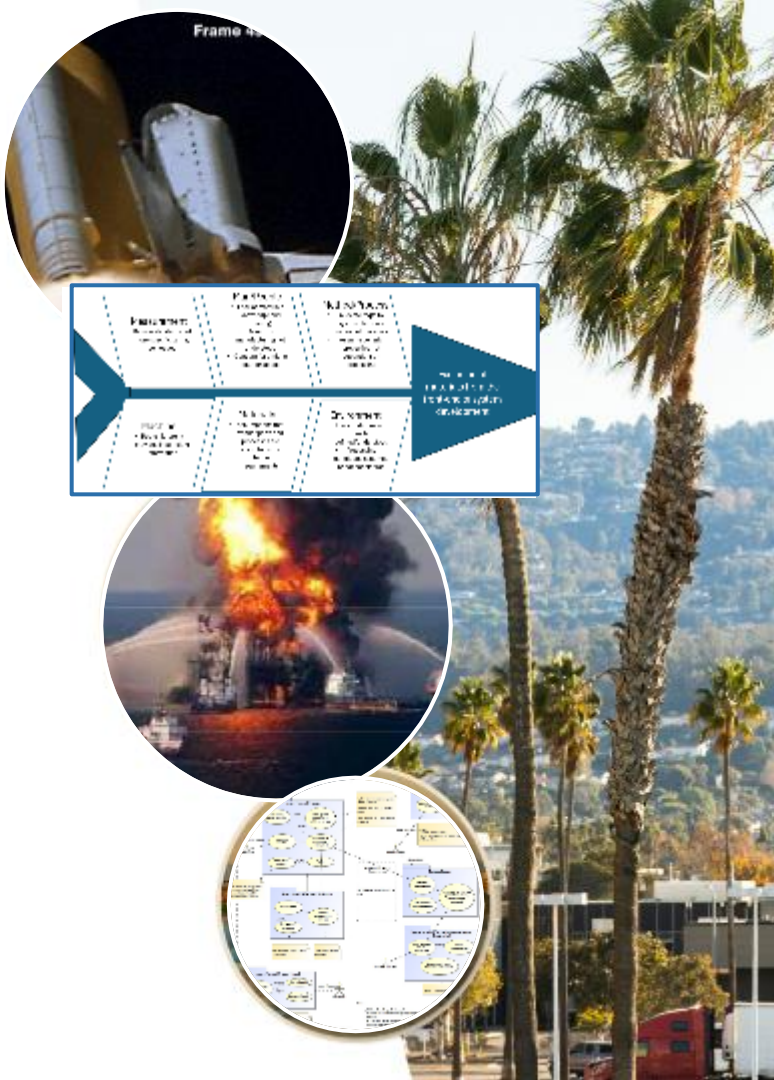
Materials in System Engineering (MatSE):
Working Group Overview

Presentation to Enchantment Chapter

August 12, 2026

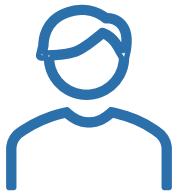
incose.org



Today's Agenda

- Introductions
- About MatSE WG
- Why Materials are Important to SE
- MatSE WG Past and Current Activities

Introductions



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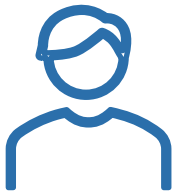

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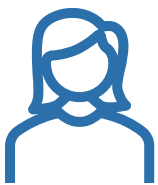

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Purpose

Introduce you to the Materials in System Engineering Working Group

- Understand why materials are important to the system engineering process
- Learn about the work MatSE WG is performing
- Encourage awareness and/or involvement

