International Council on Systems Engineering
A better world through a systems approach

The Never-Ending Story of Requirements Across the Life Cycle

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Outline

1. Where does it start & where does it end?
2. Keeping it simple let's step through a simple life cycle
    a. The Realization
    b. Characterization
    c. The vision of success
    d. Translation of success to measurable criteria
    e. Engineering a solution
    f. Evaluating outcome
    g. Evolving
3. Questions (and hopefully) Answers

1st Goal: Give you an entertaining overview of how SE applies engineering principles across the life cycle regarding requirements

2nd Goal: Get you out in time for lunch

Requirements ... Where do we start?

- I like to keep things simple so let's start at the beginning.

Every new system or system upgrade begins with the recognition of and operational deficiency or opportunity

Requirements ... Okay, but where does it end?

- It doesn't, we just start all over again

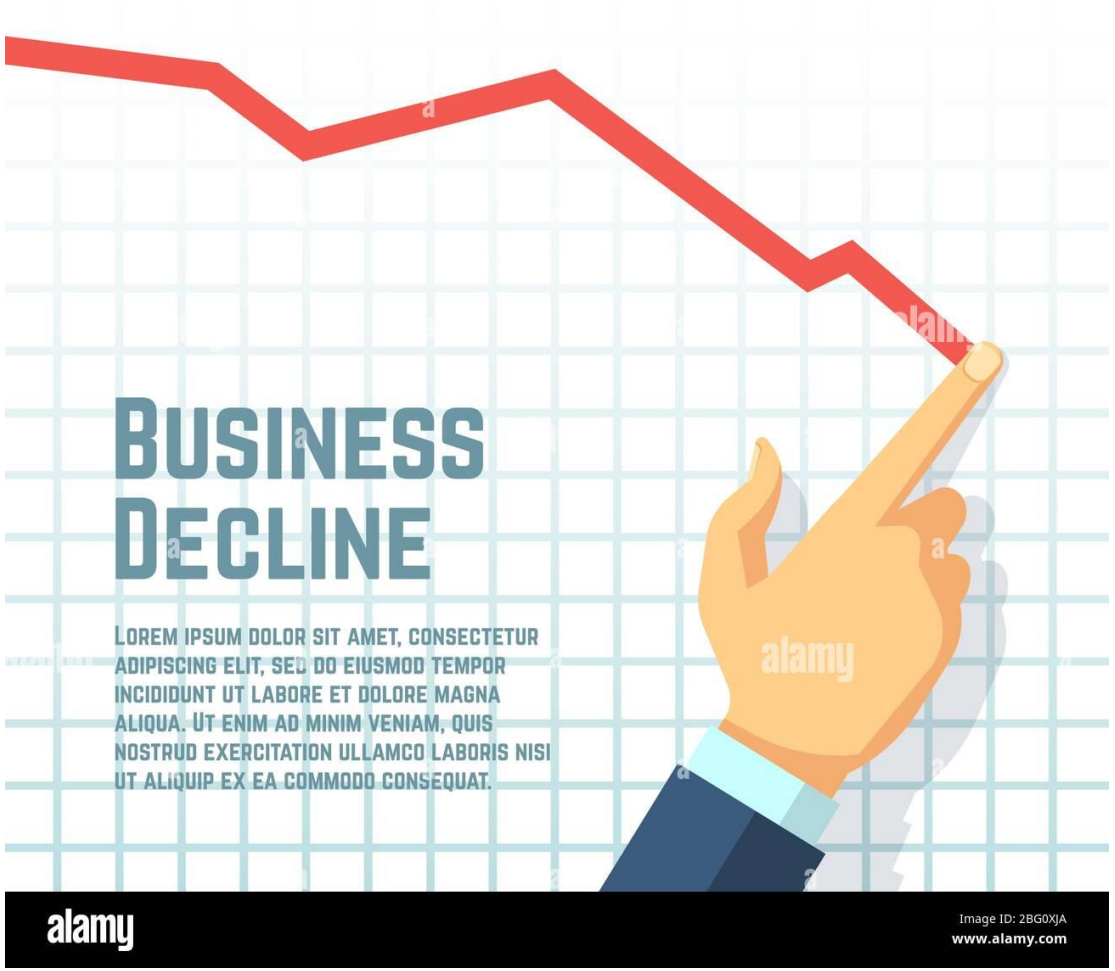
Y Corp's new **Purple Tiger** is outperforming our old **Blue Widget** in every market. How do we regain the upper hand?

