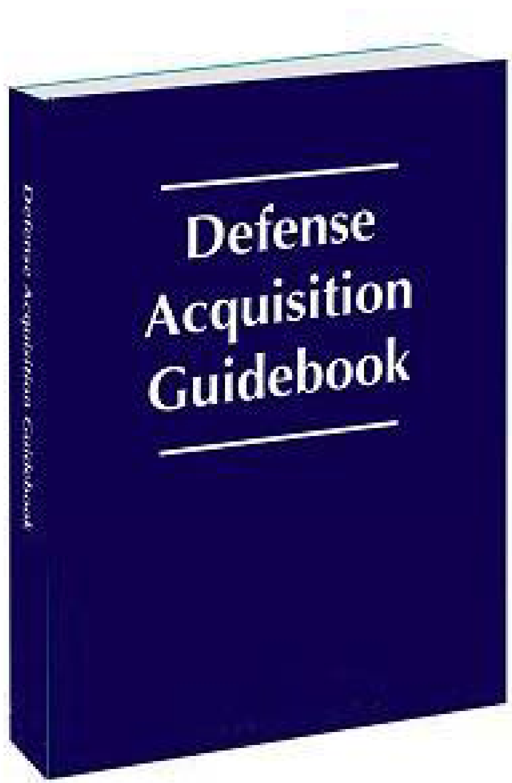
"The Systems Approach," Report to the Committee on Science and Astronautics,
U.S. House of Representatives by the National Research Council (U.S.),
Panel on Applied Science and Technological Progress, 1967.

Have we created our own Systems Engineering stovepipes?



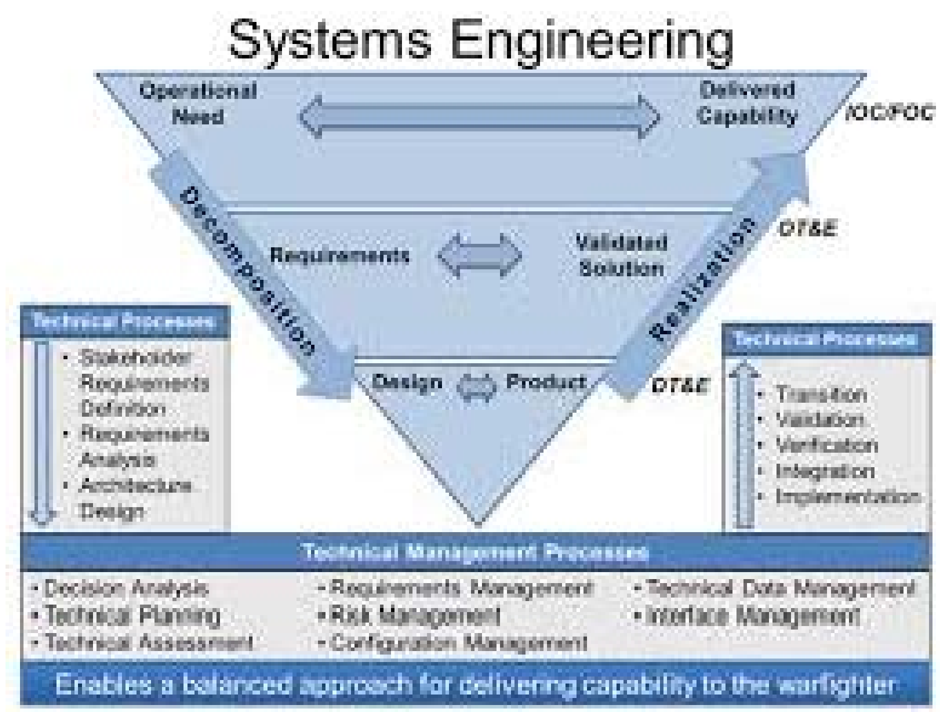
Who connects the dots?
Who owns the customer?

The DAG describes sixteen SE processes.



"These 16 processes provide a structured approach to increasing the technical maturity of a system and increasing the likelihood that the capability being developed balances mission performance with cost, schedule, risk, and design constraints."

Each with its own specified activities and products.



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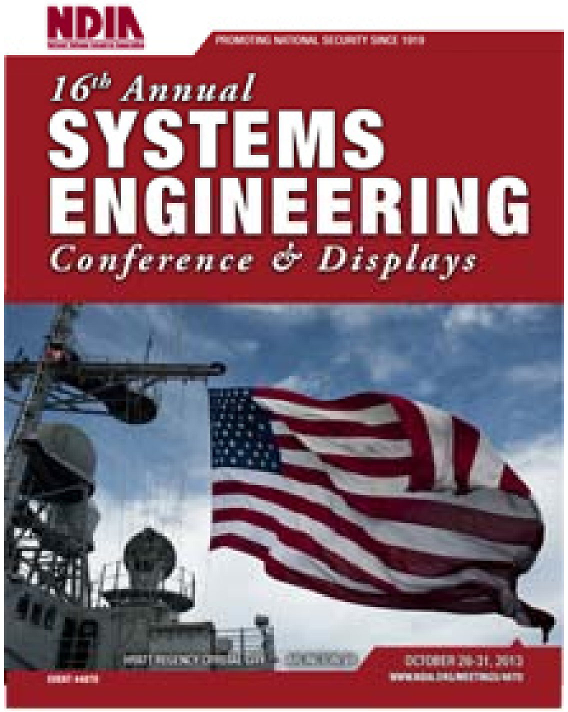
This conference offers 24 separate tracks!



"Systems Engineering is the "umbrella" engineering function that serves as the key integrating function for successful program execution and helping maintain the balance between requirements, performance, cost, schedule, and overall effectiveness and affordability."

Session Topics Include

- Affordability
- Architecture
- Early Systems Engineering
- Education & Training
- Enterprise Health Management
- Engineering Resilient Systems
- Early Systems Engineering/System of Systems
- ESOH
- Human Systems Integration
- Modeling & Simulation/Architecture
- Modeling & Simulation
- Net-Centric Operations/Interoperability
- Program Management
- Software
- System Security Engineering
- System of Systems/Architecture
- System of Systems/Net-Centric
- System of Systems/Test & Evaluation
- Statistical Test Optimization
- Systems Engineering Effectiveness
- System of Systems
- Technology Maturity
- Test & Evaluation
- Test & Evaluation/Modeling & Simulation

Russell Ackoff taught us to think outside before inside.

