



Systems Approach and Engineering Solutions to BioEnergy Systems

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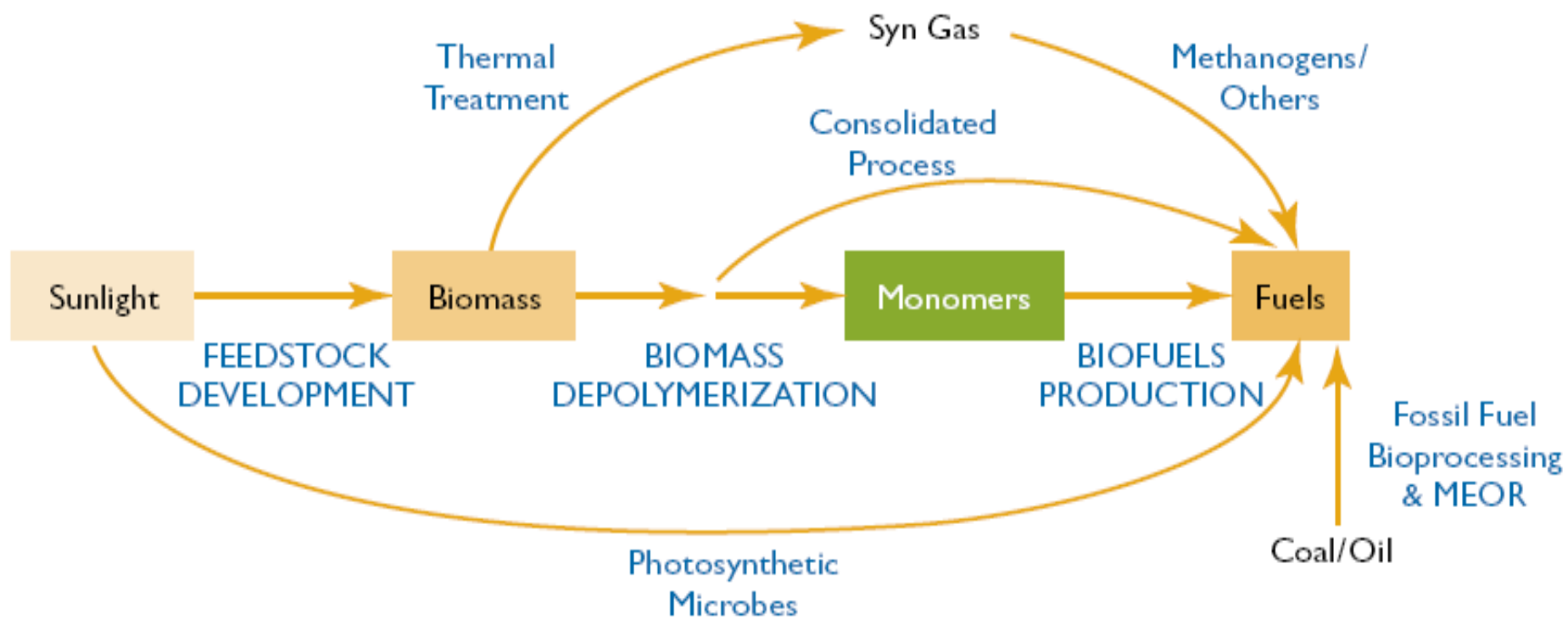
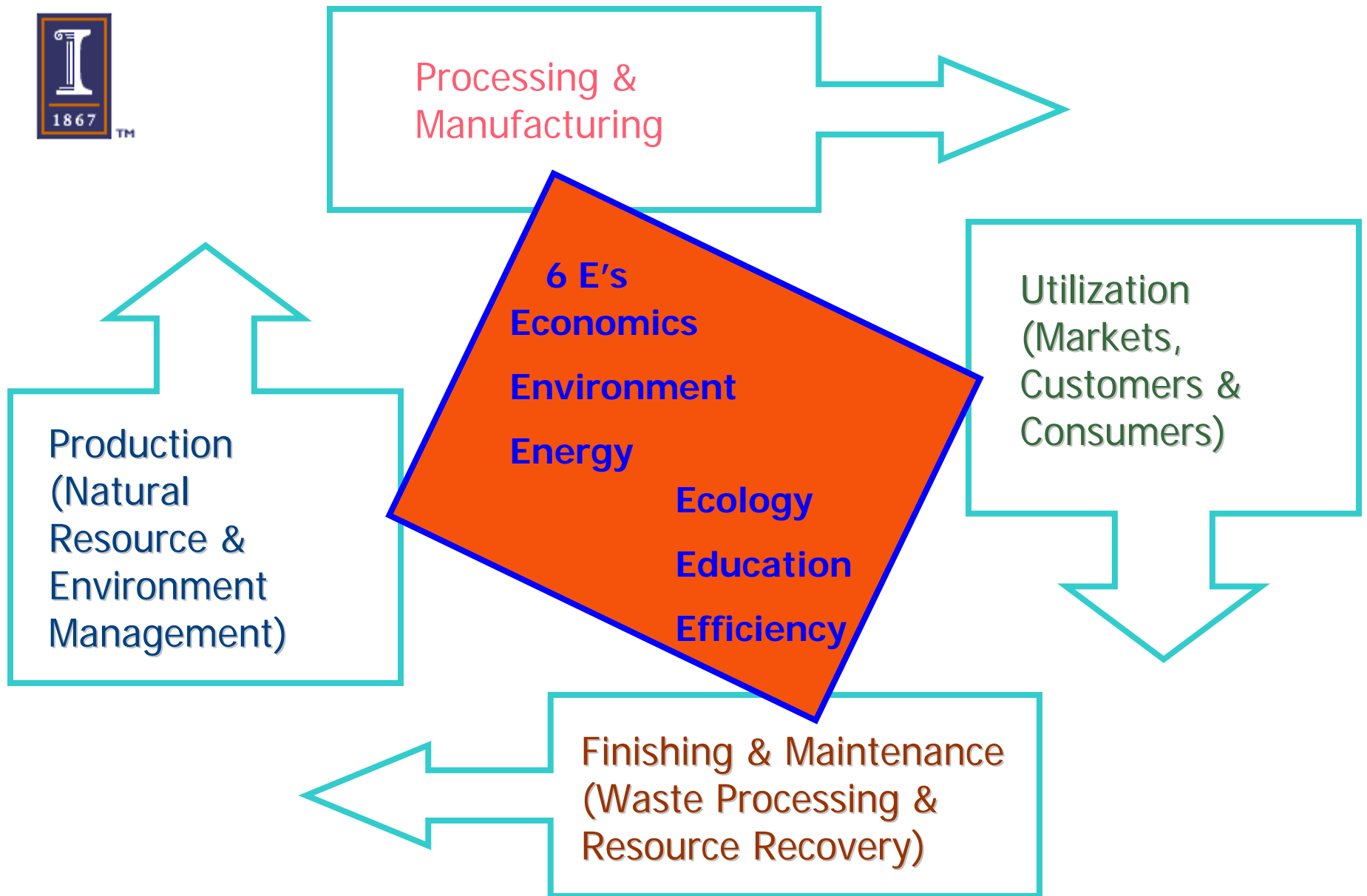


