Back to Basics

Systems Engineering is as Much About the Journey as the Destination

INCOSE North Texas Chapter
August 2017

SYSNOVATION
Systemic Innovation for Business Results
Sysnovation, LLC
13741 Johnson Memorial Drive
Shakopee, MN 55379 USA
www.sysnovation.com

David D. Walden, ESEP
Voice: +1-952-807-1388
Email: Dave@sysnovation.com

Abstract

"Success is a journey, not a destination. The doing is often more important than the outcome."
Arthur Ashe

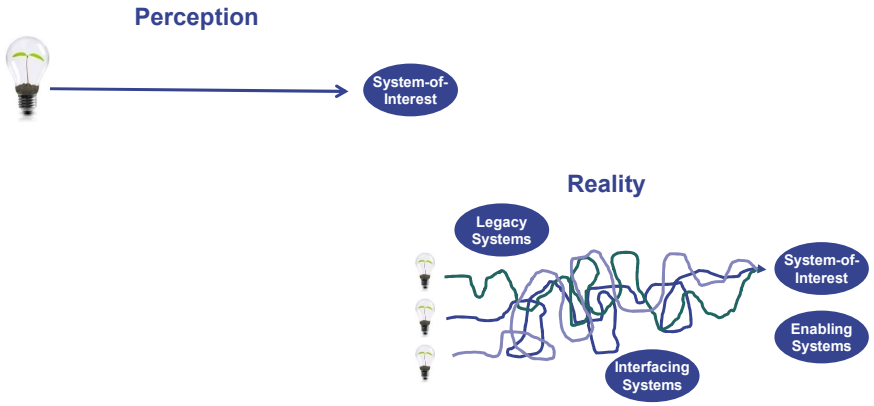
Systems engineering done poorly is obvious – missed requirements, integration issues, verification concerns, etc. Systems engineering done well is often transparent – either not noticed or assumed to be due to something else. To outside observers, many times including champions and sponsors, successful systems and the resulting systems engineering artifacts and work products appear "obvious." They see an artifact such as a system boundary diagram or N-squared diagram and they intuitively think it was stable and known from the beginning and assume it was created in a straightforward manner with trivial or no effort. However, the reality is that the artifact evolved through the deliberate application of systems engineering and the intentional interactions of the team. This paper describes the importance of the systems engineering journey and how to impress upon others the need to take that journey on every project.

Current Author Contact Information:
David D. Walden, ESEP
Sysnovation, LLC
13741 Johnson Memorial Drive
Shakopee, MN 55379 USA
Voice: +1-952-807-1388
Email: Dave@sysnovation.com
www.sysnovation.com

Original Citation:

Walden, D., "Back to Basics – Systems Engineering is as Much About the Journey as the Destination," *Proceedings of the Tenth Annual INCOSE Great Lakes Regional Conference* (Mackinac Island, Michigan, USA, September, 2016), The International Council on Systems Engineering (INCOSE), 2016.

Systems Engineering is as Much About the Journey as the Destination



"Success is a journey, not a destination. The doing is often more important than the outcome."

Arthur Ashe

SYSNOVATION
Systemic Innovation for Business Results

3

Presenter Introduction

- Dave Walden, ESEP
- Current Assignment: Principal Consultant & Instructor at Sysnovation, LLC
- Work Experience: 30+ Years Industry Experience
  - Teaching and consulting since 2006
    - Sysnovation core courses include:
      - SE Principles, Leading SE Exec Overview, Enabling SE Overview for Non-SEs, Requirements Formulation, SE Tool Belt, COTS-Based SE (CBSE), Brownfield SE, System of Systems Engineering (SoSE), SE Soft Skills, Leading Effective Technical Reviews, INCOSE SEP Prep
      - Also taught courses for ATI, CESAMES, CSM, Iowa State University, K2B, University of Minnesota, Strategy Bridge, and Vitech
    - Sysnovation core consulting areas include:
      - Coaching/mentoring, non-advocacy reviews, major review preparation, and process improvement
    - Lead Editor of the INCOSE SE Handbook Fourth Edition, Co-Editor Since v3.2
    - INCOSE Certification Program Manager 2007-2013
  - 13 years at General Dynamics Advanced Information Systems
    - Director/SE IPT Lead for the FCS ICS SoS Program
    - Director of Integrated Process and Quality
    - Systems Engineering lead on numerous programs
  - 10 years a McDonnell Douglas (now Boeing)
    - Avionics analyst on the F-15, YF-23, and IRAD/CRAD
- Education:
  - MS MOT (Mgmt of Technology) – University of Minnesota
  - MS EE & MS CS – Washington University in St. Louis
  - BS EE – Valparaiso University

