Design of Integrated Systems and Modeling

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System:

A set of interrelated components organized to achieve certain goals.

Examples -

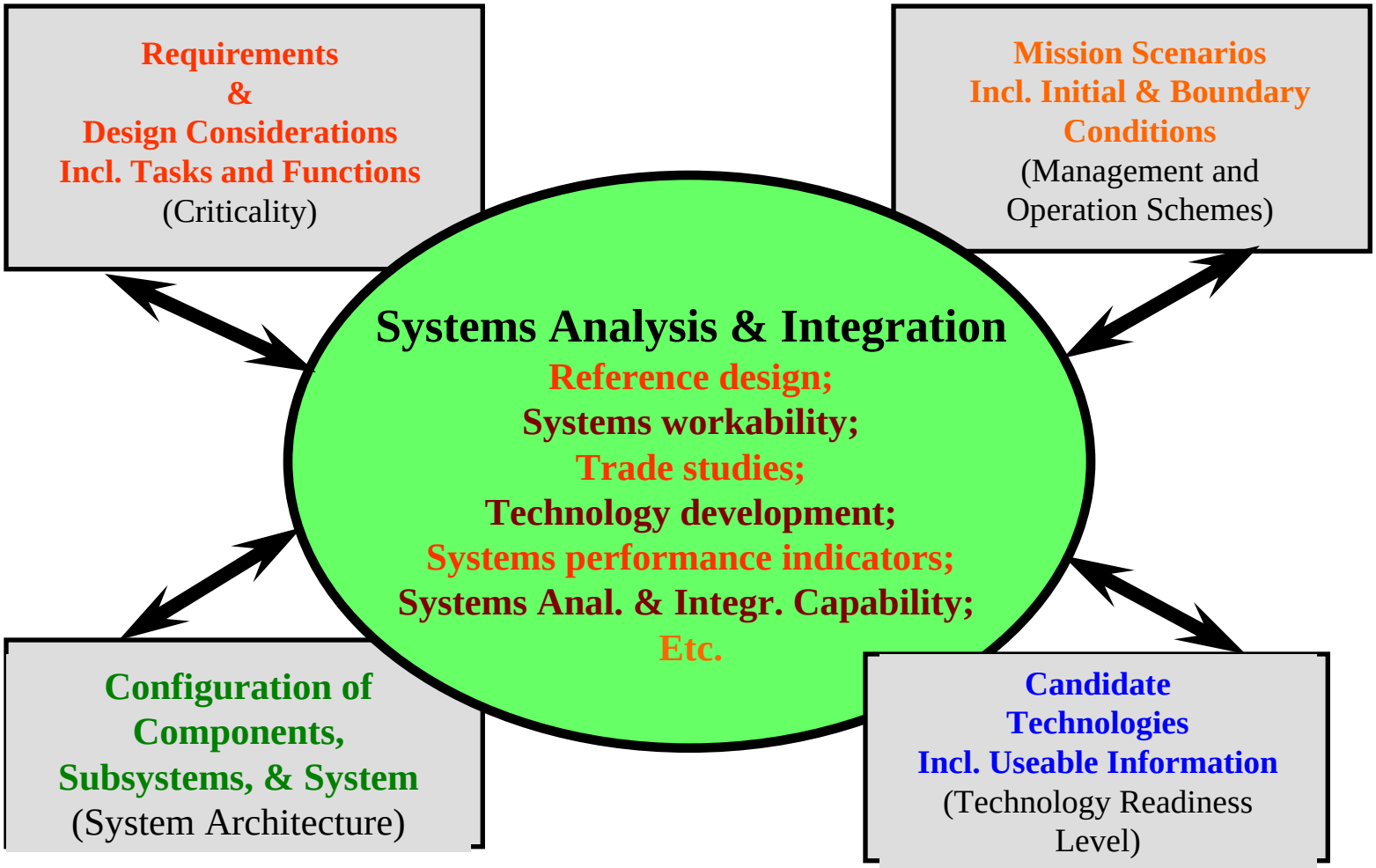
Automobile :

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

Advanced Life Support System:

crew
biomass production
food processing
waste processing & resource recovery
etc.

Underlying Concept of Systems Informatics and Analysis for Decision Support



Challenges in Integration of Scientific Information

- Many scientists have been very successful within their well defined disciplinary boundaries
- It is not clear, to individual scientists, why active participation in the effort of information integration is of any value. In fact, the effort is frequently viewed as an extra burden
- The concept of systems analysis has not been made interesting and the mechanism of systems analysis is perceived as formidable
- The tools used for systems analysis are mostly not user-friendly and incapable of dealing with dynamically changing information base in a real-time fashion
- The integration of information from traditionally disparate fields, such as life science and engineering science, is likely to encounter new challenges

