There is No (Real) Systems Engineering without Systems Thinking

Chesapeake INCOSE Chapter

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Systems Thinking

What is it?

It’s a way of looking at the world

- “(S)ystems thinking is the view that systems and problem situations cannot be addressed through reducing the systems to their component parts.” *Systems Thinking. Applied.*, Robert Edson, p.5
- “The uniqueness and behavior of the system is only present when the system is together it is not a sum of the individual components. System behavior comes about as a result of the interactions and relationships amongst the parts. In addition, systems thinking acknowledges the strong interactions between the system components, and the emergent behaviors and unintended consequences that may result from these interactions." Edson, p.5

Systems Thinking

We embrace it- *at least on the surface*

Systems engineering defined

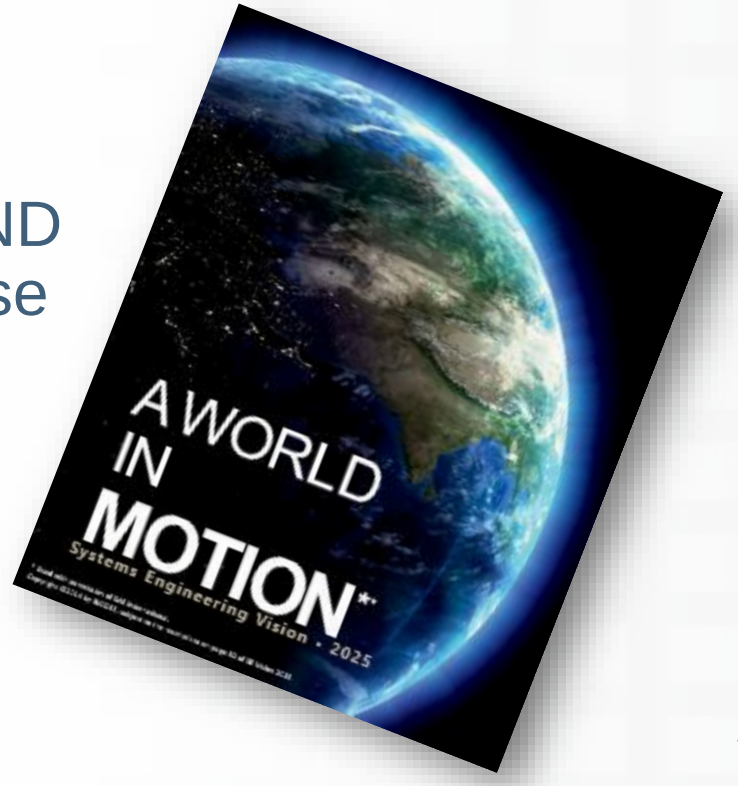
- Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, **using systems principles and concepts**, and scientific, technological, and management methods.- INCOSE
- This means (we say) we think in systems!
- A system is an **arrangement** of **parts or elements** that **together exhibit behavior or meaning that the individual constituents do not**.- INCOSE
- ***AGAIN!*** **“**“According to the systems view, the essential properties of a . . . system, are properties of the whole, which none of the parts have. They arise from the interactions and relationships among the parts.” *The Systems View of Life,* Fritjof Capra

Systems Thinking

Lofty goals

INCOSE Grand Challenges

- Vision 2025, *A World in Motion,* INCOSE 2014
- Embraces social and technical (socio-technical) challenges at a global scale
  - Climate
  - Hunger
  - Poverty
- These challenges rest on applying systems thinking AND systems engineering to understanding and solving these problems



Some examples:

- Developing the tools needed to understand the brain in action (BRAIN Initiative)
- Reducing traffic fatalities by at least 80 percent using self driving cars (Alphabet's Waymo)
- Becoming a multi planetary species ("I want to die on Mars, but not on impact." Elon Musk)
- Finding all asteroid threats to human population and knowing what to do about them (NASA)
- Developing a "tricorder" a handheld mobile device that can diagnosis a dozen diseases as accurately as a board certified physician (Qualcomm Tricorder XPRIZE)
- Providing Internet access to everyone on the planet (Facebook)
- Grand Challenges for Development, including Saving Lives at Birth and All Children Reading (USAID)
- Fostering breakthrough innovations to solve key global health and development problems (Gates Foundation)
- Creating automatic cyber defense systems (DARPA)
- Reducing infrastructure life cycle costs by 50% by 2025 and fostering the optimization of infrastructure for society (ASCE)
- Reform education systems to address gaps in systems skills in individuals (INCOSE Academic Council)

BUT . . .

Do we REALLY embrace it?

I am suggesting that we don’t!