Analysis

1. Take what you want to understand apart
2. Identify the behaviors of the parts taken separately
3. Aggregate an understanding of the the parts into an understanding of the whole

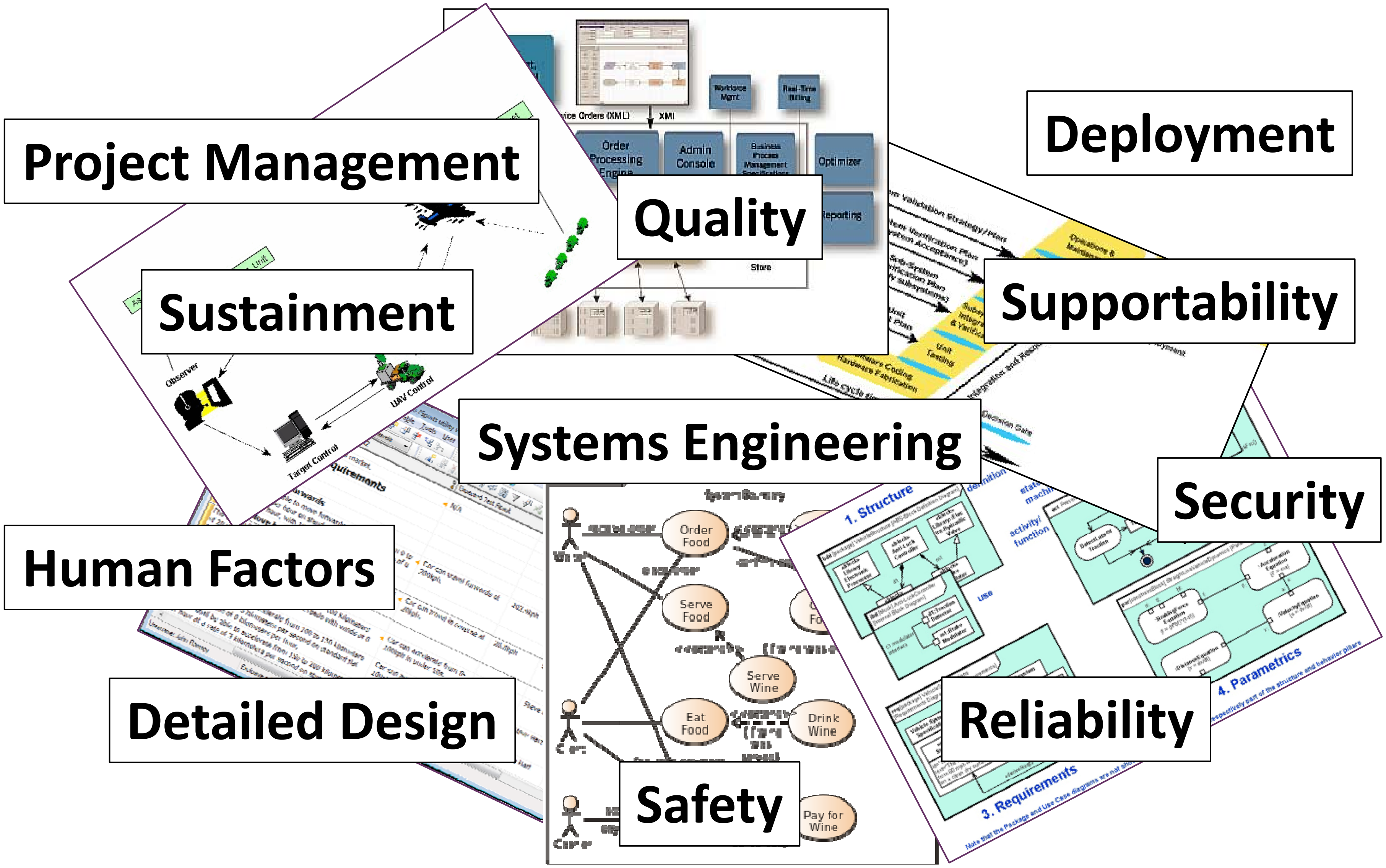
Synthesis

1. Identify the larger system within which what you want to understand is a part
2. Explain the behavior of the containing whole
3. Disaggregate the understanding of the whole to identify the role of the desired part

Ref: http://www.youtube.com/watch?v=UdBiXbuD1h4

* Dr. Russell Ackoff (1919-2009), Wharton School at the University of Pennsylvania, pioneer in operations research, systems thinking and management science.

"Identify the larger system within which Systems Engineering is a part."

