NATURAL SYSTEMS WORKING GROUP

AI/BID Evaluation Workstream

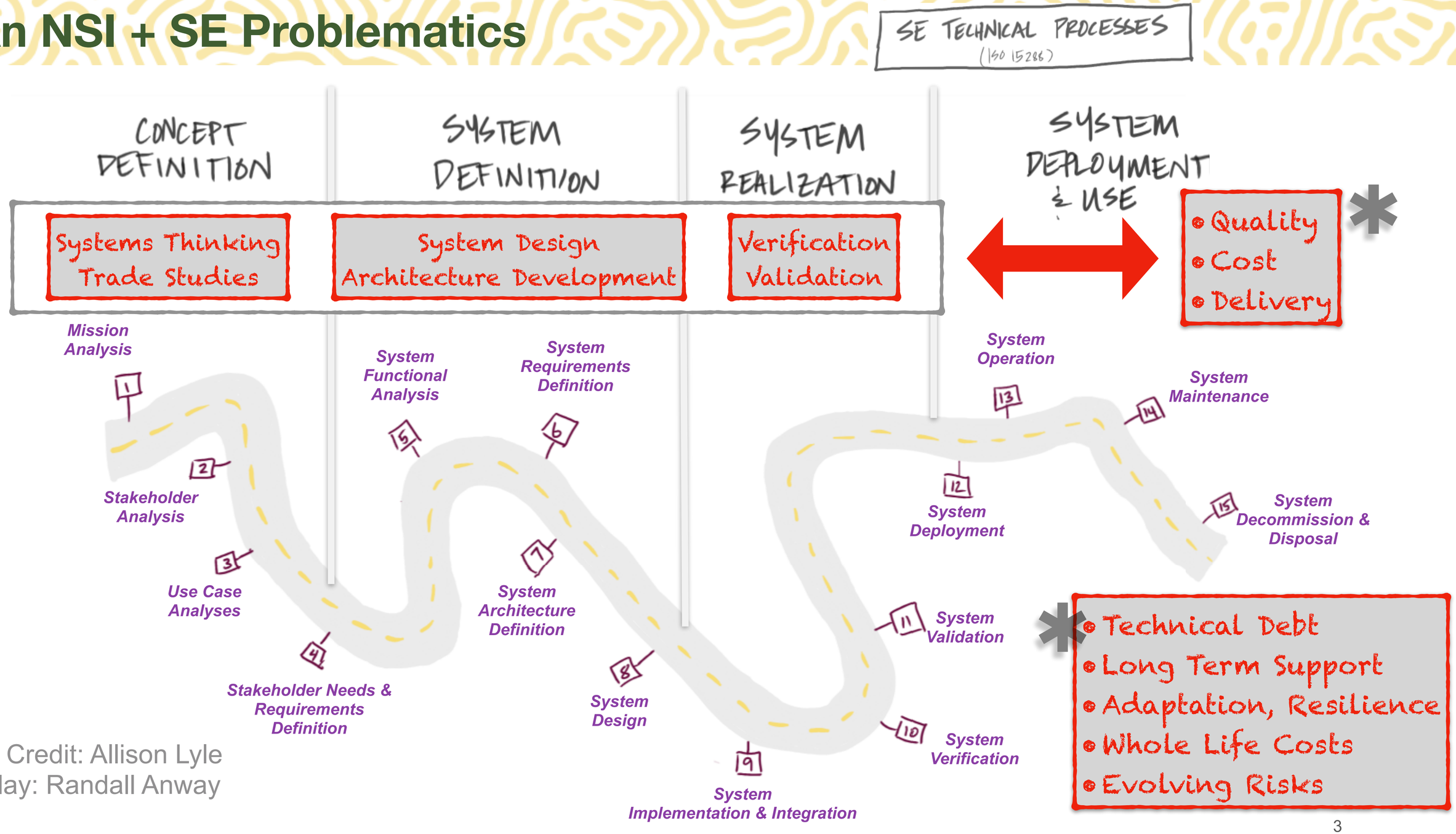
Presentation to the Sustainability Working Group