Figure 1 Routes of energy production to be explored in EBI. All caps indicate programs.

Biobased Economic Engine Value Chain–





Knowledge Bases and Applications for Complex “Living” Bio- Energy System

Applications Knowledge	Fuel or Thermal Energy	Electrical or Mechanical Power	Materials (Co-products or By-Products)	General/ Overall
Source / Feedstock				
Processes / Conversion				
Utilization				
Economics				
Environment/ Natural Resources				
System Analysis and Integration				
Policy				

Cross-Cutting Research,
Development,
Demonstration, and
Implementation of
Components, Subsystems,
and the Entire System

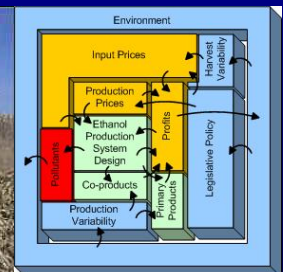
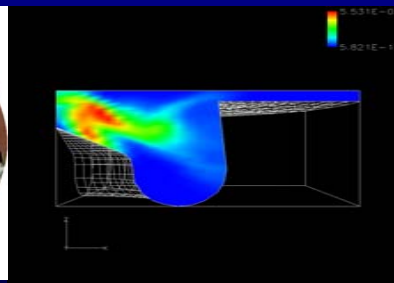


Department of Agricultural and Biological Engineering

Bio-Energy

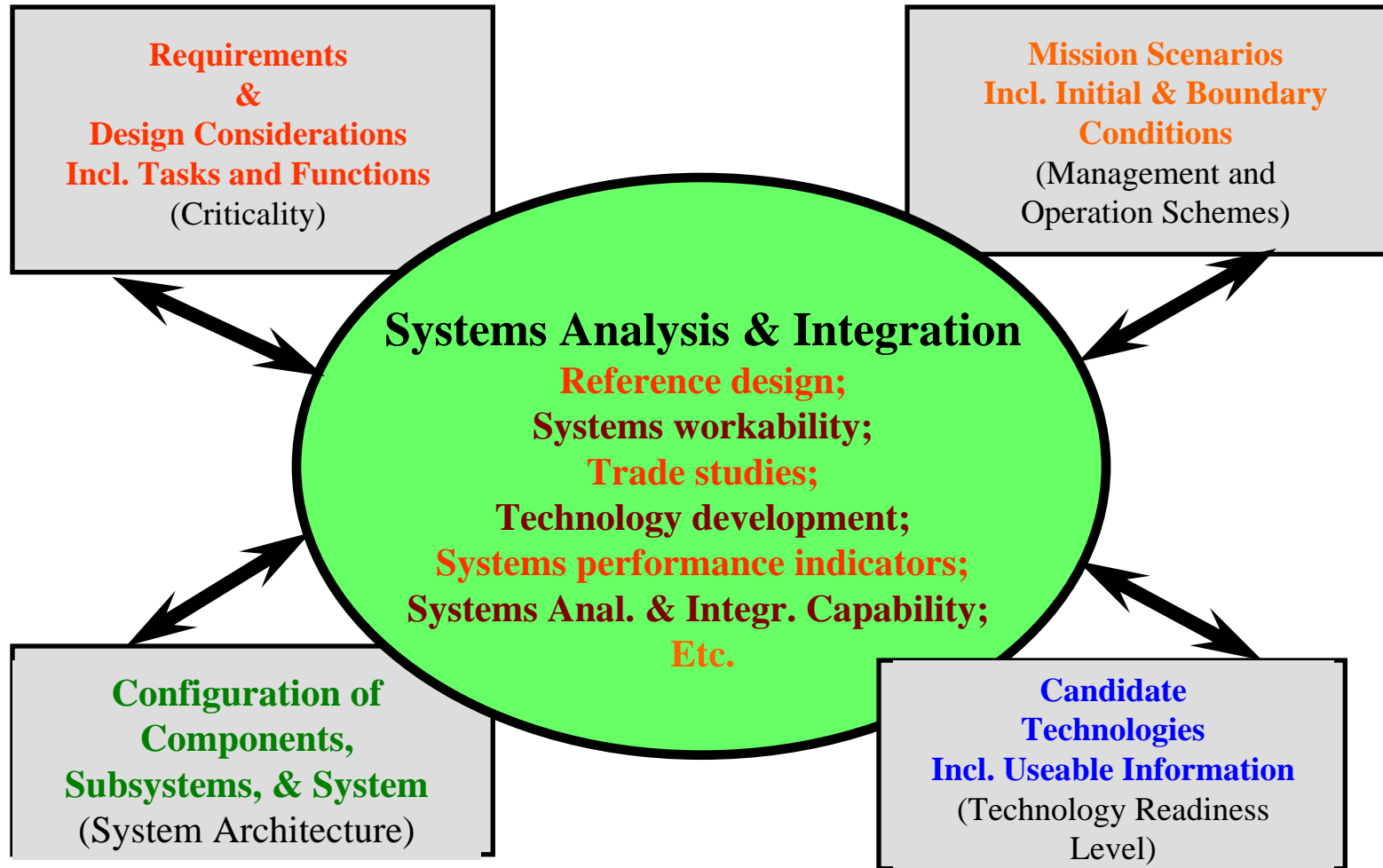
Research, Development, Demonstration, and Implementation

- **Ethanol** – Corn Dry-Grind Process and Co-product Improvement
- **Biobased Crude Oil** – Thermochemical Conversion (TCC) of Waste and Biomass to Crude Oil
- **Biodiesel** – Fuel Properties, Engine Performance & Emission
- **Feedstocks** – Engineering Solutions for Energy Crop Production
- **System Informatics and Analysis** – Information, Modeling, Simulation, & Decision Support





Underlying Concept of Engineering Solutions





The Activities
of **Systems Informatics and Analysis**
for **Decision Support**

To **gather, store, retrieve,**
analyze, synthesize, present,
and **interpret** information
to **aid** in the process of
decision-making.