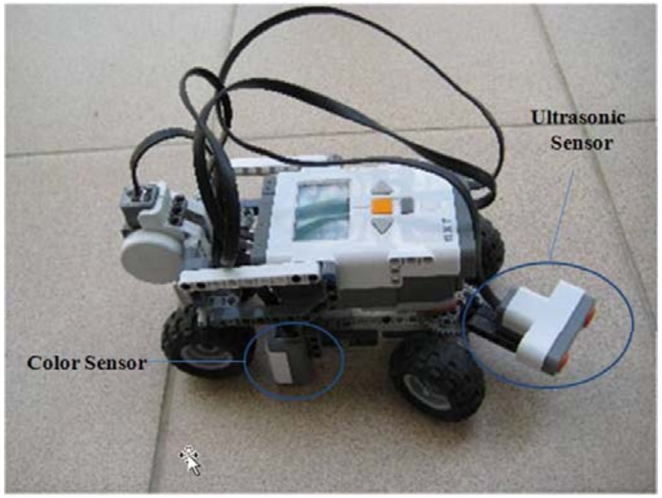


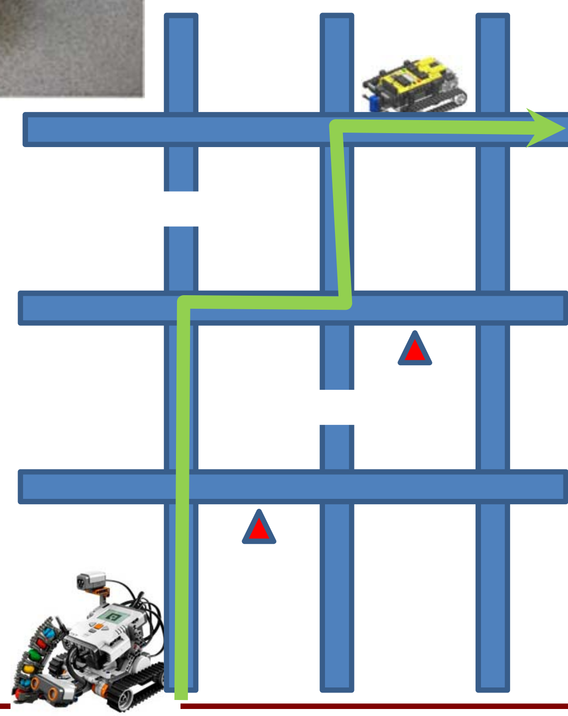
Our concern can be stated in the form of two hypotheses.

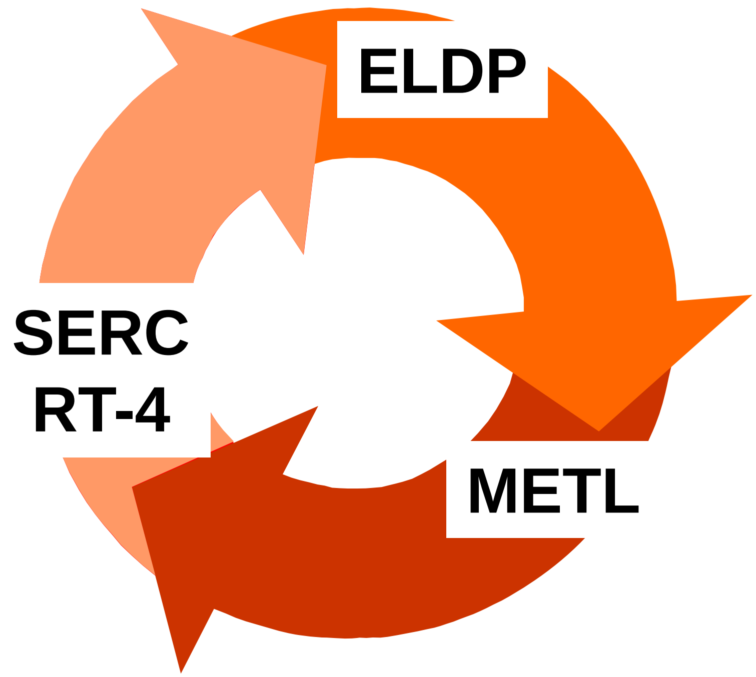
- **Hypothesis #1:** As a discipline, Systems Engineering has become fragmented, encouraging its practitioners to focus on parts rather than wholes.
- **Hypothesis #2:** This often causes there to be insufficient “glue” to hold complex projects together.

We tested these hypotheses in a series of "Experience Acceleration" experiments.

- Five Separate Experiments
- 162 Graduate Students







Each experiment required teams to utilize formal Systems Engineering processes and practices.

Ref: Robinson and Pennotti, "Accelerating Experience With Live Simulation of Designing Complex Systems," ASEE International Forum, Atlanta, GA, June 22, 2013.

We found the engineers got trapped in two nested boxes.

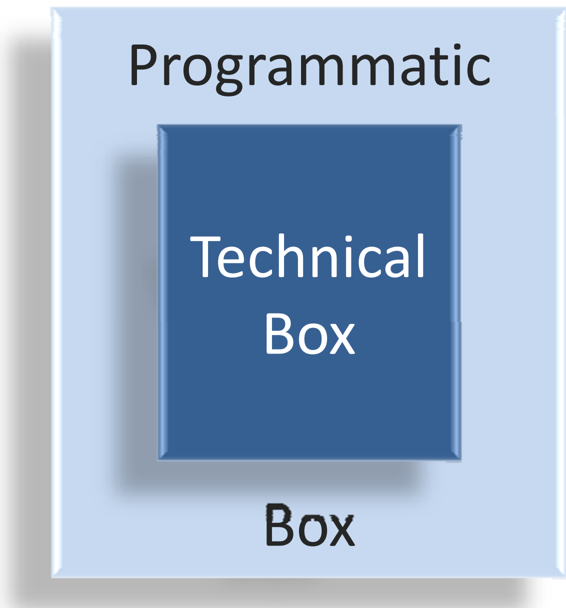
A Technical Box that encouraged them to over-design the solution, inhibited cross-team communication, and caused them to reserve insufficient time for integration and testing.

Characteristics of the Technical Box

- Talented engineers
- In-depth technical focus
- Interesting design problem
- Multiple teams
- Competition

We found the engineers got trapped in two nested boxes.

A Programmatic Box that distracted them from the technical task at hand.

