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

Welcome to the INCOSE Webinar Series

Wednesday, 21st February 2024 – Webinar 171

incose.org

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- Requirements and Verification Analysis
- Training for new systems engineers

INCOSE Enchantment Chapter

- Southwest USA

Logistics and INCOSE related questions

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INCOSE Webinar 171:

Appropriate Requirements: Writing Requirements at the Proper Level

Presented by Todd Wohling

About the INCOSE Webinar Series

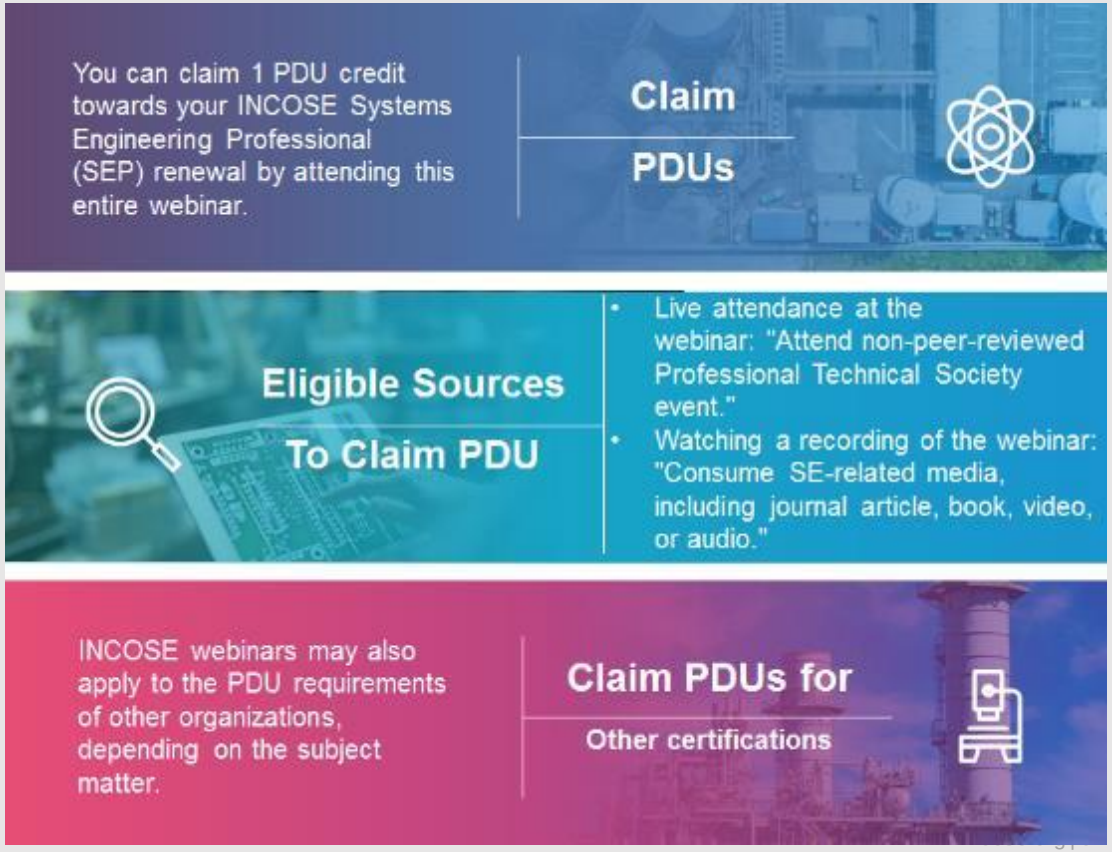
- Piloted in 2008
- A virtual offering aimed to provide relevant technical information and topics on systems engineering, on a regular basis and on an easy to access platform
- Held once a month (normally on the 3rd Wednesday)

Questions? Comments? Suggestions?
Email us at webinars@incose.net!

Webinars & SEP PDU* Credits

More information can be found on [Renewing Certification (incose.org)]

*PDU – Professional Development Unit



Webinar Cadence

- **Welcome** (2-5 minutes)
- **Presentation** (40-45 minutes)
- Please use Q&A feature via Zoom to enter your questions
- **Q&A Session** (10 minutes)
- Questions will be selected and asked by the Host
- **Brief Closing** (2-5 minutes)

This Webinar is being recorded.

The full recording and slide deck will be made available to all INCOSE members and CAB Associates within 10-12 business days from original air date in the Professional Development Portal (PDP).

Questions? Comments? Suggestions? Email us at webinars@incose.net!