About MatSE WG

- Why MatSE WG
- History
- Membership & Meetings

Why MatSE WG

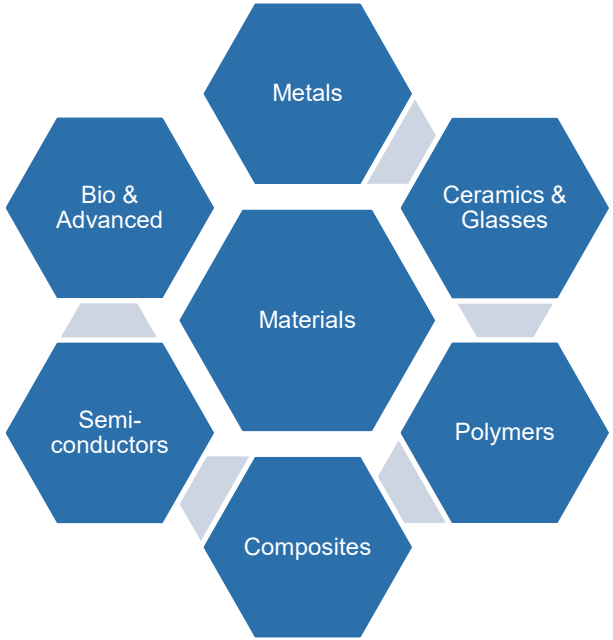
- Materials are critical to system engineering
- Gap in materials content within INCOSE
- Closing the gap to grow the body of knowledge

GOALS

- Develop a community to assess the state of practice for materials in SE processes
- Guide engineers on materials as a core part of SE
- Advance knowledge of materials lifecycle management across systems, systems of systems, and product lines

History of MatSE WG

- Created in June 2024
- Approved as a Working Group under Research Enablers
- Chartered and Scoped



- After Engineering Materials Explained, Their Types and Selection (Notes with PDF) - Learn Mechanical

Membership & Meetings

Membership

- Presently ~450 members worldwide
- Varied backgrounds and organizations

Meetings

- Virtual monthly working meetings as schedules permit
- Speaker presentations

August Meetings:

- August 11th WG meeting
- August 12th
  - Enchantment Chapter presentation

September Meetings:

- CBP presentation September 17th noon ET

Why Materials are Important in System Engineering

- Why should SEs care about materials?
- Materials-related failures of engineered systems
- Materials in the system lifecycle

Why Should SEs Care about Materials?

- Materials play important physical roles in hardware-based systems
- Metals, ceramics, polymers, and composites comprise engineered hardware from computer chips to biomedical devices to aircraft wings to weapons to satellites to…
- Materials selection affects performance, reliability, safety, cost, and integration
- Understanding how materials make up the system and how they perform, interact, degrade, or fail is essential to optimizing it

Engineered Materials Arresting Systems (EMAS) | Federal Aviation Administration

Engineered System Failures: Often Materials-Related

- Columbia Space Shuttle Accident (February 4, 2003)
  - Foam failure impacted wing: Design concern realized
- BP Deepwater Horizon Oil Spill Accident (Sept 8, 2010)
  - Insufficient cement between casings: Engineering verification test not performed during installation
- TWA Flight 800 Accident Investigation (July 1997)
  - Explosion of flammable fuel/air mixture due to wire insulation damage: Age/maintenance-related deterioration
- I-35W bridge collapse in Minneapolis (August 1, 2007)
  - Inadequate design review and quality control procedures for bridge modifications: Gusset plates design error

