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

Architecting the Future through Natural Language Processing

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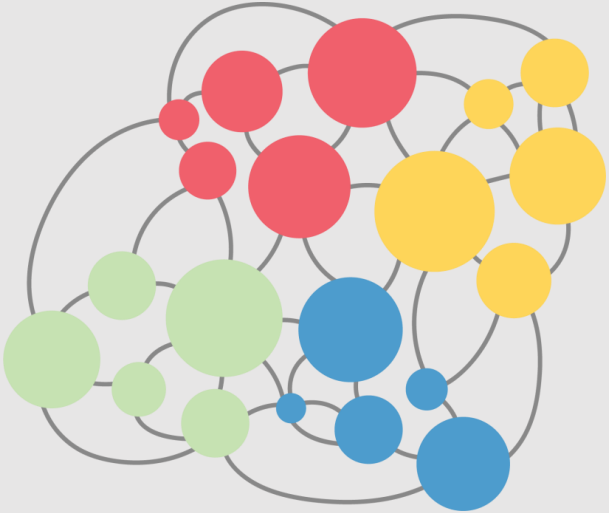
Today's Agenda



- Digital Transformation
- Digital Thread
- Systems Engineering Evolution
- MBSE Challenges
- NLP Integration
- LLM Evolution and Use Cases
- Conclusions

Digital Transformation

Core Focus:

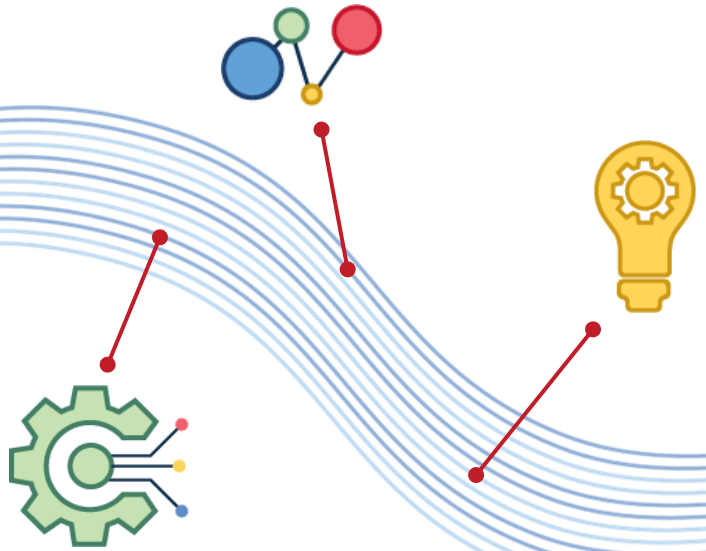
Enhancing efficiency, personalization, & decision-making through automation, real-time analysis, and interconnected systems

Benefits

- Survival & Growth
- Customer Expectations
- Operational Resilience
- Data-Driven Decisions
- Agility & Innovation
- Sustainability
- Risk Mitigation

Digital Thread

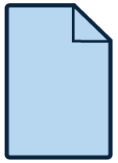
Weaving Data, Decisions, and Innovations into Every Stage



- Connects data, processes, and decisions across the entire product life cycle
- Ensures real-time data sharing and collaboration between stakeholders
- Creates a single source of truth, enabling end-to-end transparency
- Reduces errors through continuous validation
- Supports data-driven decision-making aligned with systems engineering goals

Systems Engineering Evolution

As systems are becoming more complex, many projects are shifting from piles of documents to a centralized system model



Document-Based Systems Engineering (DBSE)

Siloed information, poor traceability, & manual effort

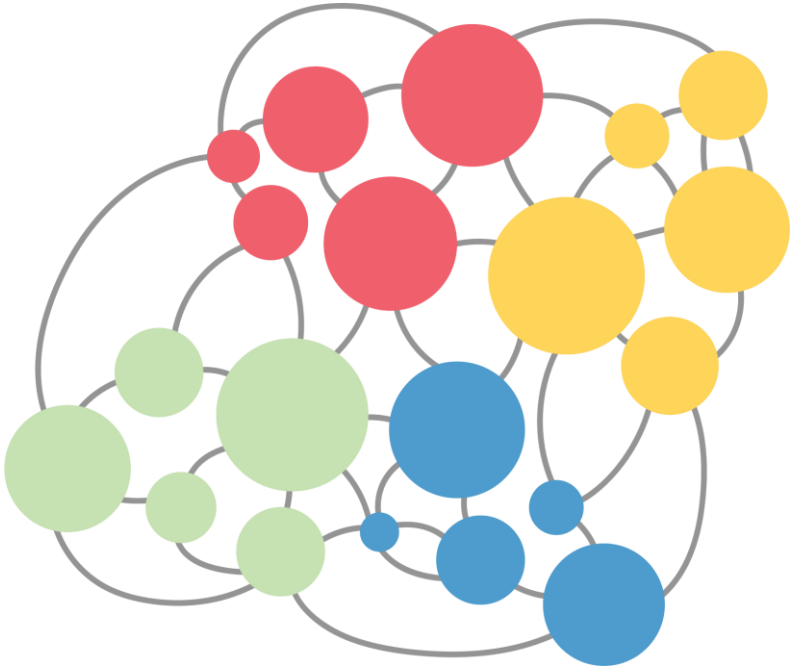
Model-Based Systems Engineering (MBSE)

