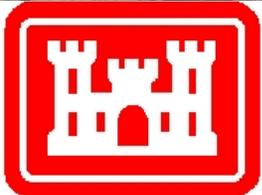


Ecological Modeling: Principles to Build and Integrate Capability

***Pat Deliman
Dave Richards
Steve Ashby
John Nestler***



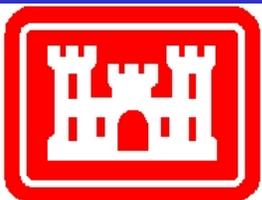
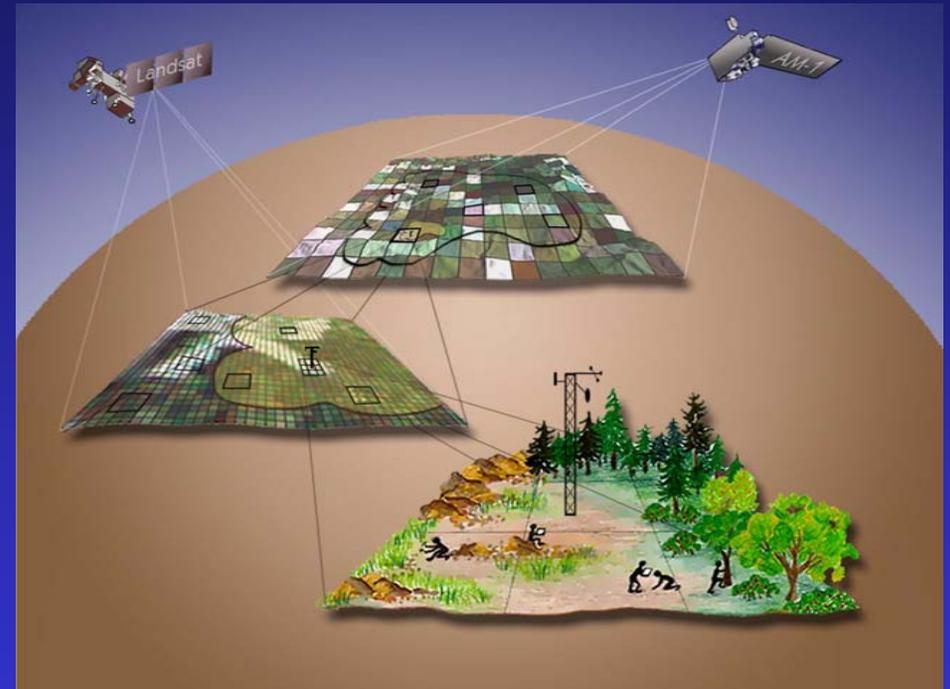
Tearing Down Walls, Building Bridges



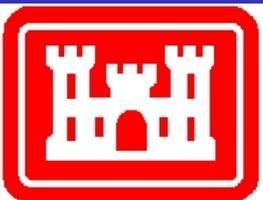
Building an Integrated Ecological Modeling Vision: But, Scientifically Why Should I Care?

Imagine if we could...

- Predict when & where nutrients & sediments would be transported to our nation's waters
- Forecast when pathogens will enter our water supplies & beaches
- Provide warning of water quality & quantity during extreme events (floods, hurricanes, droughts, water supplies, levees, infrastructure)

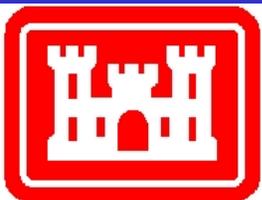
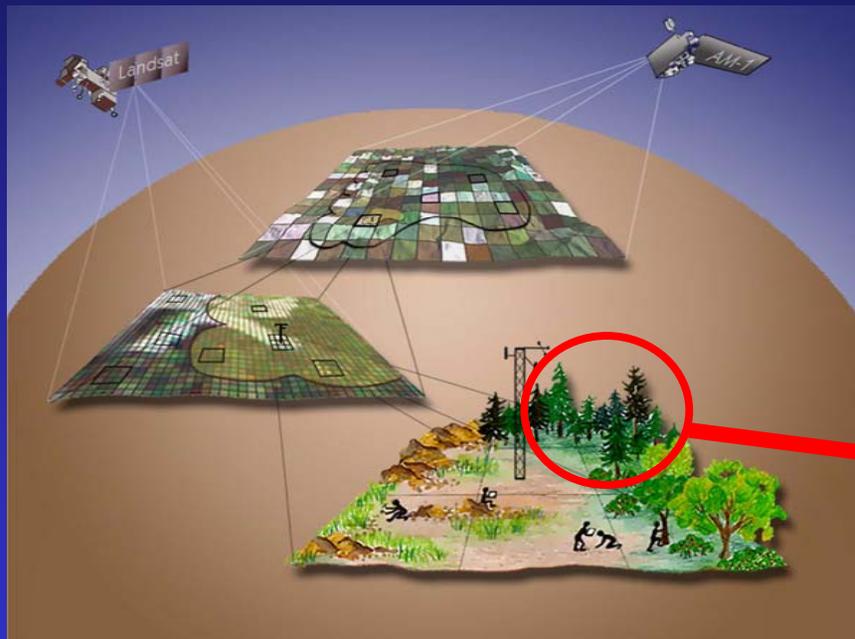


Tearing Down Walls, Building Bridges



NSF Blue-Ribbon Panel on Cyberinfrastructure (2003):

“new age has dawned in scientific / engineering research pushed by continuing progress in computing, information, & communication technology, & pulled by expanding complexity, scope, & scale of today’s challenges. The capacity of this technology has crossed thresholds that now make possible a comprehensive “cyber-infrastructure” on which to build new types of scientific & engineering knowledge environments & organizations to pursue research in new ways & with increased efficiency.”



Tearing Down Walls, Building Bridges



Guiding Principles From NSF!

Institutionally, Why Should I Care?

The CW Mission of CE!

The logo for CLEANER, featuring a stylized mountain range above the word "CLEANER" in a bold, sans-serif font.

Collaborative Large-scale Engineering Analysis Network
for Environmental Research

The logo for neon, featuring the word "neon" in a green, lowercase, sans-serif font, with a stylized green and yellow molecular structure inside the letter "o".

CLEANER VISION STATEMENT

CLEANER is envisioned to be a collaborative Engineering Analysis Network, using high performance tools & Infrastructure, to transform our scientific understanding of environmental change in Human Dominated Environmental Systems

The Big Q - How do We Fit into the Universe?

What is Our Role / Future?



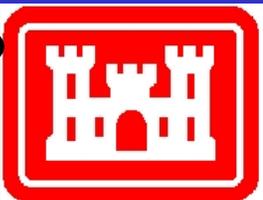
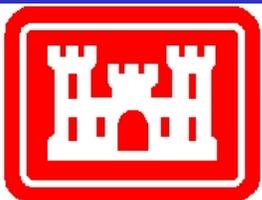
Which Model?



What are the cosmic forces that affect & bind us?

How do we become part of the cosmos?

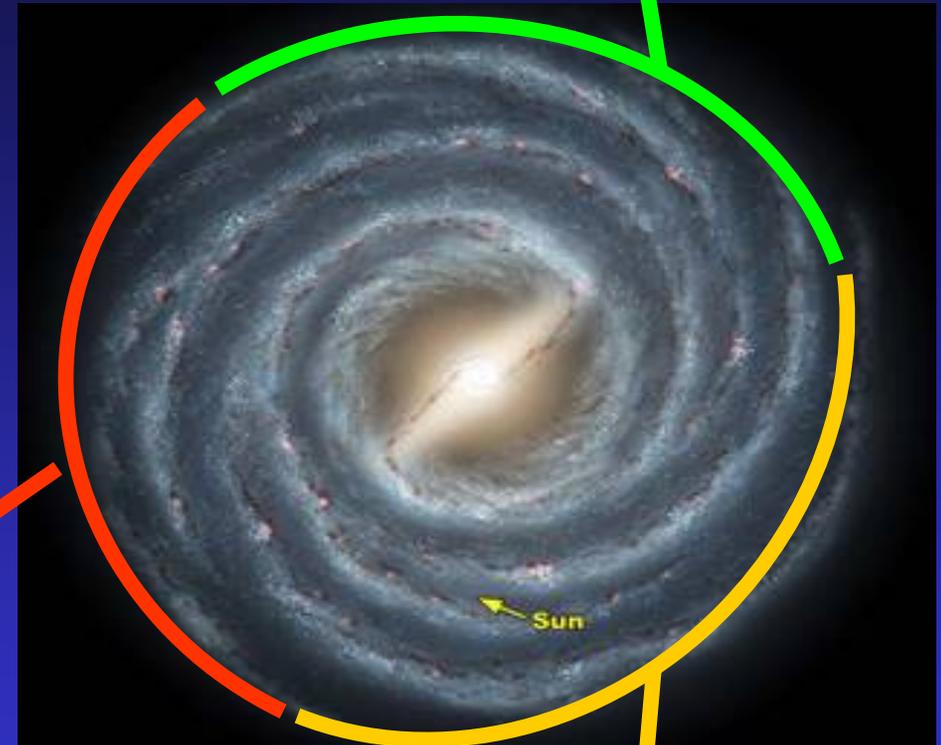
Tearing Down Walls, Building Bridges



Background on Corporate / Program Structures

- Structure splits to a functional level – e.g., thrust areas → focus areas → **WUs** or labs → divisions → branches → **teams**
- Synergistic binding principles at each level maintain cohesiveness & integrity (or a cat herd ensues)
- Binding principles come in 3 flavors:

I/O standards / GUIs / pre- & post-processors

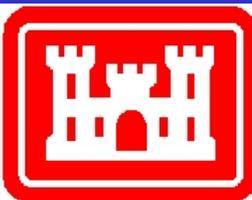
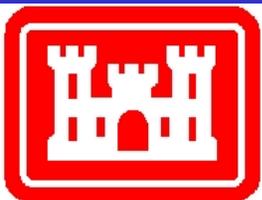


Scale and time / space conventions

\$64K Q = How do we develop an eco-modeling vision that weaves together and structures EL eco-modeling capability?

How customers address issues

Tearing Down Walls, Building Bridges



Why Eco-Modeling is Important to CE

USACE Environmental Operating Principles



- Strive to Achieve Environmental Sustainability.** An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.
- Consider Environmental Consequences.** Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
- Seek Balance and Synergy** among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
- Accept Responsibility.** Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
- Mitigate Impacts.** Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.
- Understand the Environment.** Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.
- Respect Other Views.** Respect views of individuals and groups interested in Corps activities, actively listen, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems, solutions that also protect and enhance the environment.