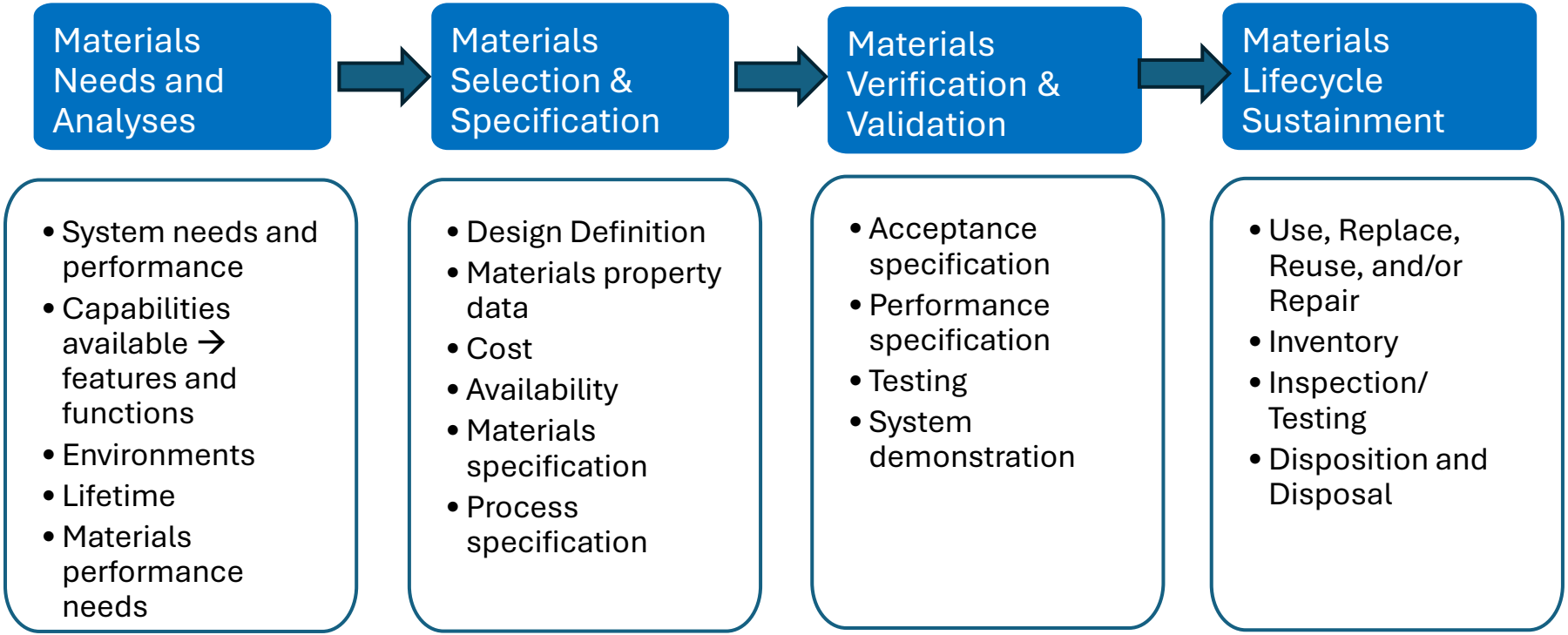

Columbia Flight STS-107


BP Deepwater Horizons Oil Spill Accident

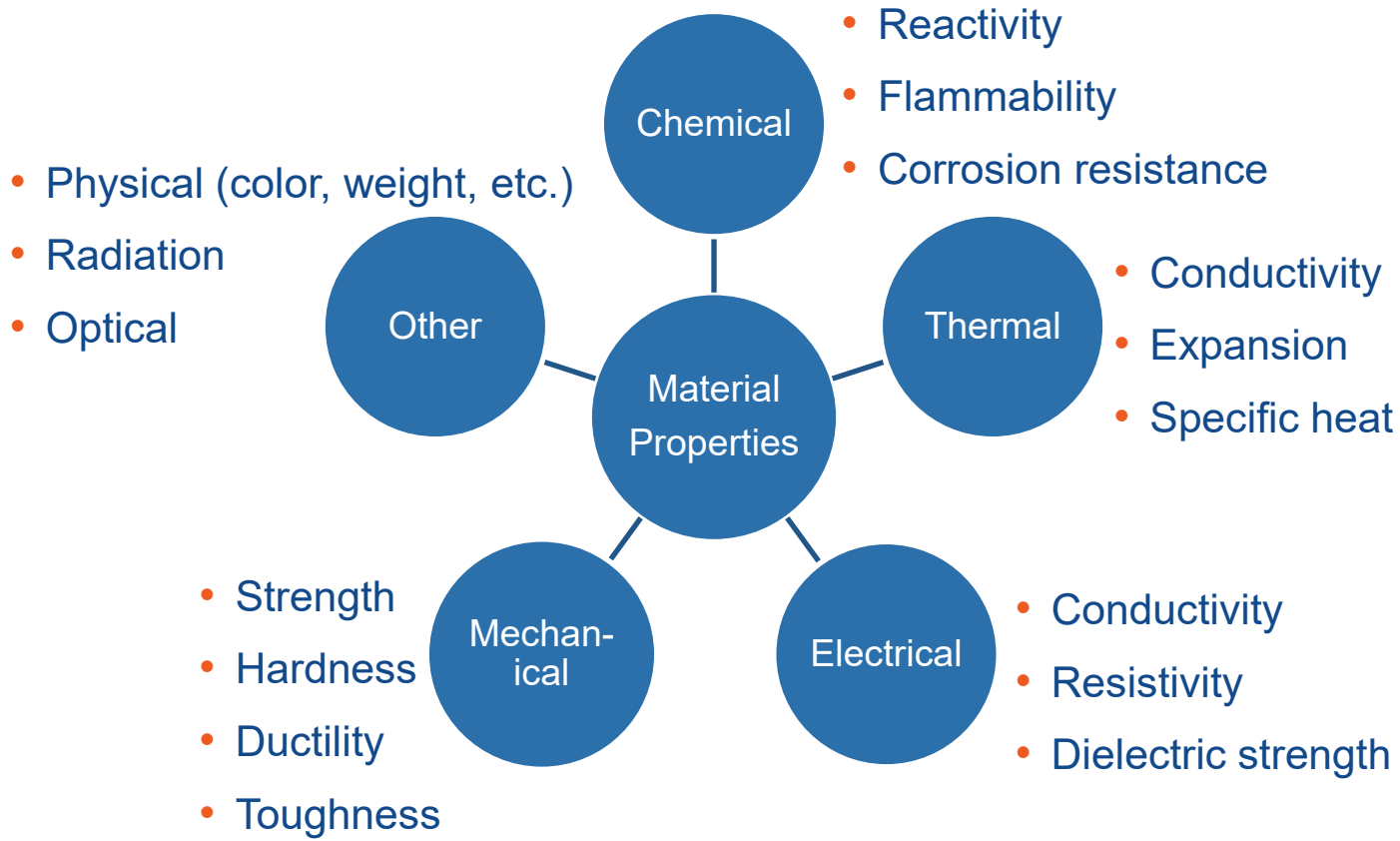

TWA Flight 800


I-35W Bridge

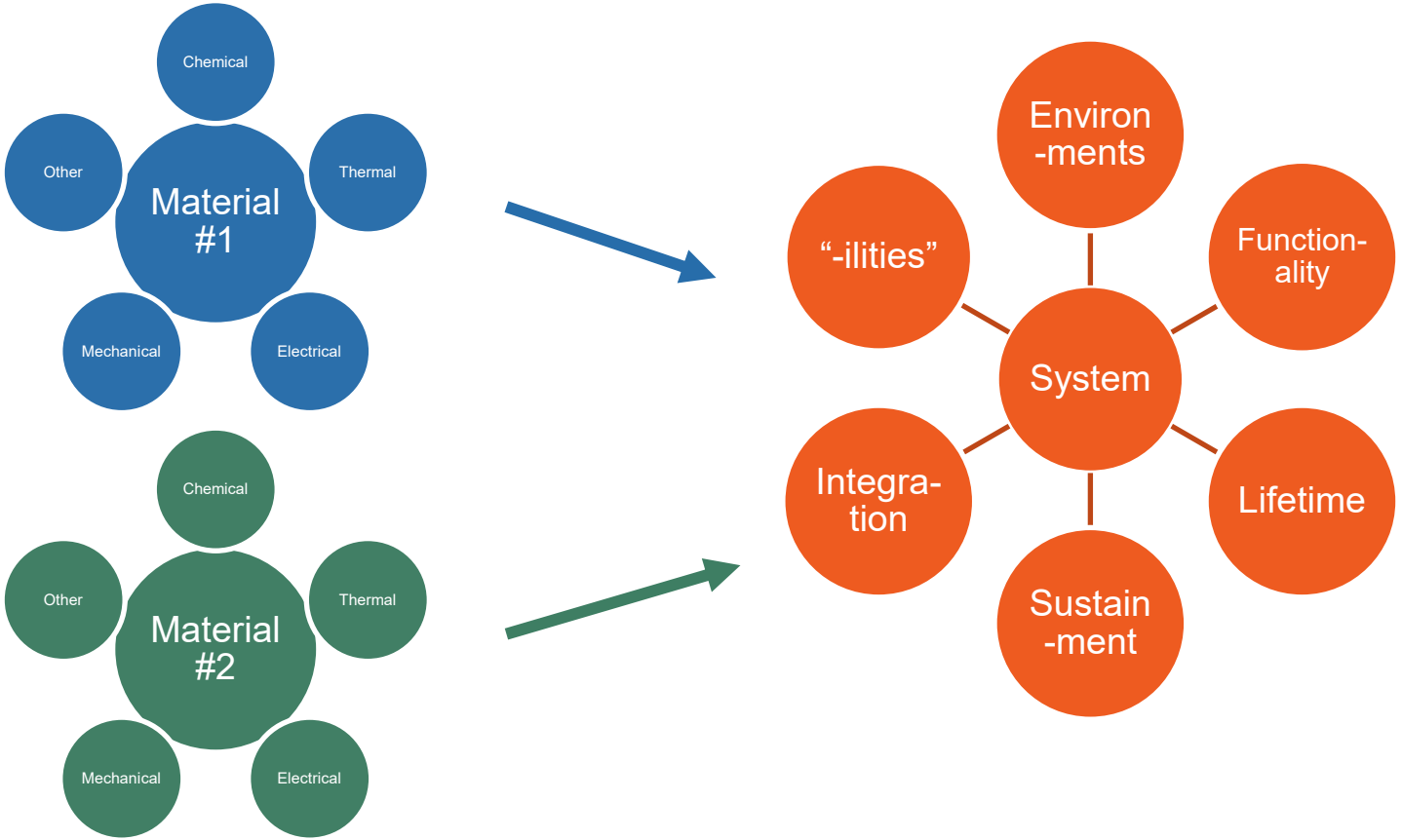
Materials in System Lifecycle



Materials Performance



Materials Performance in the System

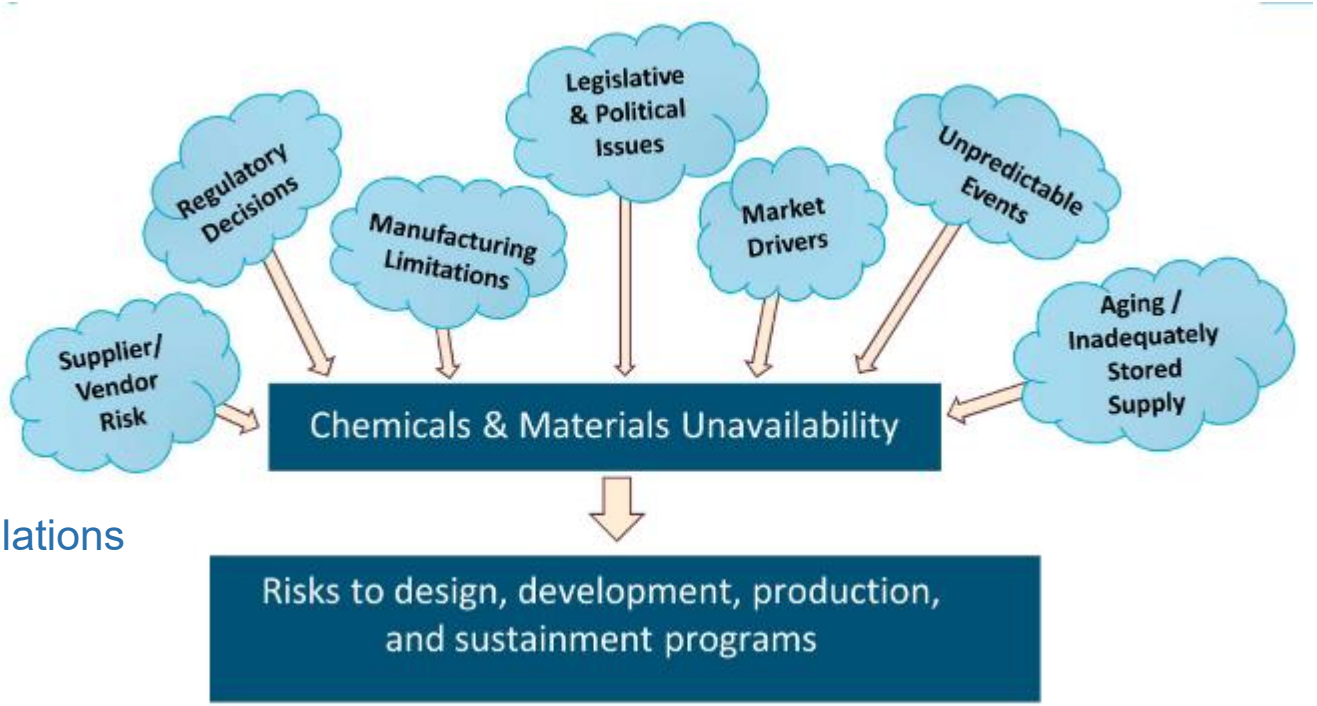


Materials Selection & Challenges

- Evaluate properties to determine most suitable candidate(s) for each component in system
- Have data to support trade studies and decision-making
  - Supply chain and cost data
  - Technical data
- Balance “-ilities” (reliability, durability, compatibility, etc.), efficiency, and cost-effectiveness

Materials Supply Chain Considerations

- Availability
- Market demand
- Producibility
- Cost
- Quality/purity
- Sources
- Existing or pending regulations