SYSNOVATION
Systemic Innovation for Business Results

4

Use and Value of Systems Engineering

- It costs much less to solve problems sooner rather than later in the project life-cycle
- SE can help any organization involved with complex projects – not just mil/aero
- Management has much more ability to act and influence events early in the life-cycle
- 60%+ of a project's cost base is determined in the first 15% of the project – SE has particularly strong leverage in the early stages
- Project Management (PM) and SE have the same ultimate project goals: PM defines them; SE delivers them

	systems cost factors
requirements	1x
design	3-8x
build	7-16x
test	21-78x
operations	29-1615x

Adapted from: (INCOSE UK Z2, 2009)

5

Products of Systems Engineering

- Tangible Products
  - Plans
  - Requirements
  - Architectures
  - Designs
  - Analyses
  - Decisions
  - Baselines
  - Verification and validation results
  - …
- Intangible Products
  - Whole system perspective
  - Technical leadership
  - Balanced trades
  - Improved team communication and dynamics
  - Improved stakeholder relations
  - Follow-on business
  - …

6

One of the Challenges is Justifying Systems Engineering

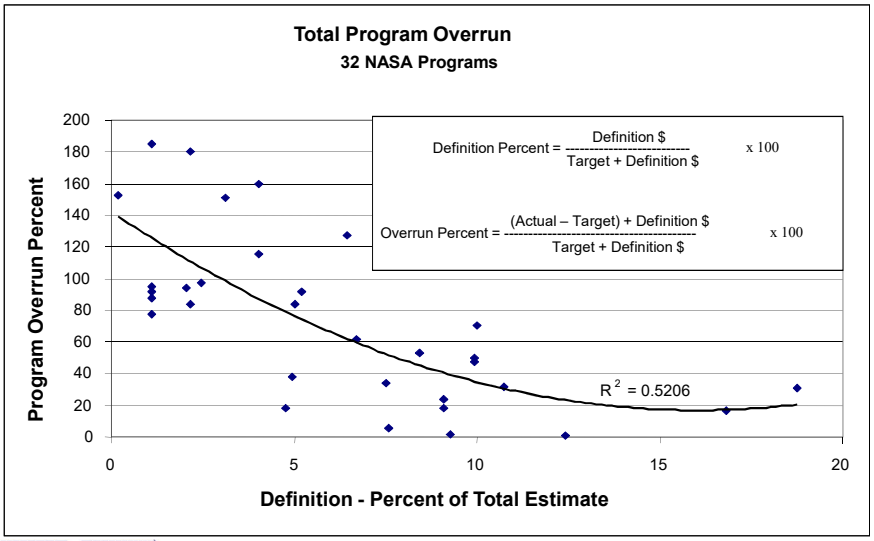
- Excellent Systems Engineering is evident by the lack of issues
- It is easier to recognize the issues that arise from poor or no Systems Engineering
  - Cost and schedule overruns
  - Unanticipated risks and hazards appear
  - Systems that do not meet stakeholder expectations
  - Systems that are of low quality
  - Systems that are cumbersome to integrate, use, and maintain
  - Systems that are difficult to dispose of

Many times we can't afford to do it right, but we can afford to do it over!