**Leadership Issue
for ERDC!**
**Chief calls - "Can
you perform eco-
modeling to
support checked
boxes?"**
What do you say?
**The answer
requires corporate
consensus.**
**Team-specific
answers
unacceptable.**

Tearing Down Walls, Building Bridges



Examples Follow, but First Premises About Scientific Integration

- **Fundamental concepts of a discipline are in its mathematical models**
- **All ecological models explore & forecast the same reality**
- **Fundamental relationships must exist among models (& the science that supports them) – they do not exist in isolation from each other**
- **Relationships guide understanding & integration of models & science into a greater corporate framework**
- **ID principles that bind & integrate our models (science) together instead of differences that separate them**
- **Principles - keys to corporate mission, identity, vision, & passion**
- **Without them - we corporately die a lingering death**
- **What are they?**



Tearing Down Walls, Building Bridges



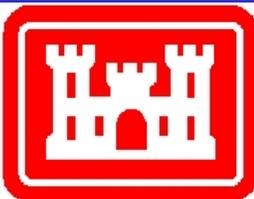
Importance of First Principles in Eco-Modeling

➤ **“....in seeking regularity and focusing on the most salient features in their environment, in order to endure and thrive, animals have empirically discovered the laws of nature.”**

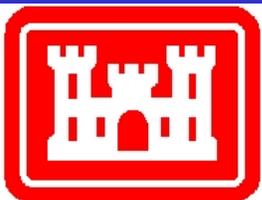
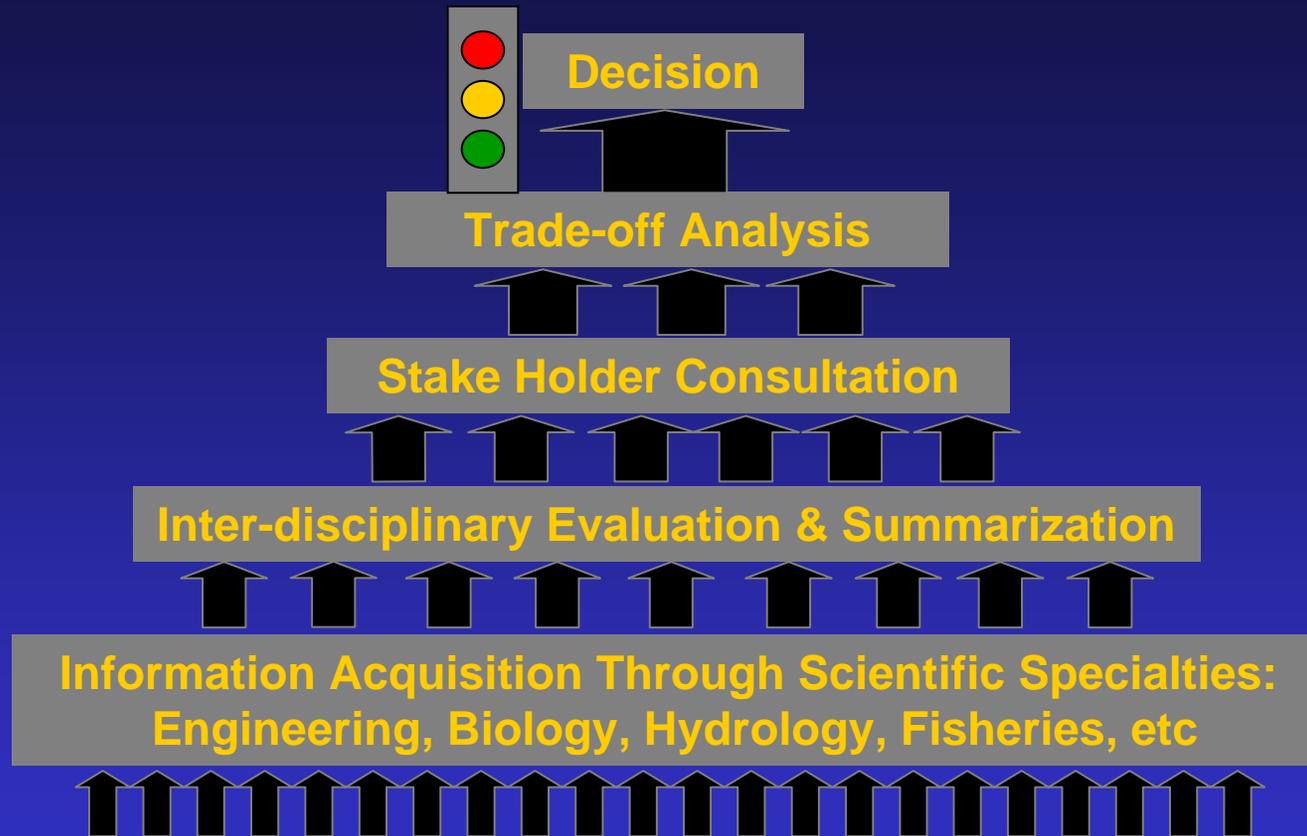
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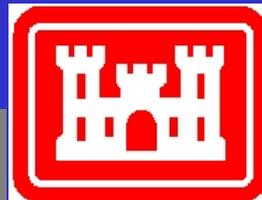
Tearing Down Walls, Building Bridges



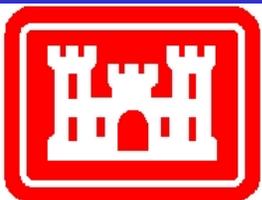
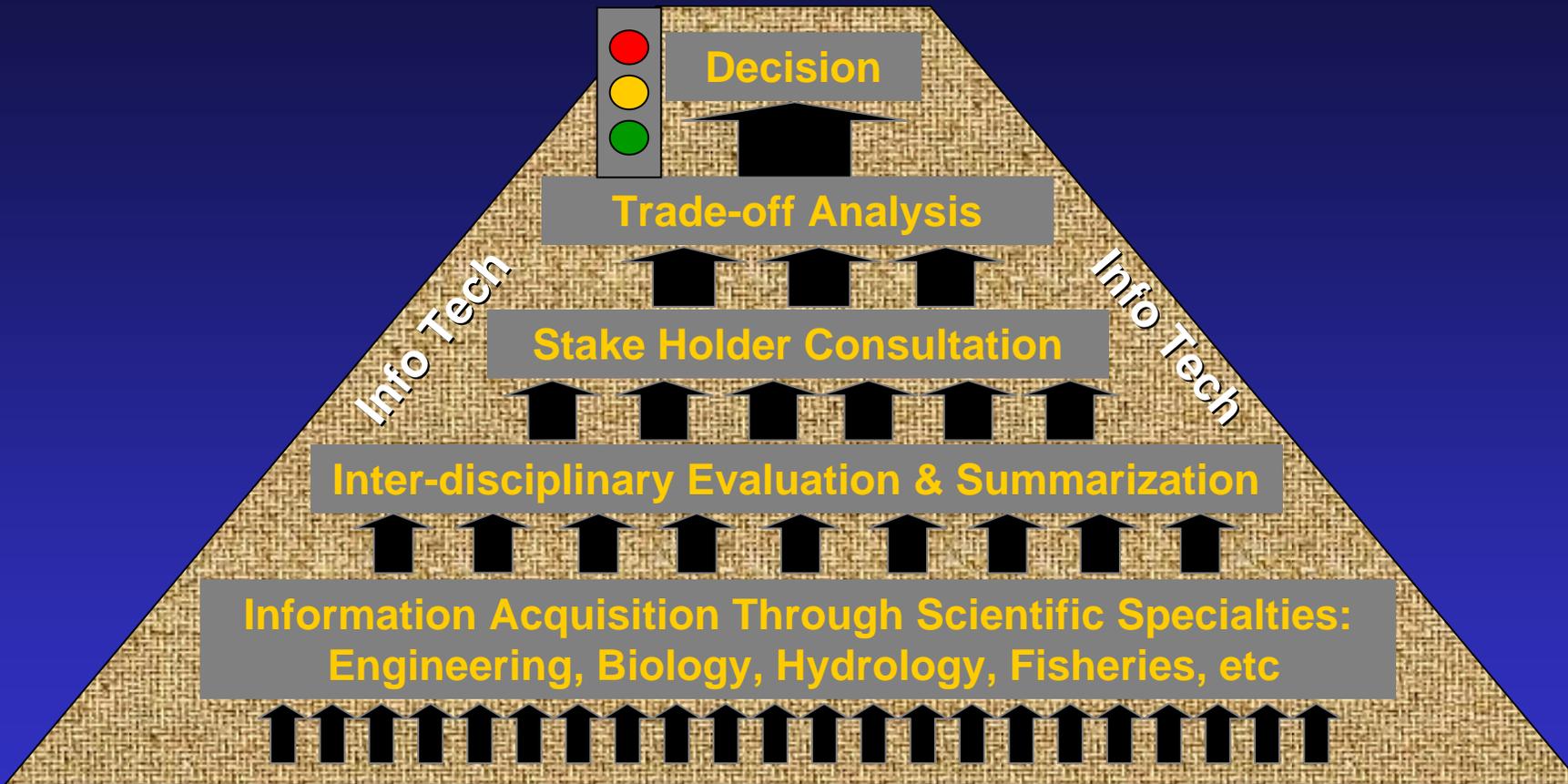
e.g., Framework Integrating DSS / IT / Science



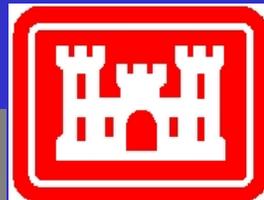
Tearing Down Walls, Building Bridges



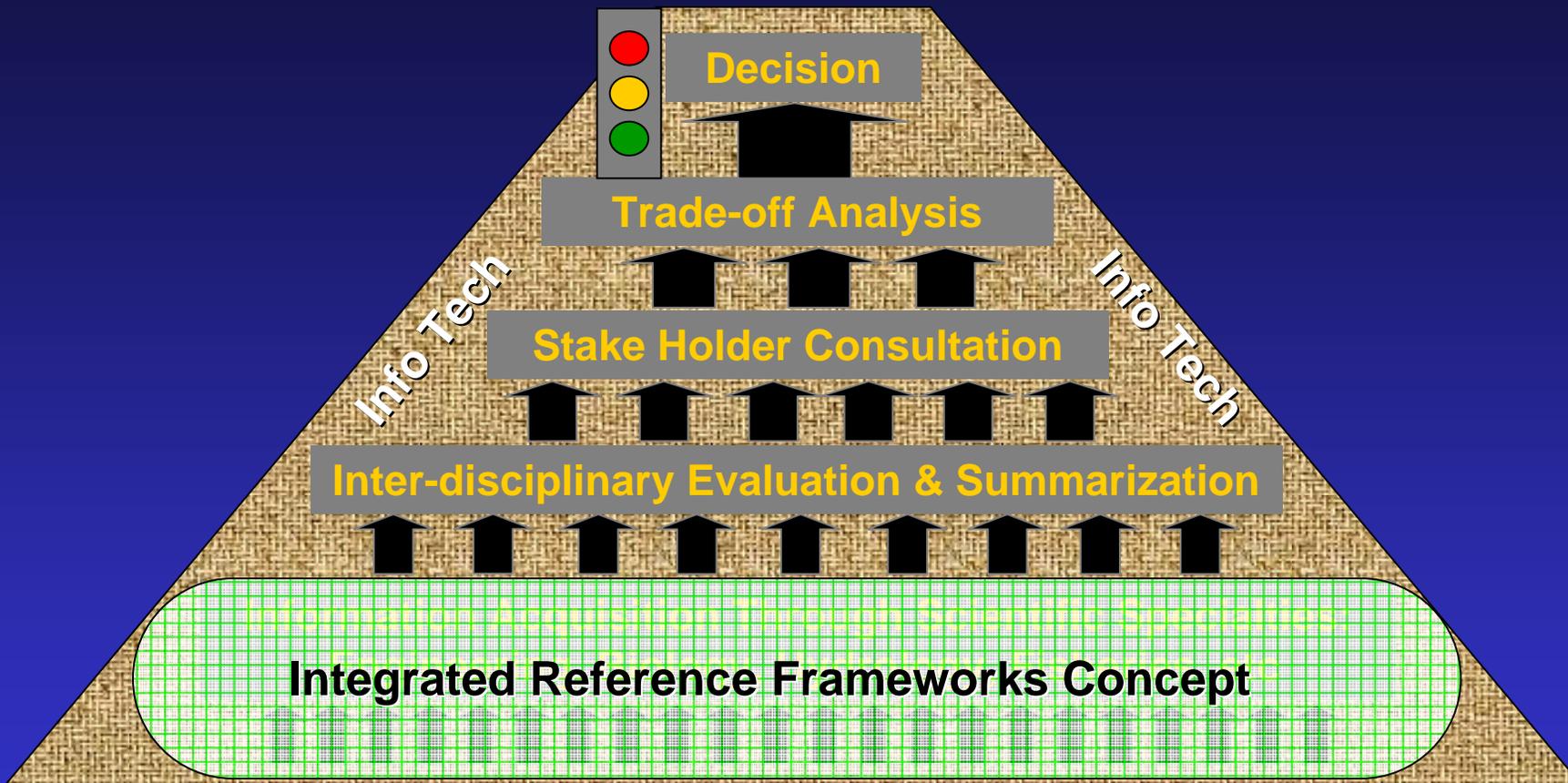
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Tearing Down Walls, Building Bridges