Recall: Every new system or system upgrade begins with the recognition of and operational deficiency or opportunity

The Realization

- Our product is losing sales

Before we can write a single “Who shall what” we need to realize the critical issues.



Characterization

- Define the issue(s)
  - Our costs are going up
  - Our technology is out of date
  - We can no longer maintain our products in field
  - Technicians using our system are discarding them

See NRM §4.3.21

The vision of success

- Mission Statement: An Artificial Intelligence enhanced computer for technicians See NRM §4.3.2.1
- Goal: It will guide our techs through the toughest jobs See NRM §4.3.2.2
- Objective: Our software can loaded on any computer that meets our specifications See NRM §4.3.2.32

Engineering a solution

- Creation of the Need statement
  - The <Stakeholders> need the <entity> to ...
- Creation of the Stakeholder Requirements
  - The <entity> shall ...
- Creation of the System Requirements
  - The <SOI> shall (verb phrase) what [condition].

See GTWR §1.7

Before we can write Needs & Requirements
we need to Engineer!

Engineering a solution

Opportunity or Deficiency

It looks simple!

There is still a lot of work to be accomplished.

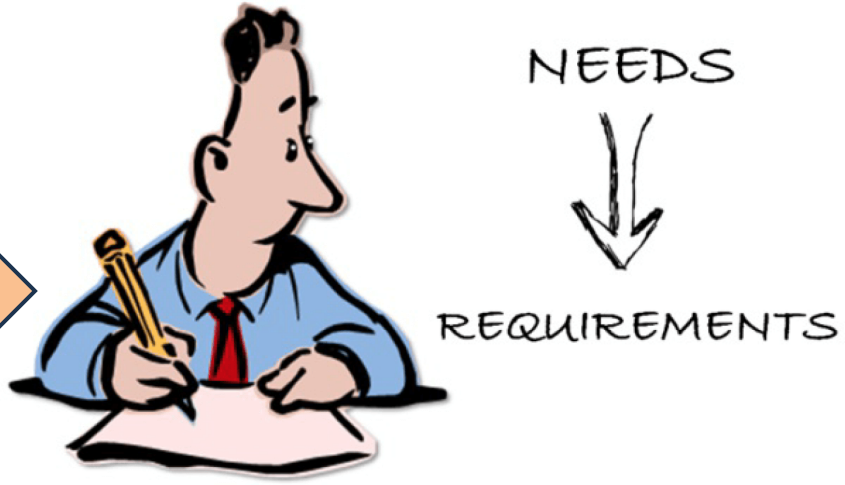


Image Source: https://www.speexx.com/wp-content/uploads/Speexx_Blog_Goal_Setting.jpg
Image Source: http://mohamedelgendy.com/blog/img/needs.png

Engineering a solution

- Begin by understanding the operational domain!

(Image Source: https://caminao.wordpress.com/how-to-implement-symbolic-representations/use-cases/)