Tracking and Analysis of At-Risk Materials at Sandia National Laboratories

Materials Data and Information

Materials Data Sources

- Materials Databases
  - Ansys Granta Materials Data
  - MatWeb
  - MATDAT
  - Open Materials Database
- Vendor Data
- Testing
- AI Tools

Materials Standards

- Professional societies
  - ASTM, ANSI, ASME, etc.
- Enterprise/company specifications
  - Approved Materials and Parts Lists
- Military specifications
  - MIL-STD, MIL-DTL

Materials Specifications

What Specifications are Needed?

- Baseline/Qualified Materials
- Lot/Batch Acceptance
- Process and/or Manufacturing
- Verification Test
- Performance
- In-service/Requalification
- End-of-life materials
- Rework/reuse/disposal

Examples of Properties/Parameters in Specifications

- **Electrical performance**
- **Thermal performance**
- **Strength / mechanical performance**
- **Dimensional tolerance properties**
- **Composition / chemistry**
- **Microstructure**
- **Moisture / contamination limits**
- **Surface quality / defects**
- **Coating/finish performance**
- **Corrosion / chemical resistance**
- **Cleanliness**
- **Life / shelf-life/ durability**
- **Other**

Materials Verification & Validation

TPM (Technical Performance Measure) — Tracks how well the material meets specific technical requirements

Technical parameters for verification

- Fatigue: S-N curve parameters from coupons with crack growth rate measured
- Corrosion: Pit depth distribution after N hours

KPP (Key Performance Parameter) — Identifies critical performance characteristics essential for success

Technical parameters for validation

- Fatigue: > 1,000 cycles to crack initiation under design load spectrum
- Corrosion: Max pit depth <0.25 mm after 500 h in salt fog