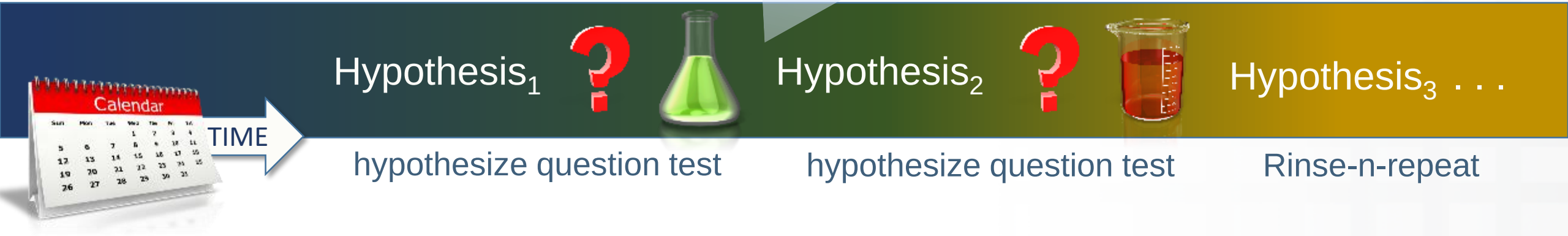
Systems Thinking

Why not? The paradigm trap

Science-Traditional view (incremental advances)

Assumptions
Methods
Tools

Enlightenment
Scientific method



hypothesize question test

hypothesize question test

Rinse-n-repeat

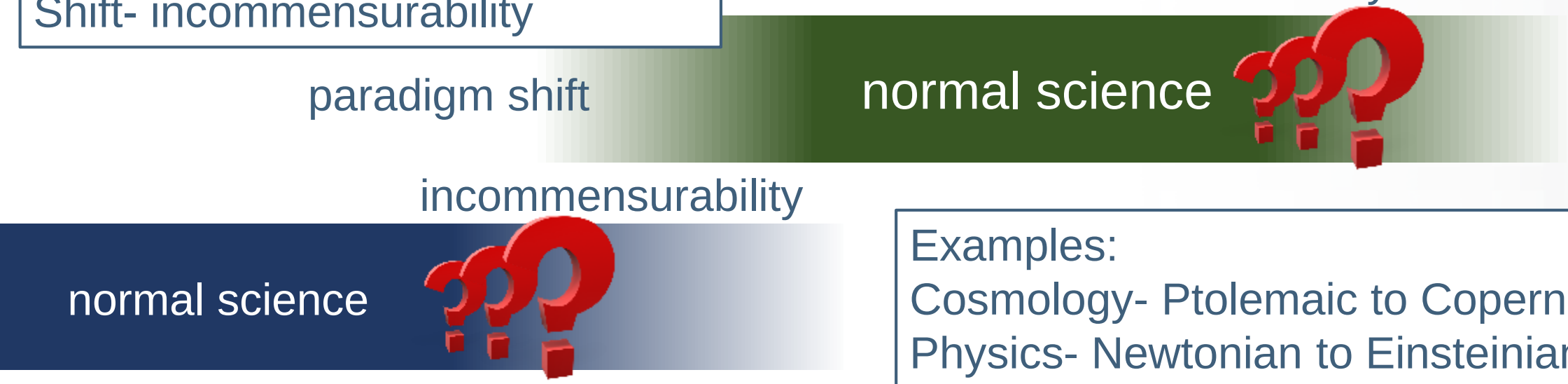
Science- Thomas Kuhn (Paradigm Shifts)

Paradigm
Contains assumptions & methods
Limits questions
Anomaly
Crisis
Shift- incommensurability

paradigm shift

normal science

incommensurability



paradigm shift

normal science

incommensurability

Anomaly Crisis

Examples:
Cosmology- Ptolemaic to Copernican
Physics- Newtonian to Einsteinian
Medicine- Germ theory

Science- Russell Ackoff (Successive Ages)

Nondeterministic
Feedback
Synthetic
Environment

Systems Age

Incommensurability

Deterministic
Cause/Effect
Reductionist
Analytic
Laboratory

Machine Age

Bertalanfy- *General Systems Theory*
Weiner- *Cybernetics*

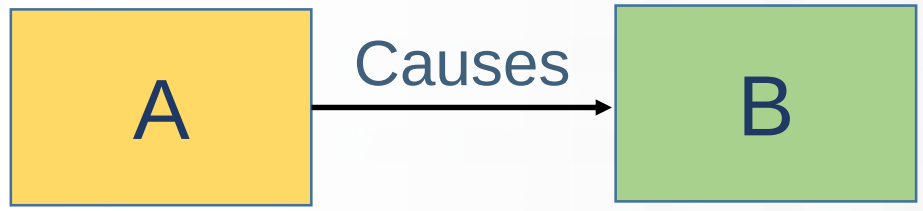
Dewey- *Quest for Certainty*
Heisenberg
Complexity