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

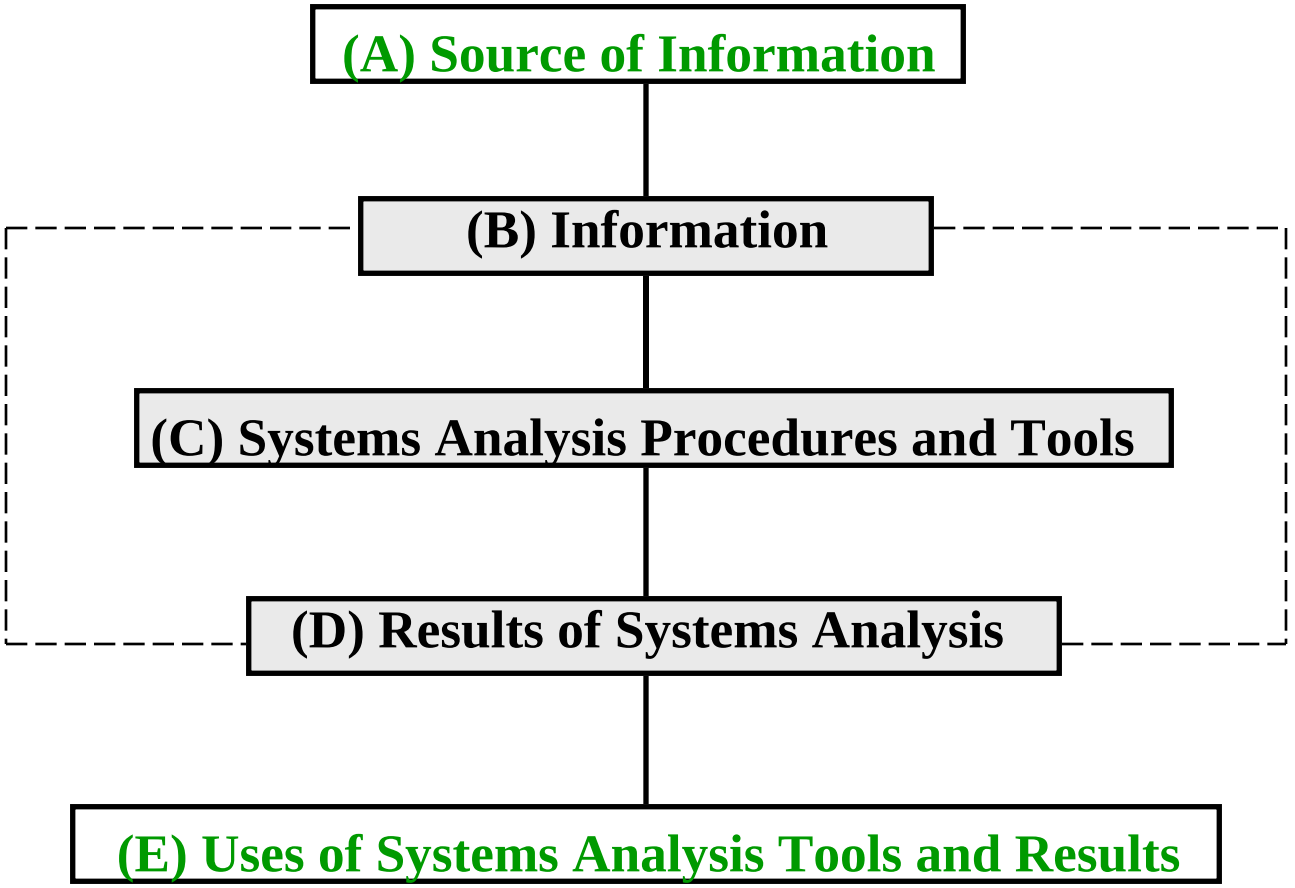
Why:

- **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**

Issues of Systems Analysis

- 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 the system and its objective
- identify descriptors of the system (including initial & boundary conditions)
- establish the relationships among the descriptors
- designate system performance indicators
- develop a model to represent a system and its operation
- verify and validate the model
- perform simulation using the model (investigate “what if?”)
- draw conclusions about the system:
  - technical workability & reliability
  - resource requirements
  - environmental impact
  - economic viability
  - optimization
  - etc.

