Enterprise Architecture to fight the 2nd law of Thermodynamics

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Agenda

- Introduction
- Physics
- The Industrial Enterprise System
- Enterprise Architecture
- ISA88/95 manufacturing modeling framework
- Conclusion

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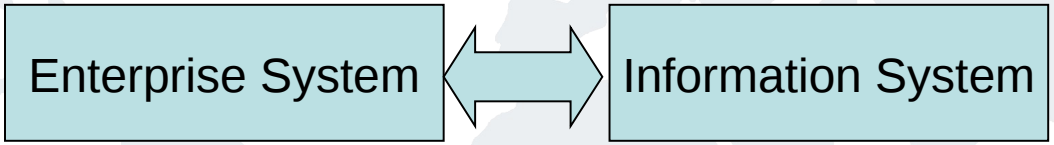
Information in Industrial Enterprise

- **Information flood, addiction**
- **Common paradigm:**
  - Computer + network + databases + software = IS
  - Information System serves the Enterprise system



- **WBF EU2008: Closing the gap between IT and manufacturing**
  - Need for a symbiotic approach more conform to the Nature

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Relative importance of IT in Enterprises

- **Service, Banks, Insurance companies**
  - The sold items are virtual = intrinsically Informational
  - IT is the production asset = investment
    - Objective return on investment
- **Industry**
  - The sold items are physical
  - IT is a supporting utility = operating expense
    - How to justify expenses? Feeling, assumptions, hopes…
    - Hard benefits of early automation: eliminated biological workforce (and associated costs)
  - What is the true IT importance?

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Sustainable development and environment

- **Industry is a major component in the Earth eco-system**
- **Fast rise of enterprises « Social Responsibility » concern**
  - Cares about social, environmental and economical footprints
  - Various motivations

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Enterprise as a scientific subject

- **Largely studied subject**
  - Academic studies often stays at the “Valid philosophy” stage
  - Intuitive, simple, common sense approaches (6 Sigma, Lean management, Theory of Constraints) more successful
- **Enterprises intuitive management**
  - Market, Shareholders, bankers, environmentalists, economics constraints
  - => genial intuitive managers
- **Leveraging relevant physics principles**
  - Help achieving short term “reasonable” objectives & long term sustainable evolution
  - Converge to Information

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Chaos

- **The nature is not deterministic**
  - Not everything is written
  - Surprises are needed for the fun… and for evolution
- **Chaos in space**
  - What is the length of French Brittany shores?
- **Chaos in Time**
  - The “Butterfly Effect”
- **Enterprise are chaotic**
  - As most natural systems
  - Unpredictable events, Unexpected outcomes – Murphy’s law..

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Complexity

- **Doesn’t mean “complicated”**
  - Interaction : Many components interacting non linearly
  - Chaotic : makes the system capable of improvements
  - Spanning several scales : Plants, Area, Work centres, Units, Drives
  - Emerging properties / behaviour : properly driven machine and appropriate knowledge can elaborate a product unknown from the machine perspective
  - Self organization, adaptability, ultimately self-reproduction
  - Involves Cooperation/Competition, Internally/Externally

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Entropy

- **The 2 laws of Thermodynamics: In a closed systems**
  1. Total energy does not change
  2. Temperatures tend to equilibrium: part of the energy mutes in a non usable form because of “Entropy”

3 Interpretations

- Irreversibility: engines produce unrecoverable heat
  - The Arrow of Time: Closed systems entropy always increases as the Universe’s
- Measure of the disorder: Kid’s room, engineer desk…
- Measure of ignorance: We are part of the system: Disorder prevents understanding

- **Entropy of an open system can increase or decrease**
  - At the expense of the surrounding system

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Information Physics

- **Information is the ultimate science**
  - Allows to build other sciences
- **Could be a primary material of the Universe…**
  - Particles interactions, particles themselves…
  - Grinbaum: Time = Ignorance (= Entropy?)
- **Information Entropy (Shannon)**
  - The minimum length of a message for a given meaning
  - Affected by coding, noise, redundancy
  - Could be generalized to measure the “effectiveness” of information processing.

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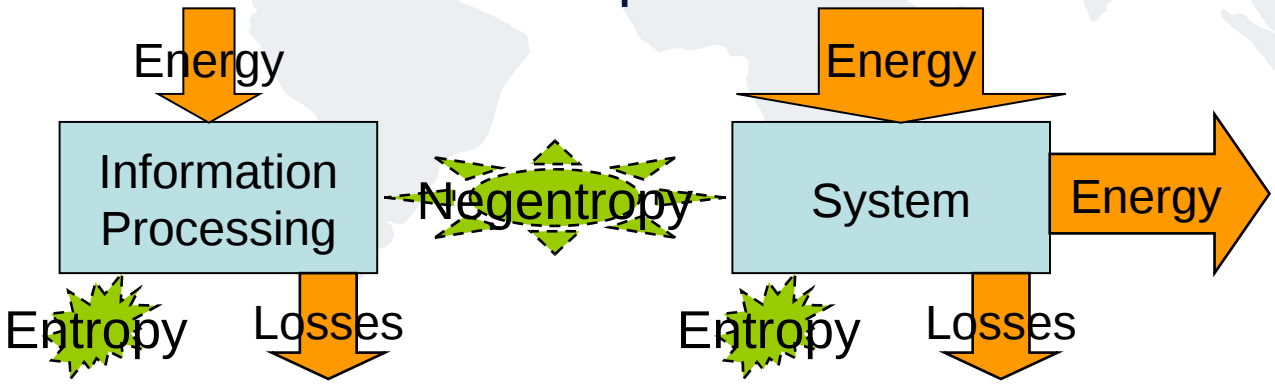
Energy and Information