Systems Thinking

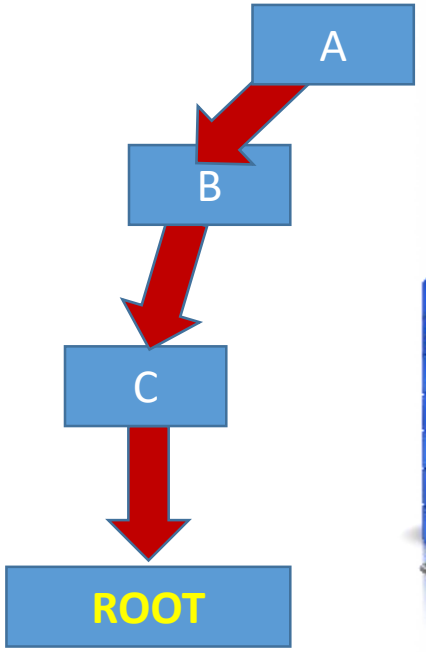
We’re caught betwixt and between

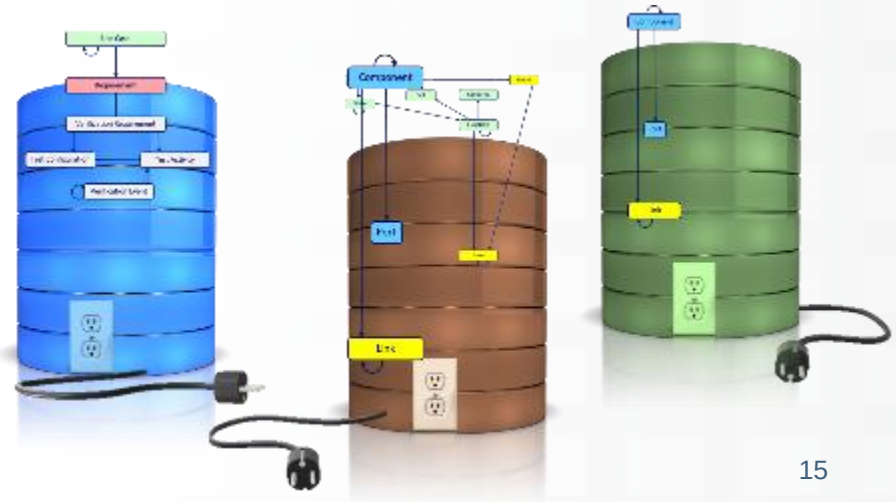
The evidence

- Language
  - Analysis = thinking
  - Root cause
  - Control theory
  - Interdisciplinary v. transdisciplinary
- Practice
  - Process over principle
  - Fragmentation/specialization
    - Requirements
    - Architecture
- Education and values
  - Specialization
  - Application over principles

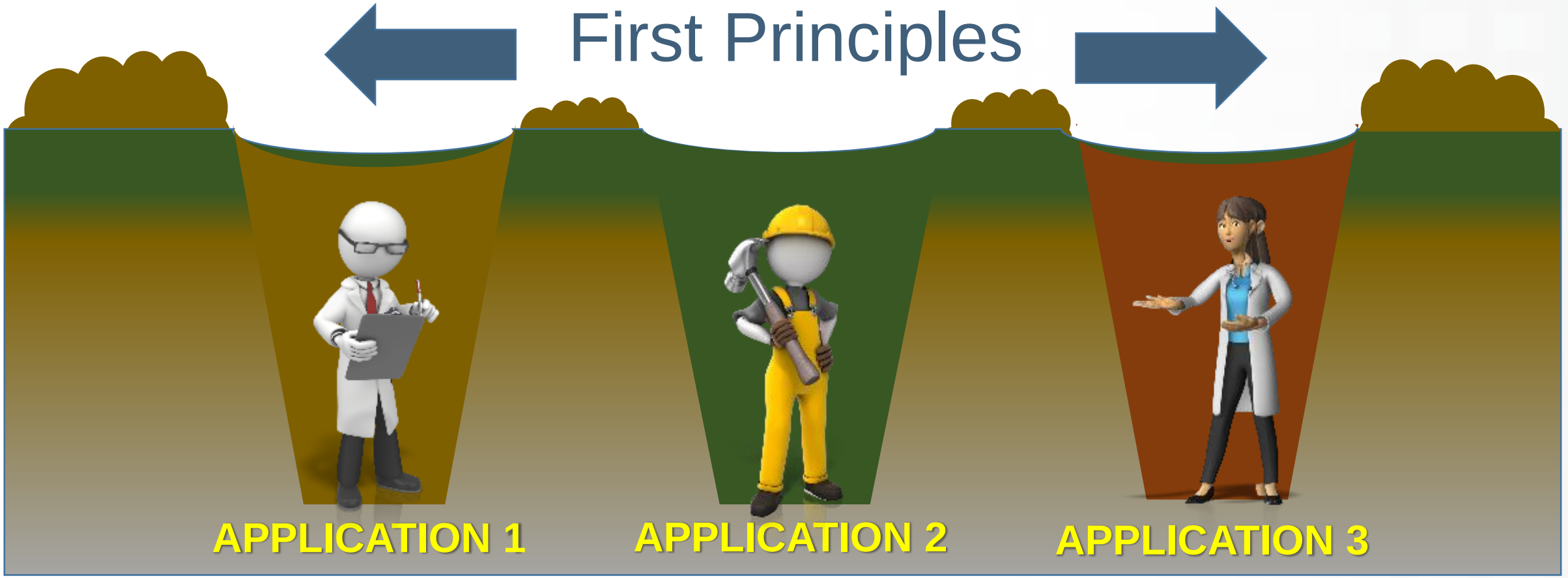


SE for . . .
Software
ECAD
MilAero
. . .





Symptom: Application v. First Principles



The key to freedom

Integration!