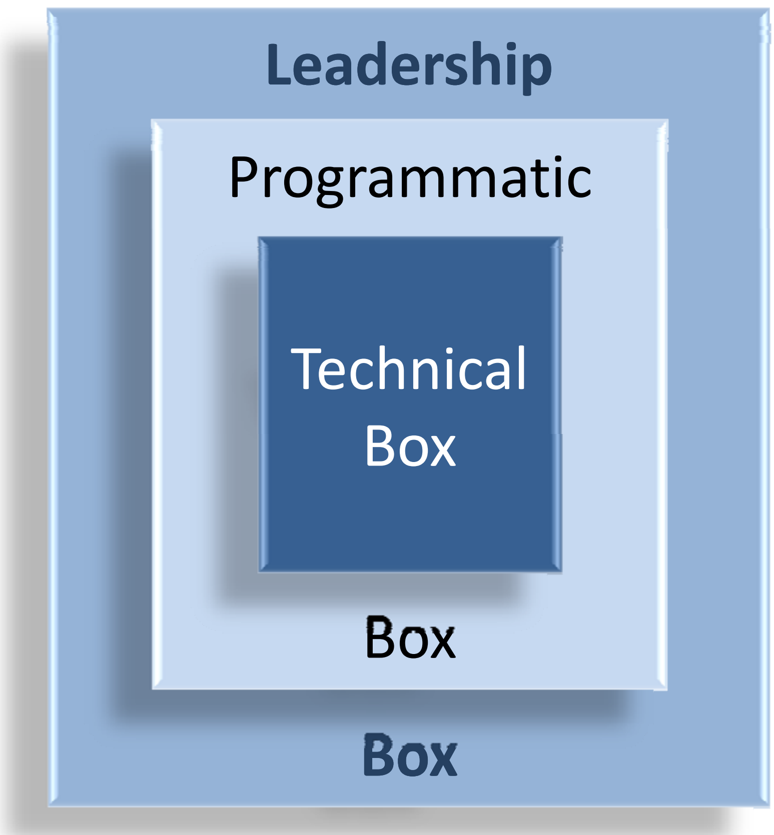


Characteristics of the Programmatic Box

- Three volume proposal
- Proof of Concept and Full Scale Prototype
- WBS and schedules
- Formal IPT structure
- Geographic dispersion with limited travel funds
- Teams expanded prior to implementation

Technical leaders found themselves trapped in a third box.

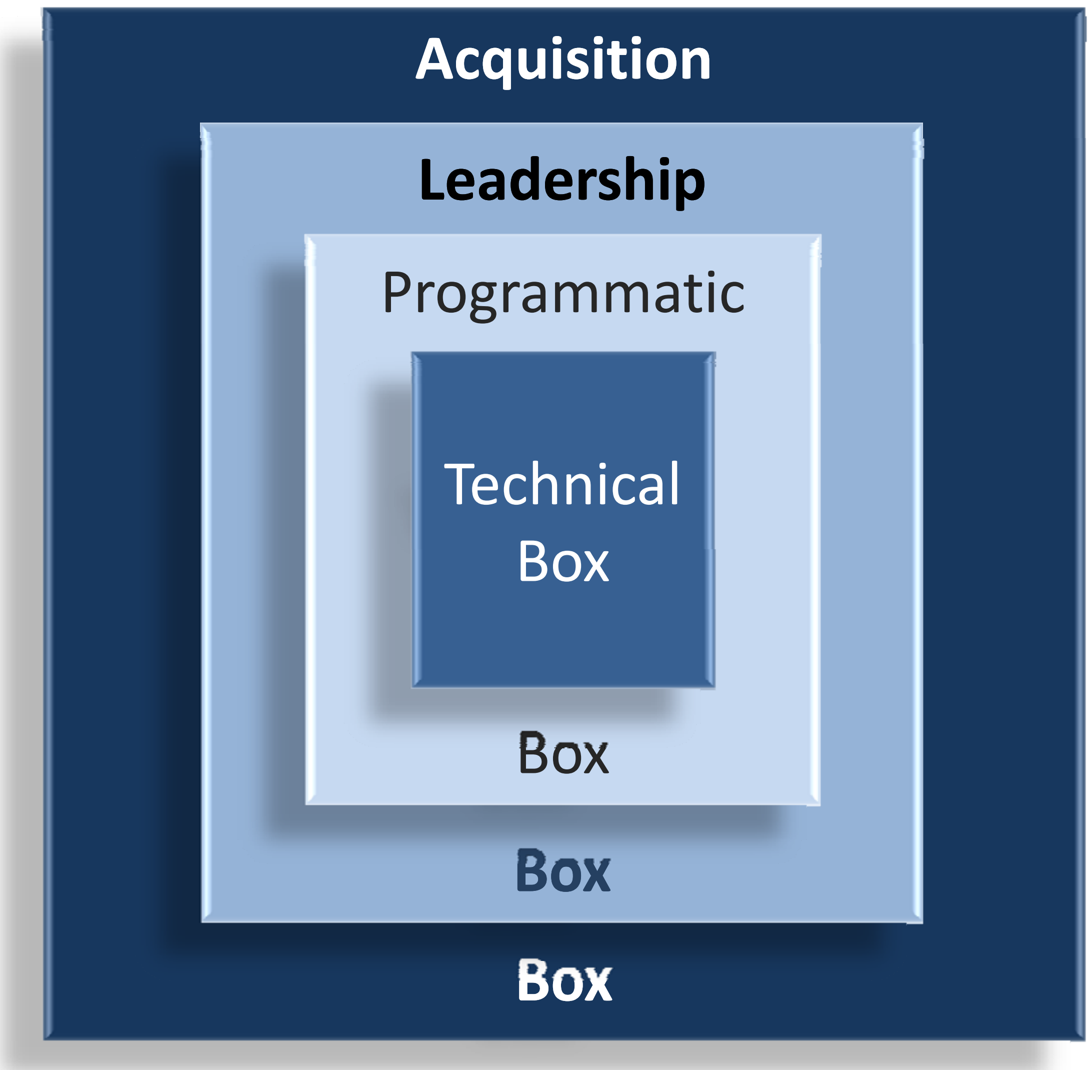
A Leadership Box that prevented them from reframing the problem when problems arose.



Characteristics of the Leadership Box

- Must-win competition
- Cost and schedule pressure
- Multiple design teams

"Customers" identified a fourth box.