Appropriate Requirements: Writing Requirements at the Proper Level

Presented by Todd Wohling

APPROPRIATE REQUIREMENTS: WRITING REQUIREMENTS AT THE PROPER LEVEL

INCOSE Webinar 21 February

About the Presenter

- Education: Wisconsin – Eau Claire
  - BS – Physics, BS – Mathematics
- Work Experience
  - Raytheon IIS, Aurora CO, USA
    - Jan 2001 – April 2015
      - Joint Polar Satellite System (JPSS)
      - GPSOCX
      - Classified Projects
  - Intech AS, Snadvika, Norway
    - March 2017 – Present
      - Bane NOR (Norwegian National Railway)
      - Sporveien (Oslo Metro)
      - Norwegian Defense Material Agency
      - Indra Navia
      - Memscap
- President, INCOSE NORSEC: 2020 - 2023

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Theoretical Foundation: What is Architectural Abstraction?

- All systems are hierarchical
- Users, Customers, and Contractors determine System of Interest (SoI)
- A User's system may be a supporting element in a higher order system
- Objectives, characteristics, outcomes, requirements, etc. are grouped in an abstraction based on commonalities
- Abstractions may be further abstracted or tailored as required to fully describe the system

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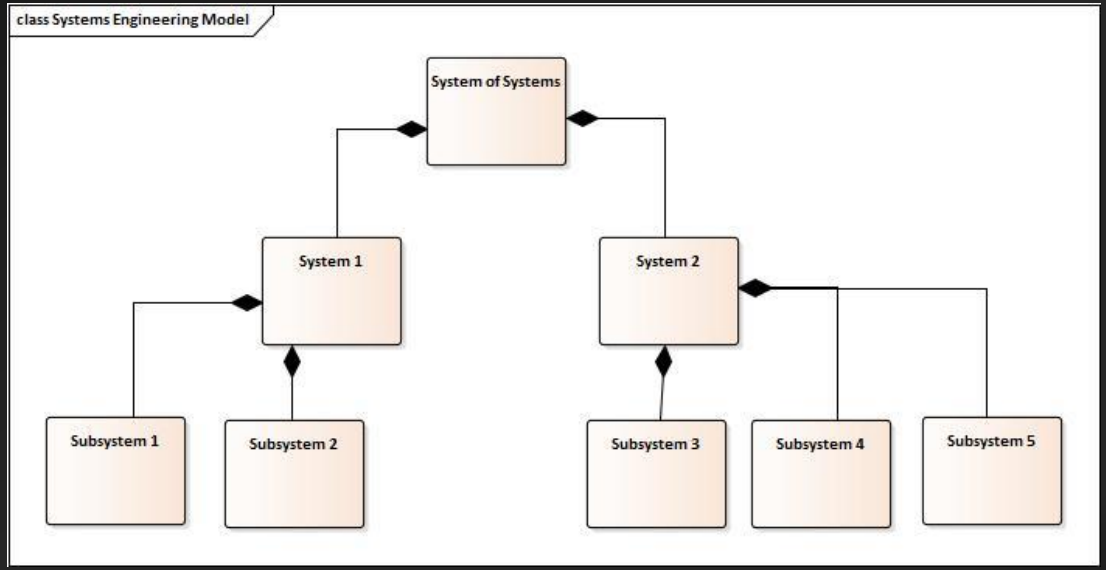
Example of Architectural Abstraction



A generic architecture

Starting at the Top

- Theoretically, Level 1 System requirements decomposed into smaller and smaller discrete requirements
- At lowest level, requirements are indivisible or undecomposable
- Simultaneously use cases, system architecture, and interfaces in development

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Requirement Counts Aren't Always Good

- Every requirement = $$$$$$$$
  - JPSS Data Processing Segment billed 160 hours per requirement for administration
- Lower level requirements in higher level specs corrupt left half of "V"
- Higher level requirements in lower level specs corrupt right half of "V"

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Starting at the Top Case Study 1 Joint Polar Satellite System

- JPSS: Level 1 Spec: 57 Requirements
  - 10 for each of 4 spacecraft
  - 17 for ground system
- Total Contract Value (2012) 1.7 billion USD
- 5 total levels of abstraction
  - System of Systems
  - System
  - Segment
  - Element
  - Subsystem

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Starting at the Top Case Study 2 Norwegian Military Home Guard Vehicle

- FMA HGV: 100+ contract requirements
  - "It shall be that the system should have four wheels"
- Total Contract Value: ~340 million NOK
- System Design Description written after the contract spec was finalized
- Maximally 2 Levels of abstraction
  - System
  - Subsystem

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Starting at the Top Case Study 3 Bane NOR ERTMS National Implementation

- Bane NOR ERTMS NI ~6000 requirements across 3 systems
  - Signaling: 2934 Requirements
  - Onboard: 409 Requirements
  - Traffic Management: 2726 Requirements
- Total Contract Value: ~2 billion Euro
- Thousands of source requirements across several sources
- 5 Levels of abstraction
  - Source Requirements
  - Generic Requirements
  - System Requirements
  - Subsystem Requirements
  - Subsystem Design Requirements