Integration! The key to the Systems Age

The systems view

. . . Thinking

. . . Practice

. . . Models

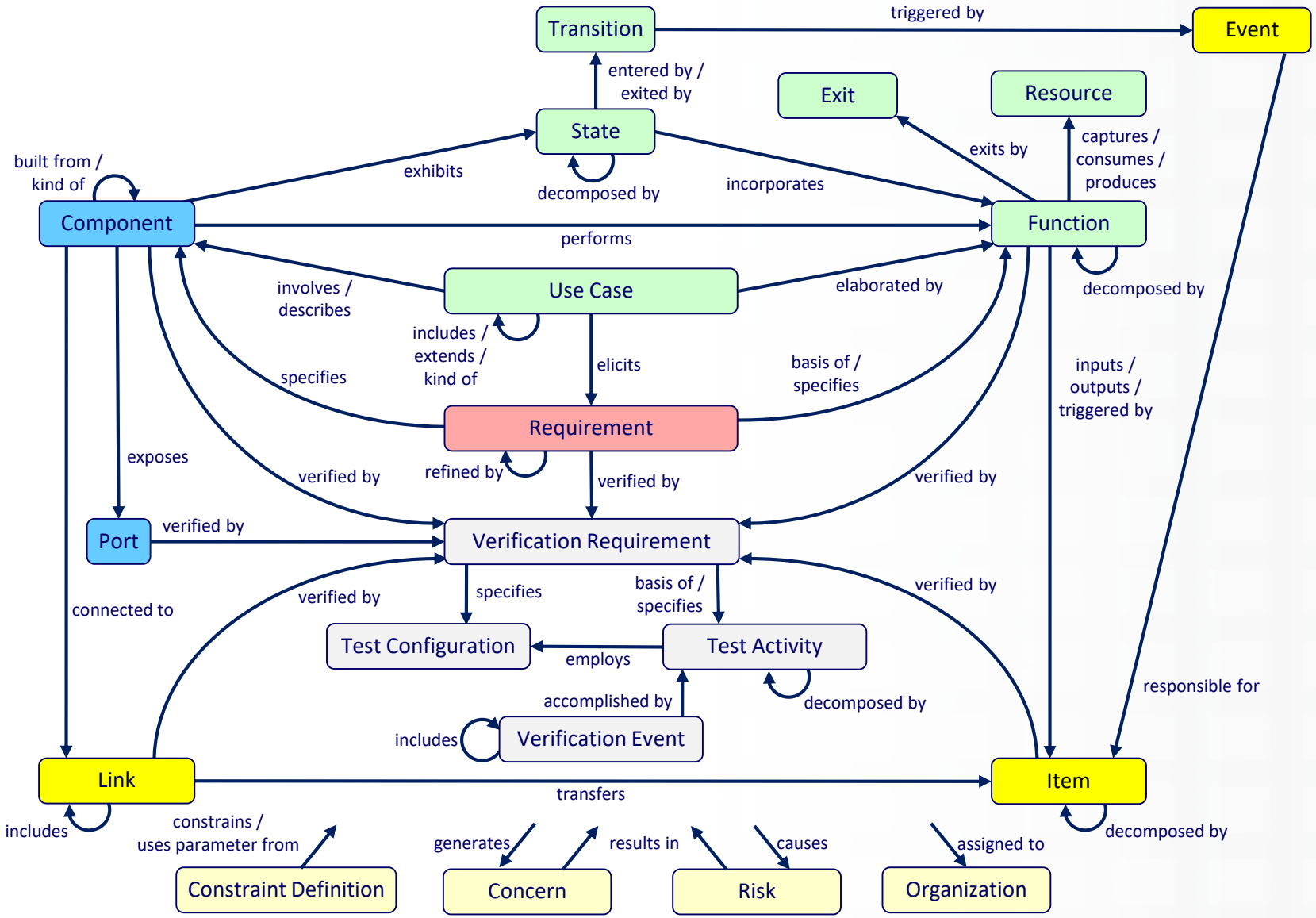
. . . Tools

Thinking in the systems view . . . The metamodel

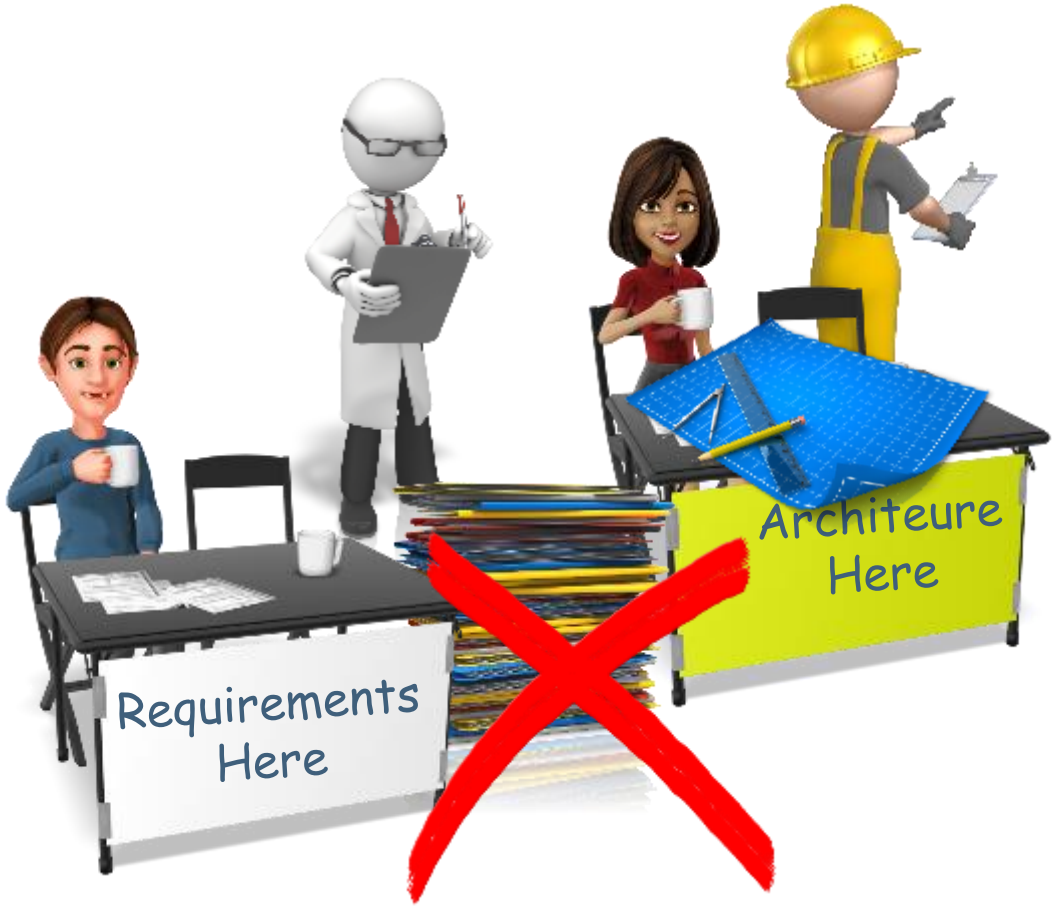
Serves as a framework for . . .