Randall Anway 09 June 2025

AGENDA

1. An NSI-SE Problematics
2. Overview of the Workstream
3. The point is: Aha's
4. Discussion

An NSI + SE Problematics



Slide Credit: Allison Lyle
Overlay: Randall Anway

Workstream Overview

BID + AI Evaluation Workstream

Collaborative inquiry

- INCOSE WG's
- Individual Contributors
- Organizations

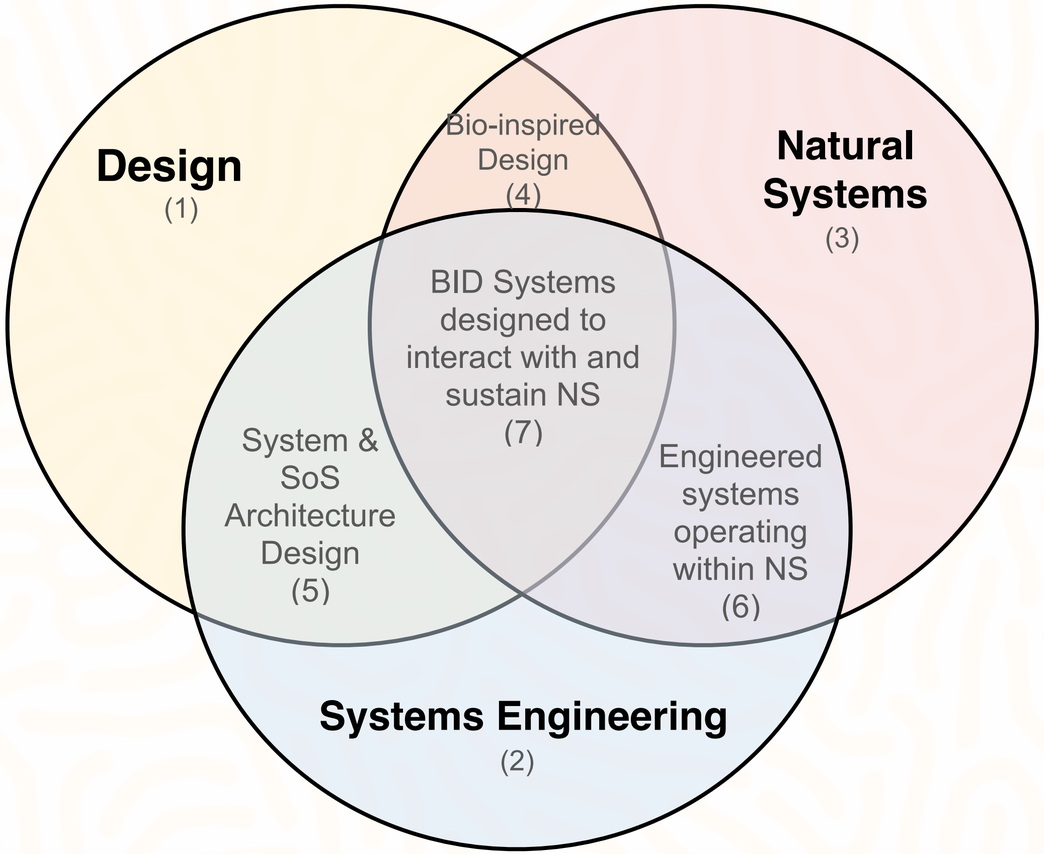
Areas of Potential Joint Interest

- NSI4-SE/SE4-NSI
- Use Cases
- Outreach - Co-labs
- Outreach - Publish
- > SEBOK
- > SE Handbook

