

Heterogeneous SoS Views and Challenges for Project Systems to Smart City

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Journey into Systems Inquiry

- EE Control, MS/PhD Systems Science Center, Oklahoma State Univ., 5yrs
- Aerospace Industry – McDonnell Douglas/NASA-JSC, 20 yrs
- Commercial systems research lab – Daewoo Corporate lab, 2yrs
- Academia – Graduate program in SE, Ajou Univ. 15yrs
- SE service industry – SE Technology, Inc., 3yrs
- Member of INCOSE since 1998

Evolution toward complexity – Why?

- Stone age + Discovery of Fire → Steel age
- Steel age + need for better weapon → Machine age
- Machine age + ICT → Systems age
- Systems age + network based tech → SoS age
- SoS age + 3P SoS (?) → Hetero SoS age
- Why ?? → Survival and success !!

What is a system ?

- INCOSE Fellow's consensus definition:
 - A system is a construct or collection of different elements that together produce results not obtainable by the elements alone.
 - The elements, or parts, can include people, hardware, software, facilities, policies, and documents; that is, all things required to produce systems-level results.
 - The results include system level qualities, properties, characteristics, functions, behavior and performance.
 - The value added by the system as a whole, beyond that contributed independently by the parts, is primarily created by the relationship among the parts; that is, how they are interconnected (Rechtin, 2000).

Positive Emergent Properties for Smart City Vision

- **Safety and security**
- **Convenient and pleasant living**
 - No traffic jam
 - No pollutions
 - Recreation
- **Jobs and happiness for all citizens**
 - Economy
 - Success and self-realization
- **How do we obtain the above PEPs**
 - Each system or SoS perform its mission with high-level of integrity
 - The interactions and relationships among them are reliable and as planned
 - All negative emergent properties are eliminated or minimized through Hetero SoS design