Thinking about systems

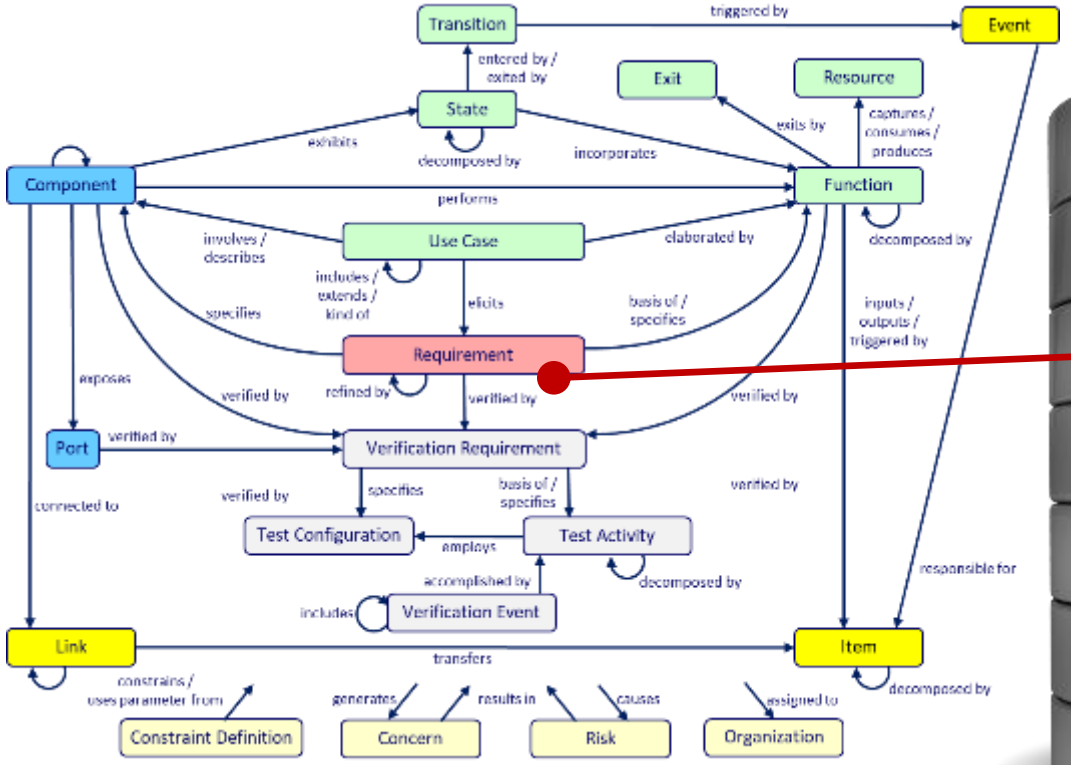
Database repository for models



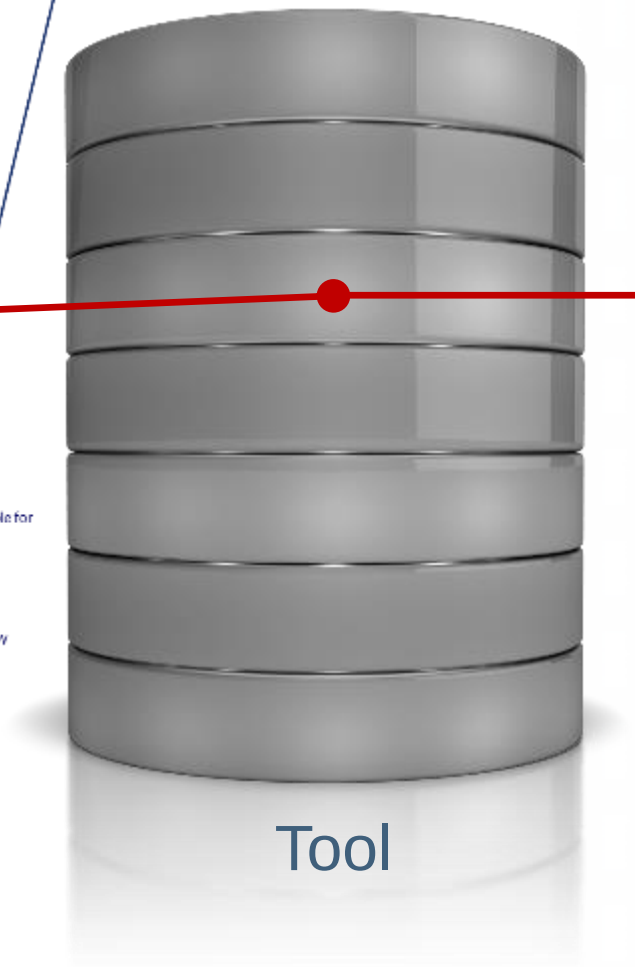
The systems view . . . practice



The systems view . . . models



Database