Potential Application Spaces

- Circular Economy
- Adaptable Systems
- SoS Architecture
- NSI Agents
- …

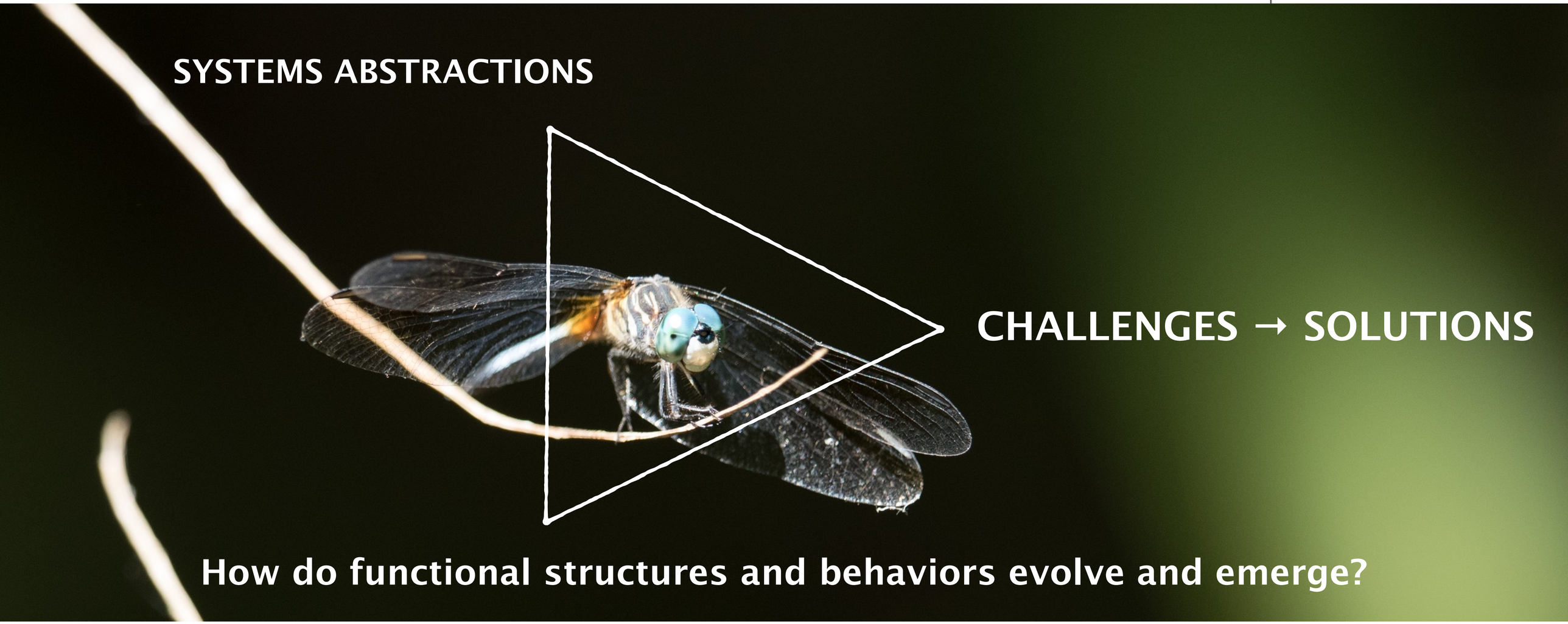
Integration of Natural Systems with Human-Design Systems



1. **Design**
   - Creation of a component, product or system with purposeful consideration for its function and form (ideation)
2. **Systems Engineering**
   - Human designed Systems and SoS following a product development process
3. **Natural Systems**
   - The natural biotic (biology, ecology) and abiotic (atmosphere, geosphere, cryosphere, hydrosphere) systems that comprise our planet
4. **Bio-Inspired Design**
   - Designs inspired by observing nature, could improve performance, not necessarily better for the environment (biomimicry of materials, structures, form, function…)*
5. **Systems and SoS Architecture Design**
   - Using user and system requirements to inform/ influence Systems of Systems design (structure, hierarchy, interfaces, flows, processes)
6. **NS interfaces/ flows included in Systems/ SoS design**
   - Using study of NS and including those as stakeholders to capture requirements, impact, tradeoffs to NS
7. **BID System/ SoS designed to interact with NS**
   - Human designed systems/ SoS inspired by NS, designed to effectively and sustainably operate within and interact with NS