SYSNOVATION Systemic Innovation for Business Results

7

The Importance of Systems Engineering: NASA Tracking (1980s)



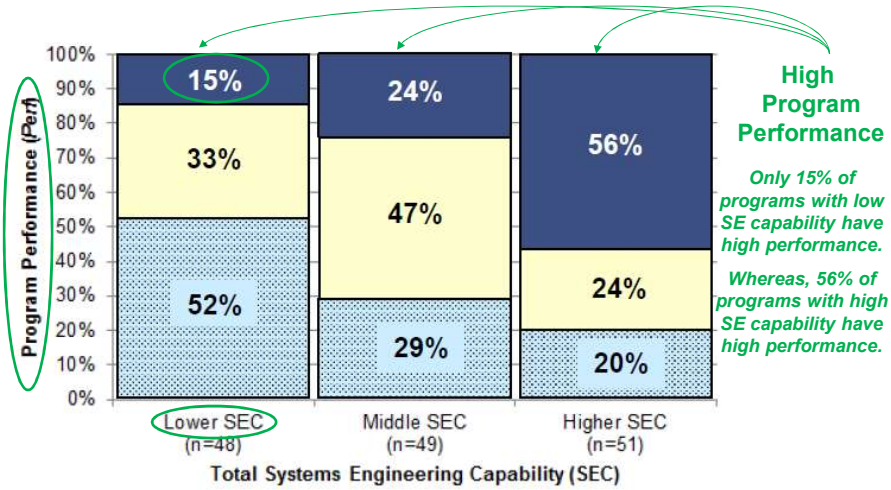
Source: NASA

SYSNOVATION Systemic Innovation for Business Results

8

SE Effectiveness: Performance vs. SE Capability

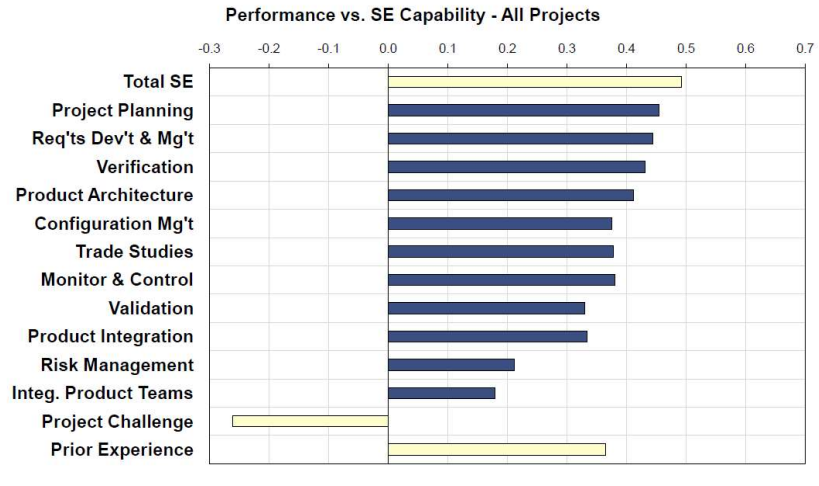
SEHv4 §2.8



Adapted from: (INCOSE SEH, 2015 – Fig 2.6) (Elm and Goldenson, 2012)

9

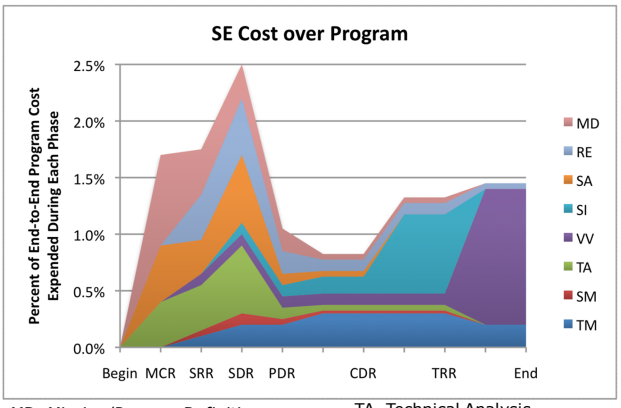
SE Effectiveness: Driving SE Capabilities



Adapted from: (Elm and Goldenson, 2012)