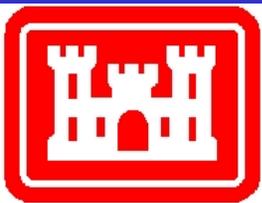
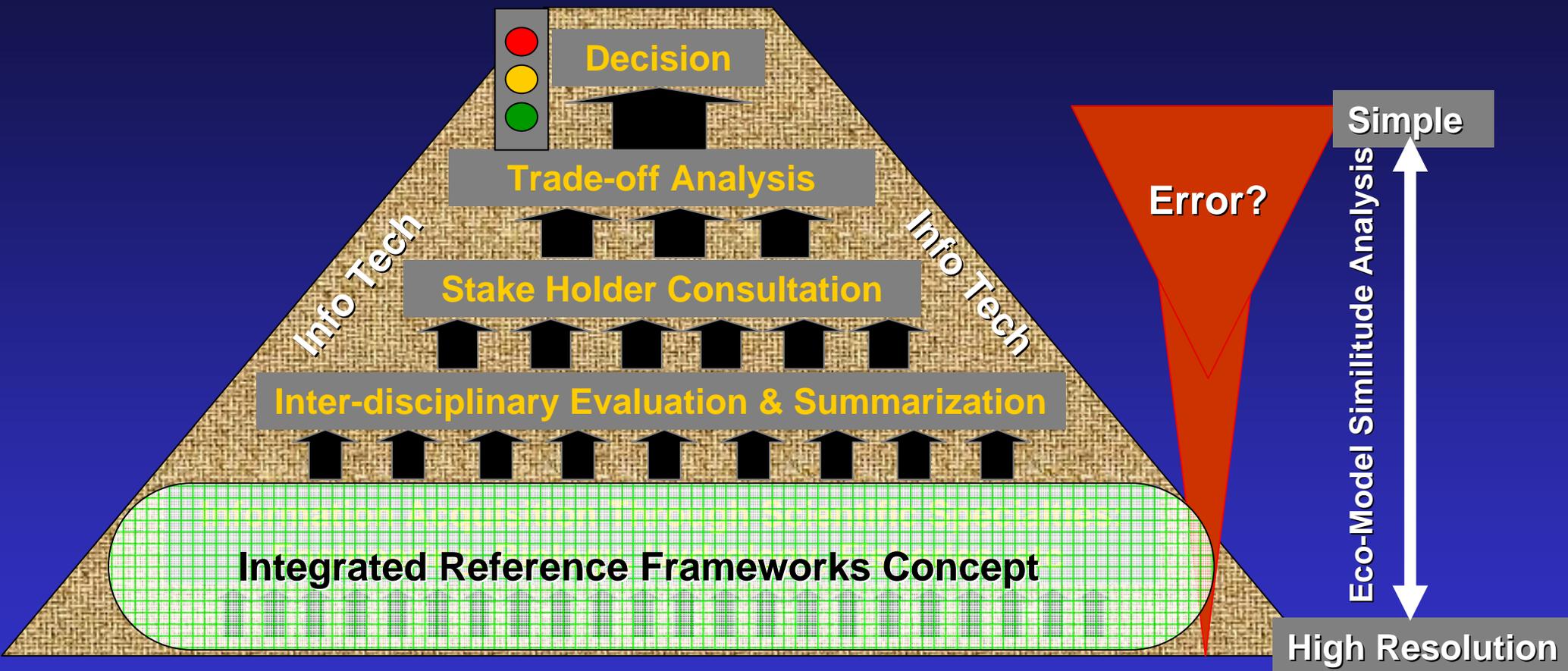
e.g., Framework Integrating DSS / IT / Science



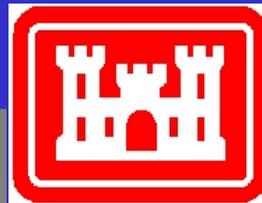
Tearing Down Walls, Building Bridges



e.g., Framework Integrating DSS / IT / Science



Tearing Down Walls, Building Bridges



Integrating Concept 1: Eco-Modeling Similitude Analysis

Eco-models can vary in complexity – e.g.,

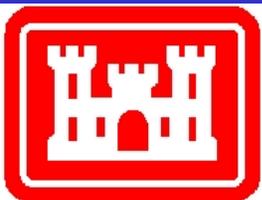
- governing equations vs indices,
- Spatially & temporally explicit vs lumped or implicit,
- multi parameter vs few parameters

Integrating concept - ENGINEERING SIMILITUDE ANALYSIS - Optimize cost & answer quality using divergence analysis among physical models that differ in scaling.

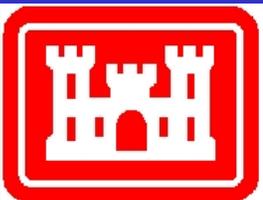
Eco-analog: error spike as time & space scales, number of parameters & state variables, & dimensionality are progressively coarsened / reduced. Formulation prior to divergence optimizes cost & answer quality.

NO SINGLE RIGHT ANSWER - DUAL-TRACK, SUPPLEMENTAL MODELS

- Track one = “tight” couple between physico-chemico change & eco-response
- Track two = simple eco-model for long time-frames & large systems

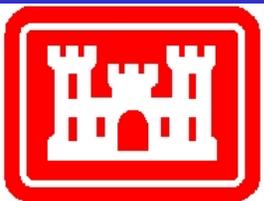


Tearing Down Walls, Building Bridges

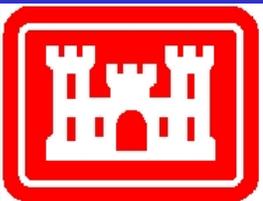


Integrating Concept 2

Integrated Reference Frameworks Concept



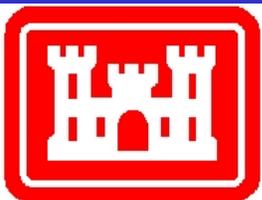
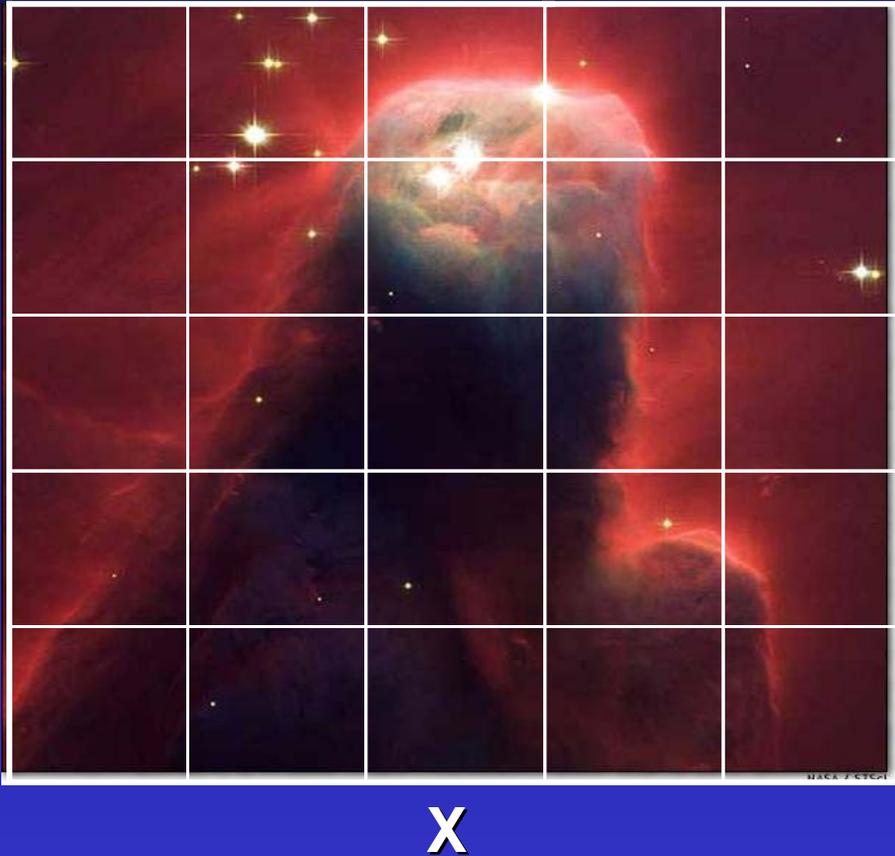
Tearing Down Walls, Building Bridges



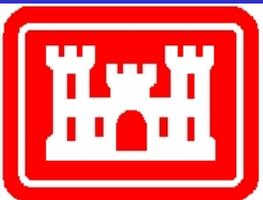
Integrating Concept 2

Integrated Reference Frameworks Concept

- Discretize it (Eulerian)
 - Interstellar dust
 - Hydraulic routing
 - Water Quality



Tearing Down Walls, Building Bridges

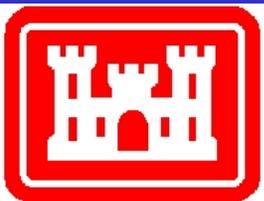
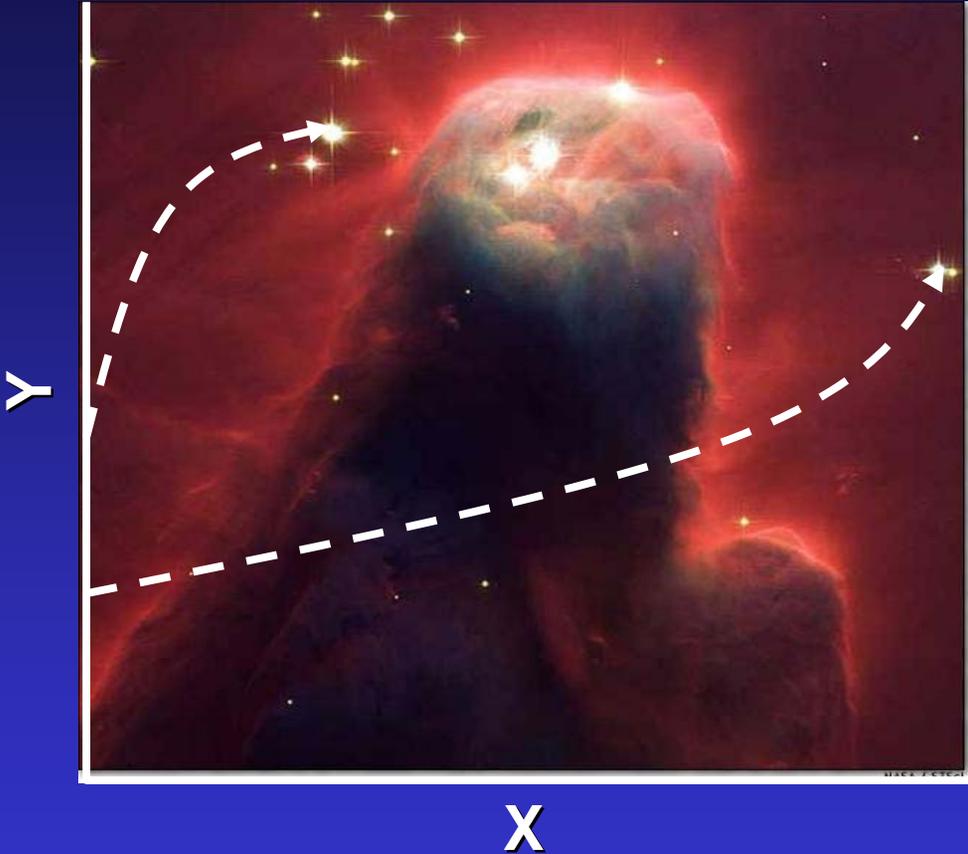