System:

A set of **interrelated components** organized to achieve certain **goals**.

Examples -

Automobile :

engine, body, wheels, transmission,
brakes, alternator, battery, stereo, etc.

Agriculture:

production
processing
utilization
finishing and maintenance



Systems Thinking

What:

emphasizing the performance of the system as a **whole** by understanding all **components** in the system, as well as the **interrelationships** among the components

Why:

- individually functioning components do not necessarily make up a workable system;
- **piece-wise knowledge about individual components does not automatically provide a complete understanding of the overall system;**
- necessary yet missing components can be detected after observing/analyzing the system as a whole



System's level issues and questions

Examples:

- technical workability
- economical viability
- social acceptability
- energy efficiency
- environmental friendliness
- system sustainability
- optimization
- operation and management

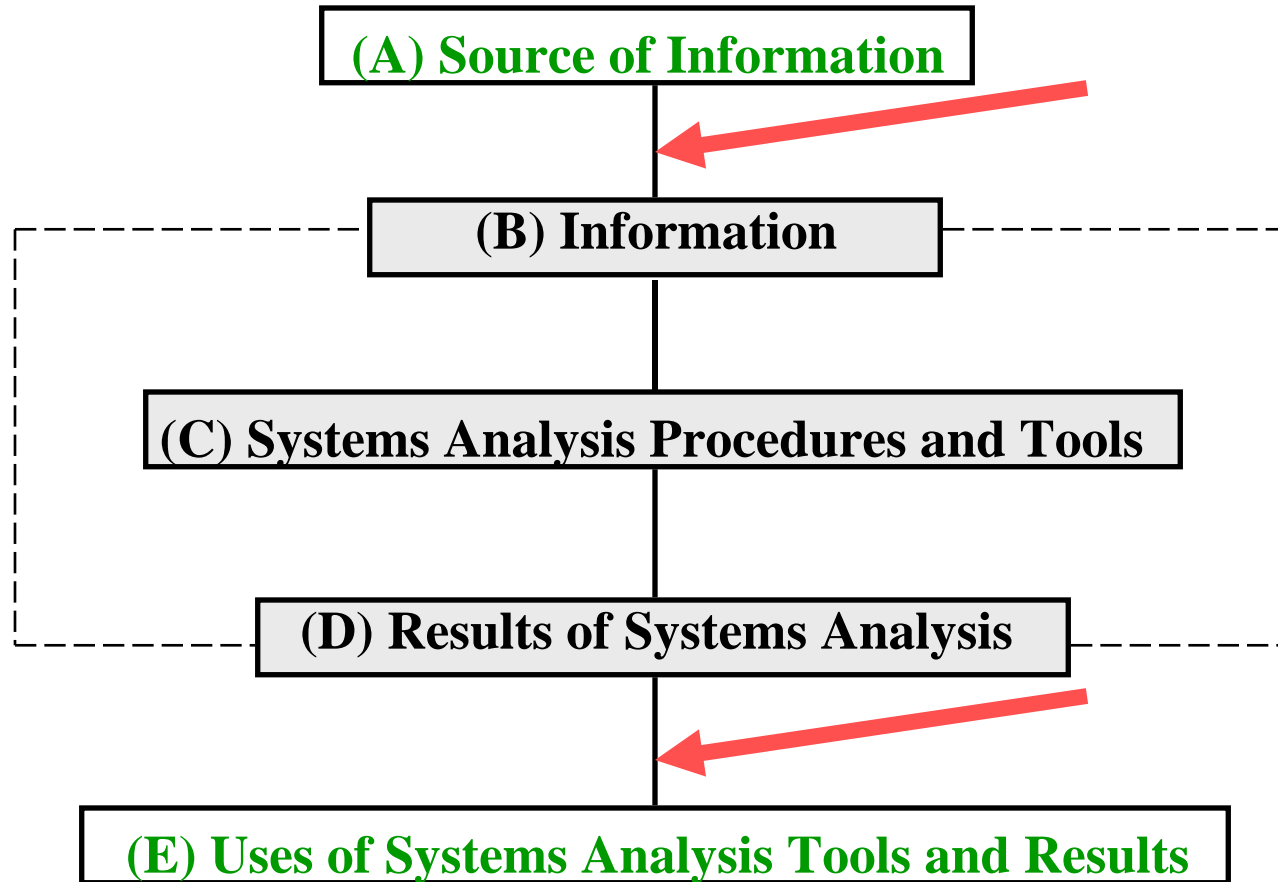


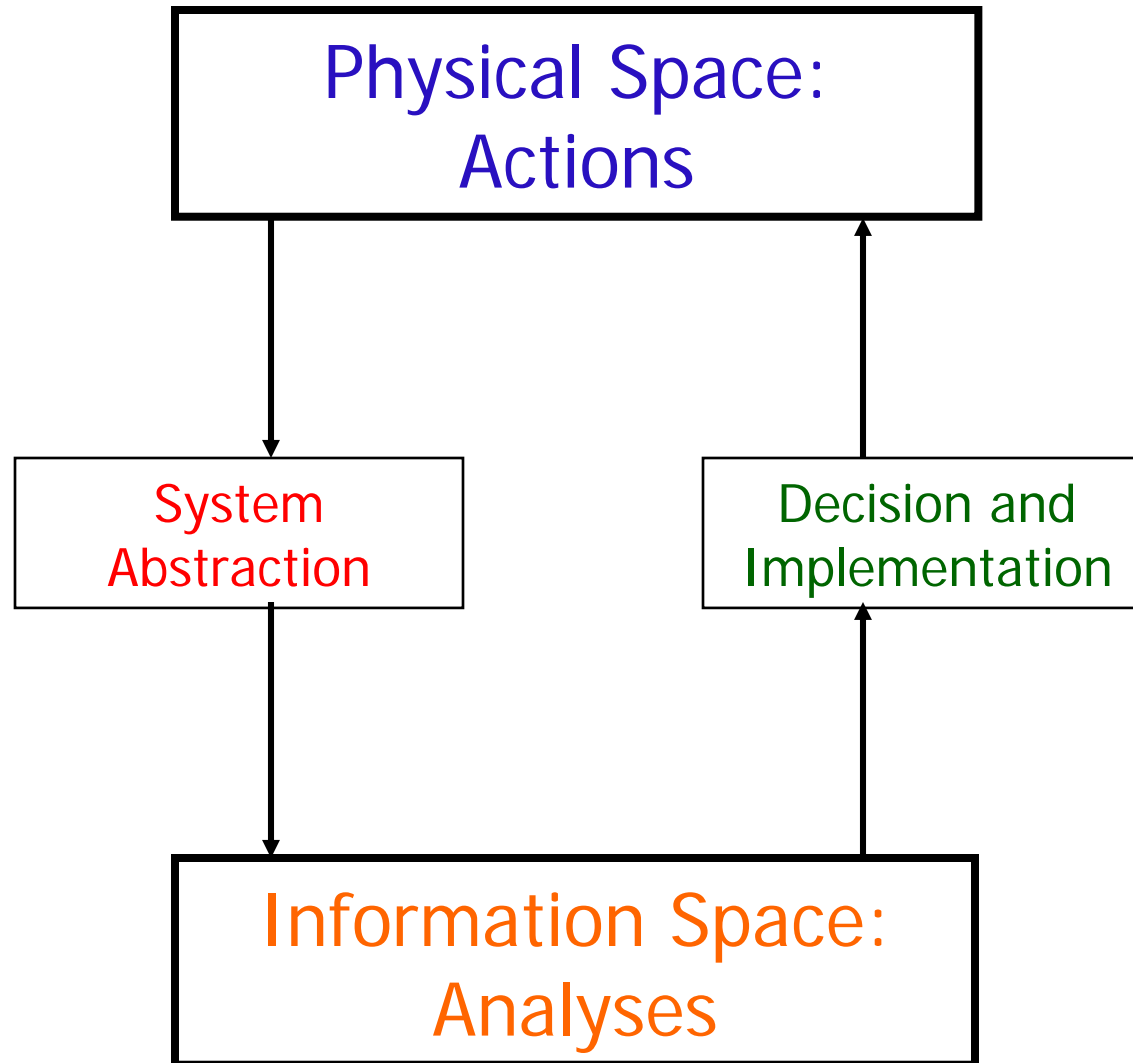
Issues of Systems Analysis

- System's level issues and questions
- Systems to be analyzed
- Case-by-case vs. tool-building
- Essential aspects of systems analysis
- Methodology needed to carry out the analysis
- Implementation of methodology for easy access by users



Essential Aspects of Systems Analysis







Systems Analysis

How:

- Define system's scope and objectives
- Identify system constraints
- Establish indicators of success
- Conduct system abstraction
 - components and descriptors
 - interrelationships and interactions
 - initial conditions (current situations)
 - boundary conditions (external factors)



Systems Analysis

How: (cont'd)

- Obtain data and information
- Handle uncertain & incomplete information, as well as heuristic & fuzzy reasoning
- Develop system model to represent a system and its operation
- Verify and validate the model



Systems Analysis

How: (cont'd)

- Perform simulation using the model (investigate “what if?”)
- **Draw conclusions about the system:**
 - technical workability & reliability
 - resource requirements
 - environmental impact
 - economic viability
 - optimization
 - etc.
- Communicate outcomes