10

SE Return on Investment (ROI): Breakout by SE Activities

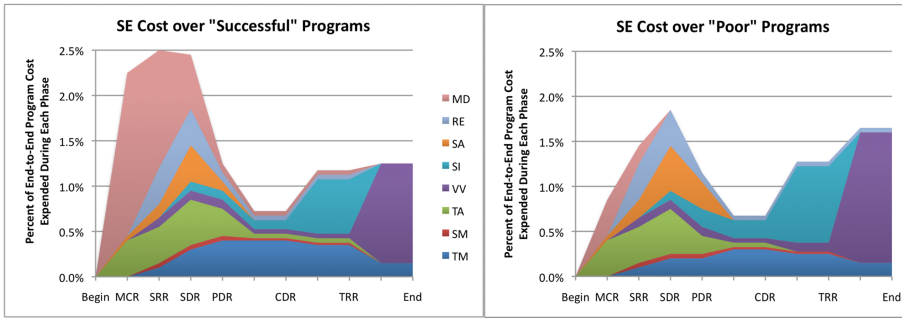


MD Mission/Purpose Definition
RE Requirements Engineering
SA System Architecting
SI System Integration
VV Verification & Validation
TA Technical Analysis
SM Scope Management
TM Technical Leadership/Management

Adapted from: (Honour, 2013)

11

SE Return on Investment (ROI): SE Investment Profiles



Successful *(~on cost)*

- **More Mission/Purpose Definition**
- **More Tech Leadership/Management**
- **More Systems Engineering**

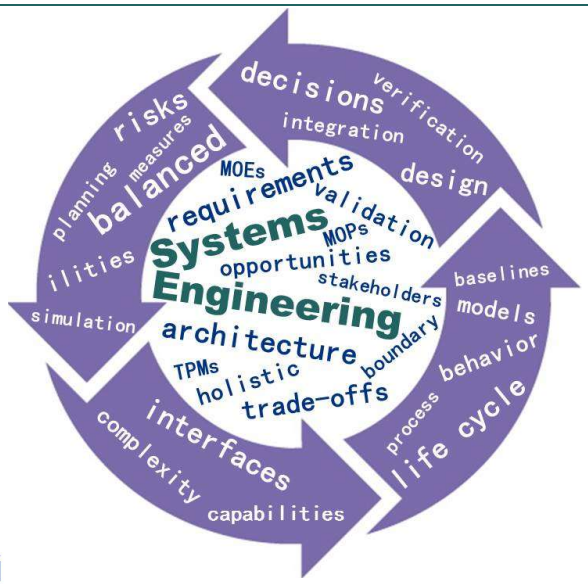
Poor *(overran cost)*

- **More System Integration**
- **More Verification & Validation**
- **Less Systems Engineering**

Adapted from: (Honour, 2013)