Heterogeneous SoS Hierarchy and Smart City

Extended Hitchins's 5 layer model

Level 5 – Socio-economic system

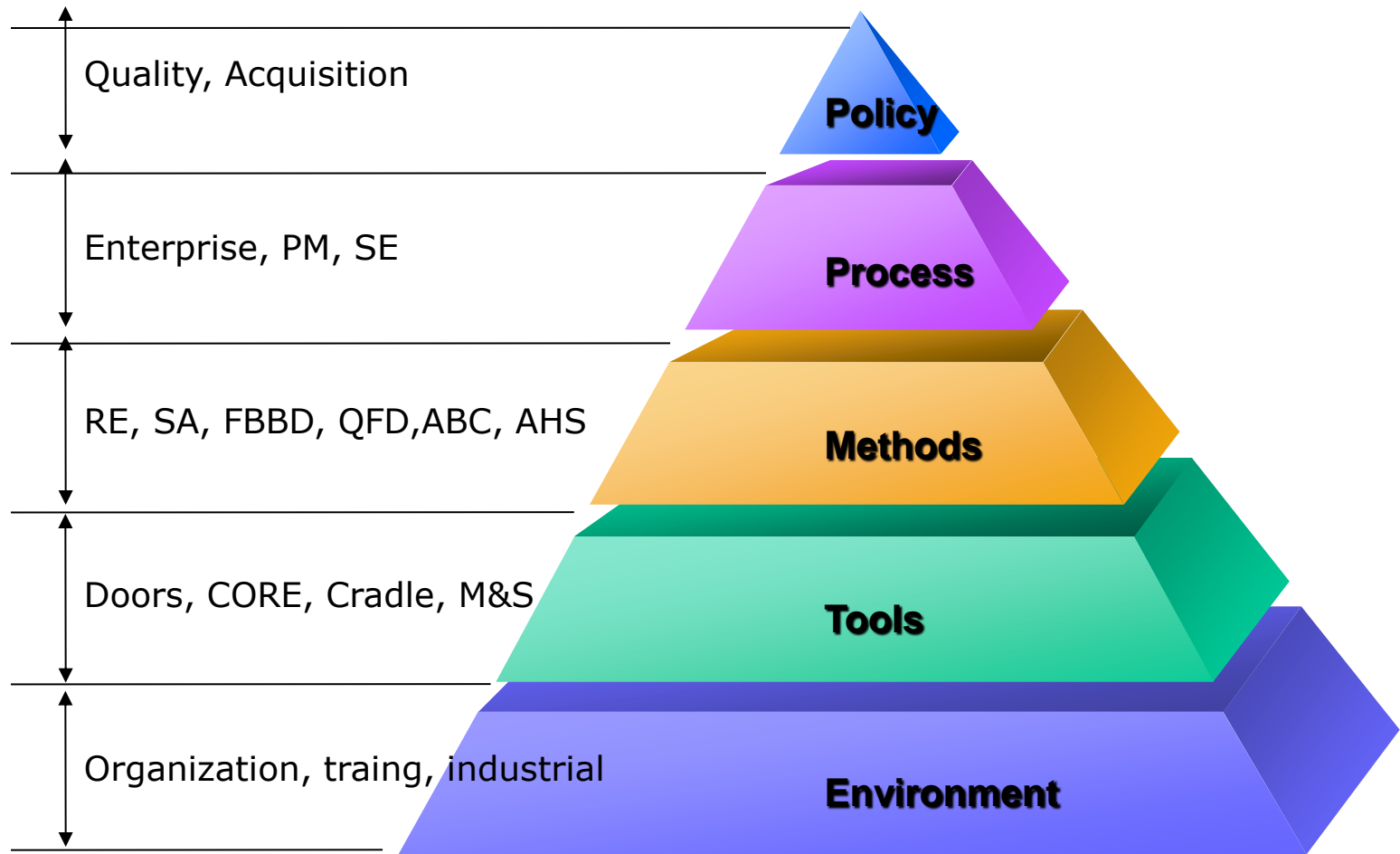
Level 4 – Industrial system

Level 3 – Enterprise system

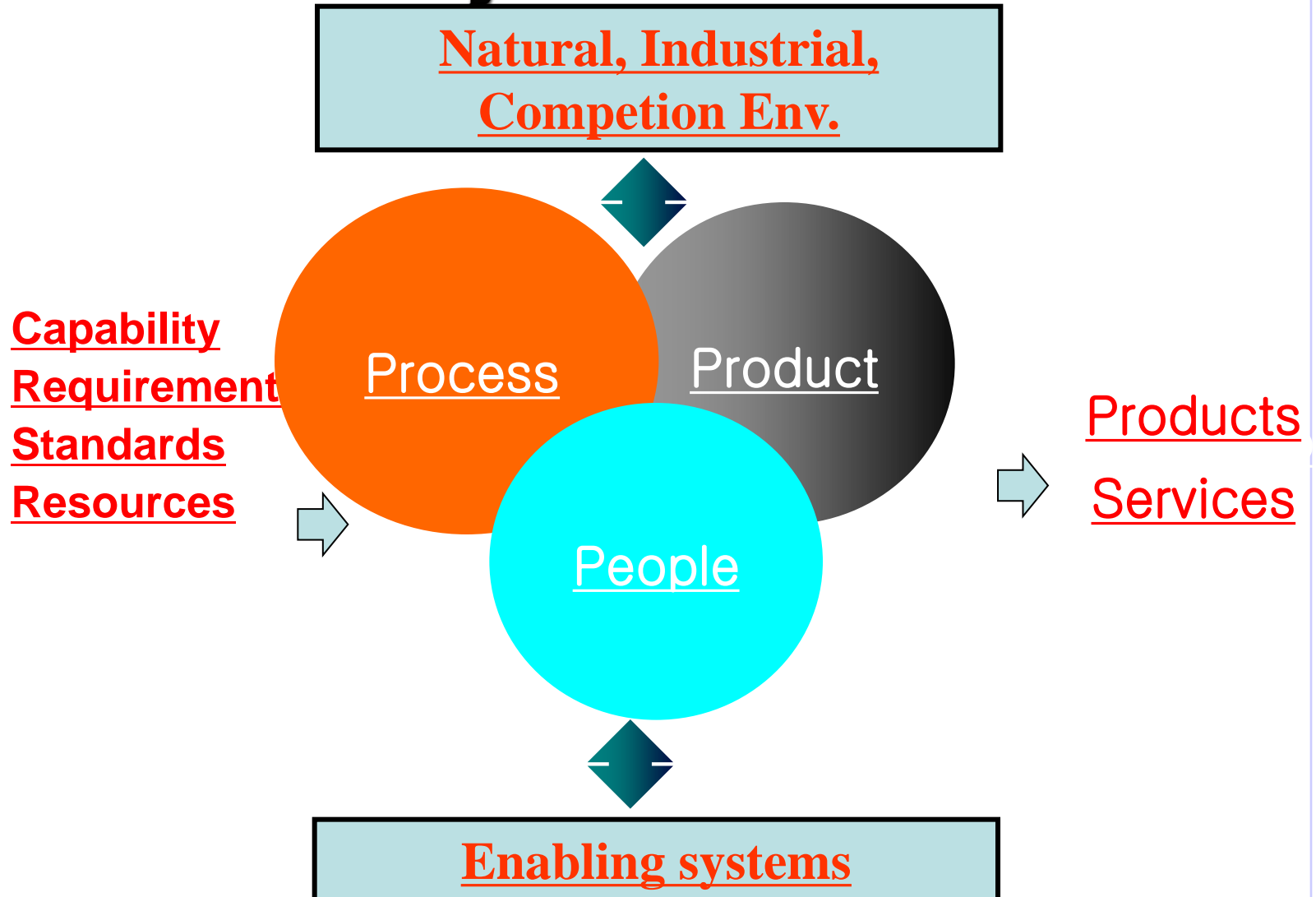
Level 2 – Project system

Level 1 – Product system

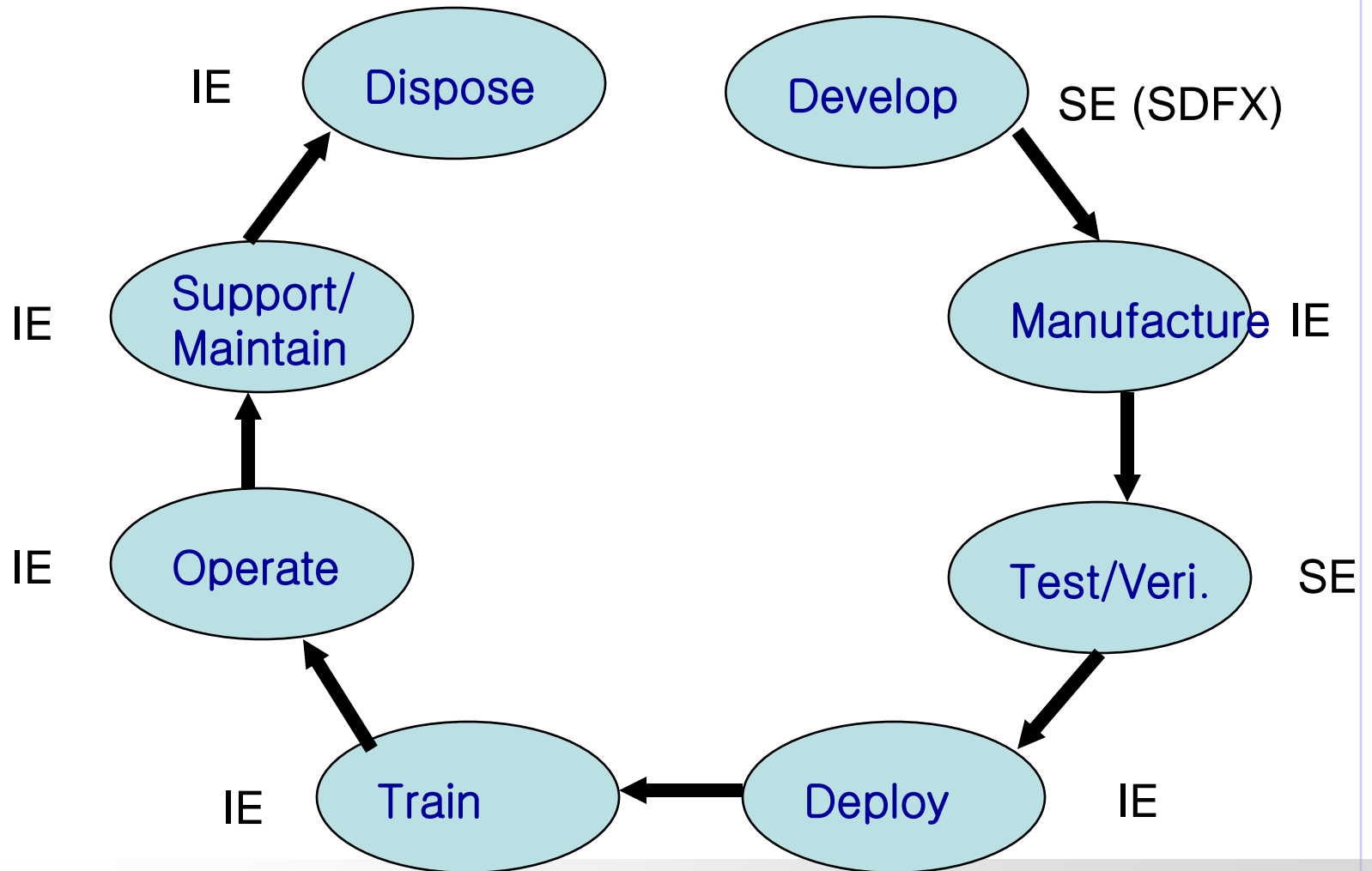
Martin's SE PMTE Paradigm



Heterogeneous SoS View of Project/Mission

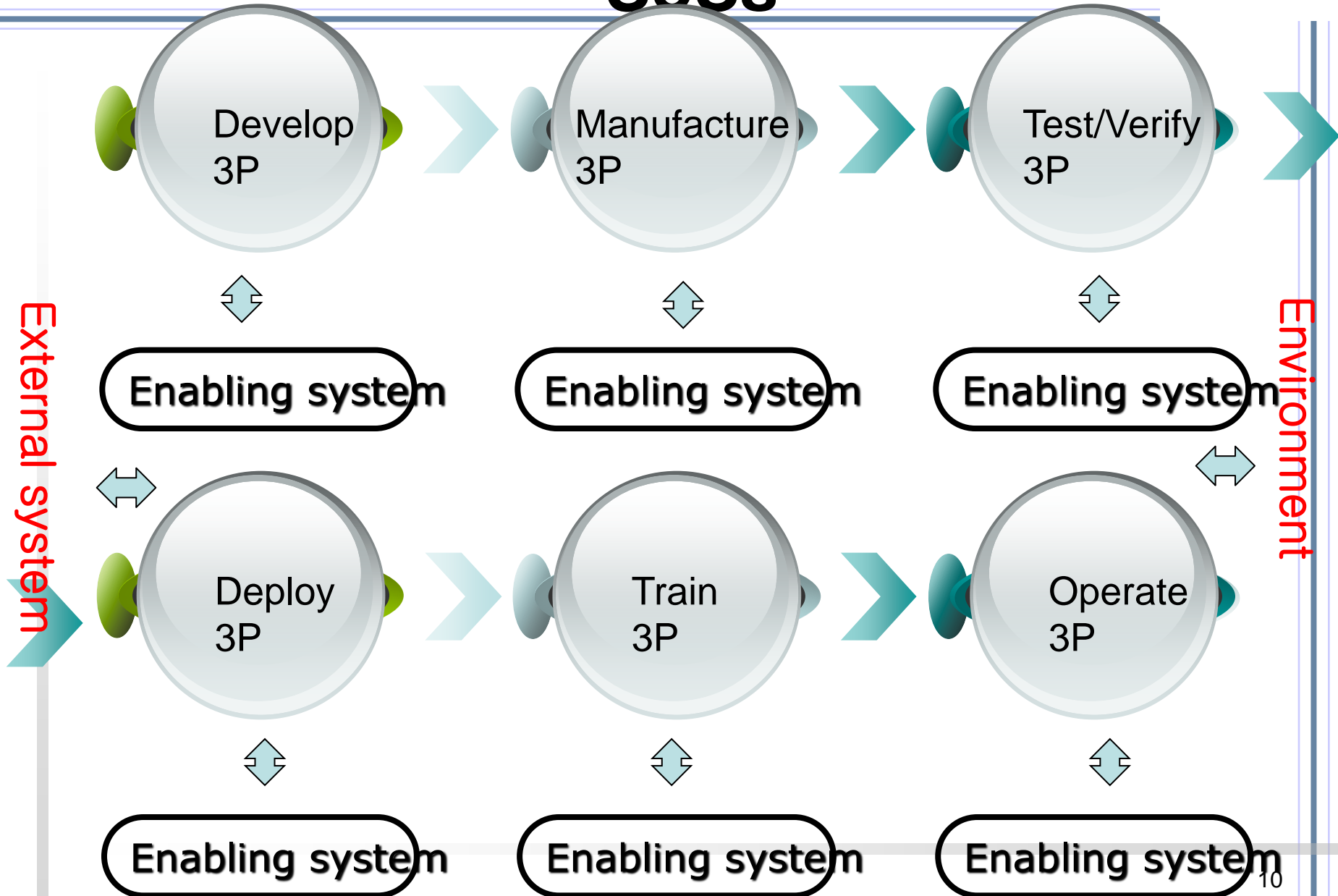


System Life-cycle Major Functions



3P (People, Process, Product)

SoSs



Challenges for Heterogeneous SoS D&M

- Hetero SoS architecting and Design
 - New R&D opportunities for Smart City