MOP (Measure of Performance) — Assesses its physical or functional attributes

Verifies design requirements met

- Fatigue life at specified R-ratio and load spectrum
- Corrosion rate in mm/year in chemical environment

MOE (Measure of Effectiveness) — Evaluates how well a material achieves its intended purpose

Validates design suitability

- Percentage of time without failure due to fatigue cracking or corrosion

Materials Lifecycle Sustainment

- Considerations
  - Traceability/Provenance
  - Cost of disposal
  - Hazards
  - Repair/refurbish
  - Transparency

- 4 R's for Sustainable Manufacturing (Zero Landfill)
  - Refuse
  - Reduce
  - Reuse
  - Recycle

Materials Economy Models

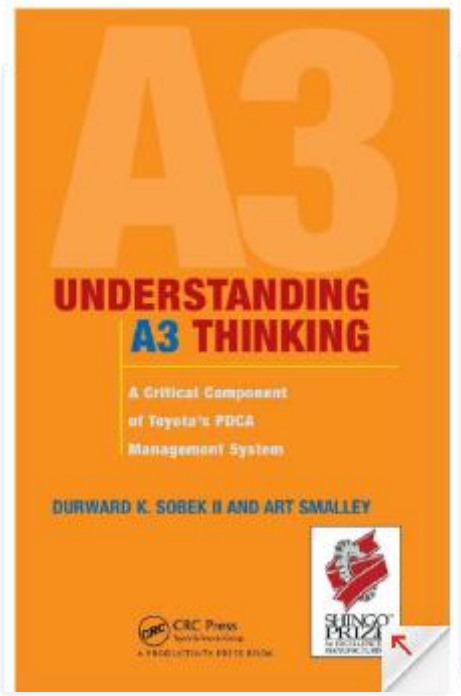
Past & Current MatSE WG Activities

- Applying structured problem-solving to understand cause(s)
- Using MBSE for solution development