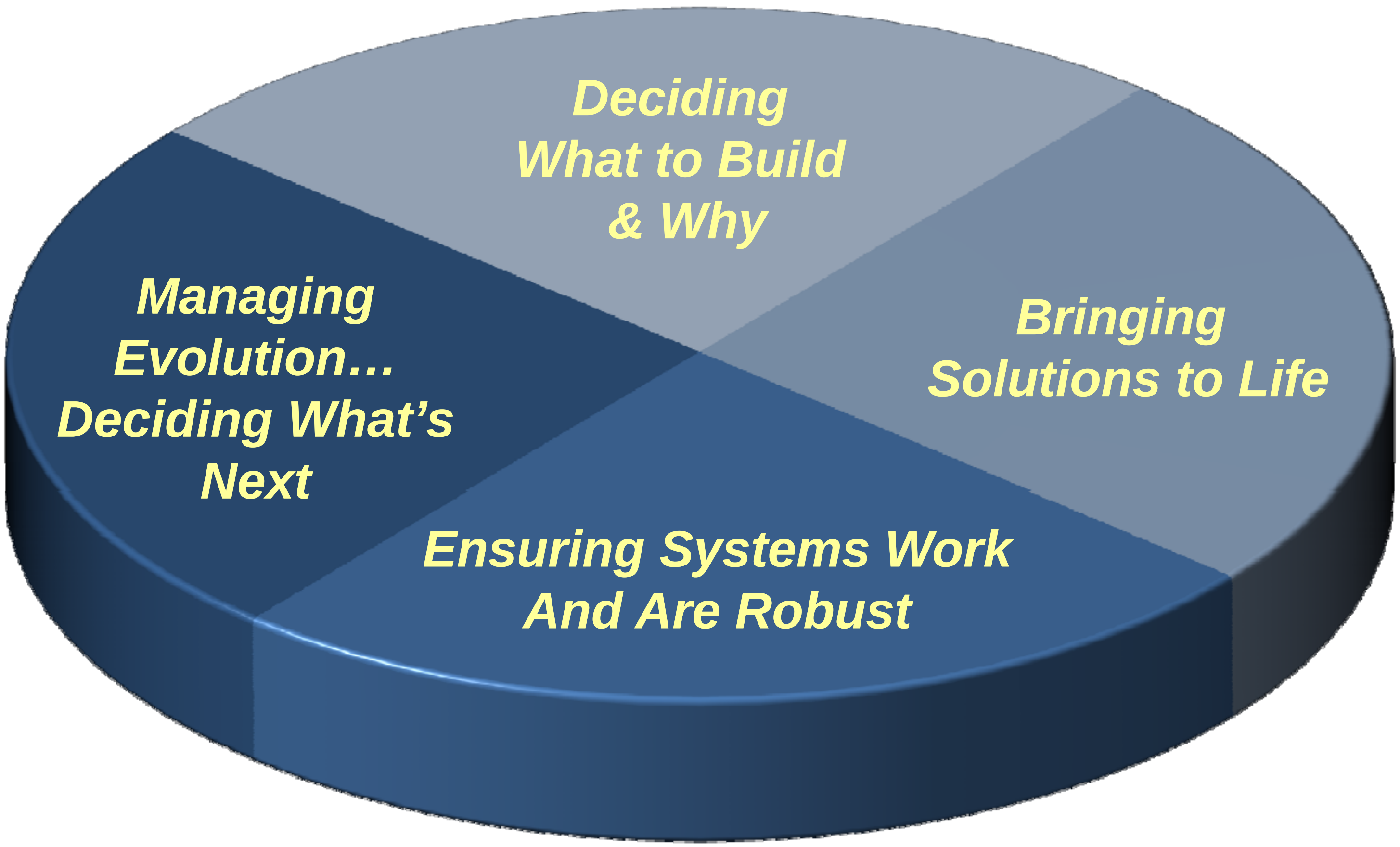


An Acquisition Box that focused them on the specification rather than the need.

Characteristics of the Acquisition Box

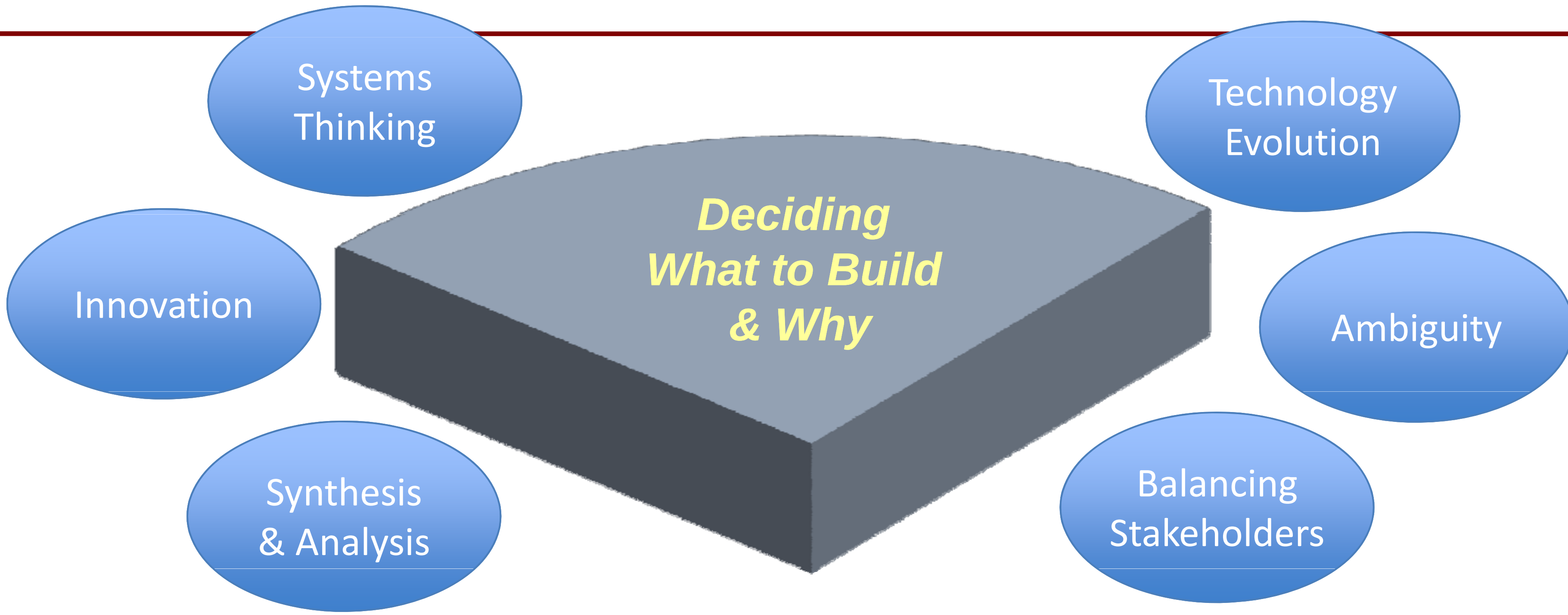
- Formal RFP process
- Predetermined evaluation criteria
- Budget and schedule pressure
- Possibility of protests

We propose a new SE framework we call "The Systems Lens."