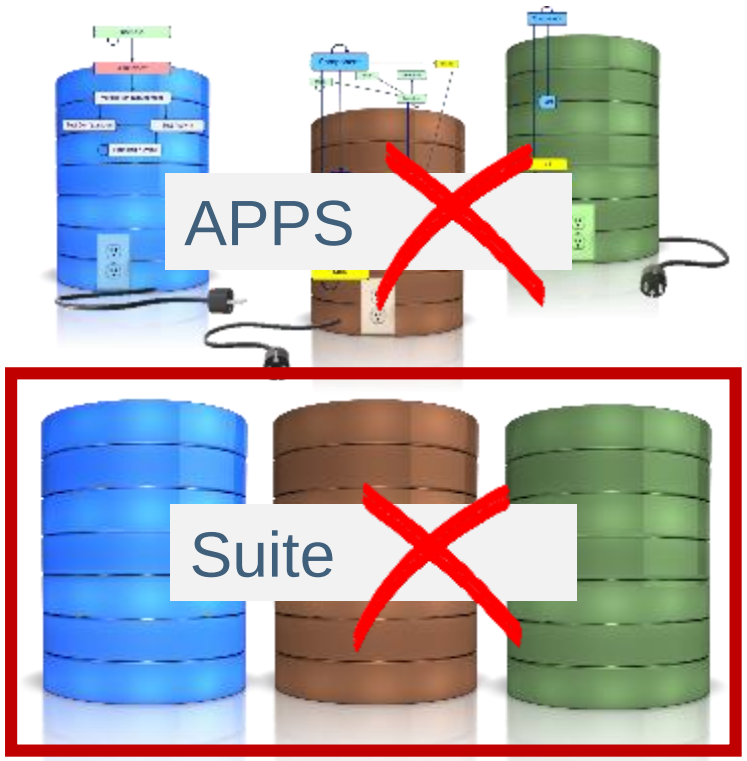


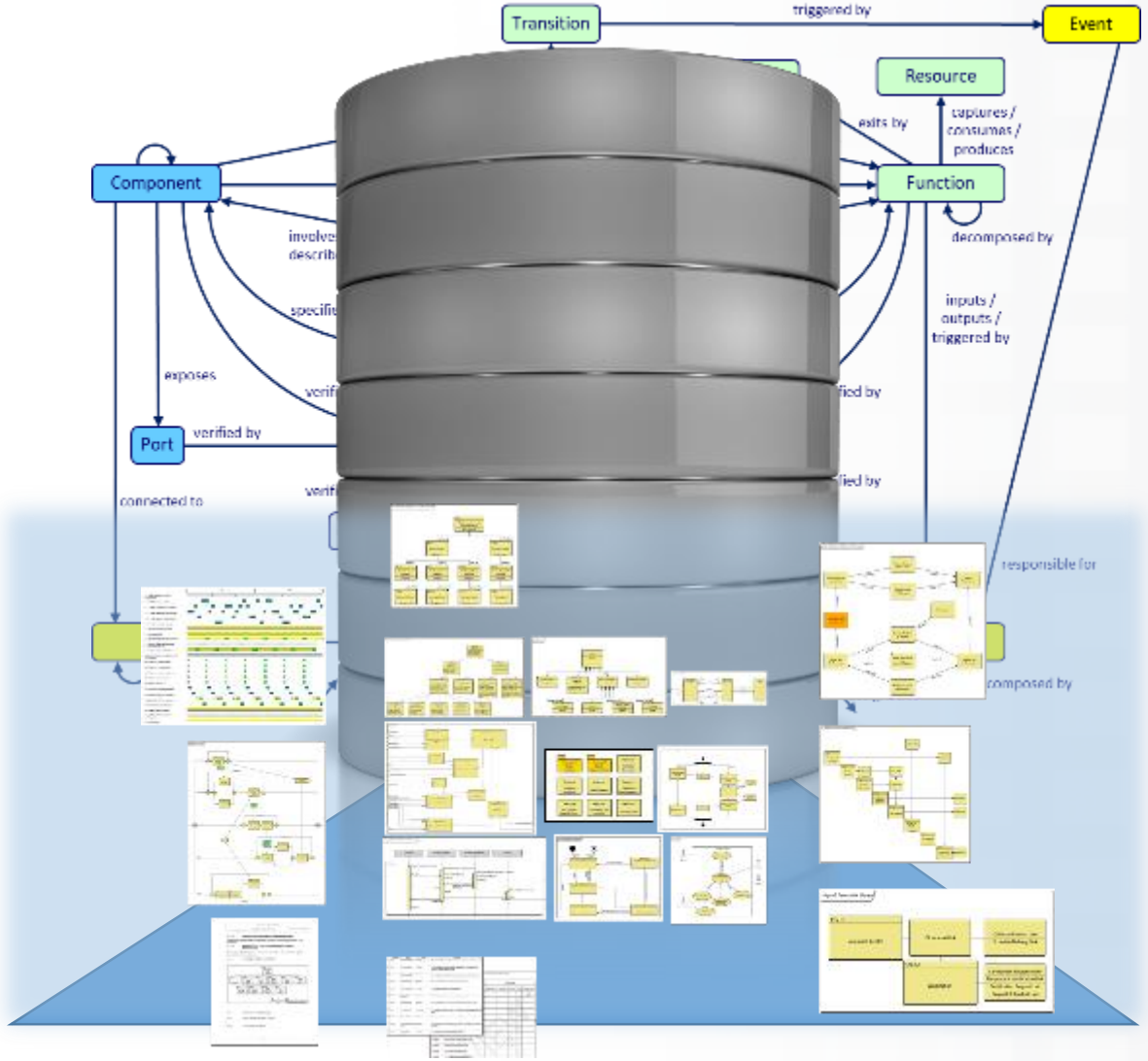
Tool

#	Description
2.1	The system shall accept information requests from certified customers.
2.1.1	The system shall accept information requests.
