

# Built Environment Sustainability: An Integrated Approach to Education, Research, and Outreach

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# Collaboration

- This paper presents the results of a collaboration between:
  - The Construction Engineering and Management Program (CEM), of the School of Civil and Environmental Engineering (CEE), of the College of Engineering (COE), at the Georgia Institute of Technology (GT)
  - The Sustainable Facilities and Infrastructure Branch (SFI), of the Safety, Health, and Environmental Technology Division (SHETD), of the Electro-optics, Environment, and Materials Laboratory (EOEML), of the Georgia Tech Research Institute (GTRI)

Background

# Current Challenges to Organizations

- They stem from three types of systems within which an organization exists and operates
  - i.e., its contextual envelope
- ... Social, cultural, political, and regulatory systems
- ... Economic and financial systems
- ... Environmental and ecological systems
- They are local, regional, national, and global, in nature
  - i.e., they have a spatial scale
- They are present today, and as trends indicate, they will continue to grow into the future
  - i.e., they have a temporal scale

# Current Challenges to Organizations (cont.)

- They are affecting their ability to fulfill their vision, mission, goals, and objectives:
  - The capacity and capability of their basic infrastructure
  - The compatibility and compliance of their fundamental processes, practices and operating procedures
  - The integrity, quality, and availability of their resource base
- These challenges are even greater for organizations in the Architecture, Engineering, and Construction (A/E/C) Industry

# Additional Challenges for A/E/C Industry Organizations

- Private and public sector Owners of capital assets (i.e., Facilities and Civil Infrastructure Systems – F&CIS)
  - Are facing increasingly constrained availability of economic resources
  - Are demanding higher levels of capital project effectiveness, efficiency, productivity, and return on investment
  - Are expecting higher technical and management performance in the delivery, operation, and maintenance of F&CIS over their complete life cycle
  - Are expecting higher functional and physical performance of the technologies and materials used in them.

# Additional Challenges for A/E/C Industry Organizations (cont.)

- The A/E/C industry
  - Has been identified as a major direct and indirect contributor to problems of global nature
    - e.g., natural resource depletion and degradation, waste generation and accumulation, environmental impact and degradation, among others
  - Faces increasingly restrictive environmental conservation and protection laws and regulations
  - Faces the emergence of international standards to address environmental quality and performance
  - Faces substantial pressures from civic and private environmental groups in A/E/C projects

# The Response

- Sustainable Development has emerged as a direct response to these challenges and influences
  - "...meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED)
- Sustainability transcends the scope of this definition, and:
  - Adds a broader spectrum of complexity
  - Is framed within economic, social and cultural, ecological and environmental, and technological dimensions
  - Has a temporal and a spatial scales