Holistic…Circular…Plain English

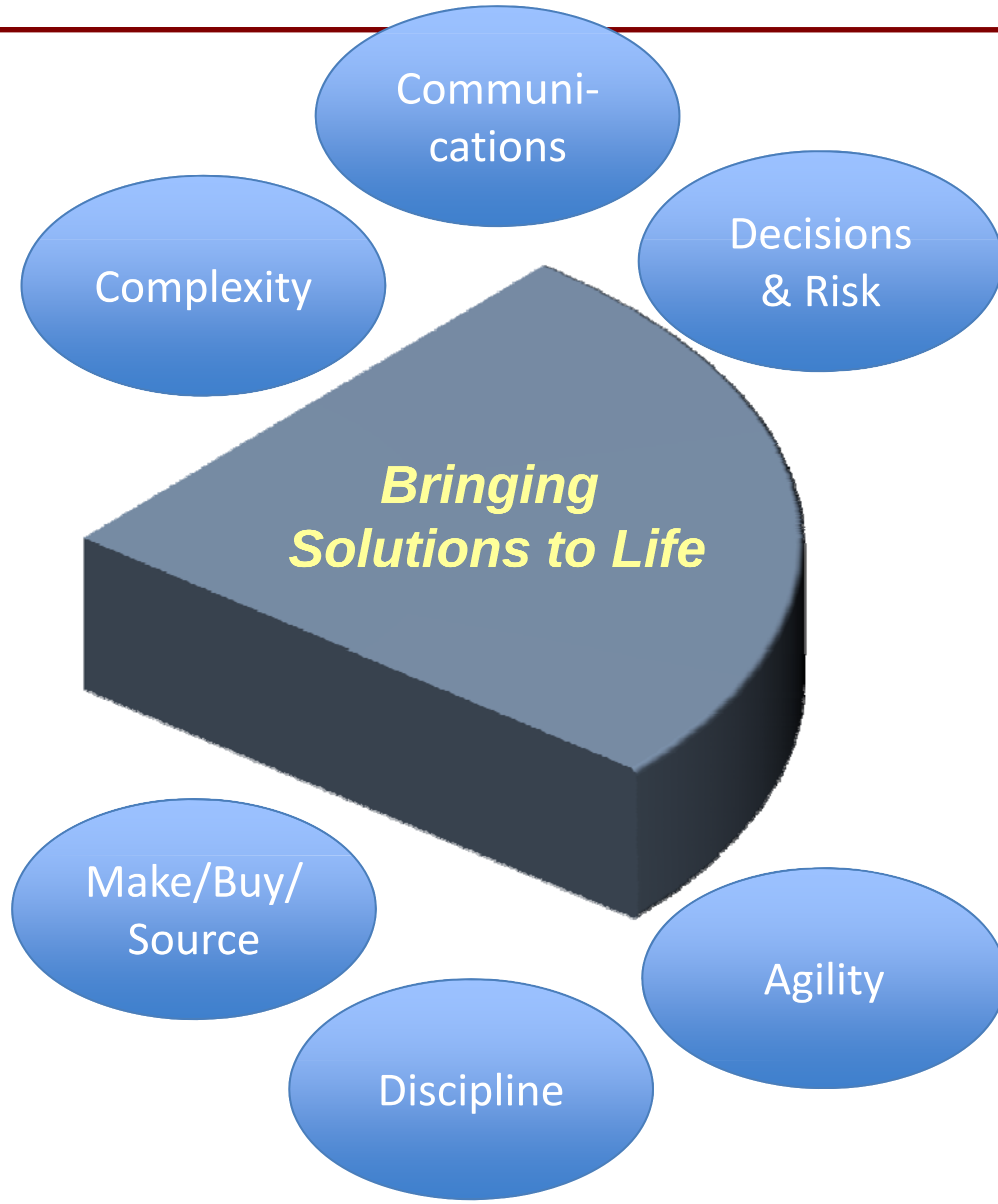
The Systems Lens



Theme – Systems engineers are at their best when the canvas is blank and the possibilities endless. They understand not only how technical systems work, but the role they play in the larger systems of which they are a part. Creative themselves, they also nurture creativity in others and recognize good ideas when they see them. They understand the pace of technology evolution and are often able to anticipate its advance. Perceiving ambiguity as opportunity, they champion new ideas and are able to enroll others to enlist their support.