Integrating Concept 2

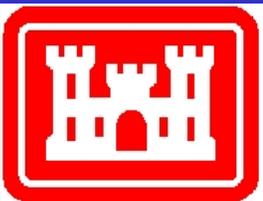
Integrated Reference Frameworks Concept

- Track it (Lagrangian)

- Stars
- Gravel
- Fish eggs

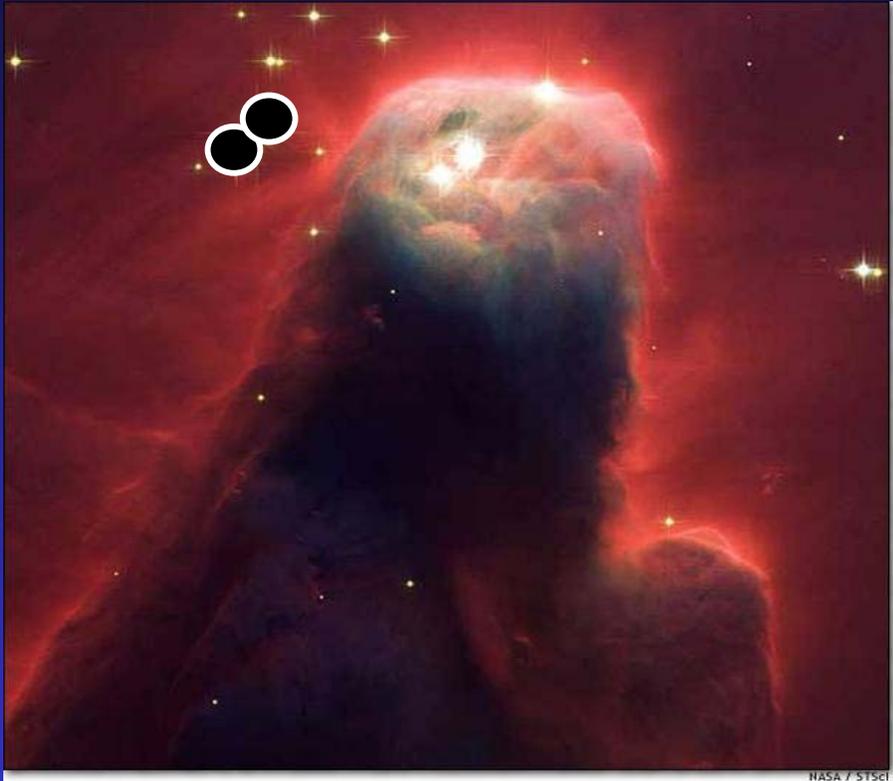


Tearing Down Walls, Building Bridges

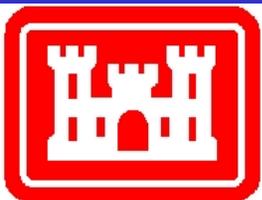


Integrating Concept 2

Integrated Reference Frameworks Concept



- **Center it (Agent)**
 - Black holes (event horizons)
 - Fish
 - Grizzly bears

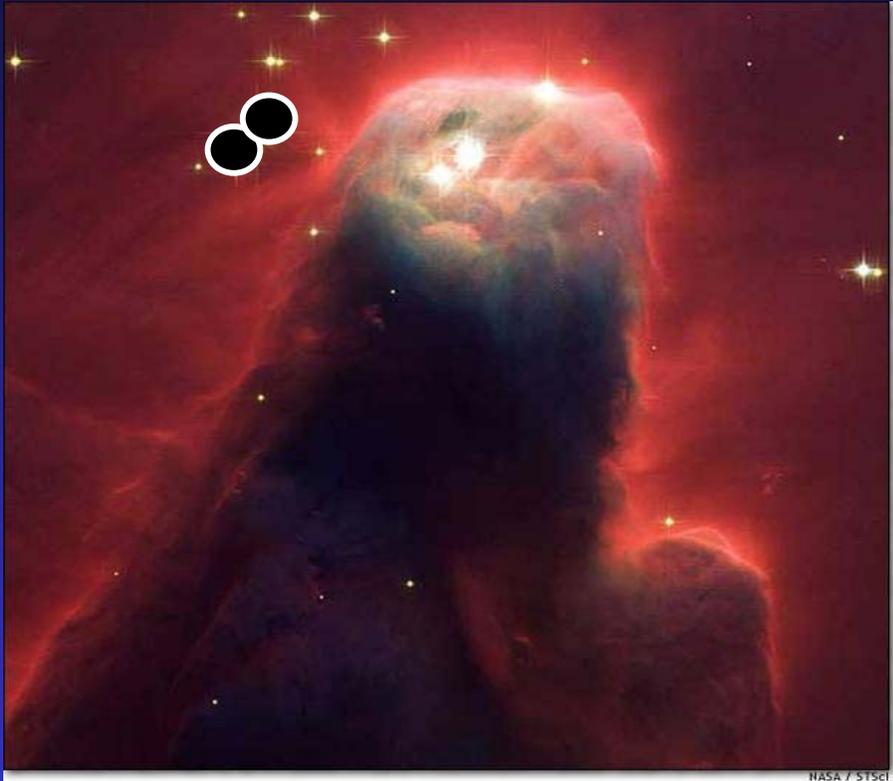


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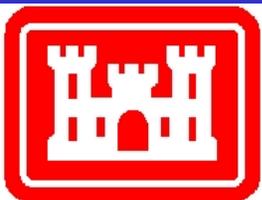
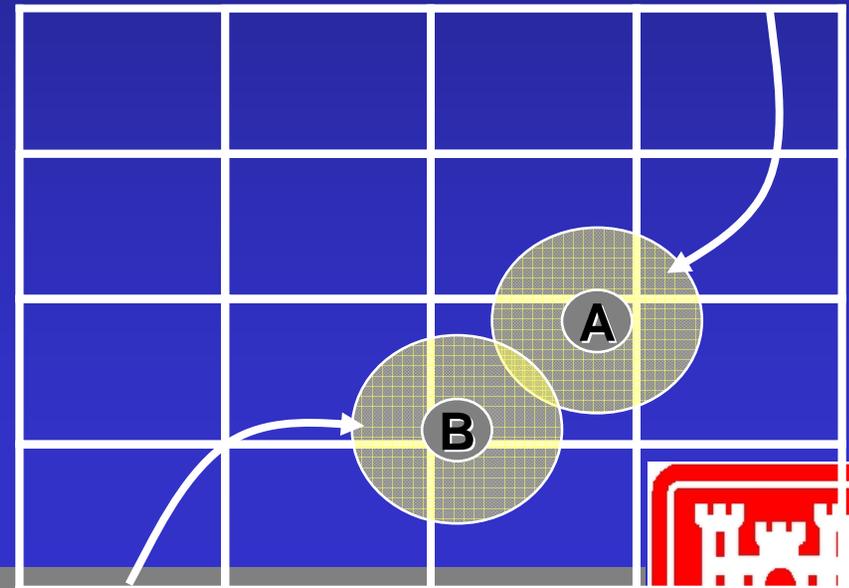
Integrating Concept 2

Integrated Reference Frameworks Concept

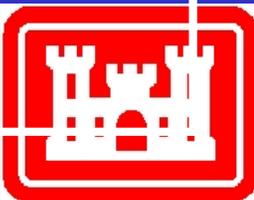


- Center it (Agent)
 - Black holes (event horizons)
 - Fish
 - Grizzly bears

Complete system description requires all three frameworks. Hence: Eulerian-Lagrangian-Agent Method