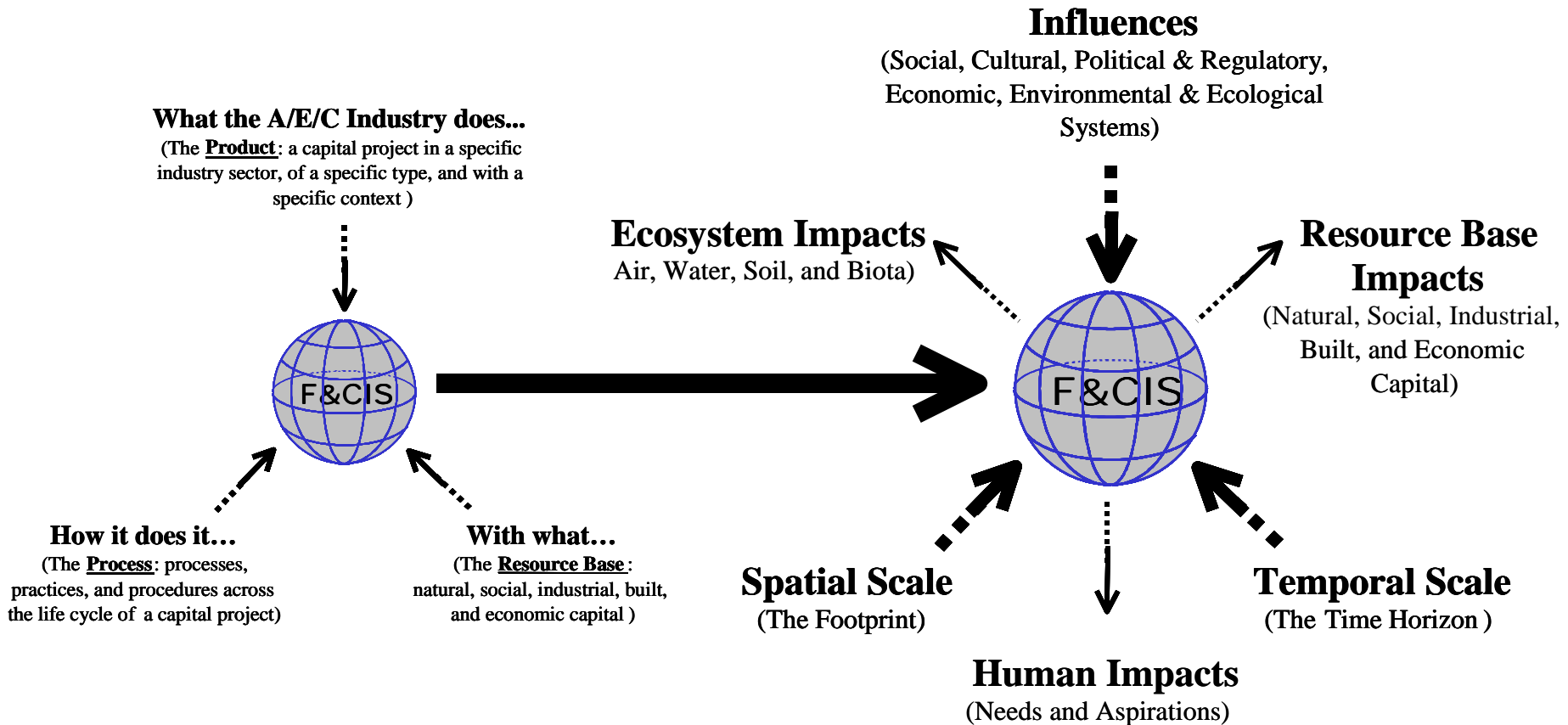
# The Response (cont.)

- Sustainability has:
  - brought together, in a relatively short period of time (the last 15 years) a wide range of constituencies
  - generated numerous definitions and conceptualizations, some of which are aligned, and some of which are in direct conflict with each other
- There are three general areas of consensus:
  - what to sustain, where, and when
  - the status quo is not sustainable in the long term, and needs to change today
  - the contextual envelope that surrounds the status quo is complex today, and will be more complex in the future

# Implications of Sustainability for the A/E/C Industry (1)

- To achieve Built Environment Sustainability (BES) owners of F&CIS (together with users and operators, architects and engineers, constructors, manufacturers, vendors, and suppliers, and many external parties), face significant changes in
  - what they do (i.e., the product)
  - how they do it (i.e., the process)
  - with what (i.e., the resource base)
  - how they respond to influences
  - how they manage their impacts

