Foundational issues in Engineering Systems: A Framing Paper

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Steps Leading to This Symposium

- Created MIT Engineering Systems Division's Symposium Committee in 2000
- Held an ESD Internal Symposium, May 2002
  - Emphasis on foundational issues
  - We surprised ourselves at the relative closeness of our collective views regarding the fundamental issues in Engineering Systems in the 30 presentations that were given
- Created committees to study certain issues
- Reports of the committees are in the *Engineering Systems Monograph* and the CD given to attendees at this Symposium

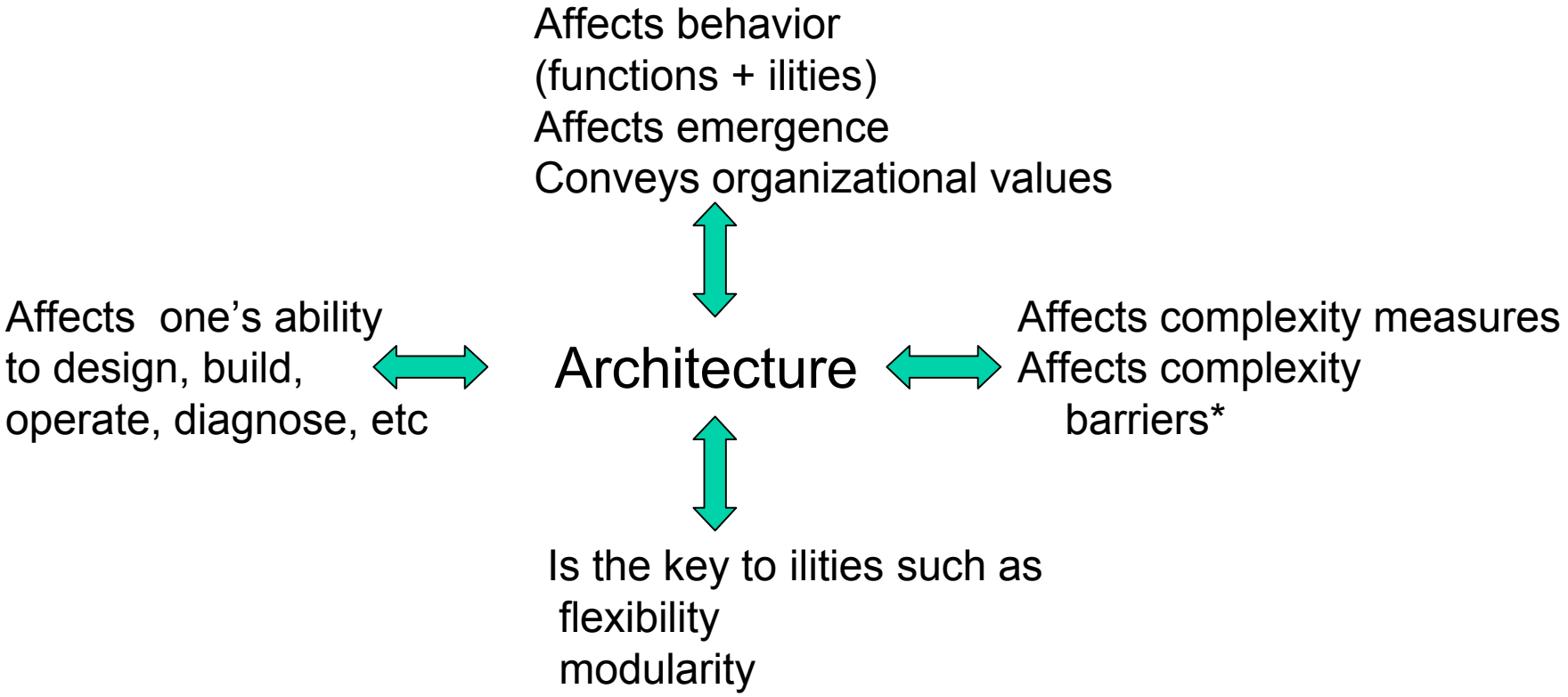
Engineering Systems: A Mode of Thought

- Be holistic in your thinking
  - Use abstractions in foundations
- Think in life cycle terms
- Manage change
  - Technological, enterprise-level, societal context
- Internalize the Externalities
- Realize the existence and use of feedback

Fundamental Issues in Large Scale Systems

- **Traditional goals**
  - –Function, performance, cost
- **Non-traditional goals**("ilities")
  - –Flexibility, sustainability, safety, robustness, maintainability, durability,scalability, quality,…
  - –These goals often involve long time spans and life-cycle issues
- **Characteristics** (Related to System Architecture or Enterprise Structure)
  - –Complexity, uncertainty, emergence
  - –Manage these characteristics, do not let them manage you
- **Relationships** between goals and characteristics
  - –These relationships or trade-offs are often the fundamental issues
  - –Information-centric relationships will vary from energy-centric ones

