



2023

Annual **INCOSE**
international workshop

HYBRID EVENT

Torrance, CA, USA

January 28 - 31, 2023

Systems Science Working Group

INCOSE WG Round Robin

www.incose.org/IW2023

SSWG | Motivation

- We can conclude there is diversity in perceptions regarding:
 1. The maturity of systems science
 2. The nature of its underpinning concepts
 3. What is considered foundational

SSWG | Motivation

- In the past 10 years we have seen advances in:
 - **Generation of Systems Principles**
 - scientific and applied – David Rousseau, Javier Calvo-Amodio
 - **Exploration of Category Theory as mathematical basis for SS and SE**
 - Larry Lambe, Kent Palmer, Mike Watson, Ken Lloyd, Spencer Breiner (NIST)
 - **Consolidation of concepts in isomorphic processes**
 - SPT Len Troncale

SSWG | Motivation

- What is the objective of SE?

“We have lost sight of the fact that engineering is an art, not a technique; a technique is a tool. From time to time, I am briefed on the results of a systems analysis or systems engineering job in a way that prompts me to ask the questions: ‘That’s fine, but is it a good system? Do you like it? Is it harmonious? Is it an elegant solution to a real problem?’”

Robert Frosch, 1969

R. A. Frosch, ‘A classic look at systems engineering - NASA SP-6102’, in *Readings in Systems Engineering*, T. Hoban and W. M. Lawbaugh, Eds. Washington DC: NASA, 1969, pp. 1-7.

SSWG | Motivation

- What is the objective of SE?

“The purpose of systems engineering, is “not the satisfaction of requirements and processes” but rather, “attaining elegant designs””

Mike Griffin, 2010

M. D. Griffin, 'How do we fix system engineering?', in 61st International Astronautical Congress, Prague, Czech Republic, 27 September – 1 October 2010, 2010, vol. 27.

SSWG | Motivation

- What is the objective of SE?
- To begin bringing clarity and consistency, the Bridge Team build from Frosch and Griffin and say that:

“The purpose of Systems Engineering is to achieve Elegant Solutions that resolve Complex Problems”

The spectrum and evolution of SE's "guiding propositions"

(the variety of contexts in which the guidance works)

Scope

universal
hyper-general

general
broad

specialized
narrow

unclear

(how predictable the consequences of applying the guidance are)

Capability

*ST & GST-grounded
transdisciplinary
holistic
elegant*

SE Principles grounded in ST & GST*

Culture determined (e.g. policy, law)

Nature determined (e.g. systems laws)

few

low unintended consequences

Heuristic Meta-Principle
Social Meta-Principle
Philosophical Meta-Principle
Scientific Meta-Principle

meta-generalization:
• socialization
• Fundamental SE Research & General Systems Research

SE principles grounded in ST & SysSci

Heuristic Principle
Social Principle
Philosophical Principle
Scientific Principle

generalization:
• case studies, trial-and-error
• experimental research

science-informed
science-explained

Heuristic
Convention
Perspective
Theory

Heuristic Principle
Social Principle
Philosophical Principle
Scientific Principle

insight:
• modelling & simulation (OR, SD, PPE)
• scientific theorizing

Heuristic
Convention
Perspective
Model

confirmation & refinement:
• case studies, trail-and-error
• experimental research

Hypothesized Heuristic
Proposed Convention
Proposed Perspective
Hypothesized Mechanism

pattern recognition

tentative

recommended

trustworthy

compelling

mandatory

Authority

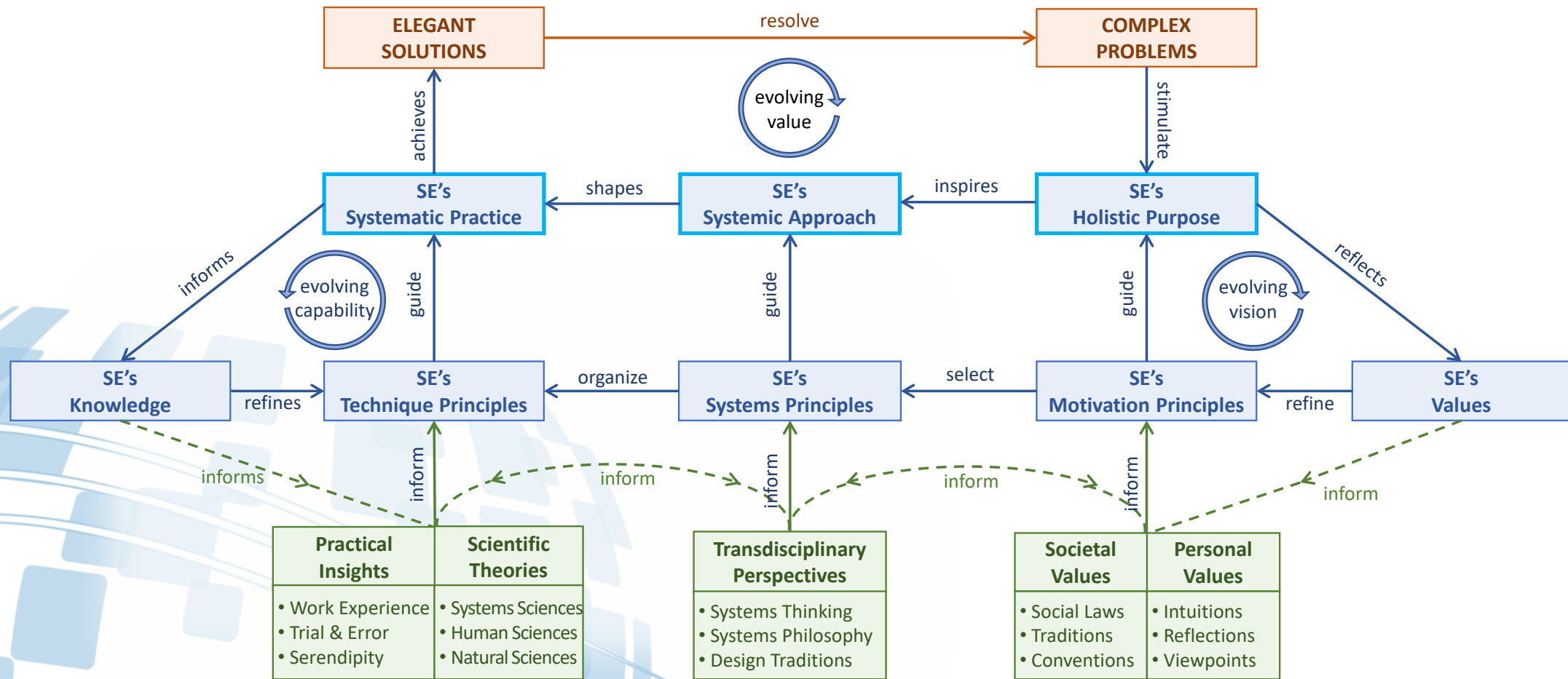
(how persuasive the guidance is)

experience

incubation

Reflection on Practice
Reflection on Community
Reflection on Values
Reflection on Nature

Systemic relationships in the evolution of SE's approach – *The Bridge*



How we do it

- Execute systematically
- Leverage methods, tools, processes

What we do

- Think systemically
- Apply systems thinking to engineering

Why we do it

- Build a better world (sustainable, equitable, ...)
- Achieve elegant solutions to complex problems

Future Work

- Continue developing frameworks to clarify what foundational theories SE needs
 - Will help map progress and coordinate efforts
 - Category theory (compositionality) as mathematical foundation