# The Dimensions of Built Environment Sustainability

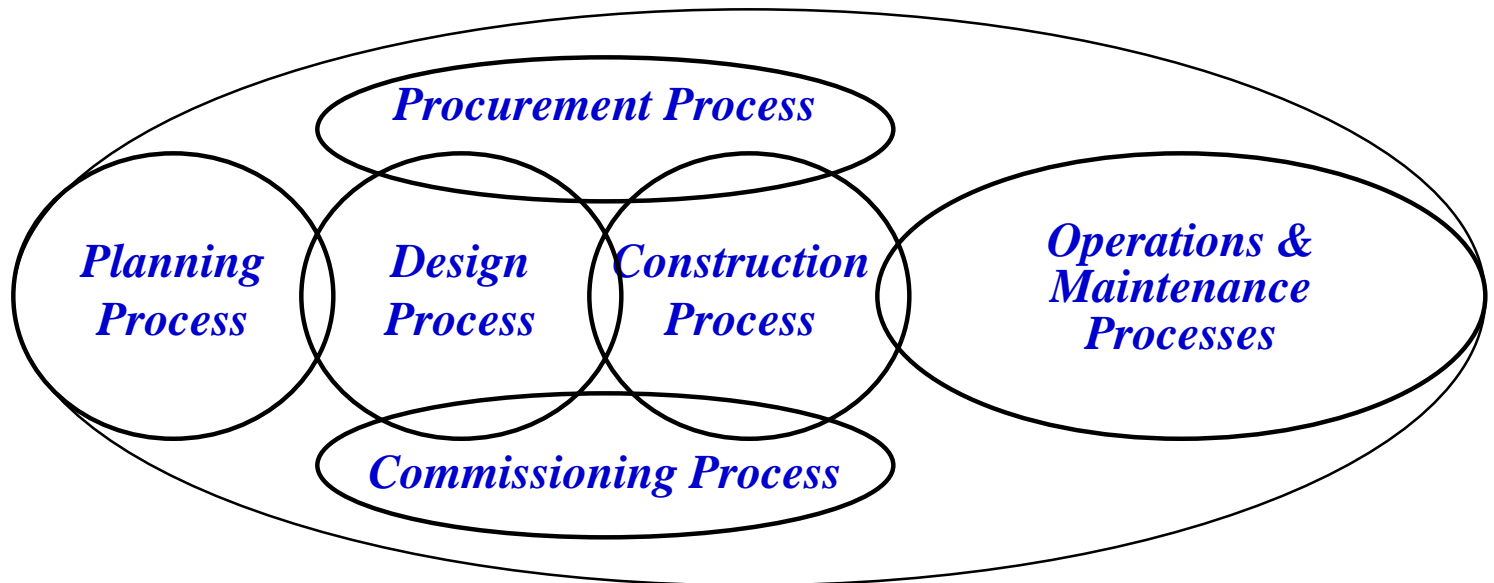
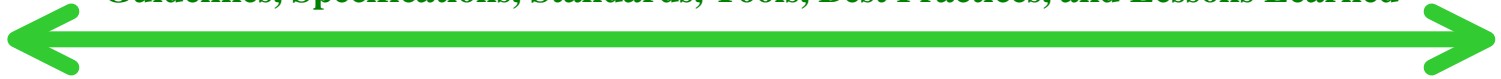