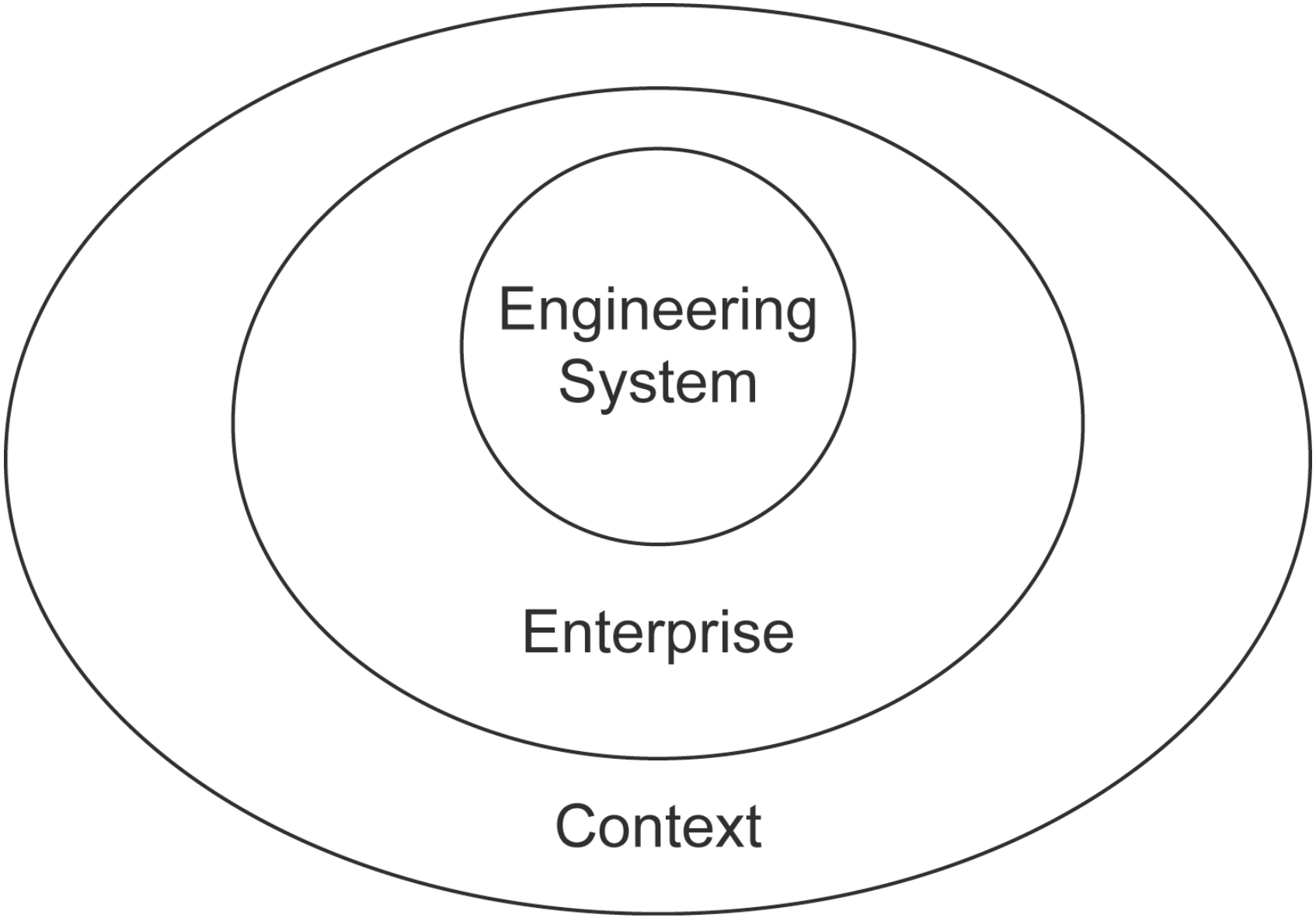
Impact of Architecture

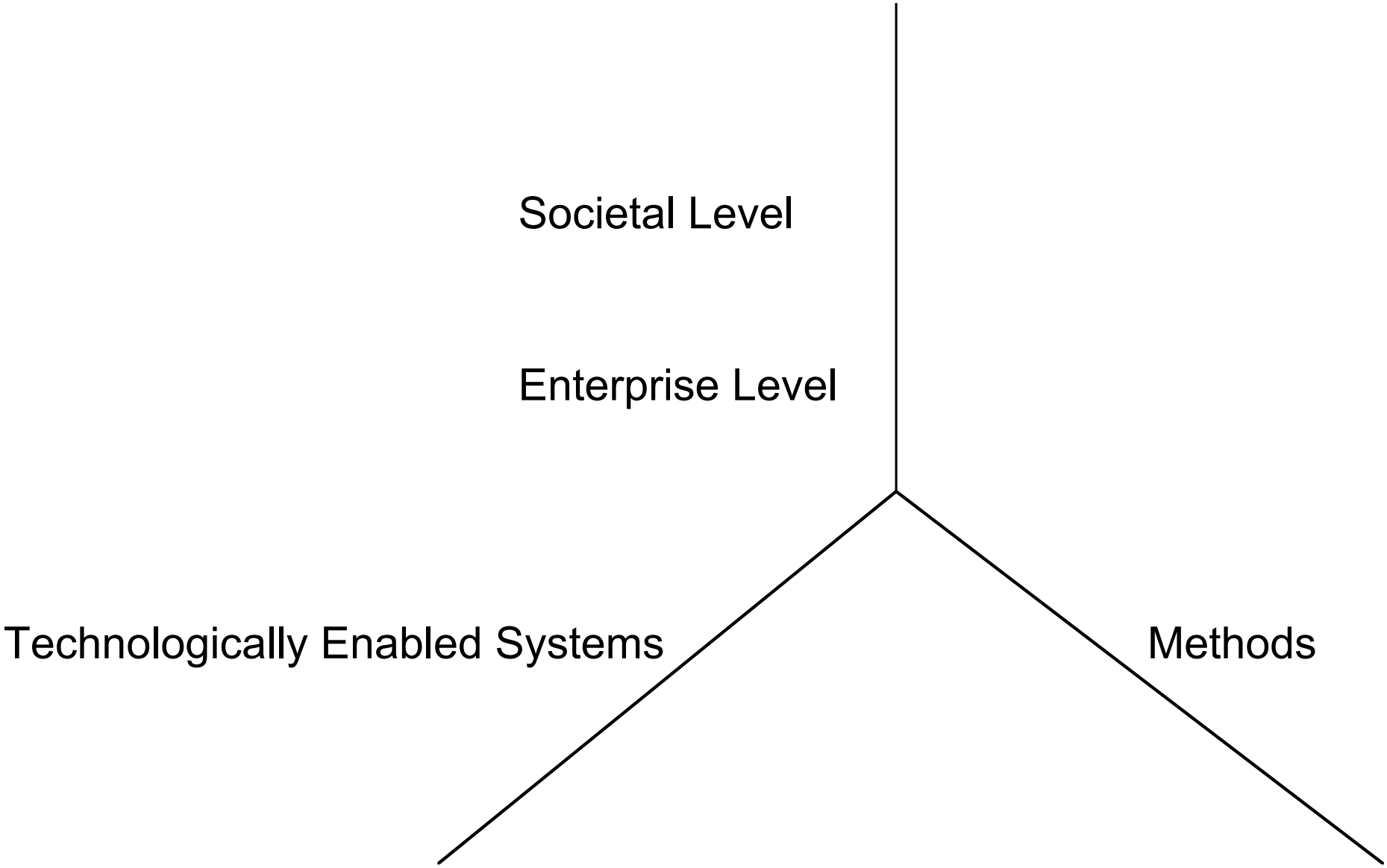


*Complexity barrier: level of complexity above which the system can be altered only with great difficulty

Relationship of Engineering Systems to Traditional Engineering Fields

- Engineering Systems covers the waterfront for large scale, complex engineering systems – it deals with design, manufacturing, operation, management and policy
- Engineering Systems fundamentals attempts to get at the "essence" of certain issues in large scale, complex engineering systems, such as flexibility, sustainability, and safety
- Engineering Systems is more abstract than traditional engineering fields, such as EE and ME, since it deals with issues that involve all such fields


Engineering
System
Enterprise
Context


Societal Level
Enterprise Level
Technologically Enabled Systems
Methods

Relationship of Engineering Systems to Other Interdisciplinary Engineering Fields

- Operations Research, Systems Engineering, Management of Engineering, and Technology& Policy also cover issues in more than one of the traditional engineering fields
- Is Engineering Systems the union of the fields above?
- Engineering Systems deals with certain issues involving large scale complex systems, such as architecture and uncertainty, at a higher level of abstraction than these interdisciplinary fields, recognizing that OR and SE are quite abstract already

Look-Ahead to the Other Talks on Foundational Issues

- Whitney et al – Systems Architecture
- de Neufville et al – Uncertainty Management
- Allen et al –Enterprise Perspective
- Marks et al – Sustainability
- Leveson et al – A Systems Approach to Safety Engineering