WG Used A3 Thinking Approach

- Recognized engineered system failures often materials-related

- In 2025, applied A3 Thinking method as structured approach to problem solving
  - Used Ishikawa cause-and-effect brainstorm and analysis
  - Implemented a Plan-Do-Check-Act (PDCA) cycle
  - Documented results in A3 Report
  - Used templates from ASQ.org to assist in A3 Thinking



Smalley & Sobek (2008). *Understanding A3 Thinking*: A Critical Component of Toyota's PDCA Management System. Taylor & Francis Group, LLC. NY, NY. CRC Press. Graphic retrieved on January 7, 2026 at https://www.barnesandnoble.com/w/understanding-a3-thinking-durward-k-sobek-ii/1121292231?ean=9781563273605

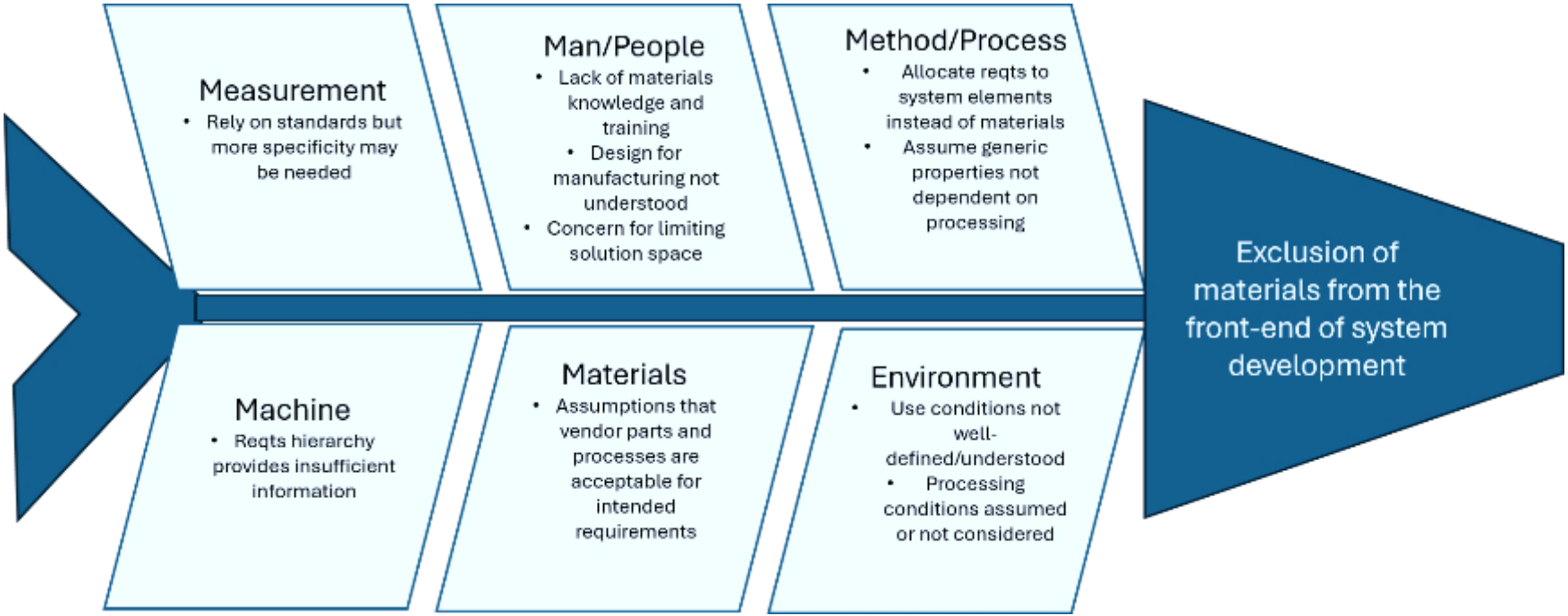
Problem Statement

Materials requirements (the wants and needs) are not included or represented early in the system lifecycle.