12

The Discipline of Systems Engineering

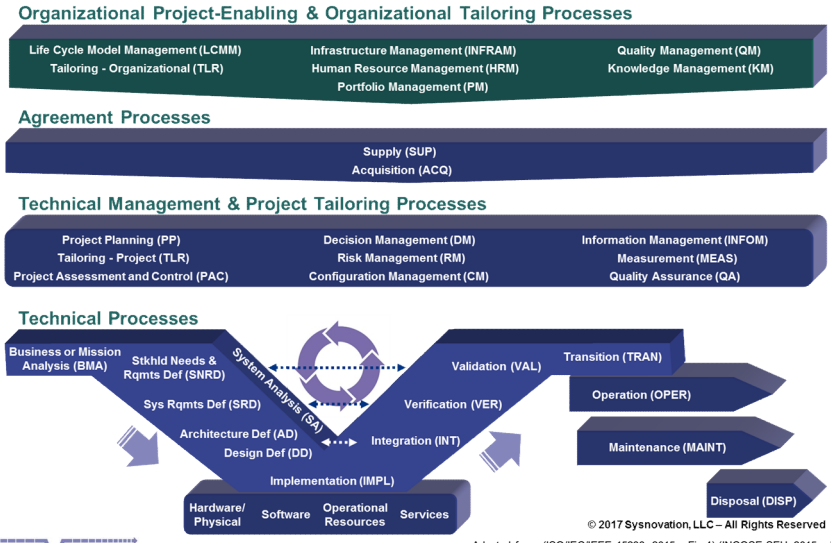


SYSNOVATION
Systemic Innovation for Business Results

13

INCOSE SEH Process Areas

SEHv4 §1.3

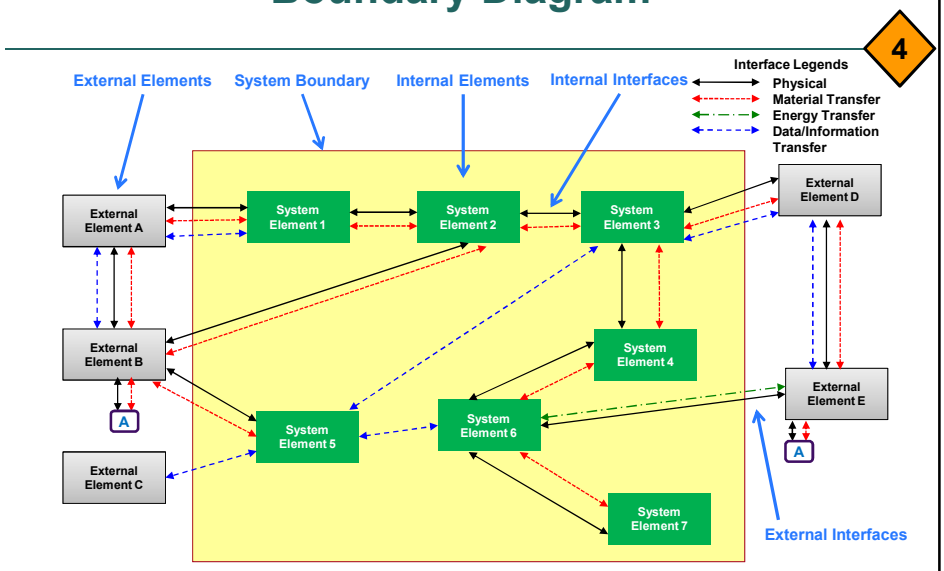


Adapted from: (ISO/IEC/IEEE 15288, 2015 – Fig 4) (INCOSE SEH, 2015 – Fig 1.1)

SYSNOVATION
Systemic Innovation for Business Results

14

Boundary Diagram



Adapted from: (Eppinger and Browning, 2012 – Fig 3.3.2)

15

Definitions of Lines

Physical connections are indicated with black arrows. It is used for physical connections of parts or parts that are touching or nearly touching. Examples: attaching parts, welded items, clearance.

Material transfers are marked with red arrows. It is used for the transfer of material from one point in the system to another system. Examples: oil, air, water, solids.

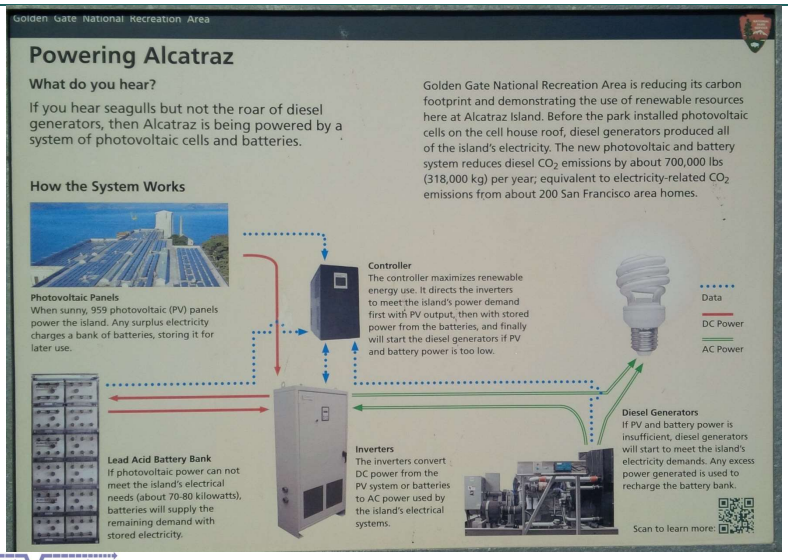
Energy transfers are marked with green arrows. It is used for transferring any type of energy. Examples: electrical power, heat transfer, vibration.

Data/Information transfers are marked with blue arrows. Data/information transfers are information necessary for the control of the system. Examples: data from sensors, commands of the operator or controllers, networks.