Content Credit: Dennis Tuckowski

Natural Systems Intelligence^2
Transdisciplinary SE



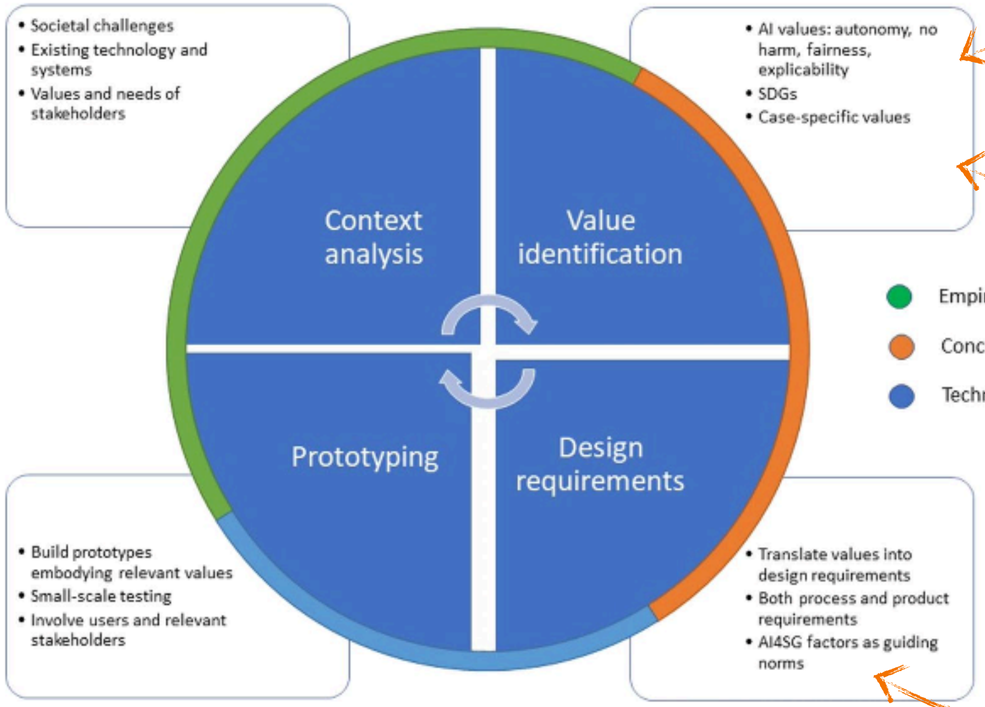
Managing AI Risks

Image Credit: National Institute of Standards and Technology Artificial Intelligence Risk Management Framework (AI RMF 1.0), 42 pages (January 2023). This publication is available free of charge from: https://doi.org/10.6028/NIST.AI.100-1

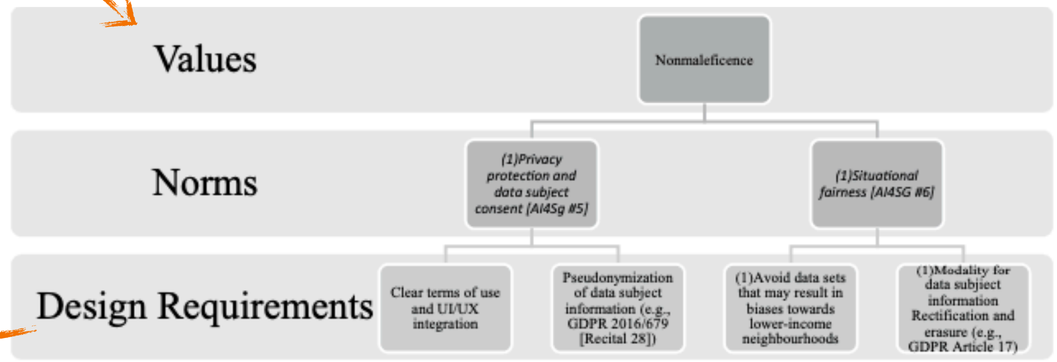
AI system lifecycle:
Key development tasks

1. People and Planet (Core Inputs)
   - A. Data sources and Model Inputs
   - B. Collect and process data
2. AI Model
   - C. Build and use
   - D. Verify and validate
3. Task and Output
   - E. Deploy
   - F. Use
4. Application Context
   - G. Operate and Monitor
   - H. Plan and design

Mapping Values to Requirements



(for example)



Images Credit: Steven Umbrello and Ibo van de Poel. "Mapping value sensitive design onto AI for social good principles." AI and Ethics (2021) 1:283–296

Value Sensitive Design

Batya Friedman and David G. Hendry. Value Sensitive Design: Shaping Technology with Moral Imagination. Massachusetts Institute of Technology (2019).

Research questions: (SE + NSI) x AI

“How can SE’s leverage NSI in their work?”

“How can SE work products & organizations flourish beside NSI?”

SE Processes	NSI x AI Processes (eg, SE IntegrationTasks)
Conceptualization	Create comprehensive models of natural systems, capturing relevant relationships and behaviors in a way that is understandable to engineers
Definition	Requirement Encoding: encode complex interdependencies that can inform the system definition process
Realization	Translate biologically inspired concepts into engineering parameters and specifications, to help realize designs that emulate natural efficiencies and innovation
Operation	Monitor system operation in a context-rich manner, utilizing natural system behaviors as benchmarks for performance and stability.
Maintenance	Understand patterns from natural systems' maintenance strategies (like an animal's grooming behavior) and apply these to predict and automate maintenance tasks
Retirement	Guide the retirement of systems by analyzing data on natural system life cycles, aiding in developing environmentally responsible decommissioning plans