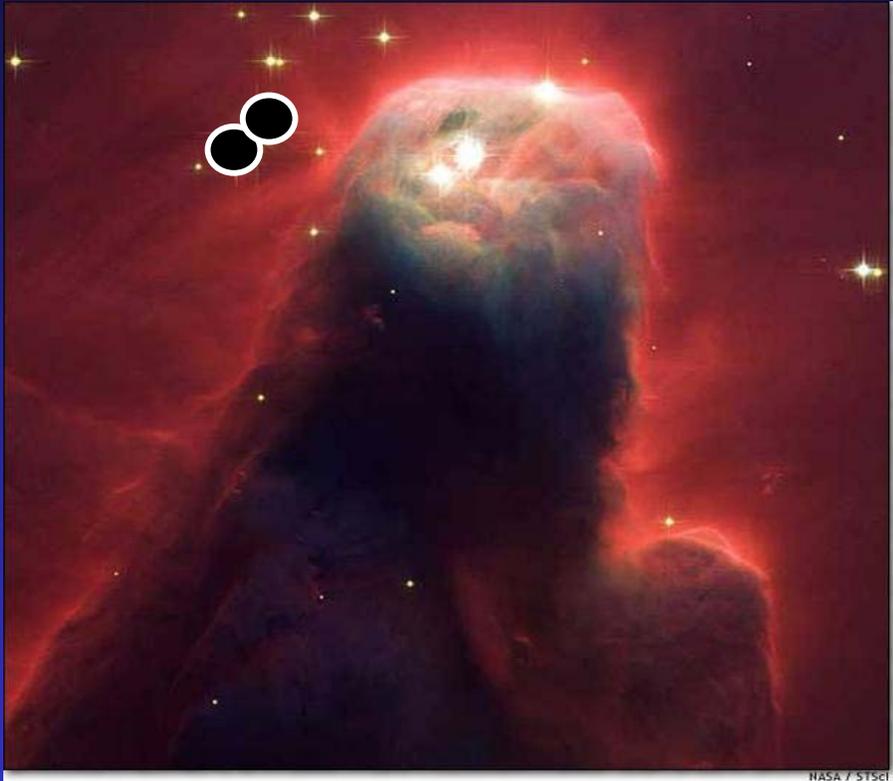


Tearing Down Walls, Building Bridges



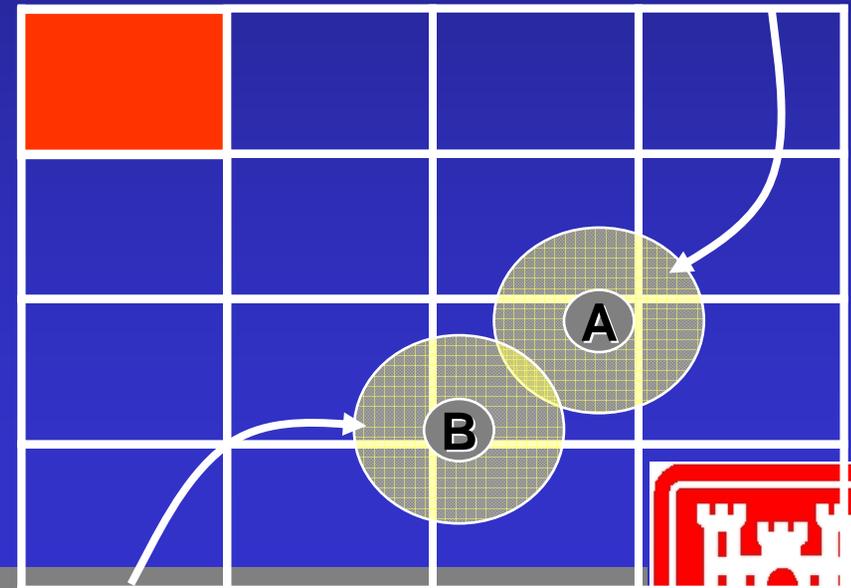
Integrating Concept 2

Integrated Reference Frameworks Concept



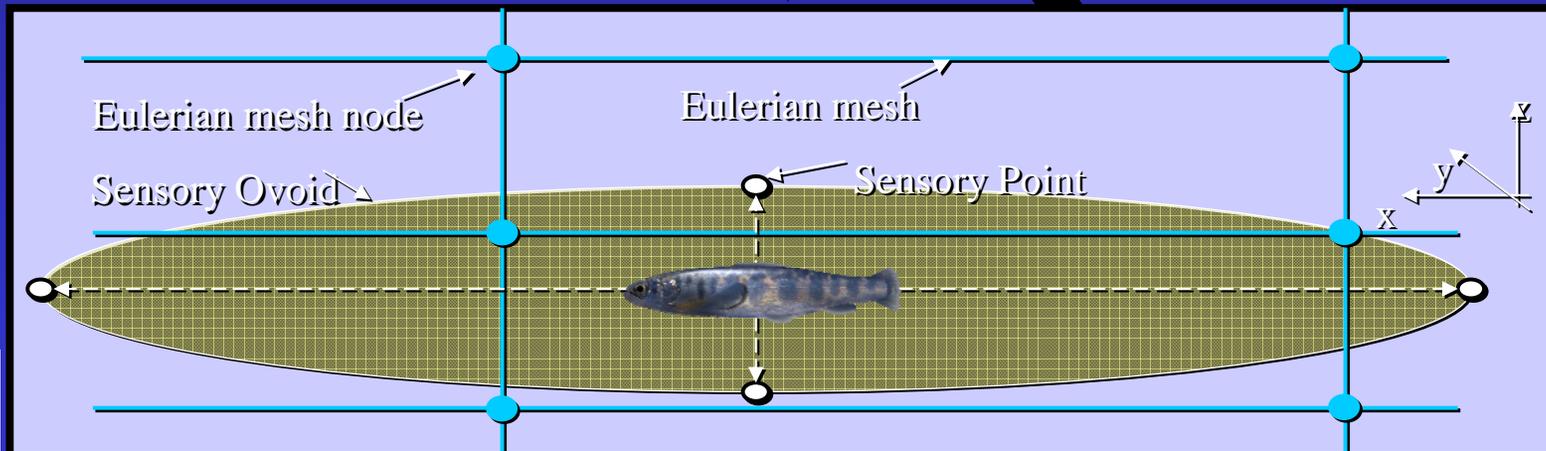
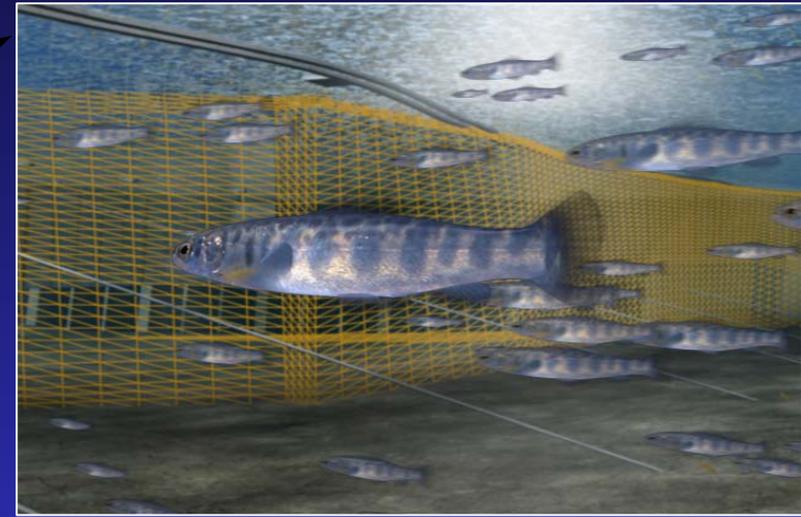
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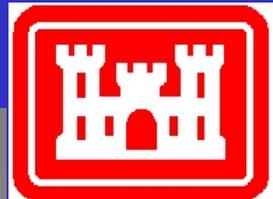
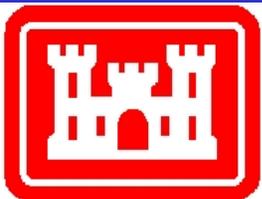