# Implications of Sustainability for the A/E/C Industry (2)

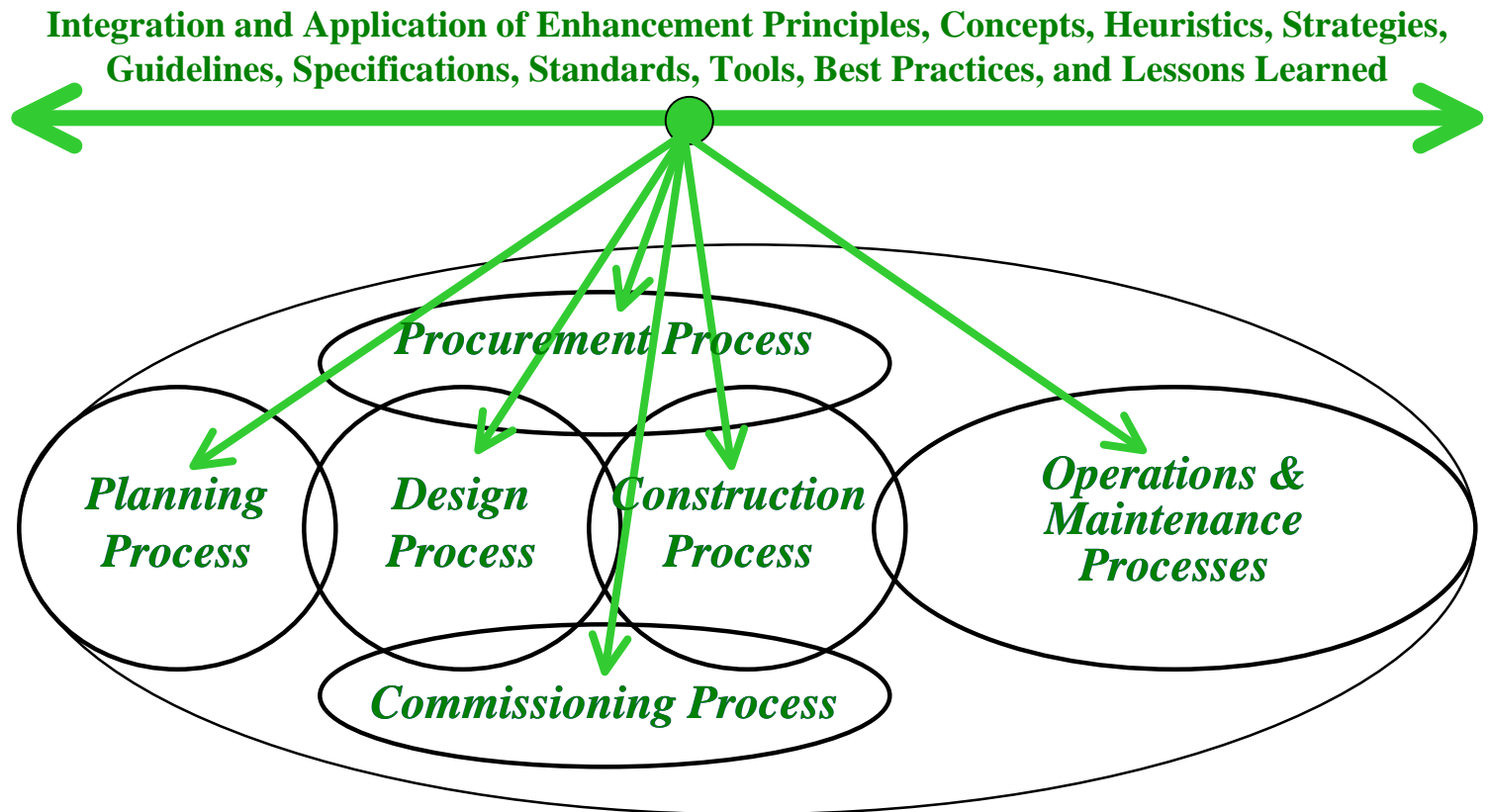
- Sustainability principles, concepts, heuristics, strategies, guidelines, specifications, standards, tools, best practices, and/or lessons learned need to be
  - formally, explicitly, systemically, and systematically integrated
  - within the capital asset delivery and management processes, practices, and standard operating procedures (SOP's)
  - at all stages of the life cycle of a capital asset.

# Sustainability Entry Points in the Life Cycle of F&CIS

**Integration and Application of Enhancement Principles, Concepts, Heuristics, Strategies, Guidelines, Specifications, Standards, Tools, Best Practices, and Lessons Learned**