2.1.2	The system shall certify customers.

View

The systems view . . . tools



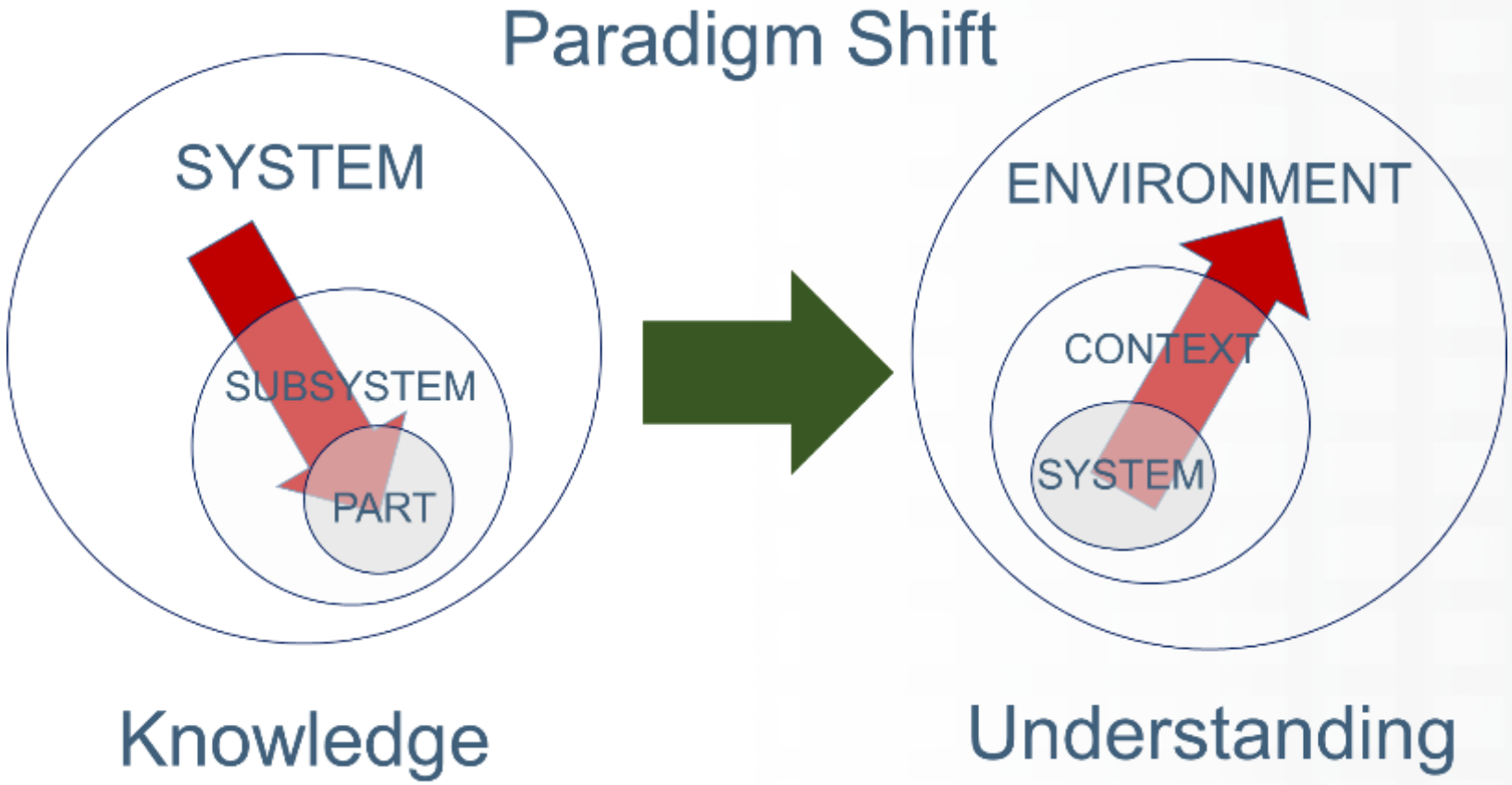


Systems Thinking

Why do we care?

Why do we care?

- Builds understanding and insight for solving problems



Why do we care?