Tearing Down Walls, Building Bridges

Example IRFC: The Numerical Fish Surrogate



Tearing Down Walls, Building Bridges



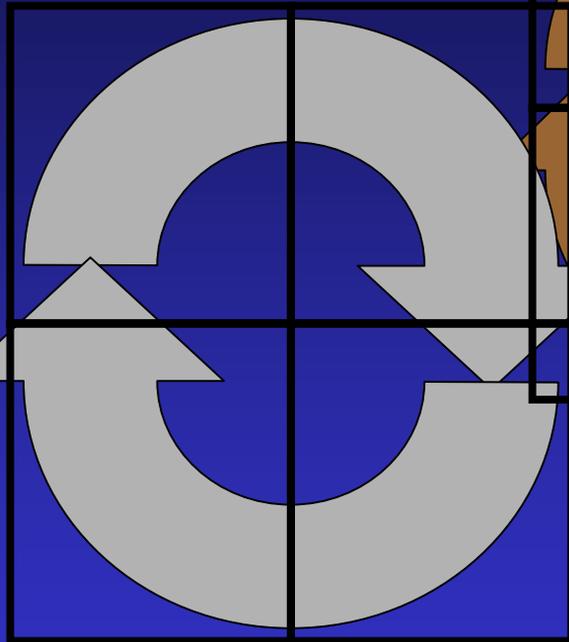
Using Integrating Concepts 1 & 2

Large

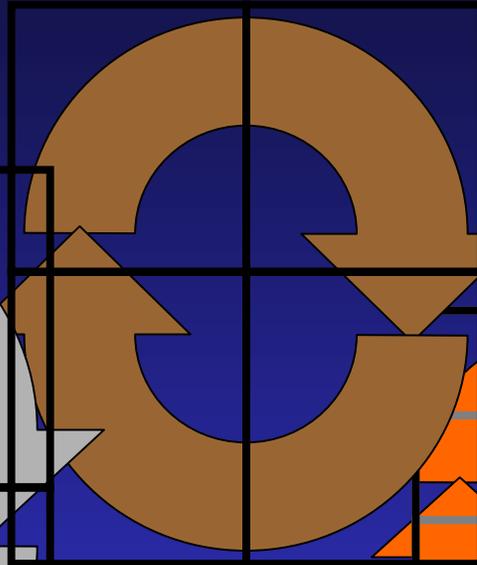
Relative Process Scale

Small

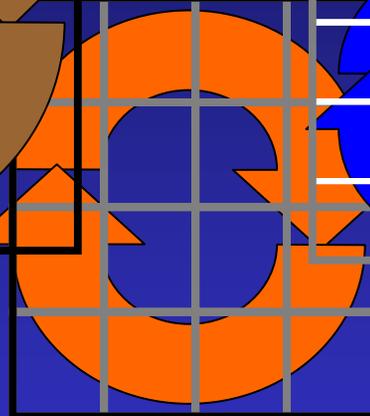
Population
Dynamics



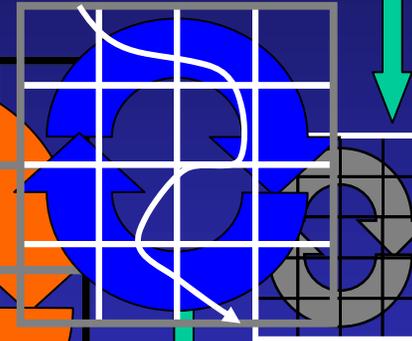
Trophic
Interactions



Water
Quality



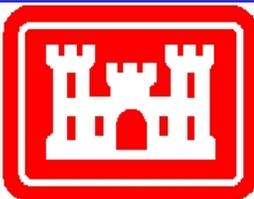
Behavior



Hydraulics



Tearing Down Walls, Building Bridges



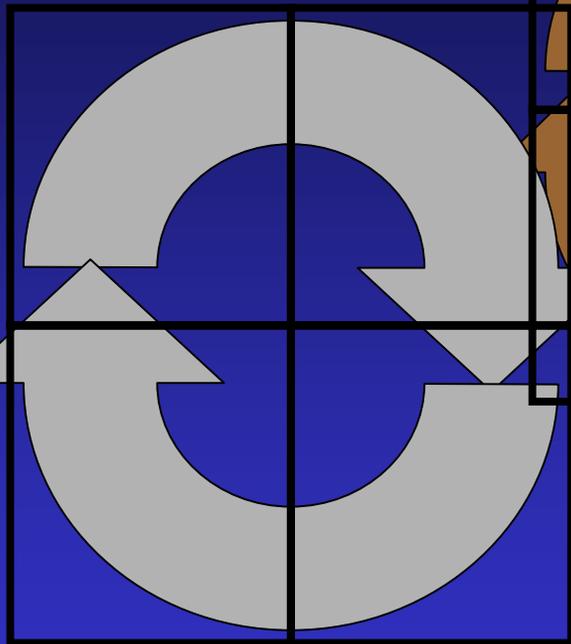
Using Integrating Concepts 1 & 2

Large

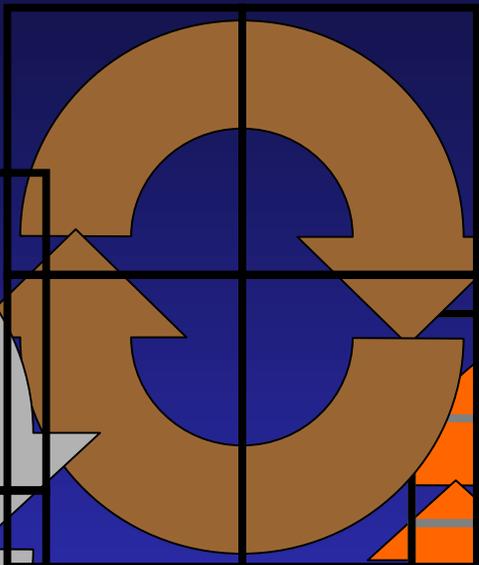
Relative Process Scale

Small

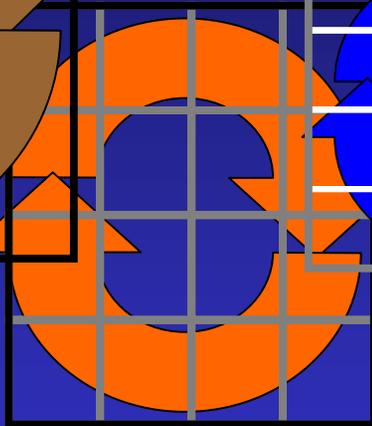
Population Dynamics



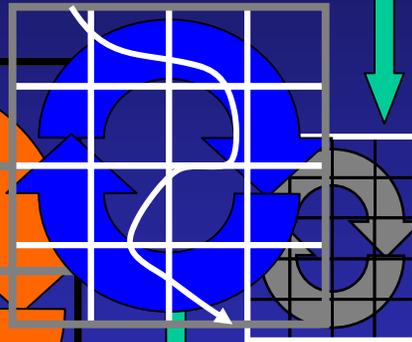
Trophic Interactions



Water Quality



Behavior



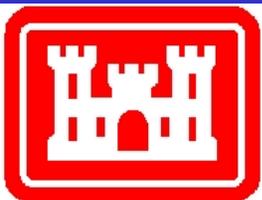
Hydraulics



Complex

Complexity

Simple



Tearing Down Walls, Building Bridges



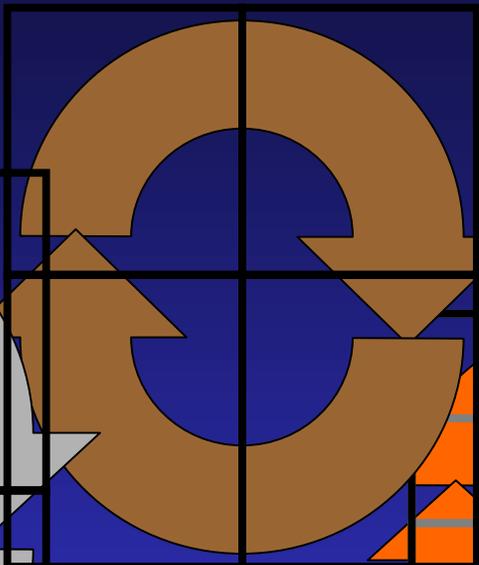
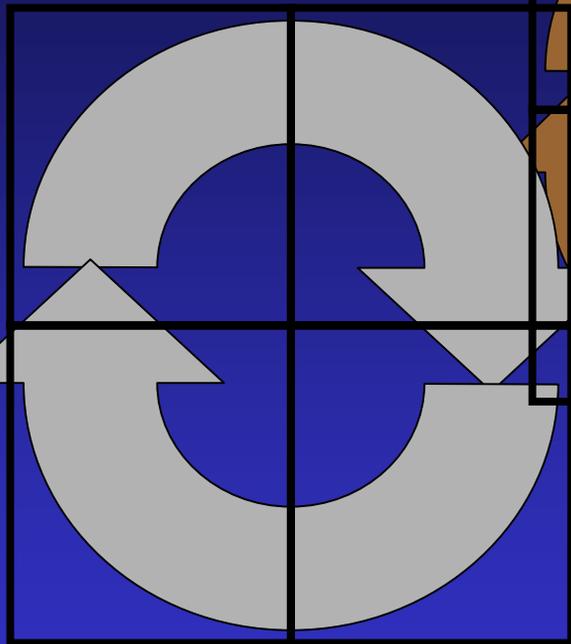
Using Integrating Concepts 1 & 2