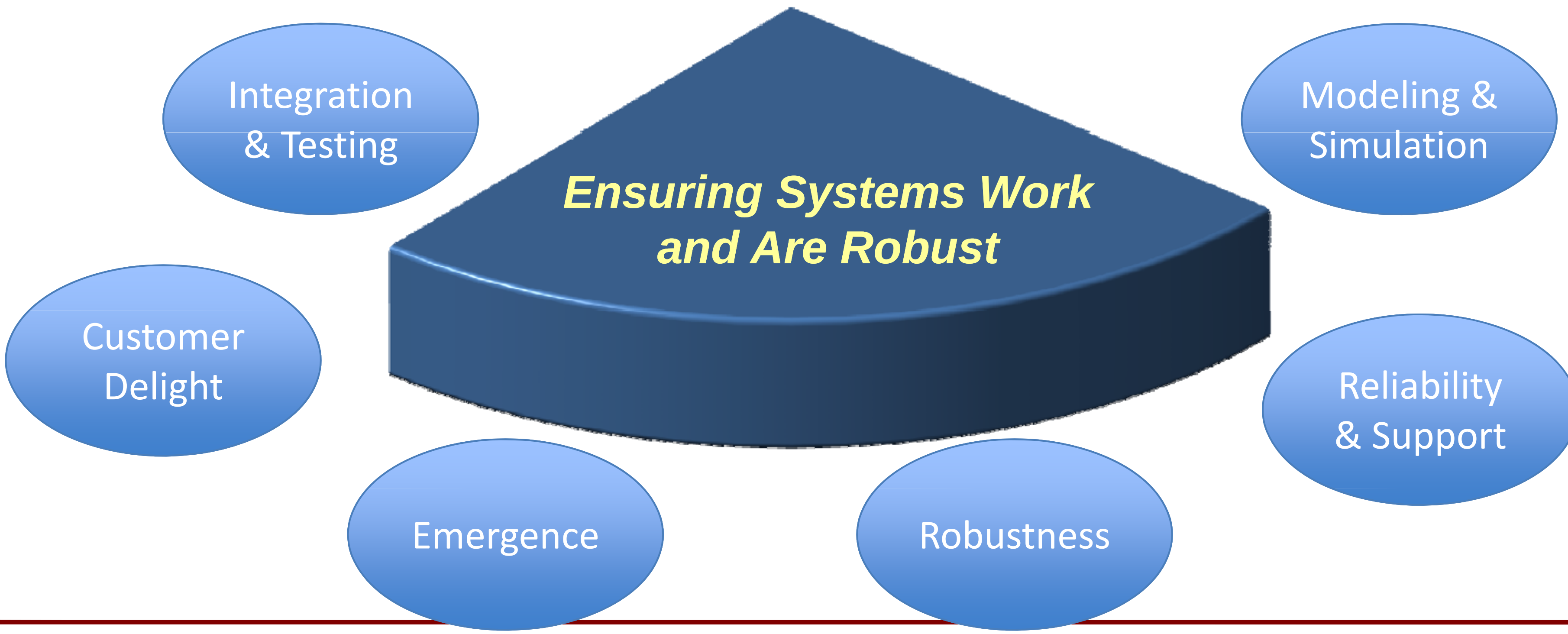
The Systems Lens

Theme – Systems engineers know how to get things done. They help development teams manage through complexity by distinguishing the truly important from that which is not. While flexible and agile in the face of changing circumstances, they maintain a singular focus on the customer/user and a disciplined approach to ensuring their needs are met. They develop multiple options to mitigate risk and balance means with ends to ensure that solutions are efficient in their use of resources.

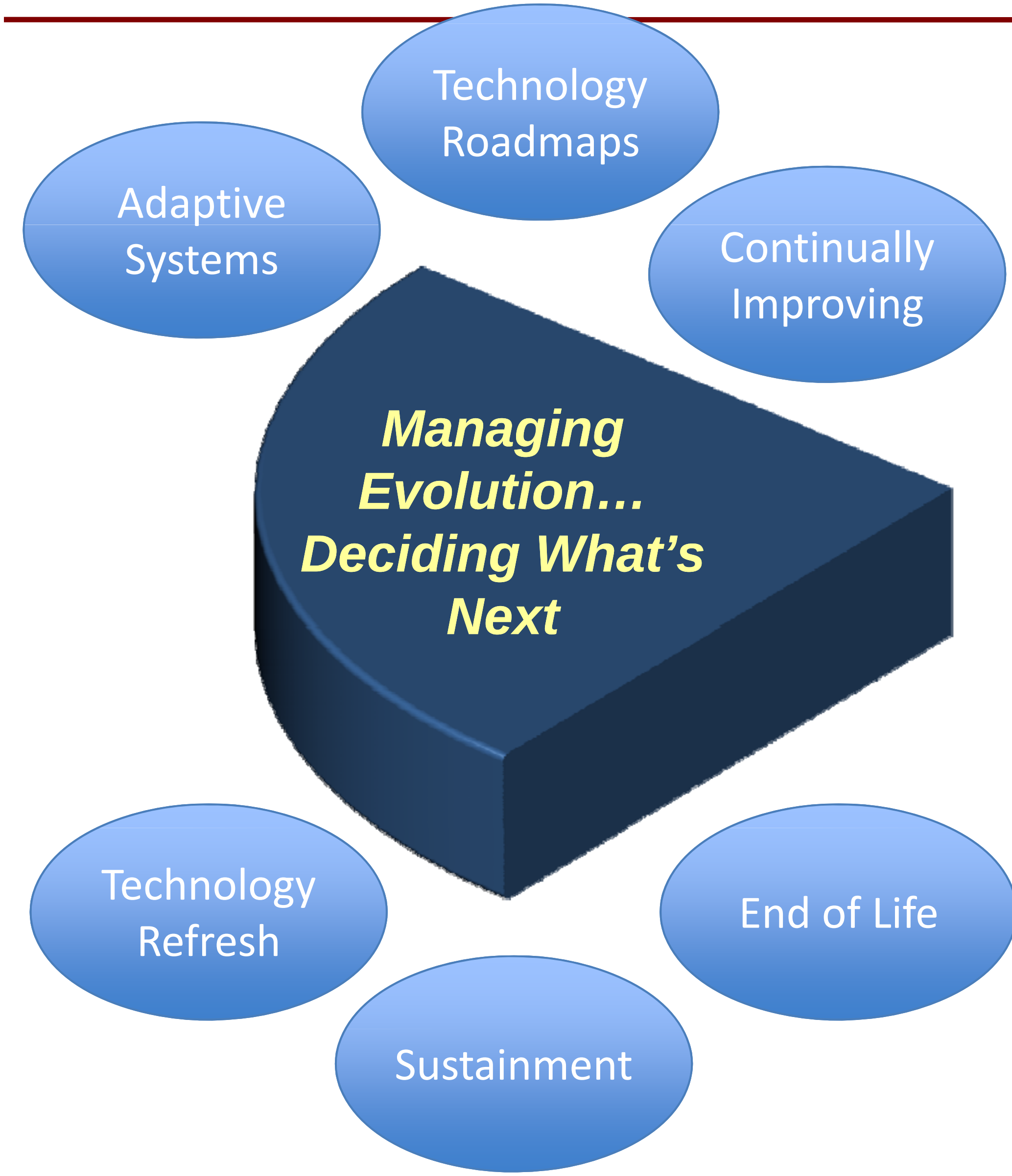


The Systems Lens

Theme – Systems engineers ensure that customer and user needs are fully met over a wide range of conditions. They recognize the importance of testing, not only for verifying what was thought to be true, but for discovering what was unforeseen, and then deciding what to do as a result. Not content to deliver systems that work as designed, they foster ongoing collaboration between their teams and their customers to ensure that systems perform well in use.