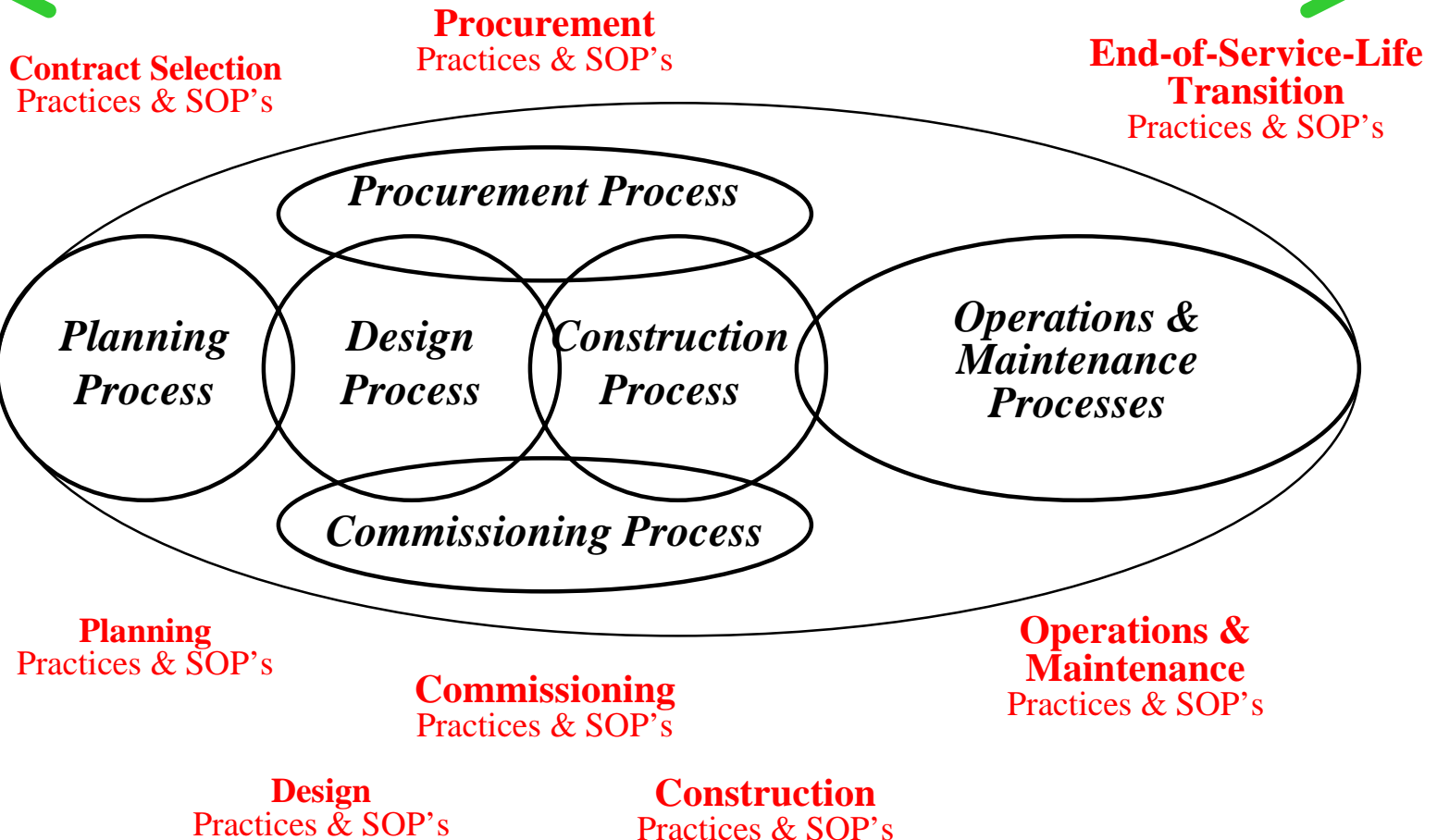


# Sustainability Entry Points in the Life Cycle of F&CIS

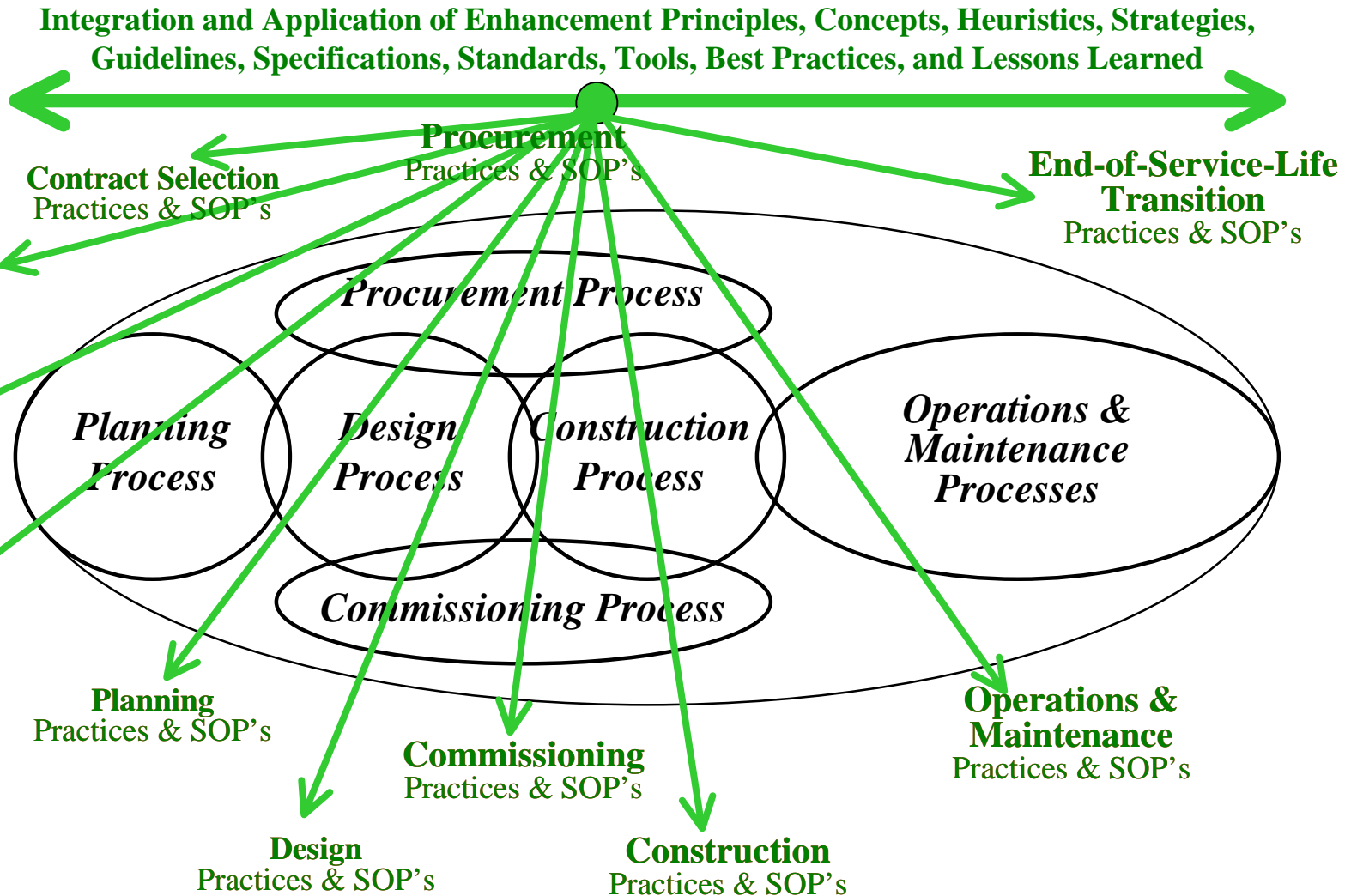


# Sustainability Entry Points in the Life Cycle of F&CIS

Integration and Application of Enhancement Principles, Concepts, Heuristics, Strategies, Guidelines, Specifications, Standards, Tools, Best Practices, and Lessons Learned



# Sustainability Entry Points in the Life Cycle of F&CIS



# The Challenge

# Critical Needs and Opportunities to Achieve BES

- Improved analysis and evaluation methods that provide for an integrated, systems perspective for F&CIS
- Better assessment and prediction of life cycle performance and sustainability of F&CIS
- Science and technology-based guidelines for policies, standards, codes and regulations that promote sustainable F&CIS
- More effective institutional structures for the delivery, management, and renewal of sustainable F&CIS

# Critical Needs and Opportunities to Achieve BES (cont.)

- Market-efficient financing strategies that incorporate the true costs of delivering and managing sustainable F&CIS
- More effective, efficient, and integrated processes for delivery and management of sustainable F&CIS
- More sustainable and cost-effective technologies, products, materials, and methods used in F&CIS
- New methods for real-time continuous measurement and management of F&CIS life cycle performance and sustainability, including approaches for assessing deterioration or damage

# Critical Needs and Opportunities to Achieve BES (cont.)

- Formal and informal education in sustainable F&CIS (K-12, undergraduate and graduate education, continuing education and training, public outreach, and life long learning)

# Research Tendencies in F&CIS

- Problem-specific
- Discipline-specific
- Fragmented and isolated
- Contextually-independent
- Short-term
- Evolutionary
- Funding source-dependent

# Education Tendencies in F&CIS

- Discipline- and course-specific
- Contextually-independent
- Teaching-driven
- Linear
- Ineffective and inefficient
- Fragmented and isolated
- Institution-dependent
- Non-diversity-oriented

# Needs and Opportunities

- The first is to integrate and leverage objectives, resources, and actions of the multiple stakeholders.
- The second is to facilitate processes of change.
- The third is to create a locus of BES data, information, knowledge, experience, and tools through the implementation of information acquisition, synthesis, and dissemination strategies.