Large

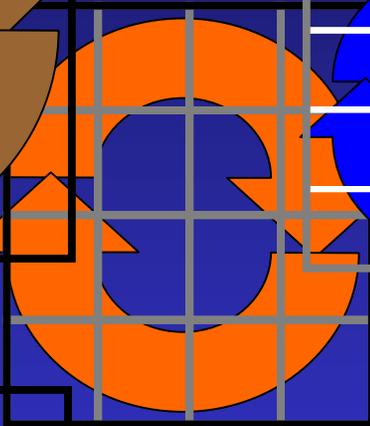
Relative Process Scale

Small

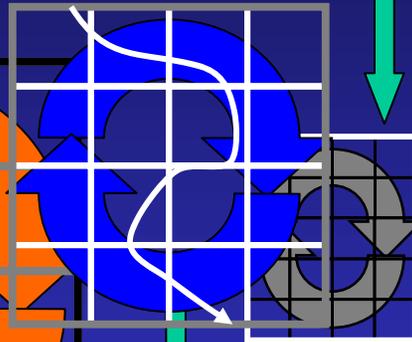
Population Dynamics



Water Quality

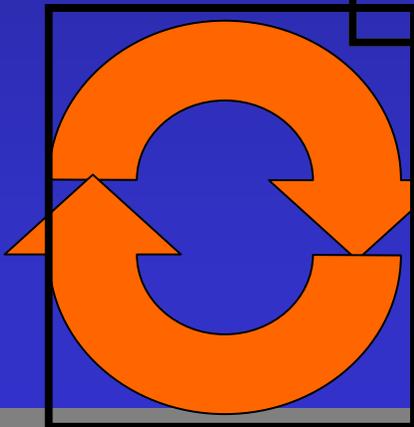


Hydraulics



Behavior

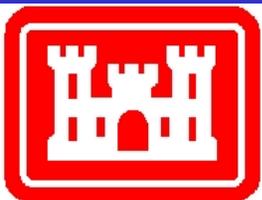
Trophic Interactions



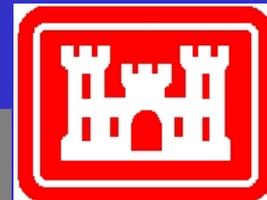
Complex

Complexity

Simple



Tearing Down Walls, Building Bridges



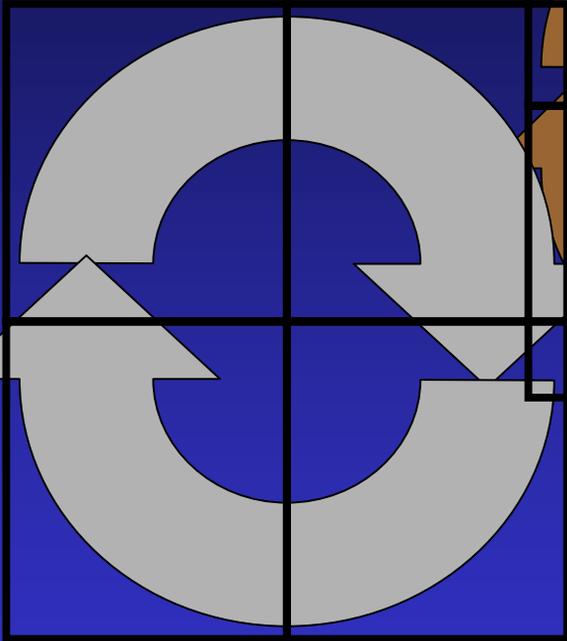
Using Integrating Concepts 1 & 2

Large

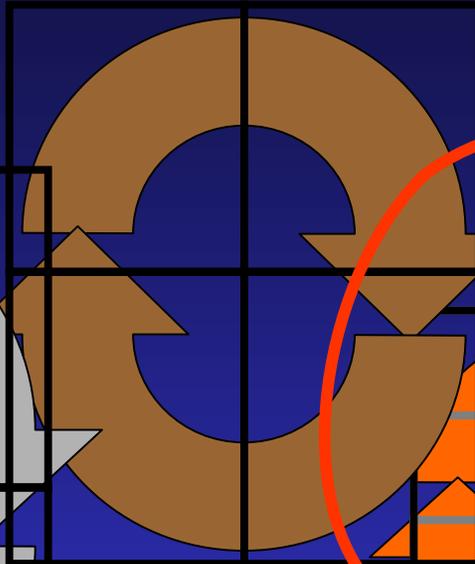
Relative Process Scale

Small

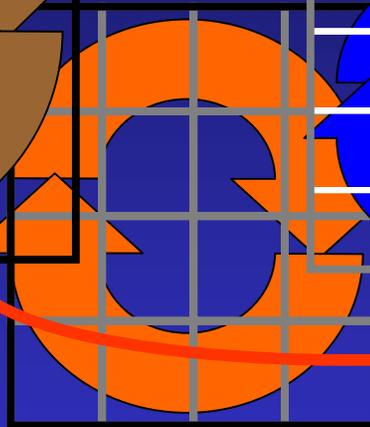
Population Dynamics



Trophic Interactions

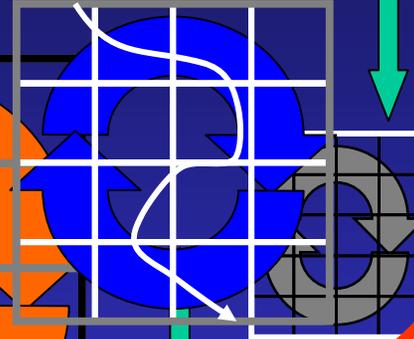


Water Quality



Extent

Hydraulics

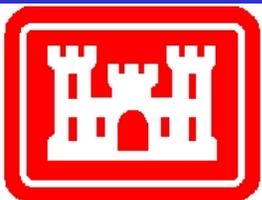


Behavior

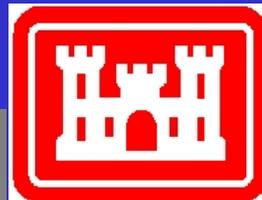
Complex



Simple



Tearing Down Walls, Building Bridges



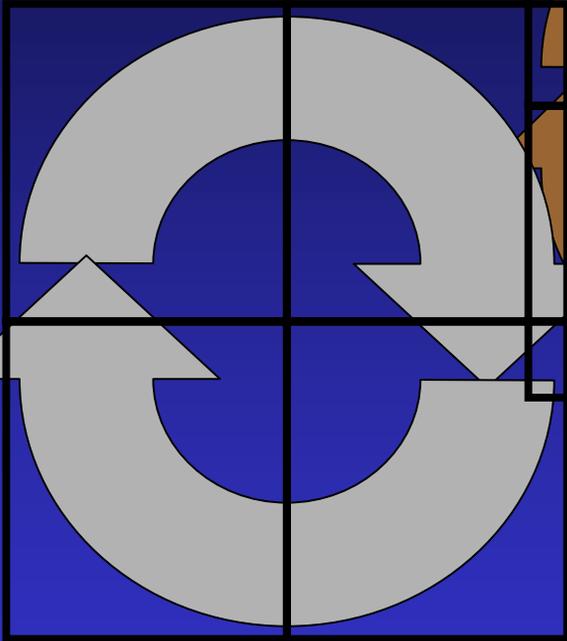
Using Integrating Concepts 1 & 2

Large

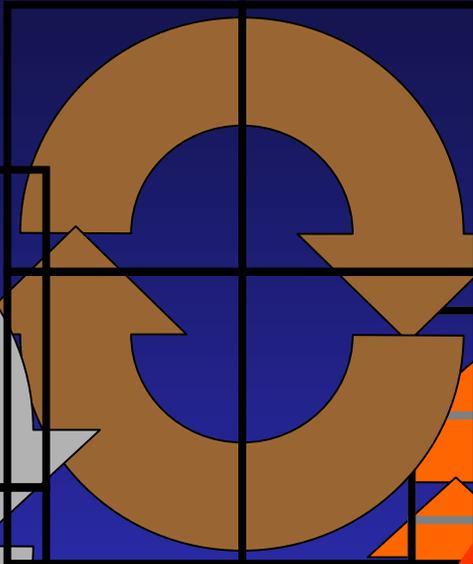
Relative Process Scale

Small

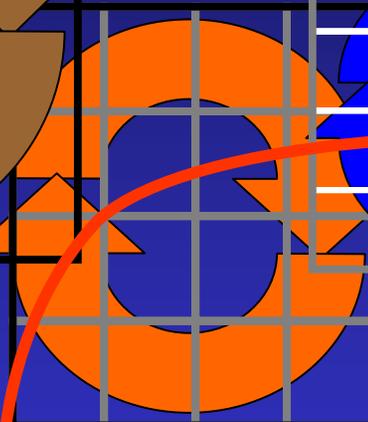
Population Dynamics



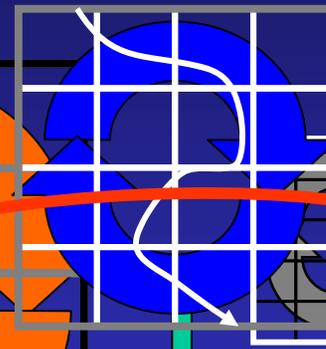
Trophic Interactions



Water Quality



Behavior



Hydraulics

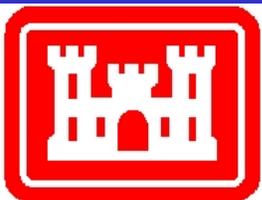


Complex

Complexity

Simple

Extent



Tearing Down Walls, Building Bridges



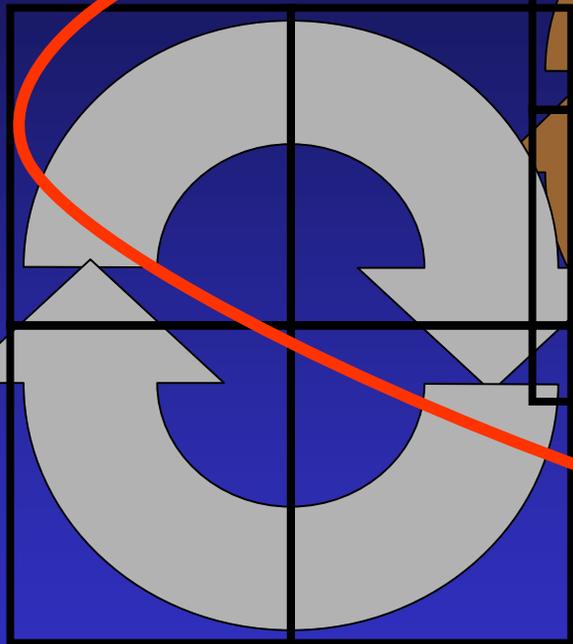
Using Integrating Concepts 1 & 2

Large

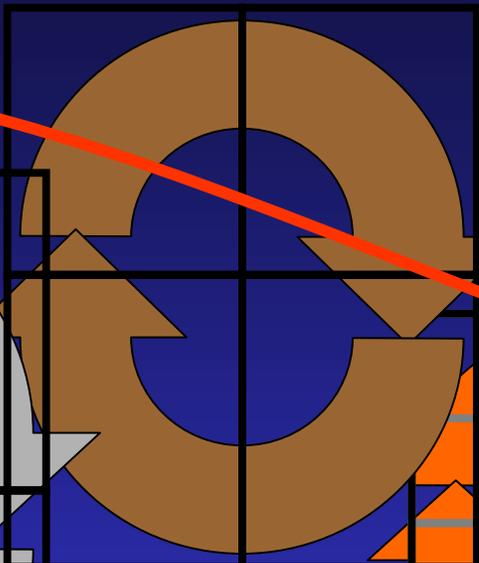
Relative Process Scale

Small

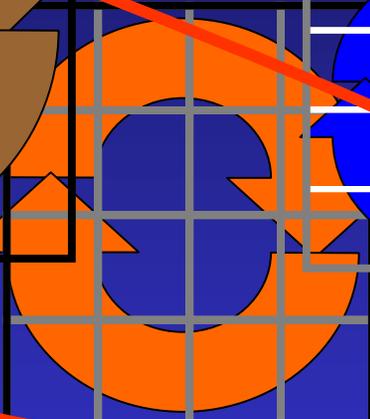
Population Dynamics



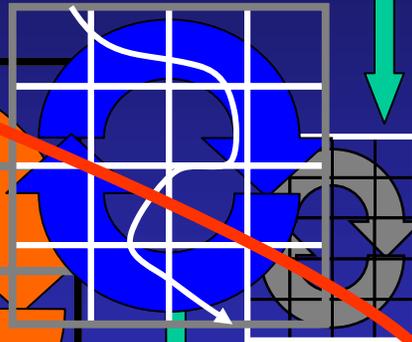
Trophic Interactions



Water Quality



Hydraulics



Behavior

Extent

Complex

Complexity

Simple



Tearing Down Walls, Building Bridges



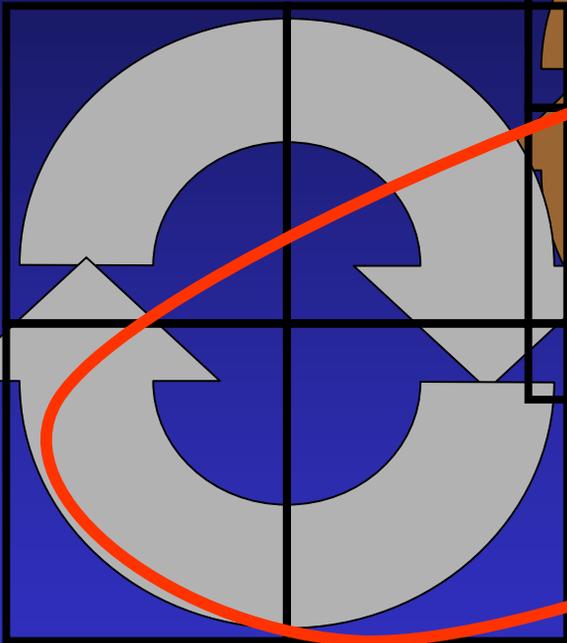
Using Integrating Concepts 1 & 2

Large

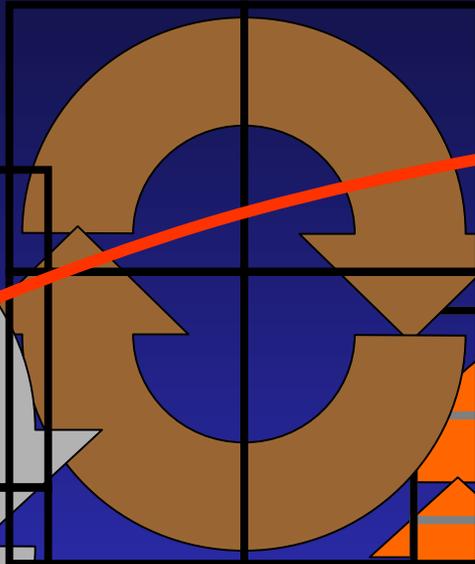
Relative Process Scale

Small

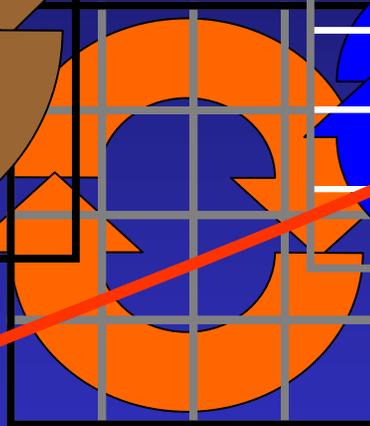
Population Dynamics



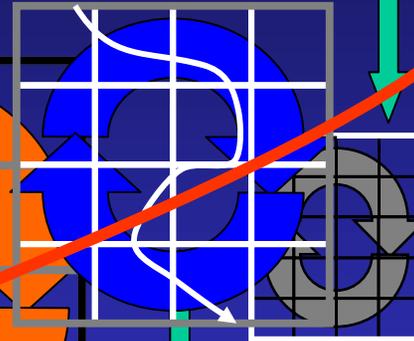
Trophic Interactions



Water Quality



Behavior



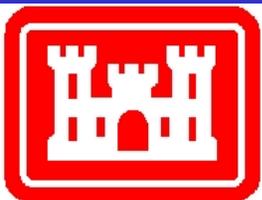
Hydraulics



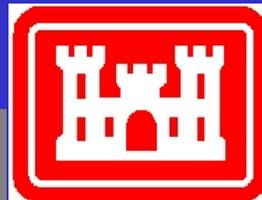
Complex

Complexity

Simple



Tearing Down Walls, Building Bridges



One Way to Think About Ourselves Corporately

Large ← Relative Process Scale → Small

PI 1	PI 2	PI 3	PI 4
PI 5	?	PI 7	PI 8
PI 9	PI 10	PI 11	PI 12
?	PI 14	PI 15	PI 16

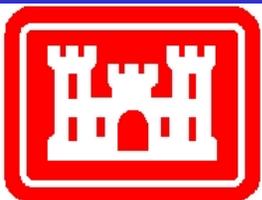
Complex



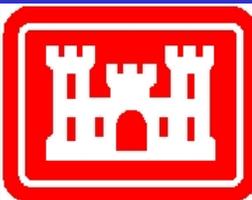
Simple

Extent

Premise: Guiding principle for eco-modeling allows programmatic capacity to be “audited” for gaps & needs



Tearing Down Walls, Building Bridges



Thinking About Ourselves Corporately - Why?

Strive to Achieve Environmental Sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.

Consider Environmental Consequences. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.

Seek Balance and Synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

Mitigate Impacts. Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.

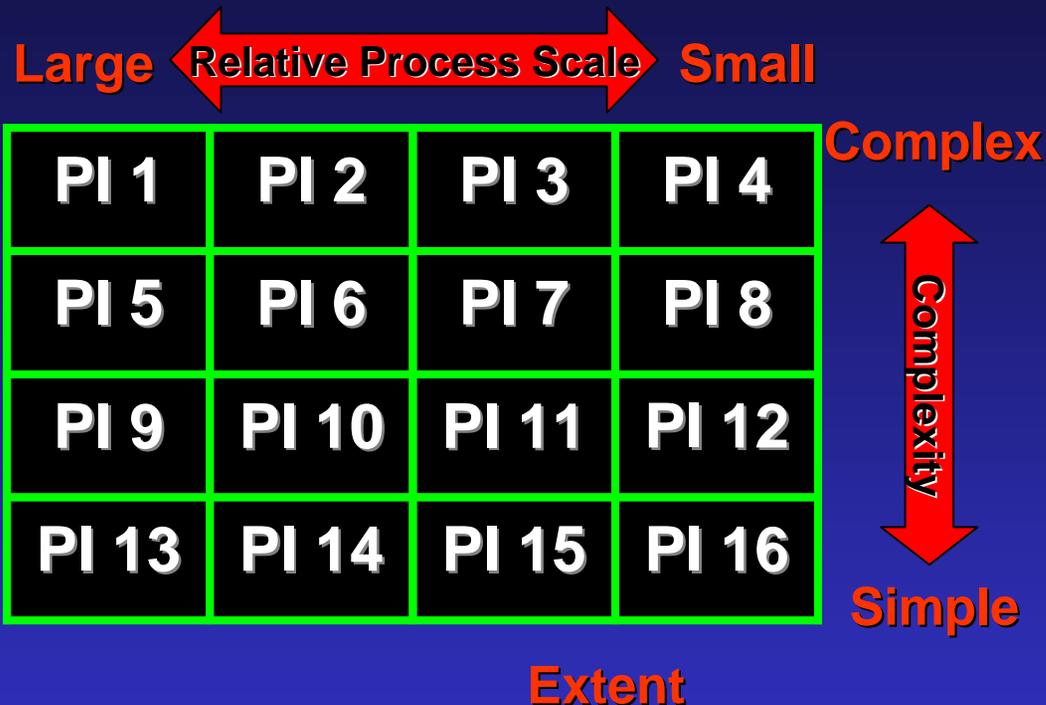
Understand the Environment. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.