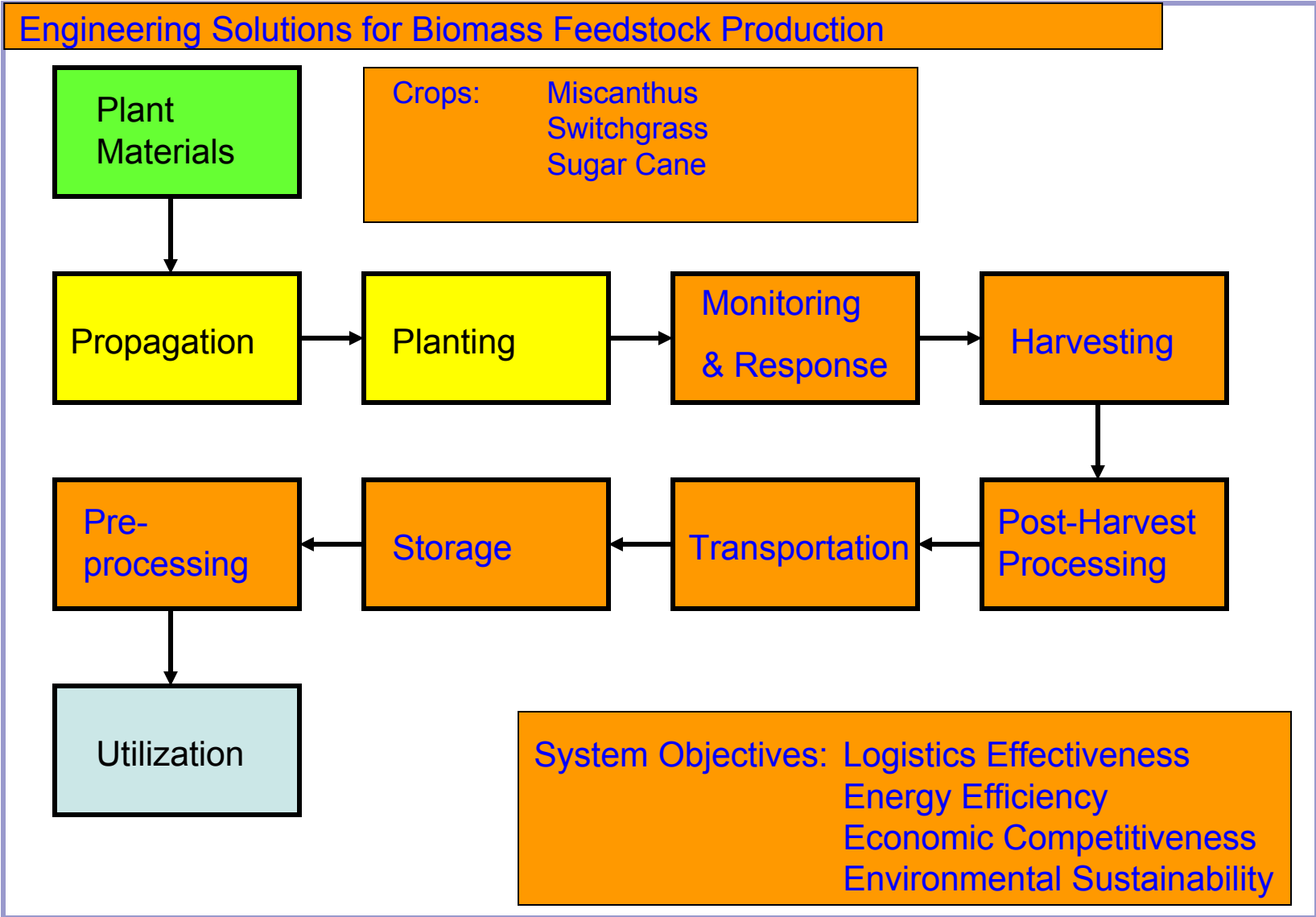


Modeling

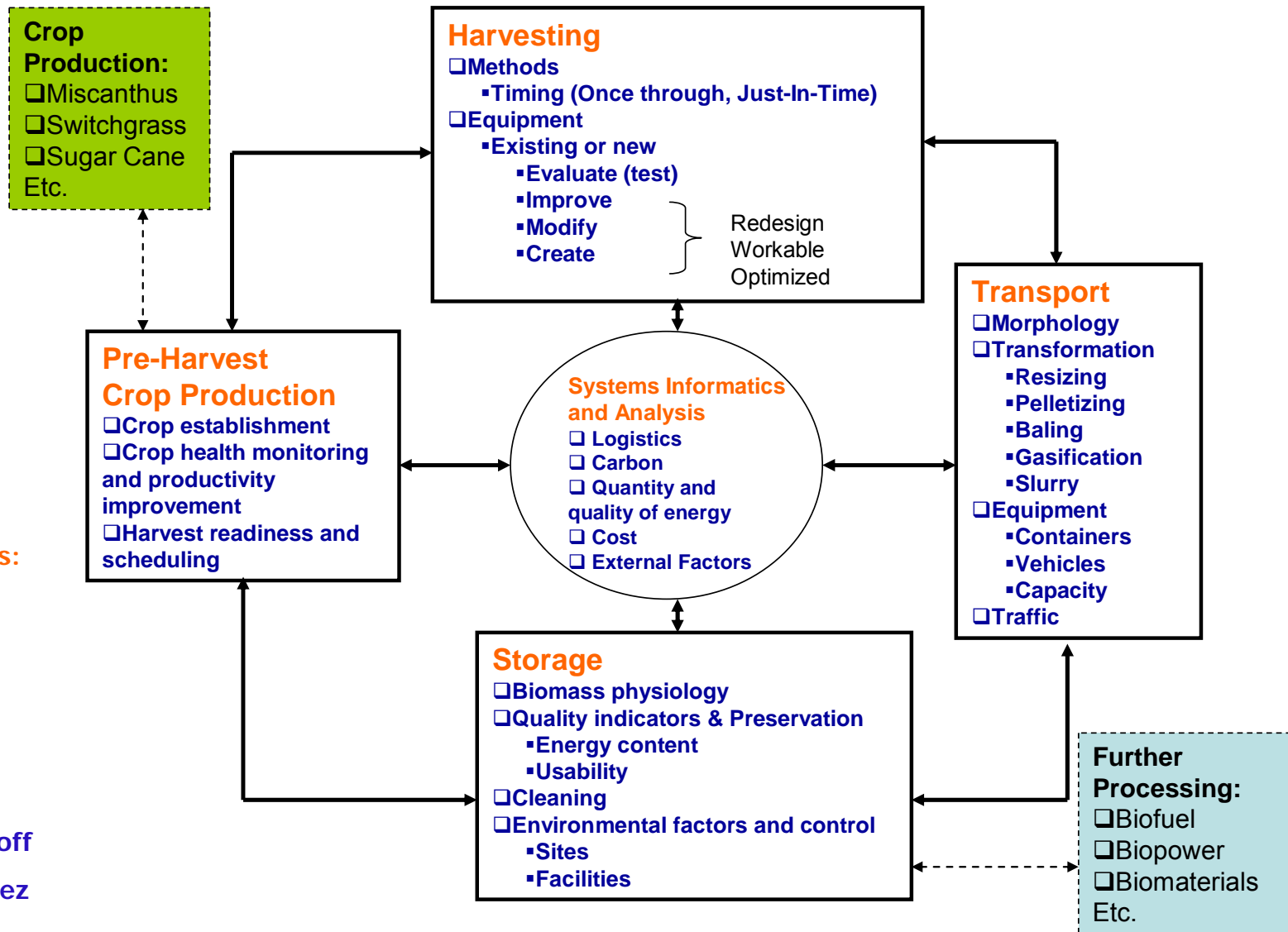
- Quantification of information and/or processes
- Mathematical and/or logical correlation of data
- Representation of real systems
- Creation of tools to enable description and/or application of concepts and ideas

In many cases, Modeling is to develop tools for Systems Analysis; but not systems analysis in itself