Engineering a solution

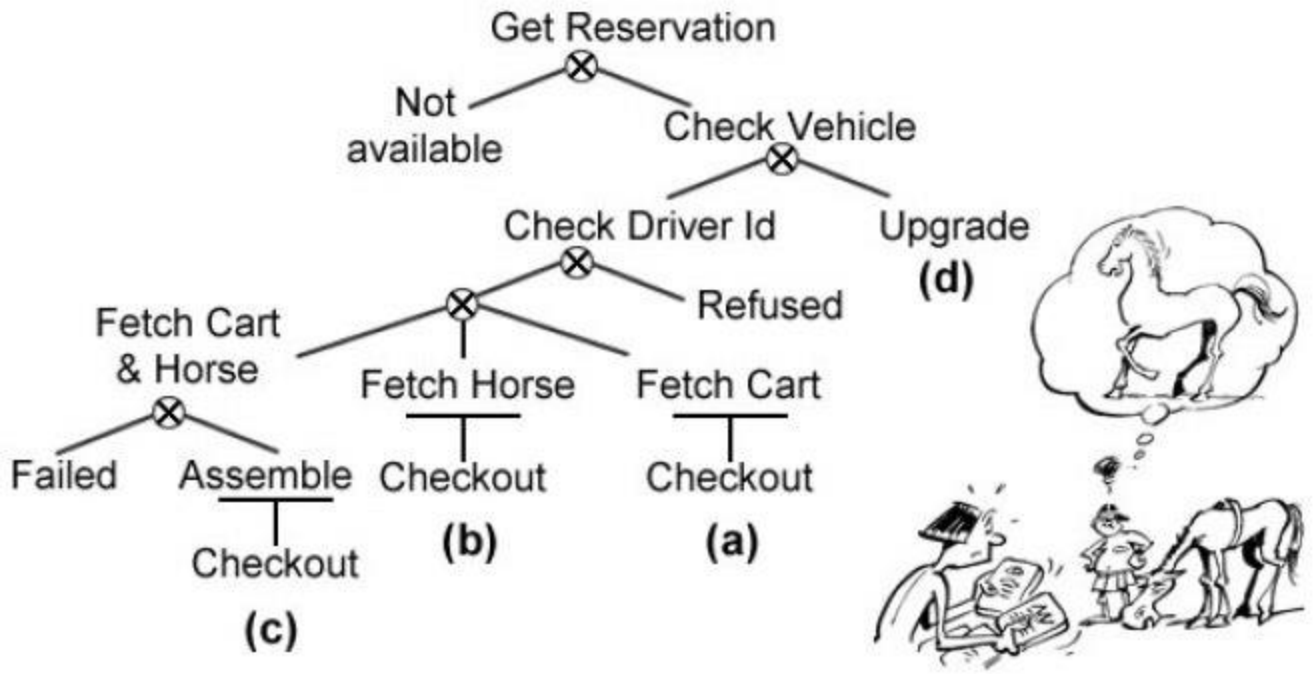


Image Source: https://i0.wp.com/caminao.blog/wp-content/uploads/2013/03/spapapa_checkout.jpg

- Define the system behaviors
  - Nominal
  - Off-nominal
- This is where you learn about needed capabilities

You are defining the operational architecture for the system solution!