Adapted from: (Eppinger and Browning, 2012 – Fig 3.3.2)

16

A Simple Boundary Diagram

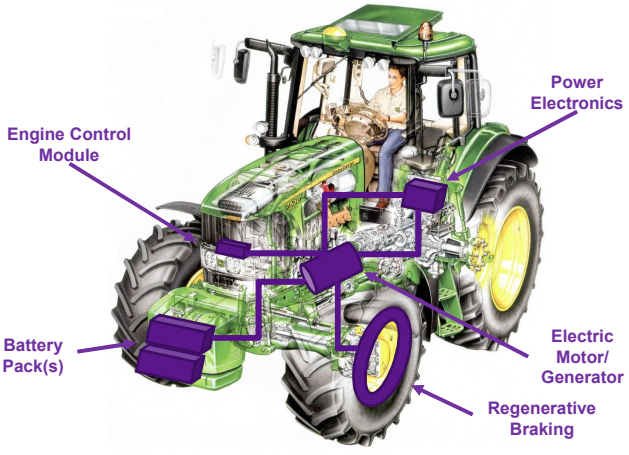


SYSNOVATION Systemic Innovation for Business Results

17

Embedded Exercise
Hybrid Tractor (HT) System

- New Sustainability Division has been established
- The goal of the HT is to provide a noticeable fuel economy to the famers at a "reasonable" tractor price increase
  - Target fuel savings is 25%
  - Minimum acceptable fuel savings is 20%
  - Desired fuel savings is more than 35%.
- Goal to use as much off-the-shelf technology as practicable
- Available as a kit that can be installed onto a base tractor
- Two main hybrid modes have been identified:
  - Start Assist
  - Draft Assist