- Information processing consumes energy
  - Does not produce any energy: thermodynamic entropy is maximum
- Information conveys ordering power, “Negentropy”
  - Information “applied” to a system increases its knowledge, its order = reduces its entropy
- Generalized Information entropy represents the entropic effectiveness of this process



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Systemics / Cybernetics

- **Systemics studies Open, Complex systems**
  - System: Set of elements in dynamic interrelation that are organised for a given purpose (J. De Rosnay)
  - Open system: Interacts with its environment
    - =/ Closed system: no matter/energy I/Os
  - Complex system: the whole more than its parts, chaos…
  - Opposes to (or complement) Cartesian, analytic approach
  - Particularly applied in sociology, biology and environment
- **Cybernetics is part of systemics**
  - Is basically about control loops…
  - Complex systems are full of them!

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Enterprise is an Open, Complex System

- **Physical interactions:**
  - Earth, other Enterprises, internal Resources
- **Noospherical interactions:**
  - Goals of the World, Humanity, Humans, Owners, other enterprises
- **Social interactions:**
  - Nations, NGOs, Trade unions, Family
- **Obeys to cybernetics' laws (i.e. PID)**

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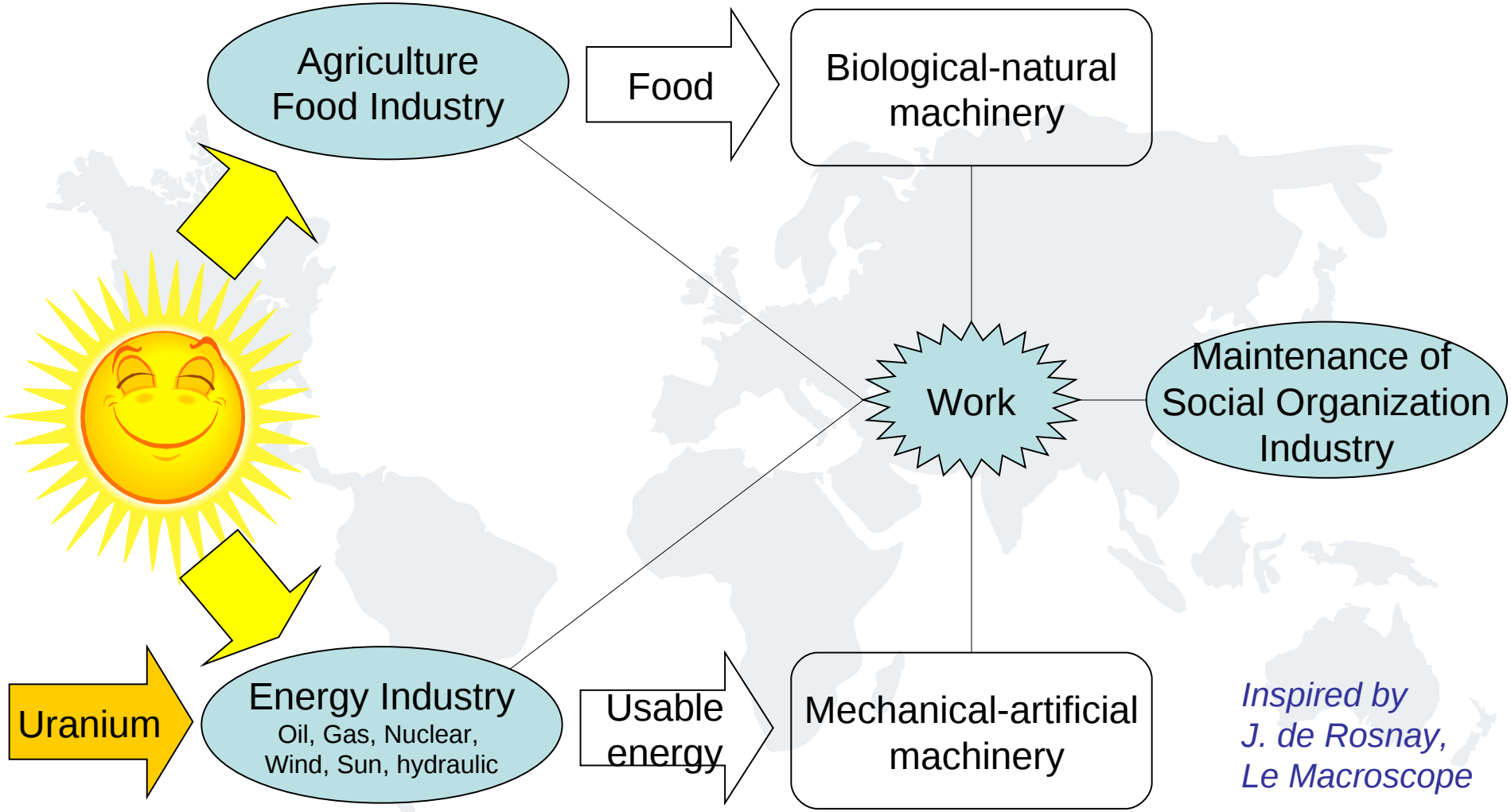
Industry eco-system