Visual models improve collaboration, reduce ambiguity, & manage complexity

However, MBSE still fails to address scalability challenges for hyper-complex systems

Complex System Requirements

Poor requirement capture leads to system failure or technical debt



Complexity produces

- Ambiguity
- Scalability Challenges
- Traceability Gaps

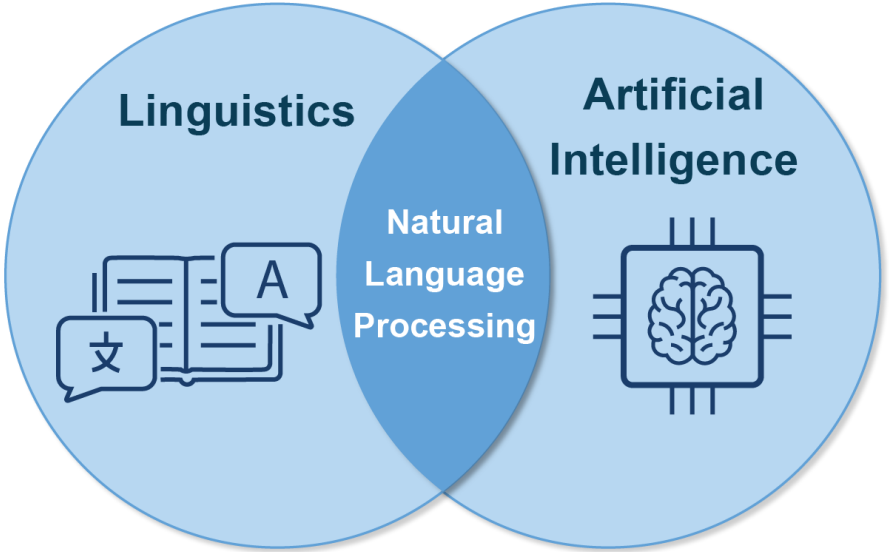
Natural Language Processing (NLP)

A workflow enhancer

Subdiscipline of AI

Allows computer algorithms to understand text and spoken words

Reads and understands documents



Our Assertion

Natural Language Processing (NLP) is a transformative enabler for MBSE.

NLP bridges the gap between human communication and precise system models to ensure clarity, consistency, and agility in complex engineering projects.

Our study shows, NLP can be used to

Automate requirement extraction, categorization, comparison, & quality assurance

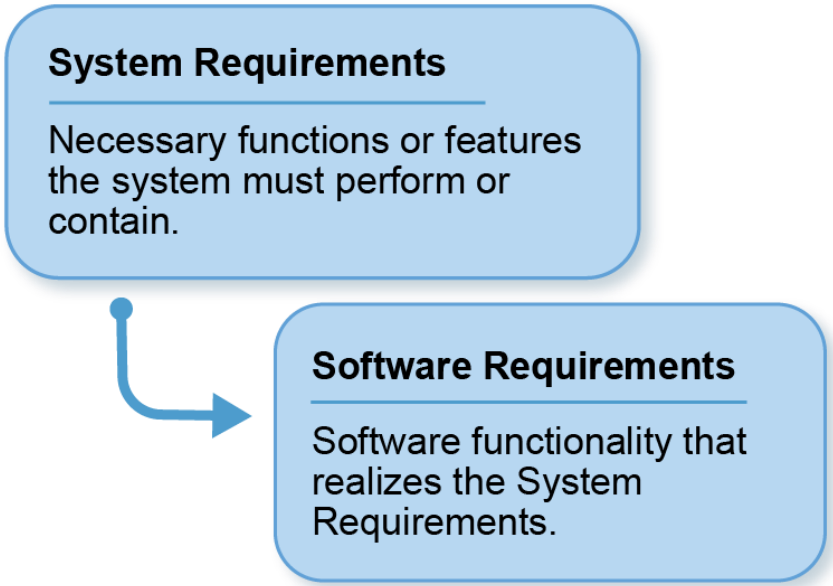
Reduce manual labor related to MBSE trace activities & data capture

Address the learning curve between novice & experienced engineers

Our Initial Study (2023)