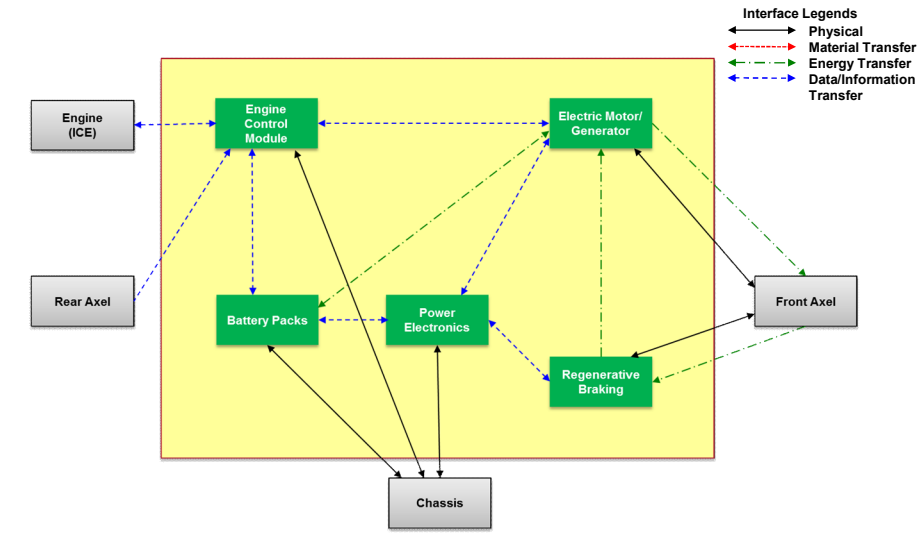


SYSNOVATION Systemic Innovation for Business Results

Tractor Image Source: John Deere

18

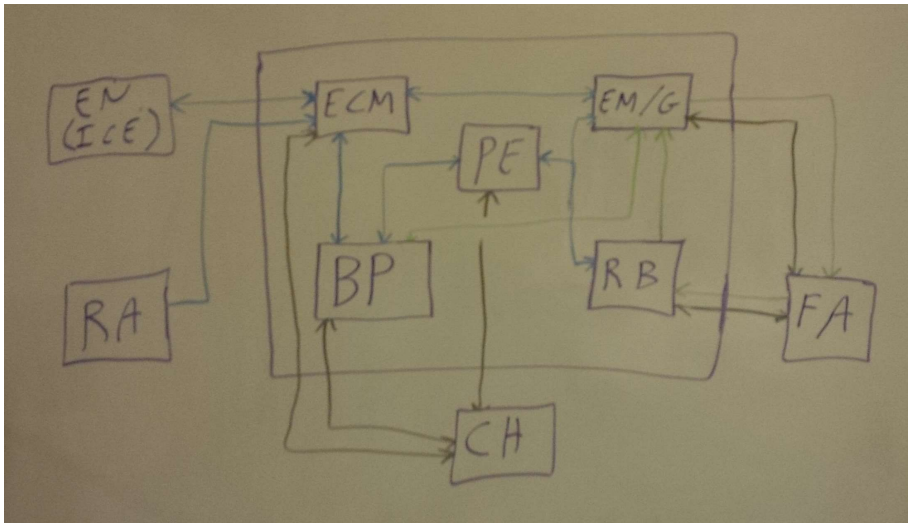
Sample Boundary Diagram for a Hybrid Vehicle



SYSNOVATION Systemic Innovation for Business Results

19

But Remember, Systems Engineering is About the Journey, not Just the Destination

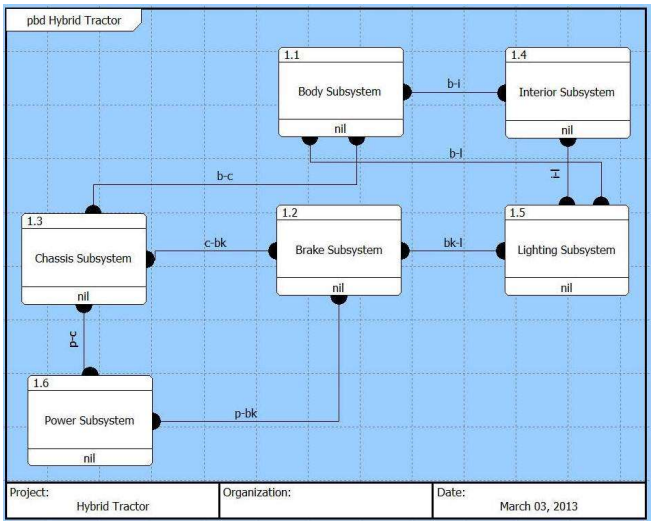


SYSNOVATION Systemic Innovation for Business Results

20

Physical Block Diagram for a Hybrid Tractor

14



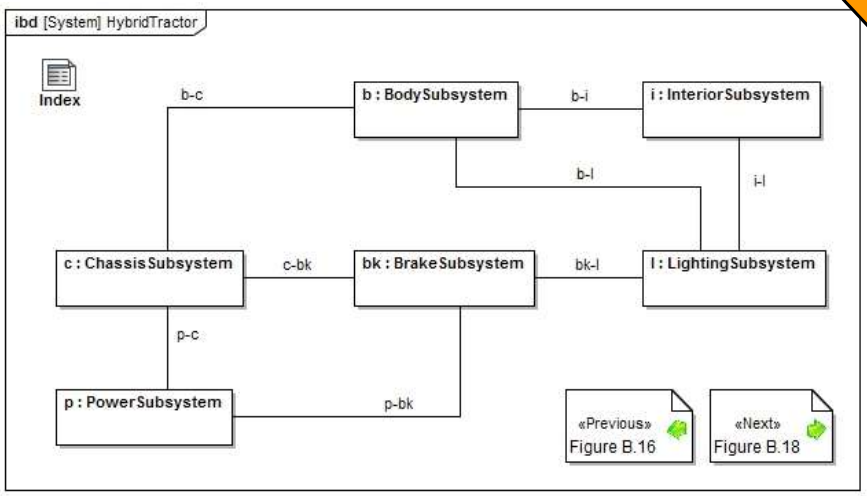
SYSNOVATION Systemic Innovation for Business Results