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Starting at the Top Case Study 4 Sporveien

- Sporveien CBTC: 15 Project Objectives
- Total Contract Value: 270 million eruo
- 1800+ technical contract requirements
  - ~1800 non-technical contract requirements
- Levels of abstraction: 5
  - Project Objectives
  - Project Requirements
  - System Requirements
  - Subsystem Requirements
  - Subsystem Design Requirements

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The System of Interest Architecture: Filling in the Gaps

- SOI comprised of the Mission System and Support System(s) – Wasson
- SOI may also be part of a larger abstraction (System of Systems)
- SOI may have lower level abstractions
- SOI is relative depending on product team

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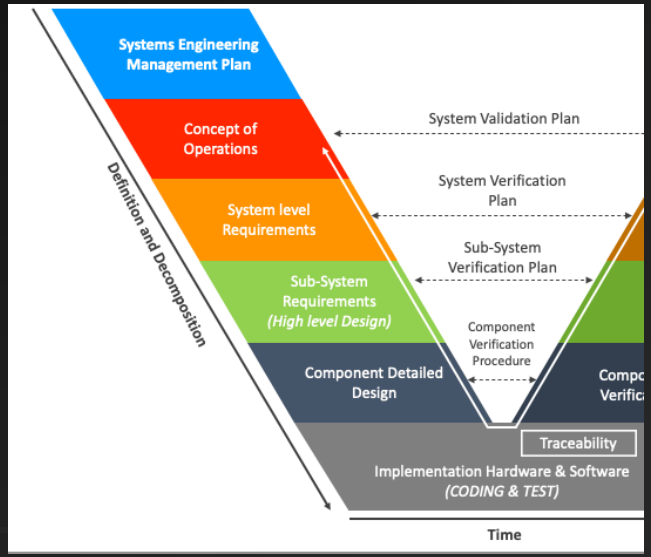
Left "V" Corruption Example



Business Requirement:
If a command is rejected, and not stored, no actions shall be taken.

Contract Requirement:
If a command is rejected, and not stored, no actions shall be taken.

System Requirement:
If a command is rejected, and not stored, no actions shall be taken.

Subsystem Requirement:
If a command is rejected, and not stored, no actions shall be taken.

Source:
https://www.collidu.com/presentation-system-engineering-v-diagram

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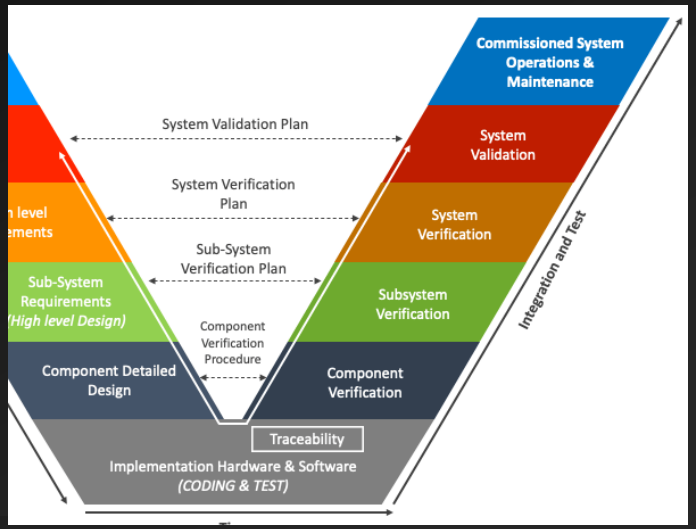
Right "V" Corruption Example



Subsystem Requirement:
<Contractor> shall deliver a fully operational Signalling System for the Generic Application suitable for the <Contract> and to be entered into service with the Specific Application.

- Requirement has no Subsystem Test Case
- Requirement has no System Test Case
- Requirement does have an integrated System of Systems Test Case

Source:
https://www.collidu.com/presentation-system-engineering-v-diagram

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Completing the picture of the SOI

- Architecture design & analysis process generates derived requirements
  - Use cases
  - Activity diagrams
  - System Architecture
  - Interfaces
- Derived requirements introduced throughout the architectural hierarchy
- Higher level requirement decomposed
- Lower level requirements need parents

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Challenges From Too Many Requirements

- Trace activities become very big
  - Each requirement is decomposed
  - Each trace requires documentation
  - Even 1-to-1 traces require effort = cost
  - More traces to sys arch, interfaces, use cases, etc.
- Verification activities are larger
  - Every requirements gets Test Case, Test Procedure
  - The same requirement gets tested over and over…
  - Or the customer lets all requirements get verified simultaneously
- Administration costs more, too
  - Set number of hours to "shepherd" a requirement through lifecycle
  - Documents are bigger, more to peer review, etc.