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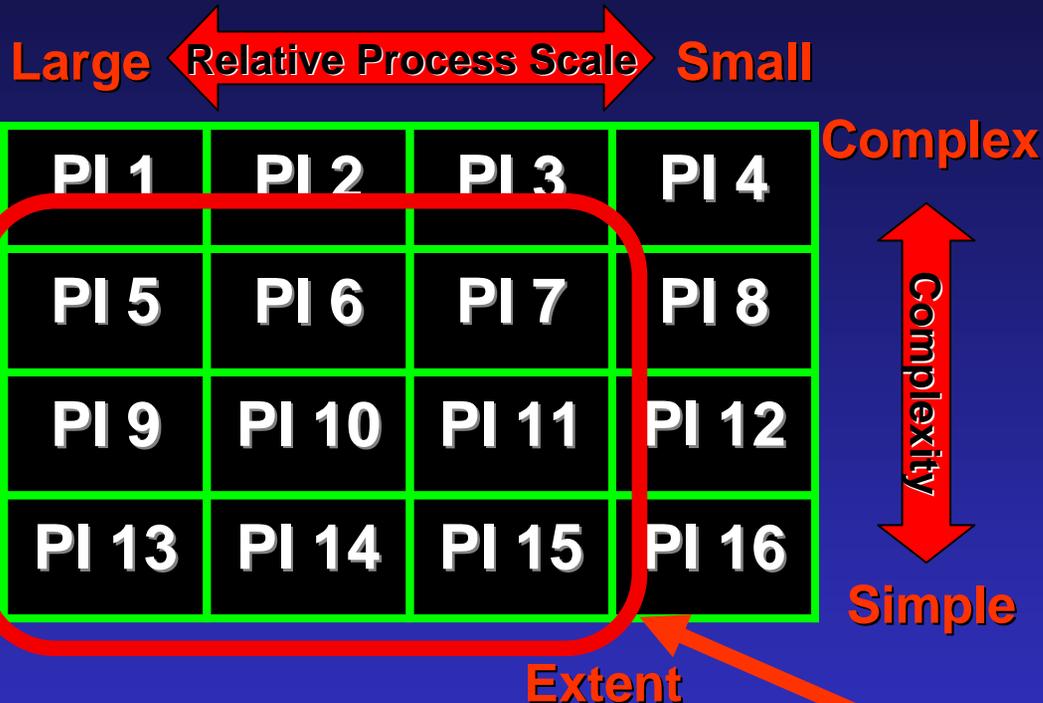
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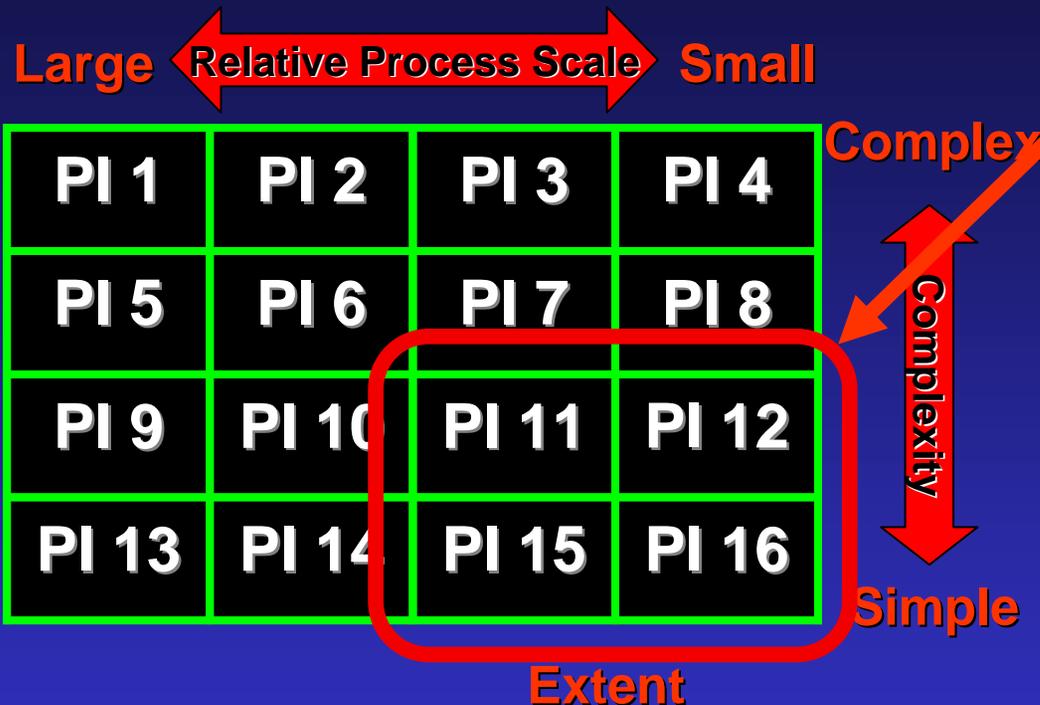
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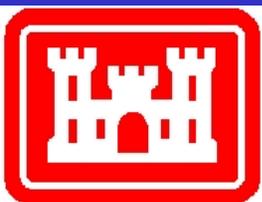
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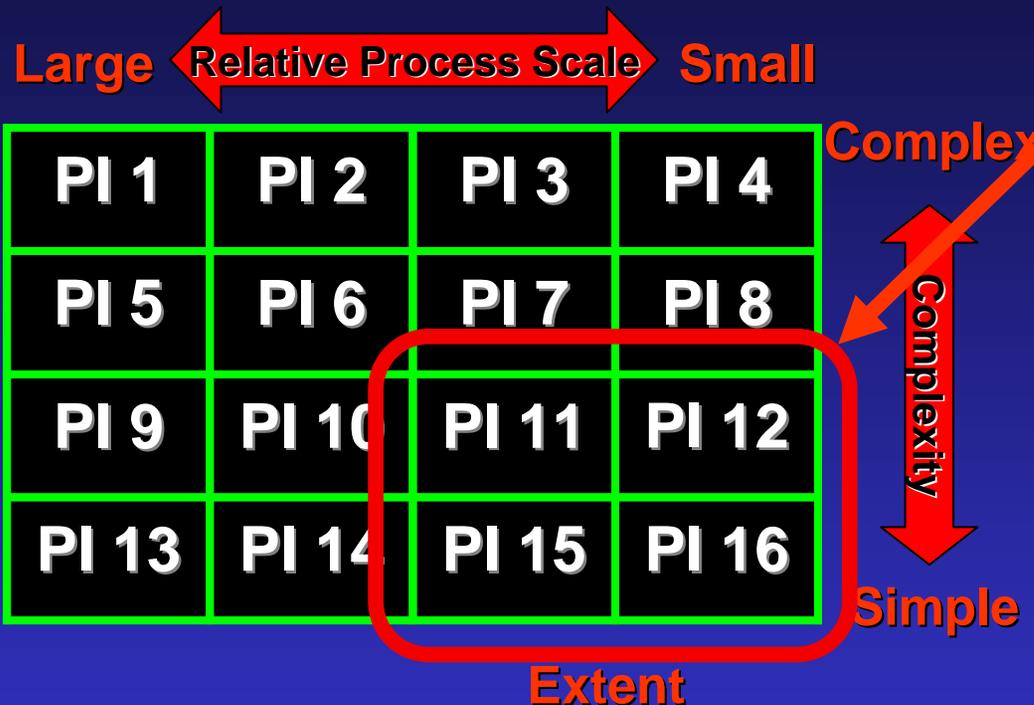
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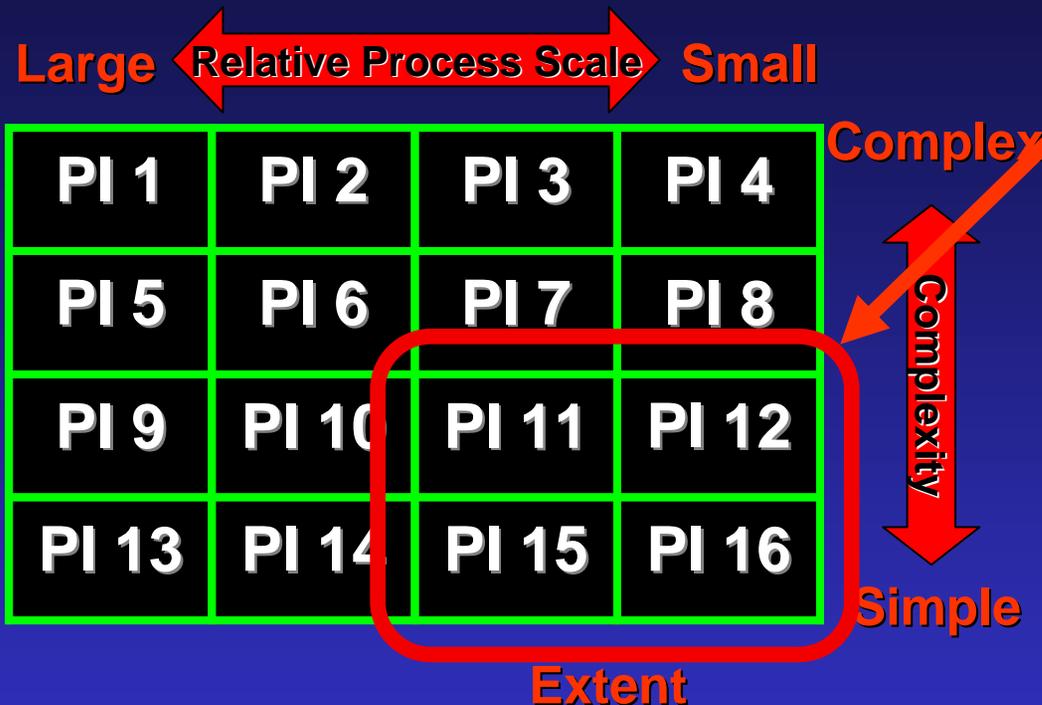
Premise: Guiding principle for eco-modeling allows us to address / resolve corporate issues, otherwise, individual opinions / projects.



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Thinking About Ourselves Corporately - Why?



**Alternatively:
Structure &
Integrate by
Business Lines.**

Premise: Guiding principle for eco-modeling allows us to address / resolve corporate issues, otherwise, individual opinions / projects.



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Workshop Goals Day 1:

- **Clearly articulate 2-4 integrating, binding concepts upon which we can ordinate ERDC eco-modeling capability**
 - e.g., Integrated Reference Frameworks Concept (scale)
 - e.g., Ecological Modeling Similitude Analysis (simple to complex)
 - + extent = The Matrix? / By EoPs? By Business Line? Both?
 - ?
- **Could your individual eco-modeling capability lie on the ordination within EL/ERDC? Would you like it to?**
- **What do you need to function in a corporate context?**
- **What's missing (tomorrow)?**
 - **Cells in the matrix?**
 - **Connectivity among cells?**
 - **Connectivity between labs?**
 - **What needs to be done now? 1 year? 3 years? 5 years?**



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Workshop Goal Day 2:

“Two-page” white paper that embodies five year strategy

- Organizing principles
- Technology audit
- Technology recommendations
 - Gaps we can easily address
 - Gaps difficult / impossible to address
 - Synergies with other initiatives
 - Timelines

Non-goal: Identify who within ERDC has best eco-modeling capability and gets to be in charge.



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