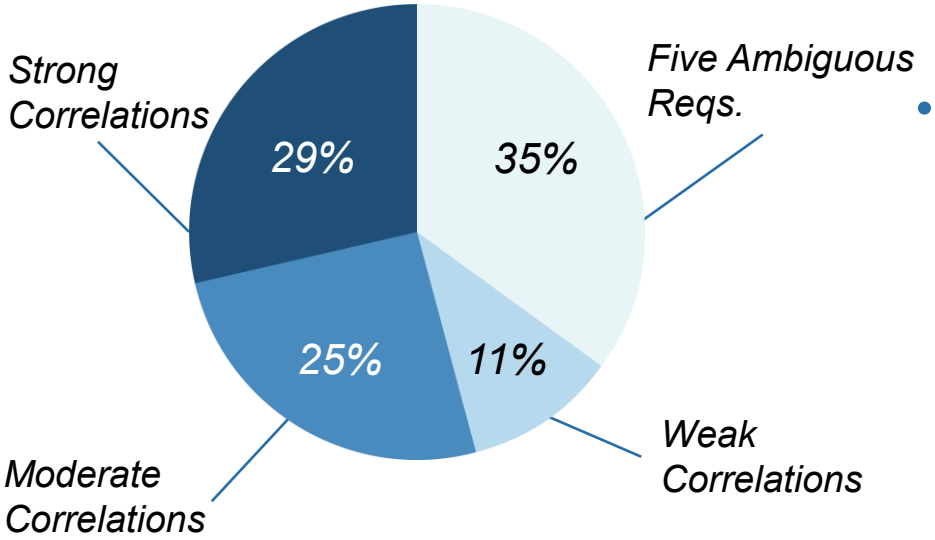
Objective: Test NLP's ability to automate requirement tracing

Method: Used NLP algorithm to evaluate internal project documents for ambiguity and tracing software requirements to system requirements



The Results
(2023)

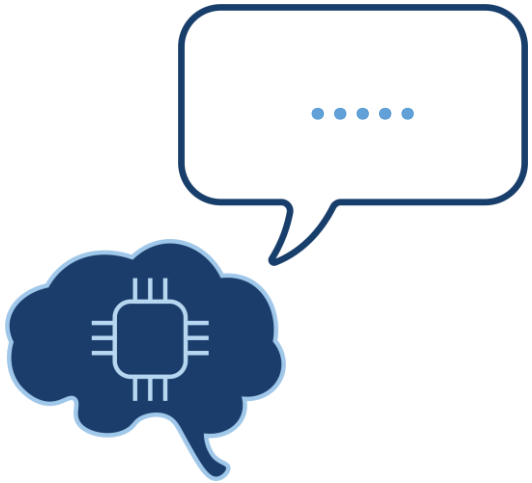
The study provided evidence toward NLP improving MBSE traceability analysis



- NLP Algorithm traced 53.97% of requirement correlations identified by SMEs
- Reduced analysis time from 7 days (manual) to 2 days (NLP-assisted)
- Identified five vague system level requirements
  - Five requirements accounted for 75% of the missed correlations

Evolution of NLP

Since the 2023 study, Large Language Models (LLMs) have become more mainstream



Shift from Latent Semantic Indexing (LSI) models (1990s) to LLMs (2020s)

LLMs are the cutting-edge tools within NLP that power modern, context-aware applications

LLMs apply NLP techniques to solve real-world problems

LLMs: Agents vs. Workflows

AI Agents

Operate more autonomously, dynamically determining next steps

AI models actively decide the sequence of actions

Path is dynamic & unpredictable, governed by AI decision-making

VS.

AI Workflows

Follow a clearly defined, path outlined in specification and code

AI models perform specific tasks at designated points

Overall flow governed by explicit, coded logic, ensuring predictability

Content reference: https://ai.intellectronica.net/the-case-for-ai-workflows

LLMs: Considerations

Not all LLMs are the same

Different LLMs are better for certain tasks

- Code writing and debugging
- Multilingual support
- Storytelling/content creation
- Fact-checking

LLMs have varying context lengths

Fine-tuned LLMs for better performance on certain data types or topics

LLMs: Impacts & Use Cases

Technology meets transformation

Categorization/Comparison

LLMs cluster requirements via semantic meaning and summarize findings

Quality Assurance (QA)

LLMs flag ambiguities, enforce standards, and ensure consistency

Automation

Reduces manual effort, enabling engineers to focus on critical tasks

LLMs & the Digital Transformation

LLMs power digital transformation through process automation & data analysis

Document Dissection

Current LLMs cannot reliably evaluate an entire large document (>10 pages) at one time

Digitization Methods

Digitized vs. Digital Native Files

OCR vs. Text-Based Parsing

Conclusions

NLP/LLMs enhance MBSE by automating tasks, improving speed, reducing errors, & flattening the learning curve amongst talent

AI is part of the future

NLP/LLMs lend themselves well to streamlining MBSE tasks such as

- Requirement Analysis
- Design Analysis
- Evaluating test results
- Comparative Analysis

LLMs are more attainable than ever with many commercial versions available

Questions?