# Inhibitors, Barriers, or Obstacles to the Implementation of BES

- The lack of consensus on what sustainability means for the built environment
- The lack of understanding of how specific sub-concepts map onto the larger concept of sustainability (e.g., environmental management, compliance, “green”)
- The lack of understanding and myths associated with the economic impacts of sustainable building practices
- The difficulty of measuring sustainability, and the subsequent challenge of decision making for sustainable facilities

# Inhibitors, Barriers, or Obstacles to the Implementation of BES (cont.)

- The difficulty in breaking out of traditional stakeholder roles and relationships; resistance to change
- Managing information overload in seeking innovative or non-traditional solutions and conversely, finding sufficient and reliable data on which to base decisions
- Finding effective and appropriate strategies to increase facility sustainability
- Integrating solutions for whole system optimisation; overcoming traditional disciplinary barriers

# The Response - Education

# New Education Paradigm

- Complements, supplements, and adds value to the existing education infrastructure within civil and environmental engineering.
- Its goal is to enable stakeholders in the built environment to become agents of change
- Resources and focus are oriented toward
  - specific activities and actions
  - general dissemination and outreach efforts
  - the development of an information management and communications technological infrastructure.

# Elements

- K-12 Education Foundation
  - The robustness of any informal or formal educational effort in BES depends on the quality of the educational foundation at the K-12 level
- Trade School/On-the-Job Education/Training Foundation
  - Not everyone goes through a professional education path; many people who work in construction, maintenance, or operation activities for F&CIS rely on
    - two-year trade school or college education programs
    - specific in-house programs of their employers
    - miscellaneous “on-the-job” training opportunities.

# Elements (cont.)

- Undergraduate and Graduate Education Foundation
  - The core of any formal educational effort aimed at BES is the undergraduate level, supplemented with graduate education.
  - There is a need to support the implementation of an integrated pedagogical strategy
- Life Long Learning Foundation for Practice in Business, Industry, and Government
  - The ultimate measure of success of any educational effort aimed at BES is the performance of the individuals educated both informally and formally to serve business, industry, or government, and their ability to engage in life long learning.

# A Strategic Framework for Curriculum Development

- Fundamental education composed of mathematics, sciences, engineering, and humanities
- A systems-based core BES education, which introduces and exposes students, in an integrated way, to selected topics relevant to BES from multiple disciplines
- Specialized BES education, which enables possible specialization in the areas of assessment, planning, design, construction, or operation of F&CIS.
- Systematic mechanisms for motivation and scaffolding, and for reflection, synthesis, and integration, link these three bases.

# A Strategic Framework for Achieving Learning Outcomes

- An introduction, exposure, and proficiency in fundamental knowledge, skills, and tools sets
- Individual and team development and application of core BES knowledge, skills, and tools sets to establish the intellectual foundation for contextual understanding of BES problems, for
  - solving problems in BES
  - designing solutions in BES
  - understanding and applying technology
- Individual and team development and application of specialized BES knowledge, skills, and tools sets

# A Strategic Framework for Enabling Learning Outcomes

- Specialized faculty with access to general resources in math, science, and engineering
- Integrated interdisciplinary faculty teams composed of faculty from multiple fields as needed, with access to case studies from industry and academia, in addition to previous resources
- Integrated interdisciplinary faculty/practitioner teams composed of faculty and practitioners from multiple fields as needed, with access to lessons learned and best practices from industry and academia, in addition to previous resources.