- In 2025, our first initiative was problem analysis:

“Why aren’t materials represented at the front end of development?”

Ishikawa Brainstorm for Causes & Effects



A3 Analysis

A3 Analysis using Delphi Method narrowed causes and effects down to 2 key reasons:

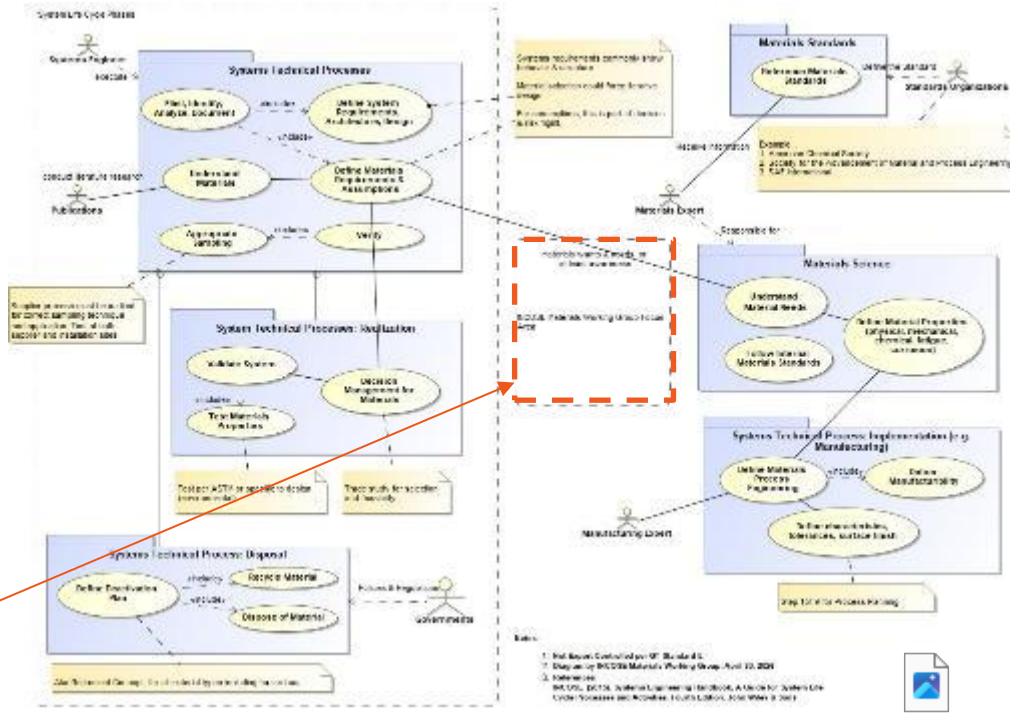
1. Systems Engineer's thought process or procedures were not conducive to flushing out materials requirements.
2. Systems Engineers do not typically research the manufacturing environment during requirements elicitation.

This began the solution space analysis.

MBSE: Solution Model

- SysML chosen for context diagram representation
  - Illustrates Problem scope and Solution space
  - Identifies stakeholders, interactions, and boundaries
  - Emphasizes importance of materials and manufacturing experts

MatSE WG focusing on center dashed box



SysML diagram.jpg

*INCOSE WG will not publish materials standards but acknowledges their use in the SE process

Path Forward

- GOAL: In defining a concrete solution, we want to have an INCOSE-unique solution to assist Systems Engineers.
  - Because Materials Experts have access to expensive and extensive materials references, we must find a niche.
  - Considering adding Capabilities Based-Planning (CBP) to other requirements elicitation methods for materials inclusion to SE processes.
  - In 2026, starting developing a SysML Block Diagram defining methods and technical aspects of materials science.

- Please consider joining and participating in our MatSE WG.

Thank You!

Questions?

Comments?