Biomass Feedstock Production



Engineering Solutions for Biomass Feedstock Production



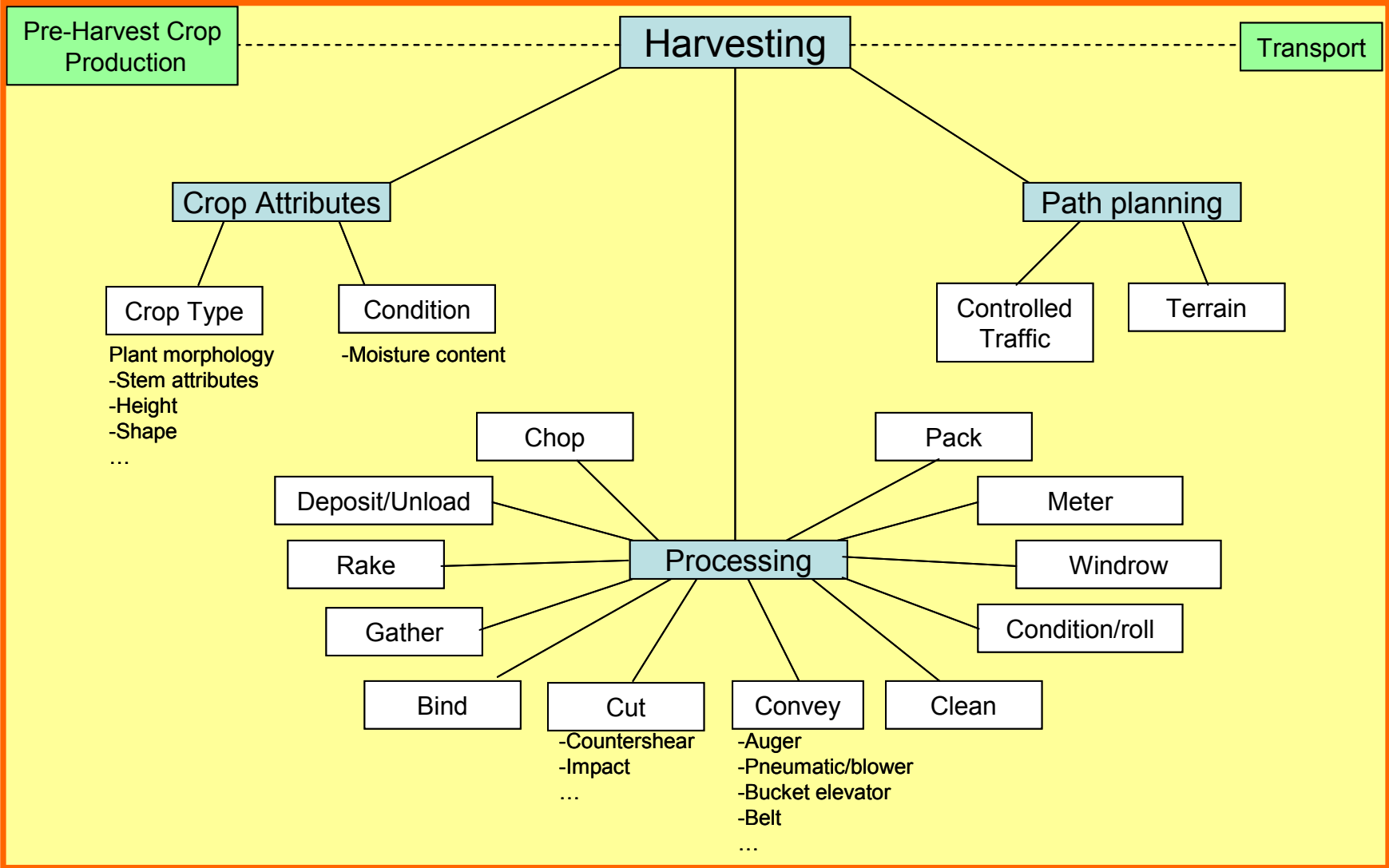
Investigators:

- K.C. Ting
- Alan Hansen
- Qin Zhang
- Tony Grift
- Lei Tian
- Steven Eckhoff
- Luis Rodriguez

Example of states and functions for Harvesting task

- Crop Production:**
- Miscanthus
 - Switchgrass
 - Sugar Cane
 - Etc

- Harvesting**
- Methods
 - Timing (Once through, Just-In-Time)
 - Equipment
 - Existing or new
 - Evaluate (test)