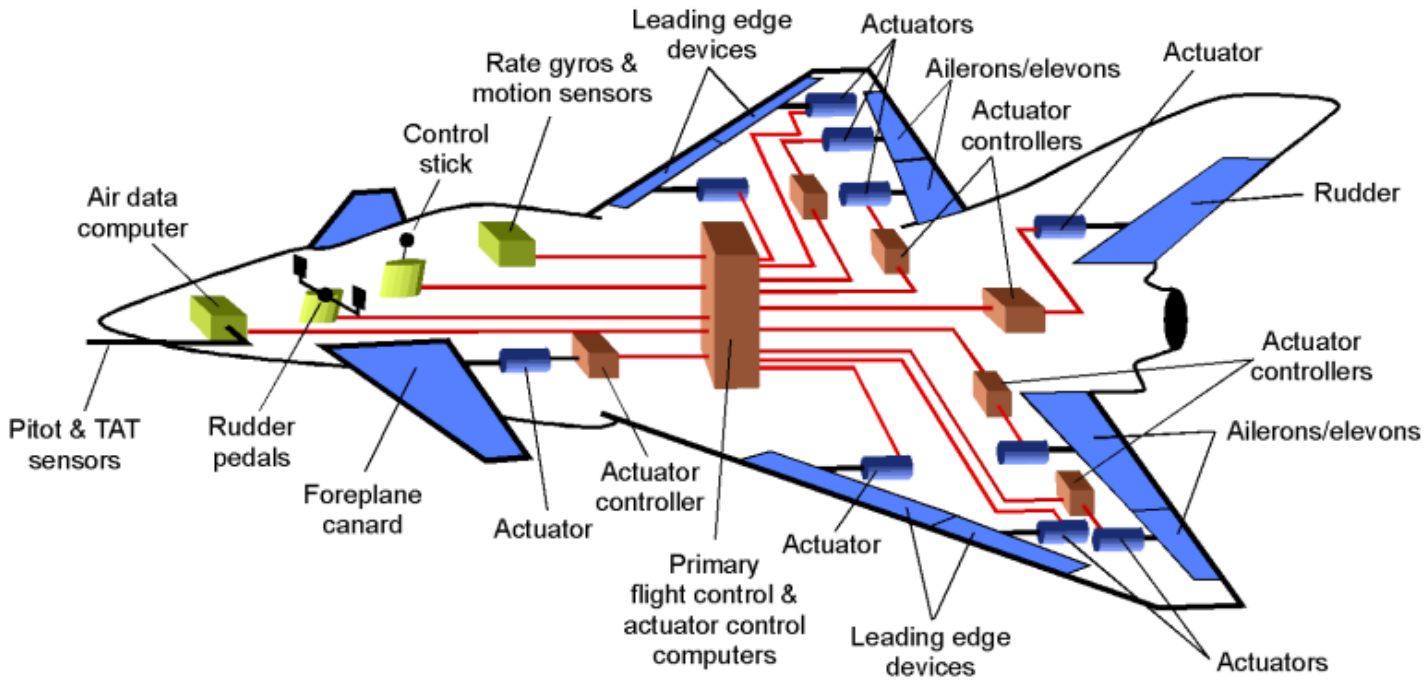
Translation of success to measurable criteria

- Measures or Suitability (MOSs)
- Measures of Effectiveness (MOEs)
- Measures of Performance (MOPs)
- Key Performance Parameters (KPPs)
- Technical Performance Measures (TPMs)
- Leading Indicators (LIs)

- Translating these measurable criteria into requirements are critical first steps in the requirements process.

Engineering a solution

- Definition of
  - Requirements
  - System architecture
    - Logical
    - Physical
    - Verification architecture *(next slides)*



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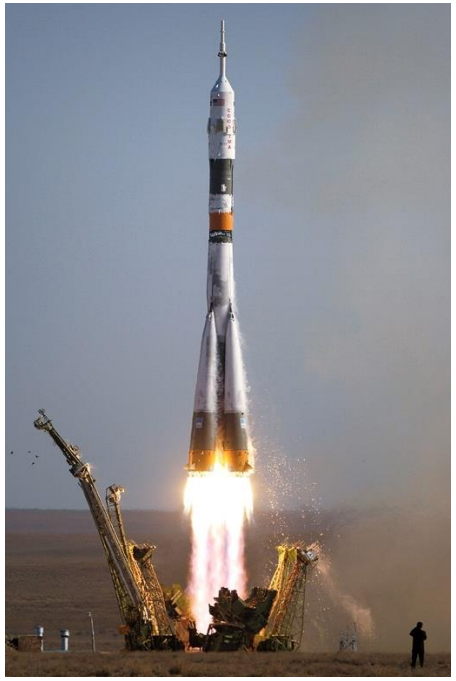
Evaluating outcome

- Verification

Planning



- Our 1st job is to plan how the full set of requirements will be verified.
- Creation of a verification architecture that will determine what the verification program looks like.