# The Response - Research

# BES Research Program

- Points of Departure
  - Identification and characterization of the principal stakeholders in BES
  - Identification and characterization of BES typologies and problem contexts
  - Identification and characterization of processes for delivery and life cycle management of F&CIS
  - Identification and characterization of technologies and products used in F&CIS
- The ultimate goal is to provide tangible products and deliverables to all BES stakeholders

# BES Research Thrusts

- Development of a consistent, theory-based **conceptual framework** for understanding BES
- Development of a **taxonomy** for systematically identifying, classifying, obtaining, and managing the kinds of BES data, information, knowledge, and experience
- Development of a **web-based multimedia system** for acquisition, storage, and retrieval of principles, concepts, heuristics, strategies, guidelines, specifications, standards, tools, best practices, and/or lessons learned for BES

## BES Research Thrusts (cont.)

- Development of **models** for integrated analysis, evaluation, and development of guidelines and recommendations for policies, standards, codes, and regulations influencing or affecting BES
- Development of a set of systematic and bounded **processes** for problem-definition, problem-solving, analysis, and decision-making in BES
- Development of **toolbox** for evaluating the economic impacts of BES alternatives and actions, including methods for clearly understanding those impacts in terms of the language of economics-driven decision-making

# BES Research Thrusts (cont.)

- Development of a set of **strategies, tools, technologies, and methods** for increasing BES
- Development of **advanced sensing and control technologies** for real-time continuous measurement, documentation, and management of BES performance
- Development of a set of **operational strategies** for proactively addressing resistance to change and the limitations of traditional stakeholder and organizational roles
- Development of alternative **new products and materials** for F&CIS made from recovered construction demolition waste, and/or other waste sources

## BES Research Thrusts (cont.)

- Development of alternative **new construction technologies, equipment, and methods** for F&CIS that minimize negative environmental impacts
- **Modular design and construction solutions** for disassembly, recycle and/or reuse of F&CIS
- Development of a comprehensive **technology transfer and dissemination program** for the A/E/C industry on BES, and sustainable building technologies, systems, products and materials

# The Response - Outreach

# Outreach Activities

- A professional continuing education series in Sustainable Facilities and Infrastructure, under the direction of Dr. Annie Pearce, designed to
  - Meet the needs of built environment stakeholders who are seeking to make their facilities more sustainable
  - Highlight the opportunities that sustainability offers to save money; to reduce liability; to attract new customers; to open new markets; to increase their competitiveness over the long term; and to learn to:
    - Understand what sustainability means and how it might benefit their enterprises
    - Measure the sustainability of current and future projects
    - Understand the economic costs and benefits of this new approach
    - Work with diverse teams to make sustainability happen
    - Use state-of-the-art tools and resources for analysis, design, and problem solving
    - Prioritise and apply potential specific strategies for improving project sustainability

# Outreach Activities (cont.)

- Active participation and support from Dr. Jorge Vanegas, to the U.S. Army, and various national and international technical committees, commissions, task groups, and forums, that are addressing sustainability, including:
  - The American Society of Civil Engineers (ASCE)
  - The American Society for Engineering Education (ASEE)
  - The International Association of Bridge and Structural Engineers (IABSE)
  - The International Council for Research and Innovation in Building and Construction (CIB)
  - The National Center for Construction Education and Research (NCCER)
  - Leadership for Environment and Development International, Inc. (LEAD)
  - Urban Genesis Institute (UGI)
  - The U.S. Army Environmental Policy Institute (AEPI)

# Conclusions

# Conclusions

- Sustainability of F&CIS (or BES) is a complex knowledge domain that requires that the principal stakeholders in F&CIS within the A/E/C industry find and implement new ways in their:
  - products
  - processes, practices, and procedures
  - resource base,
- An integrated approach to education, research, and outreach is necessary to facilitate, implement, and achieve these changes.

## Conclusions (cont.)

- Through a collaborative partnership, CEM/CEE/GT and SFI/SHETD/GTRI have begun a quest toward a more sustainable future for the built environment by:
  - engaging and educating students
  - educating and training professionals
  - working with public and private sector organizations
- This partnership has proven to be rewarding and fruitful, and is starting to make a visible difference
- The path to BES may be long, but at least the journey has begun

Thank you!

# Contact Information

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