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Challenges From Not Enough Requirements

- System fails to meet user needs
  - Bad Publicity
  - Damage to reputation
  - Customer review (https://tinyurl.com/bdd2sbck)
  - Cancellation of contract
- Late requirements cost more
  - "Dutch Boy" requirements to plug functional "leaks"
  - Little oversight in the proposed requirements
  - Late changes to requirements or redesigns
- Validation on the back end

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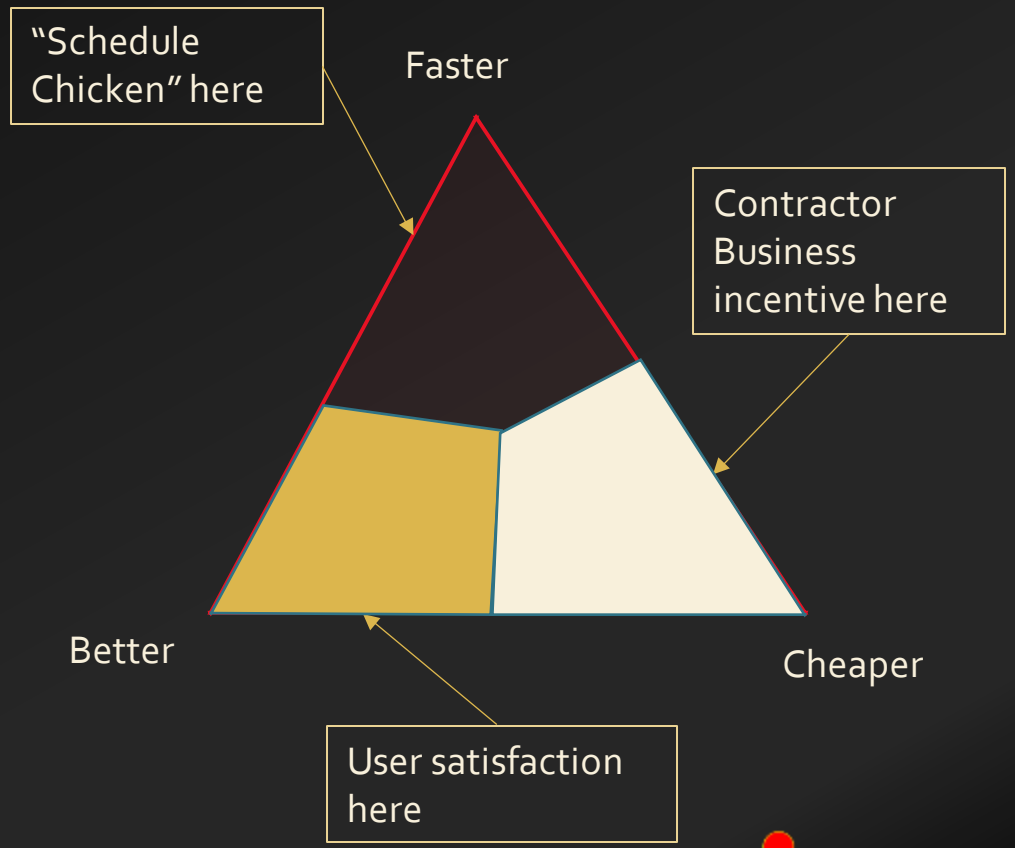
Technical Management's Prisoner's Dilemma



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Schedule Chicken

- Overall project/program made up of smaller projects
  - ERTMS: Signaling, On Board, Traffic Management
  - Sporveien: CBTC, Fornebubanen, Majorstuen Stasion
  - JPSS: Space and Ground
- Overall project has a date that integrates the smaller projects
  - No one wants to be late, but someone will be
  - Everyone else uses first schedule slip to slip their schedules

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How Did We Get Here?

- "I know what I want, so just spec that"
  - Assumes solution space is totally known
  - Prevents novel solution spaces from forming
  - Prevents innovation
- Domain experience v. SE Experience
  - Much more art than science
- Talking SE v. Doing SE
  - Culture, culture, culture

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Summary

- Systems made up of architectural abstractions
- Appropriateness needs to be considered when writing requirements
- There are risks associated with writing inappropriate requirements
- It's as much art as science

Extra

Why I Like MIL-STD-498

- Burning Platform: Need a document, but unsure what to put in it
- Could synthesize from scratch
  - Costly – developing structure v. content
  - Risky
- MIL-STD-498
  - DID (Data Item Descriptions)
  - Provide document structure of SE docs
  - Old enough to tailor w/o guilt

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Q&A Session

Please submit your questions in the Zoom's Q&A feature.

Next Month's Webinar:

Wednesday, 20th March 2024 at 11:00AM EST / 15:00 UTC

Enhancing Systems Engineering Through Generative AI (GAI)

Presented by Steve Dam

Quick Reminders

- All the previous webinars are now located in the Professional Development Portal (PDP).
- Attending a Webinar does count as 1 PDU credit towards your SEP renewal

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