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Image Source: https://zorgle.co.uk/wp-content/uploads/2023/11/Use-of-thematic-analysis-in-quantitative-research-2048x1365.jpg

Evaluating outcome

- Verification

Execution

- It is our job
  - to capture the evidence of compliance
  - Organize the data
  - Support audits and review (with the support of SMEs as necessary)

Image Source: https://www.castoredc.com/wp-content/uploads/2019/05/an-essential-guide-to-edc-in-clinical.png

Evaluating outcome

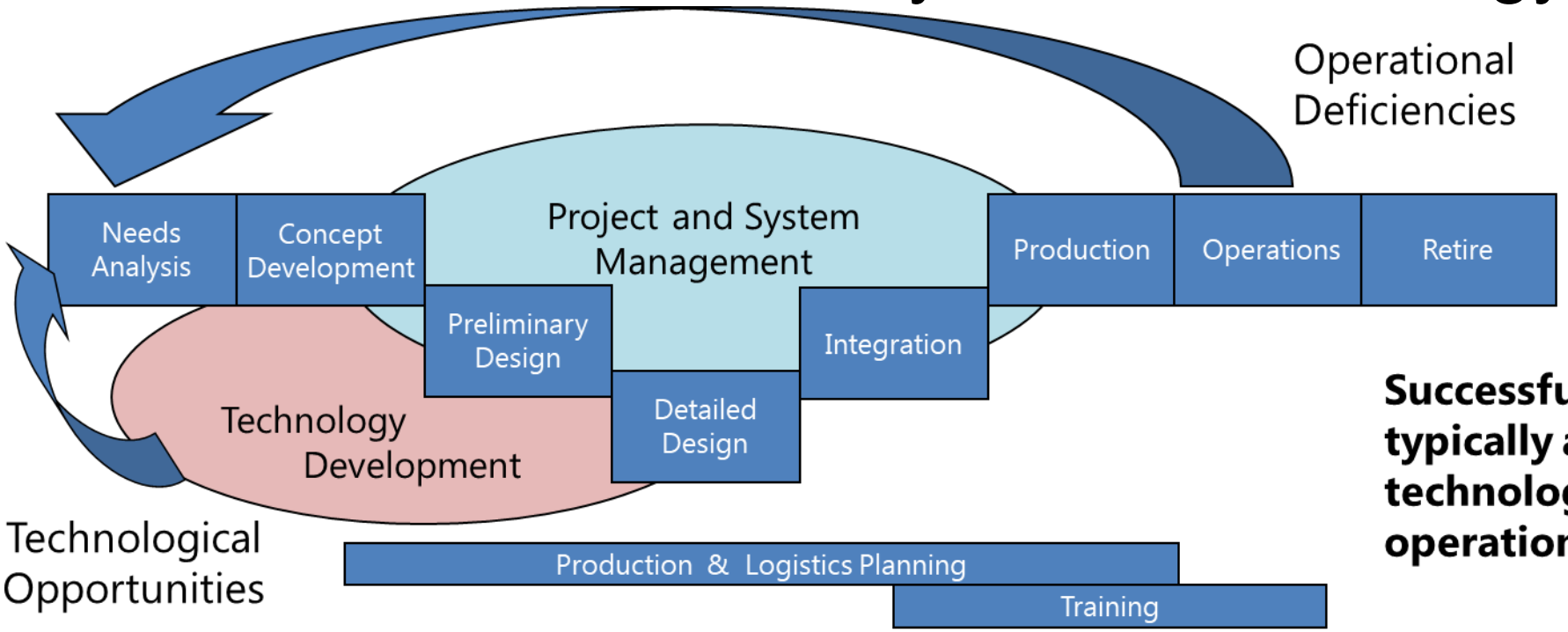
- Validation

Planning

- If you are in an acquisition role you will perform similar activities
- You focus will be on demonstrating that the ***Needs*** are satisfied.

Evolving

- Evolution of a system is a result of realized operational deficiencies and availability of new technology



Successful systems are typically a marriage of technology development and operational deficiency.