Diagram created in: Vitech CORE

21

Internal Block Diagram (SysML) for a Hybrid Tractor

14



SYSNOVATION Systemic Innovation for Business Results

Diagram created in: : NoMagic Cameo Systems Modeler/Magic Draw

22

Wrap-up/Summary

- Systems engineering done poorly is obvious
- Systems engineering done well is often transparent
- To outside observers, successful systems and the resulting systems engineering artifacts and work products appear "obvious"
- They see a SE artifact and they intuitively think it was stable and known from the beginning and assume it was created in a straightforward manner with trivial or no effort
- However, the reality is that the artifact evolved through the deliberate application of systems engineering and the intentional interactions of the team
- This presentation described the importance of the systems engineering journey and how to impress upon others the need to take that journey on every project

SYSNOVATION Systemic Innovation for Business Results

23

Implications

- For Systems Engineers
  - Recognize SE is a journey
  - Expect iteration and recursion
  - Expect change – internal & external
  - Communicate early and often
  - Remind your team of the journey they are on
- For Managers/Leaders
  - Recognize and respect SE is a journey
  - Ask the right questions at the right time
  - Recognize the importance of the early program churn
  - Dig deeper as necessary – based on risk

SYSNOVATION Systemic Innovation for Business Results

24

Shameless Plug for GLRC11

11th Annual INCOSE
Great Lakes Regional Conference

SUPERIOR SYSTEM SOLUTIONS FOR TODAY'S COMPLEX ENVIRONMENTS

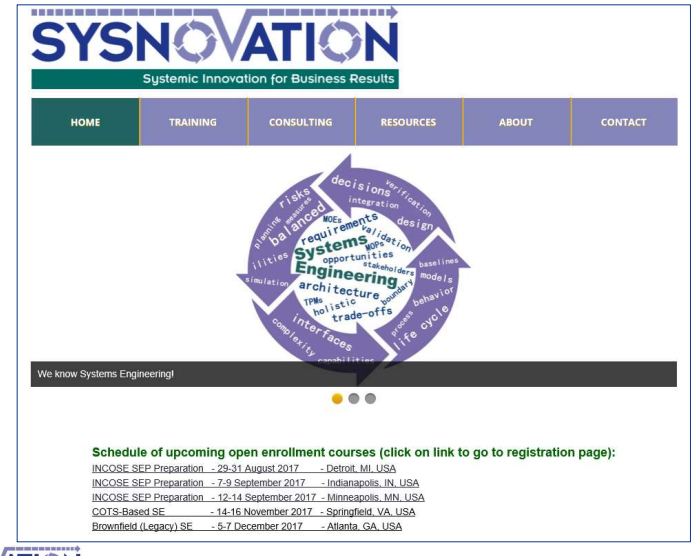
11 - 14 October 2017 | Twin Cities, Minnesota

www.incose.org/glrc11

SYSNOVATION Systemic Innovation for Business Results

25

Shameless Plug for Upcoming Sysnovation Open Enrollment Training

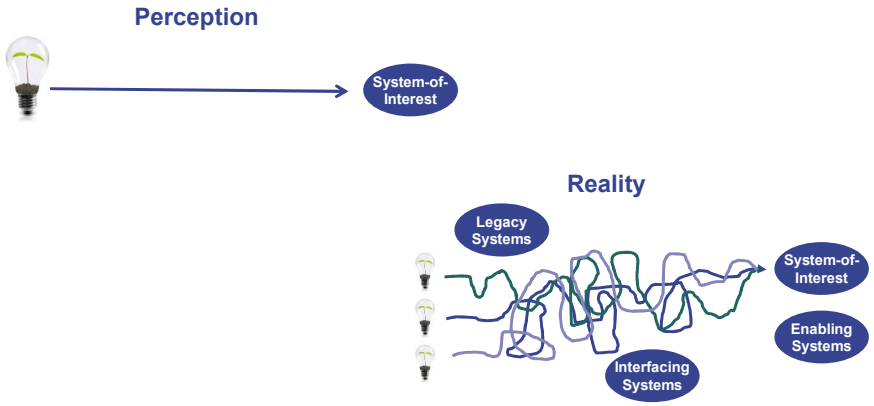


SYSNOVATION Systemic Innovation for Business Results

www.sysnovation.com

26

Systems Engineering is as Much About the Journey as the Destination



"Success is a journey, not a destination. The doing is often more important than the outcome."

Arthur Ashe

SYSNOVATION Systemic Innovation for Business Results

27