- Allows us to make the systems engineering prediction
  - This solution will/will not satisfy the needs that drove its creation

SEE

Vitech

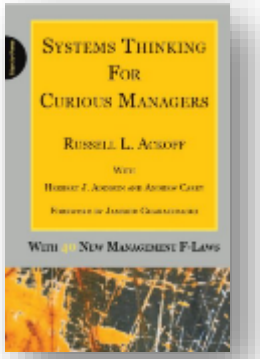
Why do we care?

- Allows us to transcend particular applications (first principles thinking)
  - Solve new kinds of problems
  - Solve multidisciplinary problems (e.g.- sociotechnical)

Systems Thinking

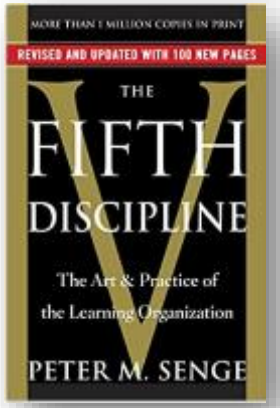
Resources

Books

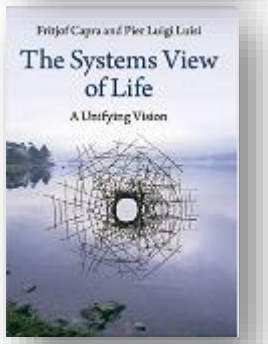


Systems Thinking for Curious Managers, Russell Ackoff 2010

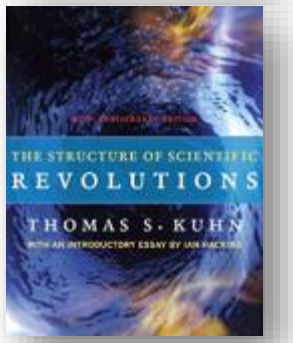
Systems Thinking. Applied., Robert Edson 2008



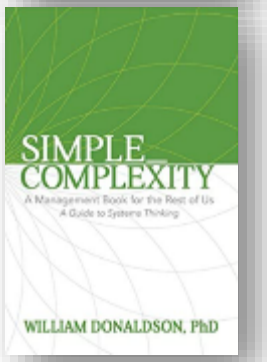
The Fifth Discipline (Rev Ed) Peter Senge 2006



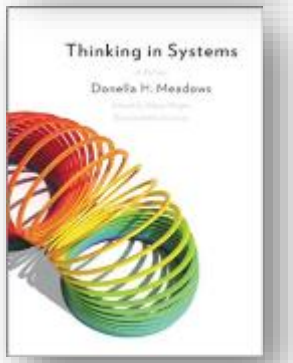
The Systems View of Life, Fritjof Capra 2014



The Structure of Scientific Revolutions., Thomas Kuhn 1962



Simple Complexity, William Donaldson



Thinking in Systems, Donella Meadows 2008

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Videos

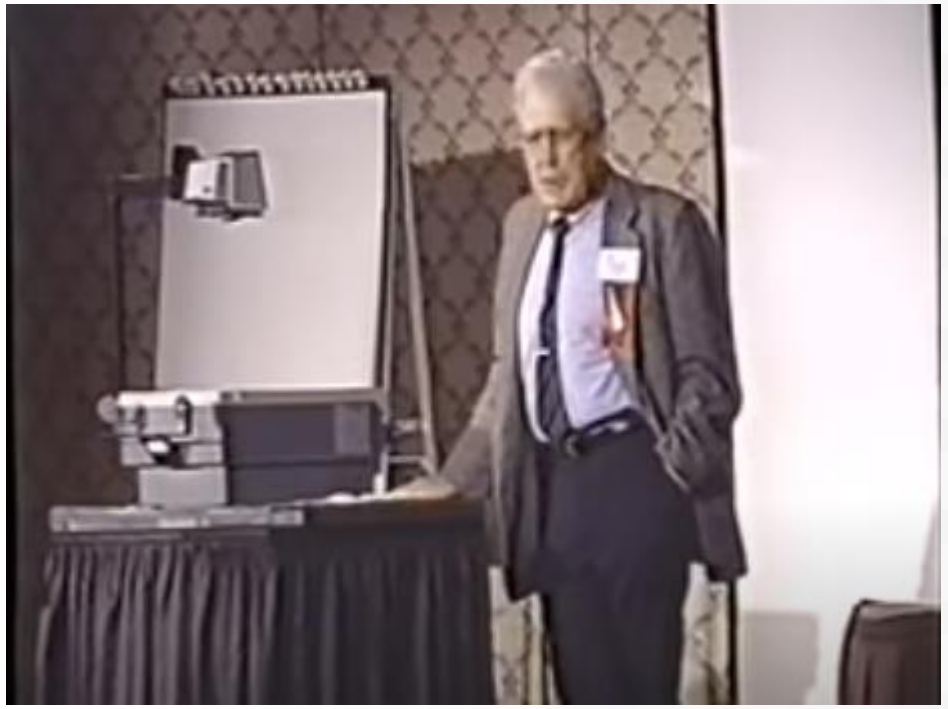
https://www.youtube.com/watch?v=Uec1CX-6A38

Mindwalk

Bernt Capra

Sam Waterston, Liv Ulmann, John Heard

1990



https://www.youtube.com/watch?v=yGN5DBpW93g

From Mechanistic to Systemic Thinking

Russell Ackoff

1993

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Thank You!

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