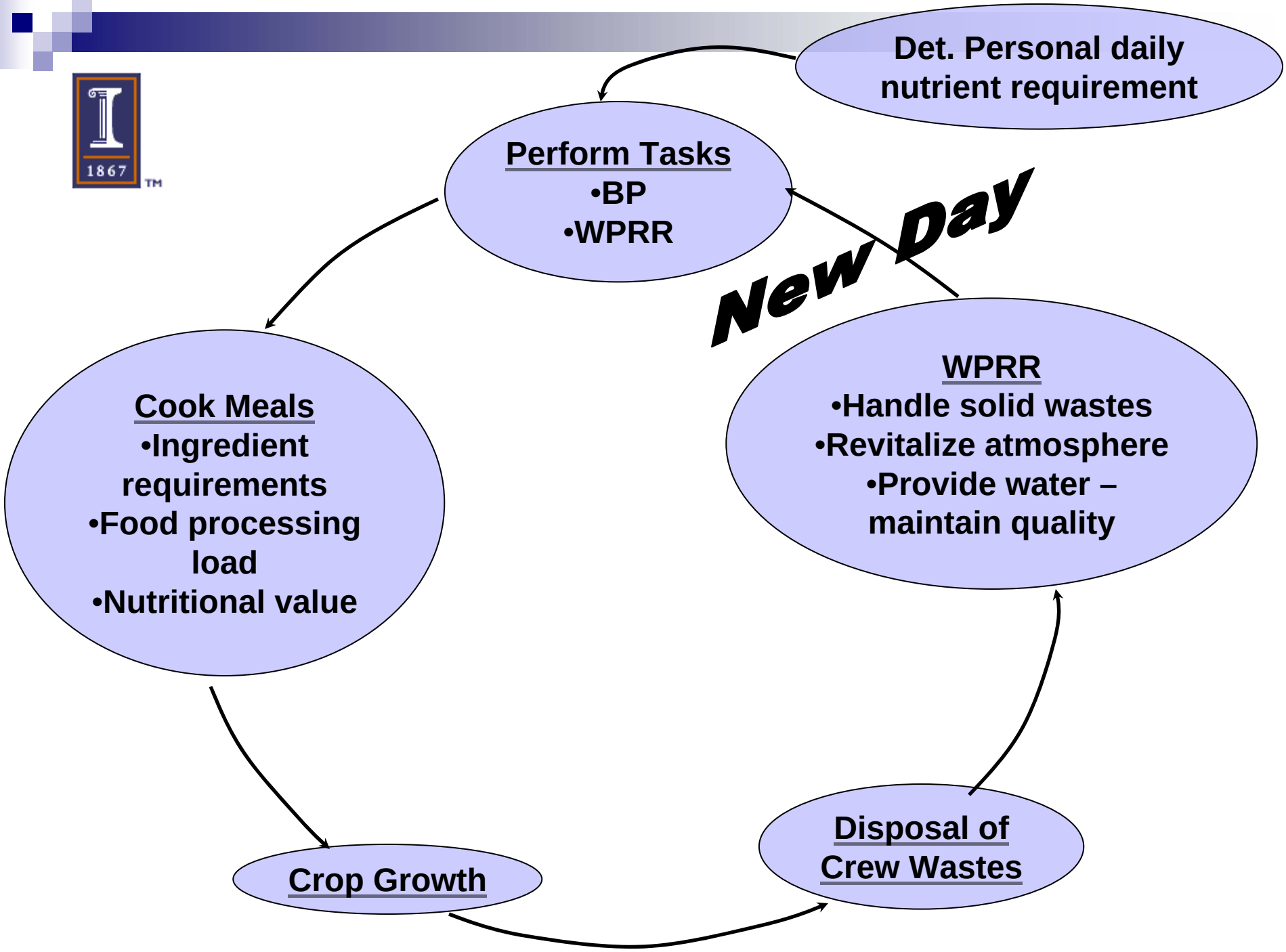
Modeling

- 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

Modeling goals for each subsystem in the ALSS top-level model (Rodriguez, 2002; Rodriguez et al., 2003; Rodriguez and Ting, 2003; Ting et al., 2003; Fleisher et al., 2006)

Subsystem	Simulation Goals
Biomass Production (Fleisher et al., 1999)	■ Crop growth ■ Culture tasks ■ Facility maintenance
The Crew (Goudarzi and Ting, 1999; Goudarzi, 2003)	■ Perform daily tasks ■ Generate system loads ■ Consume system resources
Food Processing and Nutrition (Hsiang et al., 2001; Hsiang, 2002)	■ Cooking ■ Determine ingredient requirements ■ Determine food processing loads ■ Determine nutritional requirements of the crew ■ Determine nutritional value of daily diet
Waste Processing and Resource Recovery (Rodriguez et al., 1999; Rodriguez, 2002)	■ Solid waste handling ■ Waste water processing ■ Air revitalization


Det. Personal daily nutrient requirement
Perform Tasks
•BP
•WPRR
New Day
WPRR
•Handle solid wastes
•Revitalize atmosphere
•Provide water – maintain quality
Cook Meals
•Ingredient requirements
•Food processing load
•Nutritional value
Disposal of Crew Wastes
Crop Growth

Challenges in Integrated Systems Design and Modeling

- 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)

Concurrent Science and Engineering (CS&E)

The concept

(1) Integrate information and knowledge related to the base camp 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

Opportunities

-Systems Approach to Sustainability Analysis of Base Camp Systems

Definition of Sustainability: Continuing to do "well"

- **Identify critical system needs to form basis of study**
- **Identify candidate technologies**
- **Explore feasibility of dissimilar redundancy**
- **Prepare for stochastic simulation**
- **Assign probability distributions; perform simulation; and determine failure modes**
- **Utilize simulation results to determine model-based sustainability**
- **Develop integrated actions for sustainability improvement**
- **Conduct concurrent sustainability assessment**

Questions/Answers and Discussion

emPower Human
Capacity
with
knowledge and Wisdom
(kW)

Integrate
Life and Engineering
for Enhancement of
Complex Living Systems

……Thank you!