 - Integrate systems science for all social/natural science and systems engineering disciplines
 - Knowns and Unknowns on PEPs and NEPs
 - Meta Models and tools
- CSD&M future challenges
 - Human System Integration(HIS)
 - Product SoS vs People SoS
 - Process SoS vs People SoS
 - Enabling SoS vs People SoS

Systems Approach

- Separation of concerns; Divide and conquer
 - Problem definition vs Solution definition
 - Phased-in approach: Plan, Concept, System design, Detailed design, Build, Verify/Validate
 - Operational, Functional(Logical) and Physical domains(views)
 - Known, Uncertain(Degree of uncertainty), Unknowns
 - You don't know what you don't know – Most risky(ignorance is most costly): Eliminate unknown knowns first!
 - Prepare an plan for unknown unknowns

Systems Approach

- Risk management based approach:
 - » Safety: Hazards are threats to survival
 - » Success: Risks are threats to success(effectiveness)
 - » Security: problems are threats to success and survival
 - » Quality and reliability: faults and flaws are threat to success and survival
- Design and tailor the problem solving or development **process SoS** to eliminate the most risks expending the minimum time and resource

Systems Approach

- Be holistic:
 - To define problems as well as to define the solutions
 - Consider the entire life-cycle stakeholder needs and concerns,
 - products, disciplines involved,
 - enabling systems,
 - environments (social, natural, competitions, threats, concerns, ...)
 - Identify, analyze, define and manage risks
- Pay attention to how PEPs and NEPs are generated:
 - interactions, interfaces, relationships, co-operations, collaborations, integrations and communications
 - Trust
 - All human attributes

Conclusions

- R&D challenges for Heterogeneous SoS
 - More integration, R&D and education
 - Process, methods and tools for Hetero SoS modeling
 - HSI and socio-economic systems
- Reuse the wisdom of systems thinking and approaches
- CSD&M challenges for all of us !!