Concept of Object-Oriented Analysis (OOA): A systems abstraction tool

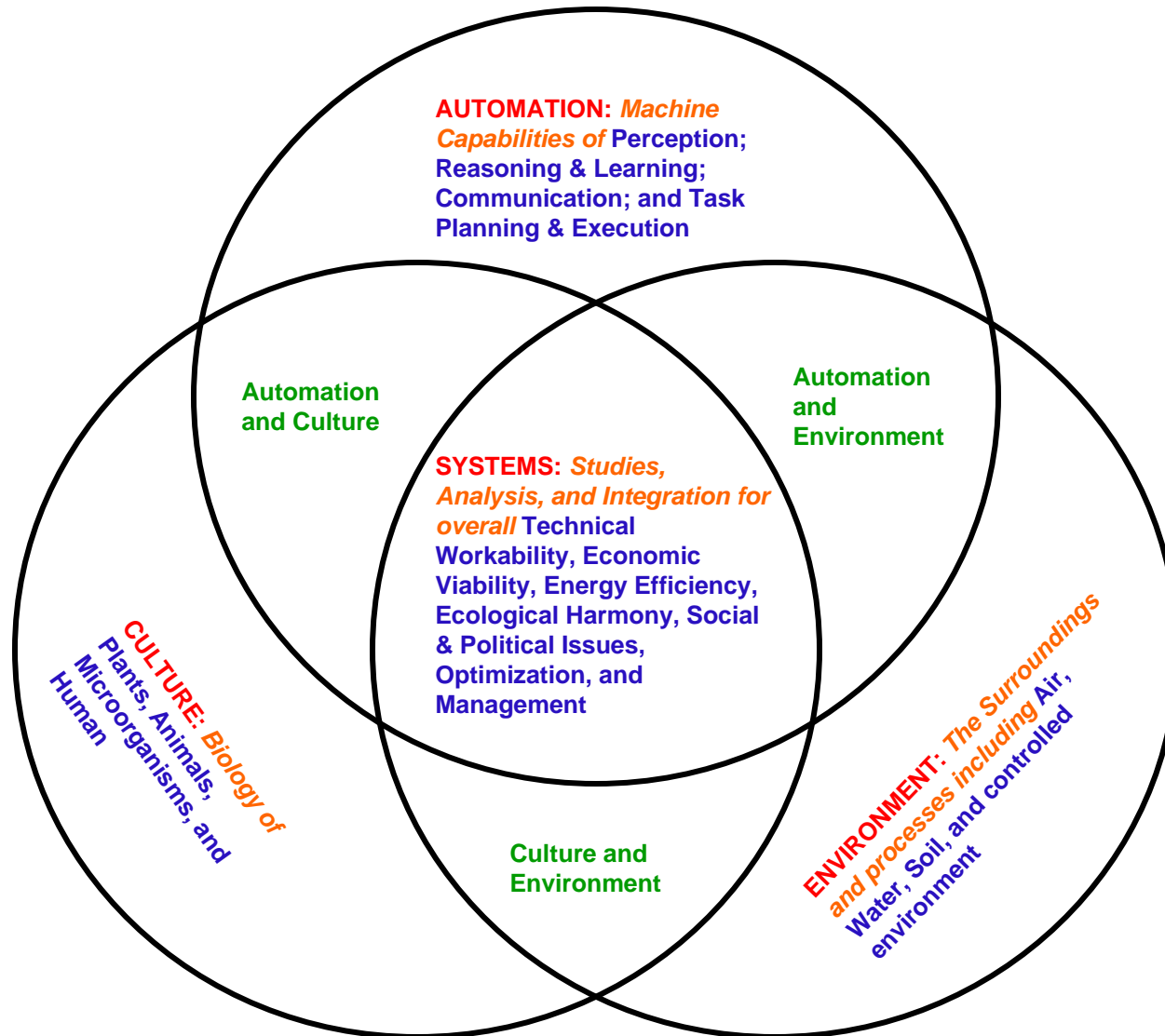
- Everything (physical or informational) can be viewed as an “object”
- Every object can be described using a list of “attributes” and every object can hold certain “methods”
- The attributes serve as “holders” of information about the object and “protocols” of information exchange between information providers and users
- A group of objects can be represented by a “Class”
- The information contained in attributes can be accessed and/or processed using “methods”
- The outcome of methods may change information contained in attributes

<p>Class Title</p> <p>Biomass</p>
<p>Attributes</p> <p>Crop name: Production area (ha): Yield (kg/ha): Cost (\$/ha): Price (\$/kg): . . .</p>
<p>Methods</p> <p>(accessing other objects; update and compute attribute values)</p>



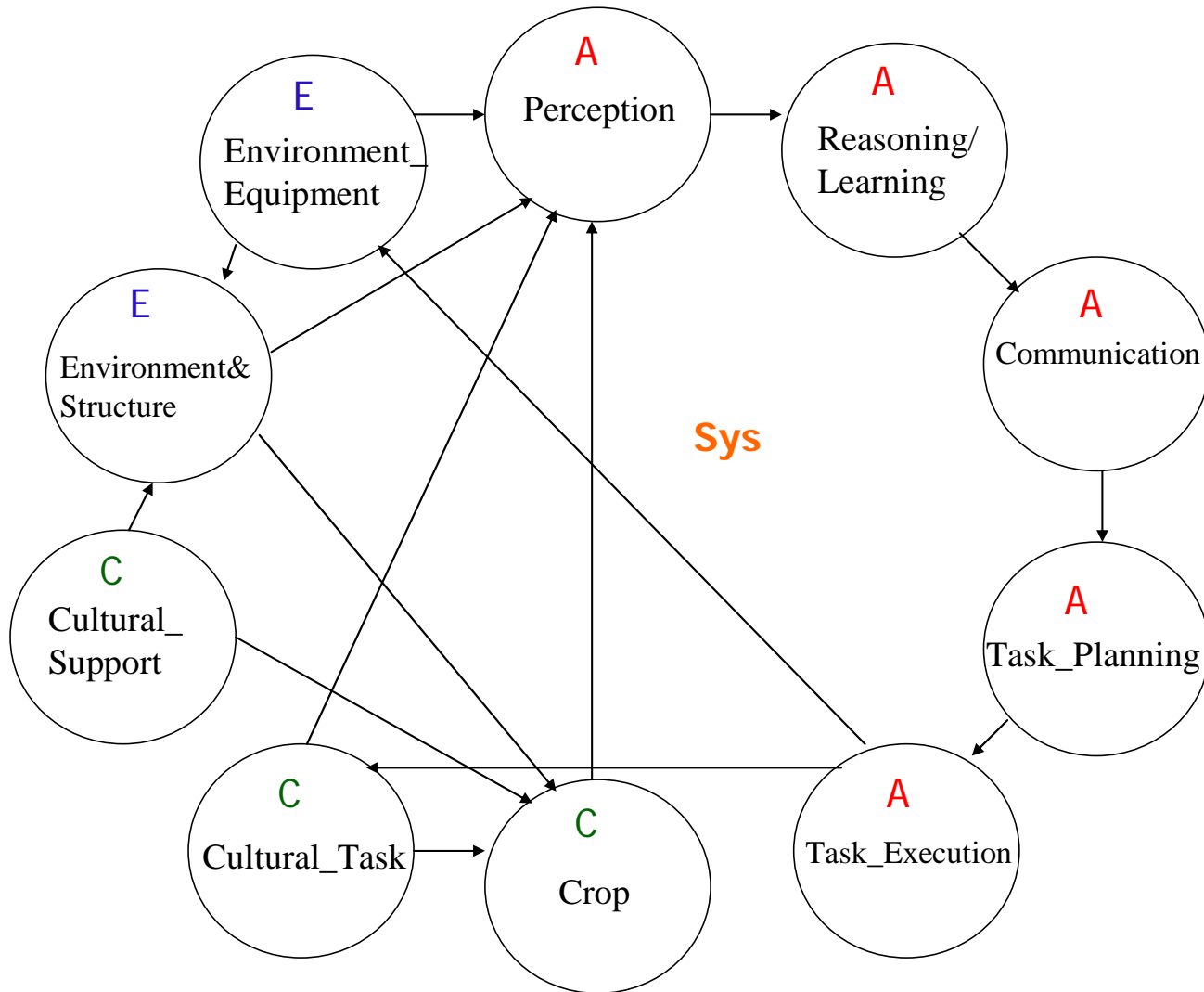
Automation-Culture-Environment-Systems (ACESys)