Workstream opportunity areas

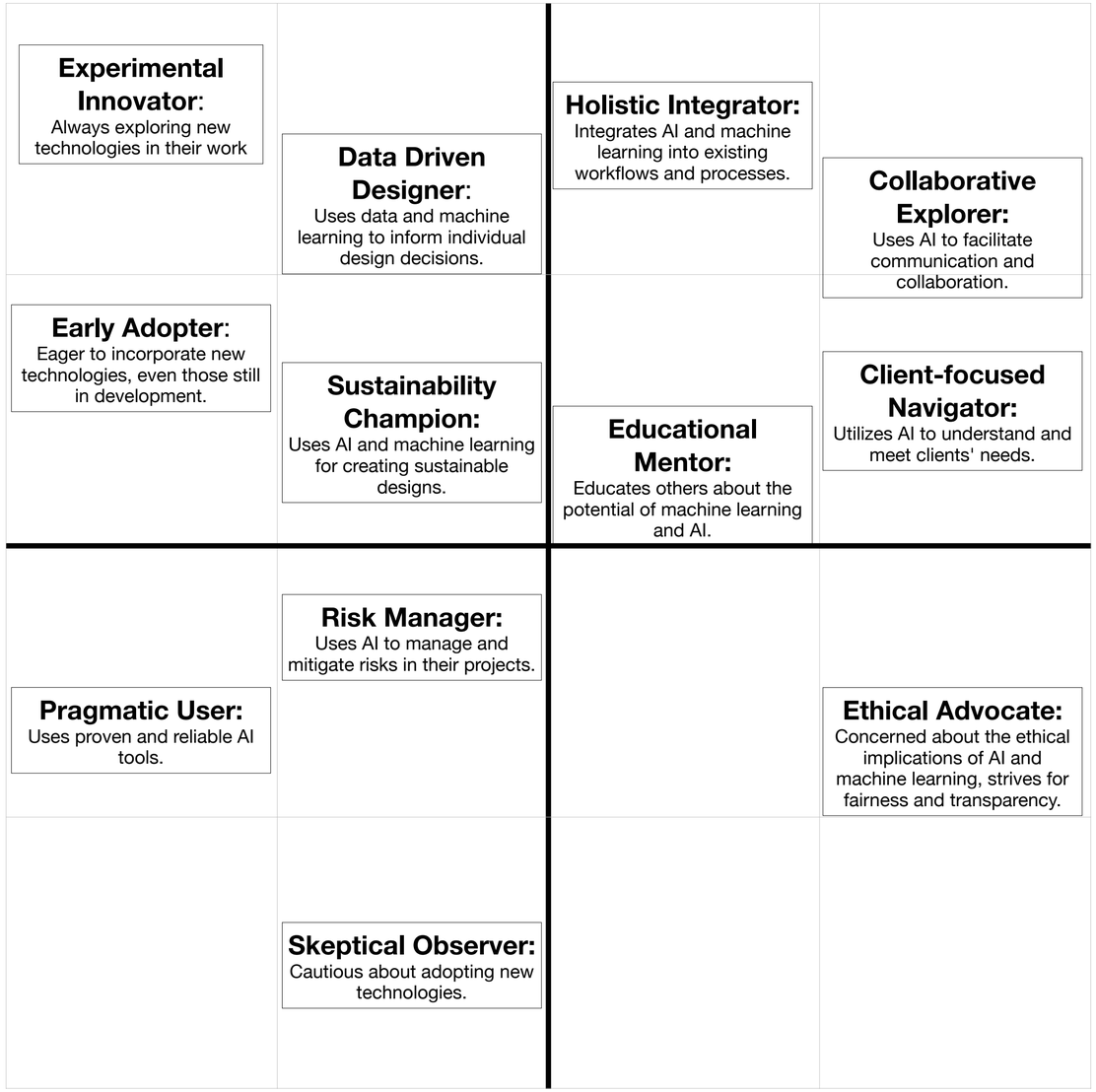
- Evaluate AI-augmented NSI for SE/SE for NSI
- Literature Reviews
- Case Studies
- Surveys and interviews with SEs, NSI experts, and AI researchers
- Workshops and focus groups with SEs, NSI experts, and AI researchers
- Proof-of-concept demonstrations or prototypes.
- Comparative Analysis of different NSI approaches, AI techniques, and SE methodologies
- Return on Investment (ROI) Analysis, including Life Cycle cost, Technical Debt, Risk Recovery.
- Risk assessments, such as data quality, algorithmic bias, security, and mitigation strategies.
- Assess new methods, tools, and frameworks: modeling, simulation, optimization, etc.
- Lead SE-NSI culture with AI educational materials, training programs, and workshops.

Discussion:

Mapping Organizational Ecologies: Personas and User Journeys

Provide a list of 8-12 ways a practicing engineer (male or female) might classify or categorize their approach to technological/methodological change in practice related to machine learning, large language models, or image transformer applications in their work, once they had a little experience with it.

Segment the above into 4 quadrants on 2x2 dimensions. explain the dimensions and which categories fall into which quadrant.



The Technology Adoption dimension refers to how aggressively or cautiously the engineer adopts new technologies, particularly AI and machine learning.

The Application Focus dimension refers to whether the technology is primarily used to enhance the engineer's individual work or to foster collaboration with others (clients, colleagues, broader community).

These quadrants can help engineering business units understand their own approach to technology adoption and guide their future learning and development efforts.