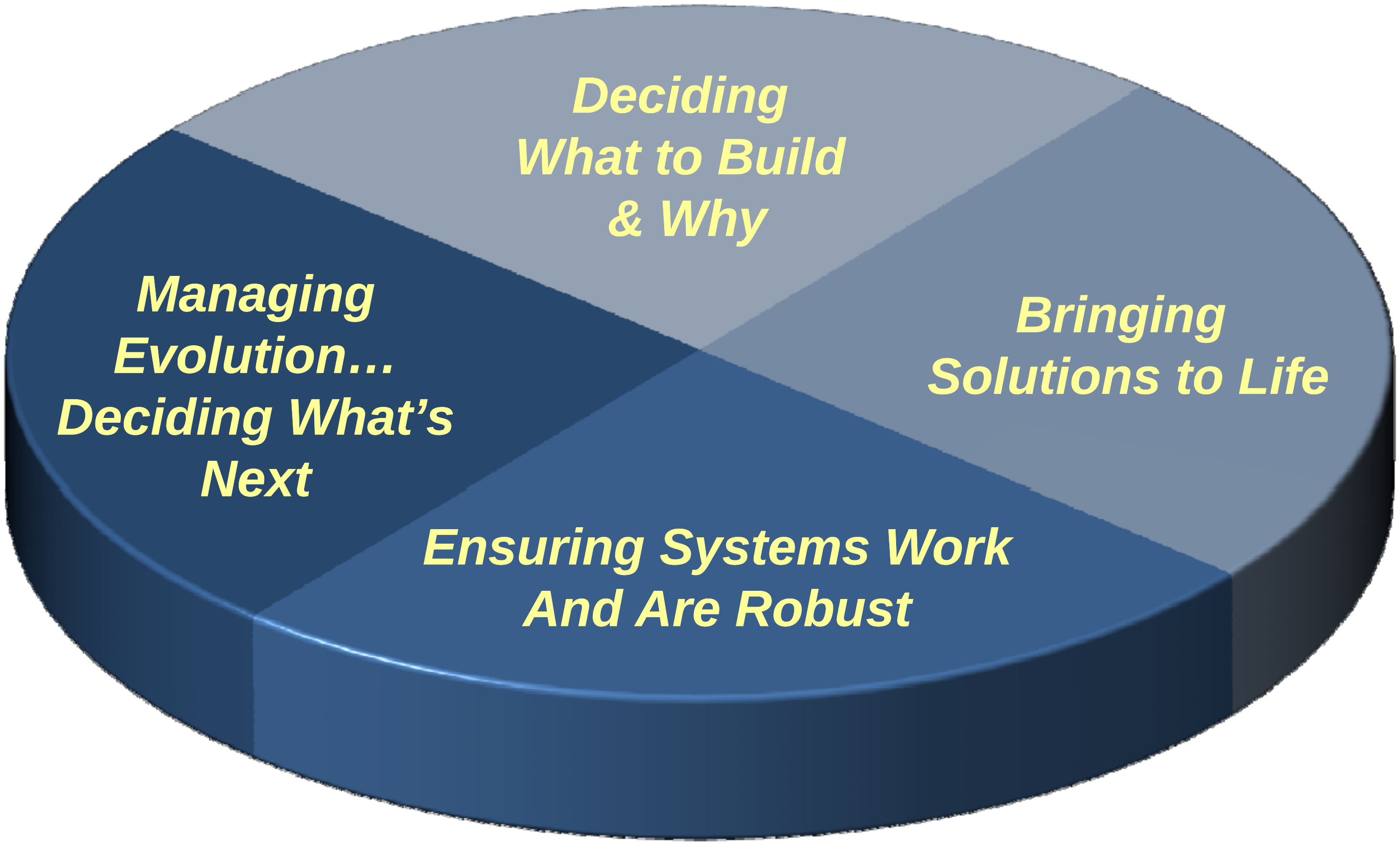


The Systems Lens

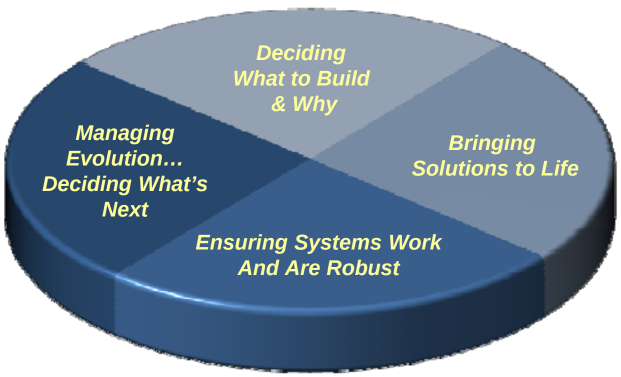


Theme – Systems engineers thrive in a game that never ends. They recognize that whenever new solutions are introduced, into the marketplace or the battle space, they fundamentally alter the ecosystem into which they are deployed. They continually invent new ways to leverage advancing technology to improve existing solutions and to develop totally new ones as competitors adapt and customers' expectations rise, thus ensuring that today's innovations do not simply become tomorrow's legacy.

The Systems Lens



Conclusions



- **That people got trapped in boxes is evidence of the lack of a holistic systems perspective.**
- **Such perspective was lacking despite the consistent use of formal systems engineering processes and practices.**
- **The Systems Lens offers a framework for helping systems engineers – and many others – avoid the traps.**

One final question: If any of this is consistent with your experience, what will you do differently?

1870

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Authors' Contact Information

- Michael Pennotti, Ph.D.
  Stevens Institute of Technology
  E-mail: michael.pennotti@stevens.edu
  Phone: 973-632-8836

- William Robinson
  Stevens Institute of Technology
  E-mail: william.robinson@stevens.edu
  Phone: 973-216-2177