Example Foundation Classes





Example ACESys Objects and Interrelationships for Plant Production System





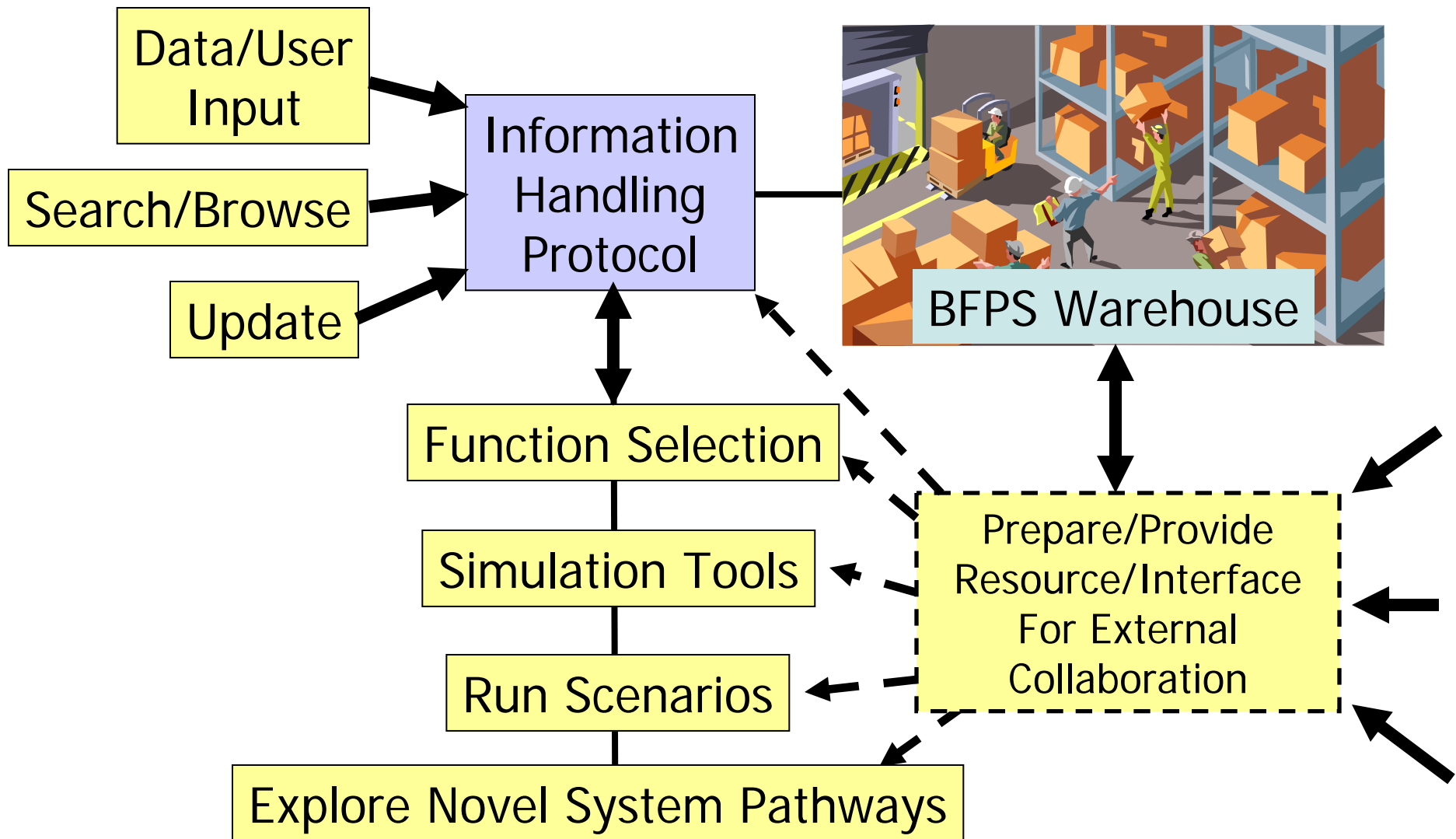
Concurrent Science and Engineering (CS&E)

The concept

- (1) **Integrate** information and knowledge related to the bioenergy system from various sources in a **real-time fashion**
- (2) **Perform** systems analysis (including optimization)
- (3) **Evaluate** systems level performance
- (4) **Deliver** the results of analysis based on the most current information, also in a **real-time fashion**



Engineering Solutions for Biomass Feedstock Production





Challenges in Integrated Systems Modeling and Design

- **Top-Level vs. Process Level**
- **Breadth vs. Depth**
- **Information/Data Exchange Protocol**
- **Expandability, Compatibility, and Adaptability**
- **System Abstraction**
- **Computational platforms**
- **Targeted participants and audiences**
- **Validation**
- **Handling of heuristic, uncertain, and incomplete information**
- **Deliverables – case-by-case vs. computational tools**
- **Coordination of activities (i.e. concurrent science and engineering)**



Opportunities (an example)

- Systems Approach to Sustainability Analysis of Bioenergy Systems

Definition of Sustainability: Continuing to do "well"

- Identify critical system needs to form basis of study
 - Identify candidate technologies and use cases
 - Explore feasibility of dissimilar options/redundancy
 - Prepare for stochastic simulation
 - Assign probability distributions; perform simulation; and determine system's "wellness"
 - Utilize simulation results to determine model-based sustainability
 - Develop integrated actions for sustainability improvement
 - Conduct concurrent sustainability assessment
-
- Repeat the above steps as often as necessary



Questions/Answers and Discussion



emPower Human
Capacity
with
knowledge and Wisdom
(kW)

Integrate
Life and Engineering
for Enhancement of
Complex Living Systems

.....*Thank you!*