Diagram developed by: Paul J. Componation, Ph.D., CPEM, Fellow-ASEM,
Associate Dean of Graduate & Interdisciplinary Affairs, College of Engineering, University of Texas at Arlington

Closing

- Note that the process is not 100% linear
- There are feedback loops throughout the life cycle
- Figure 2.12 from the Needs & Requirements Manual illustrates this
- If you are new to Systems Engineering this is a must have resource
- In 2026 we will have the Model Based Guide to Needs & Requirements

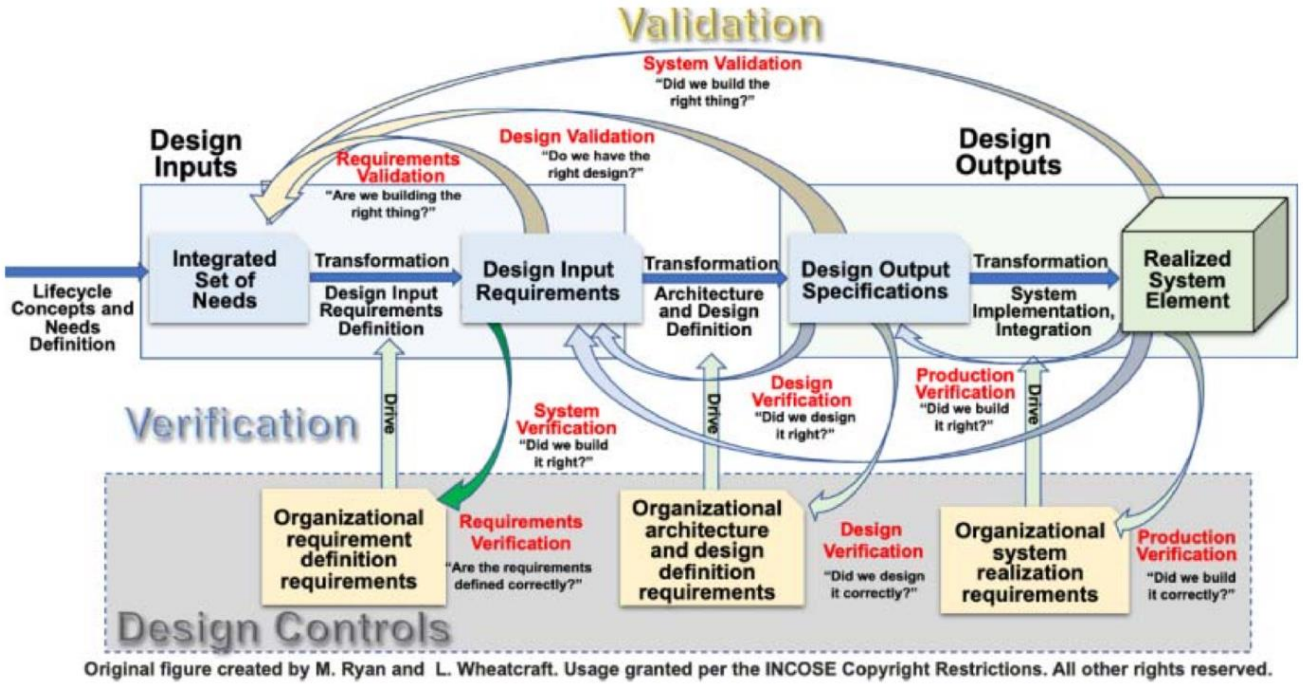


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FIGURE 2.12 Verification and Validation Confirm that SE Artifacts Generated During Transformation are Acceptable. Source: Adapted from Ryan and Wheatcraft [14].

Questions & Answers

You chose

- Questions & Answers

Image Source: https://cdn.pixabay.com/photo/2015/11/03/09/03/question-mark-1019993_1280.jpg

- Break for Lunch

Image Source: https://www.pinterest.com/pin/391391023849122732/

List of References

- INCOSE Needs And Requirements Manual, INCOSE-TP-2021-002-01, Louis S. Wheatcraft, et al ., Published by John Wiley & Sons, Inc., Hoboken, New Jersey
- Guide to Writing Requirements, INCOSE-TP-2010-006-04, Vers/Rev:4, 1 July2023
- Product Evolution diagram: Paul J. Componation, Ph.D., CPEM, Fellow-ASEM, Associate Dean of Graduate & Interdisciplinary Affairs, College of Engineering, University of Texas at Arlington