Inspired by
J. de Rosnay,
Le Macroscope

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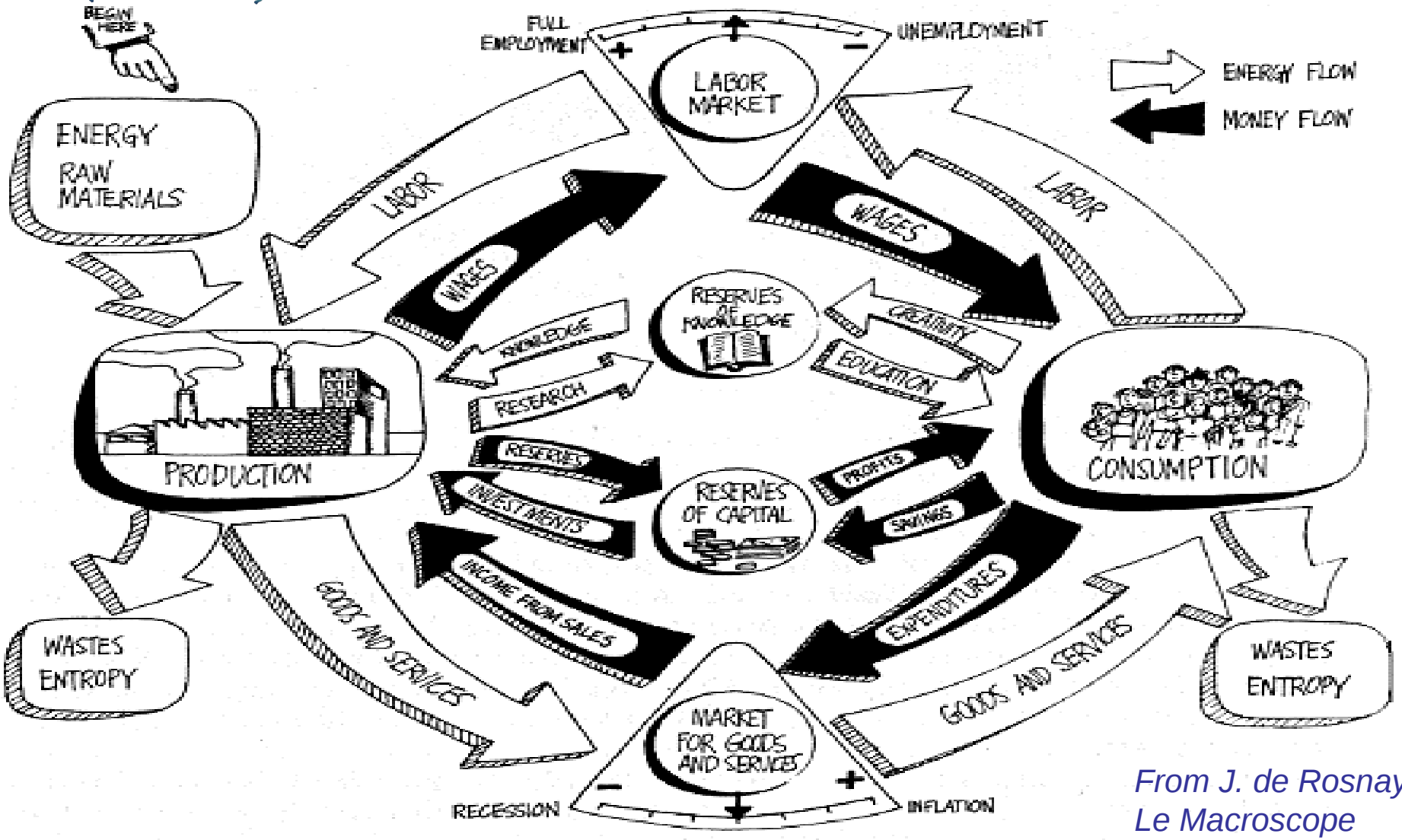
Industry Economics



From J. de Rosnay, Le Macroscope

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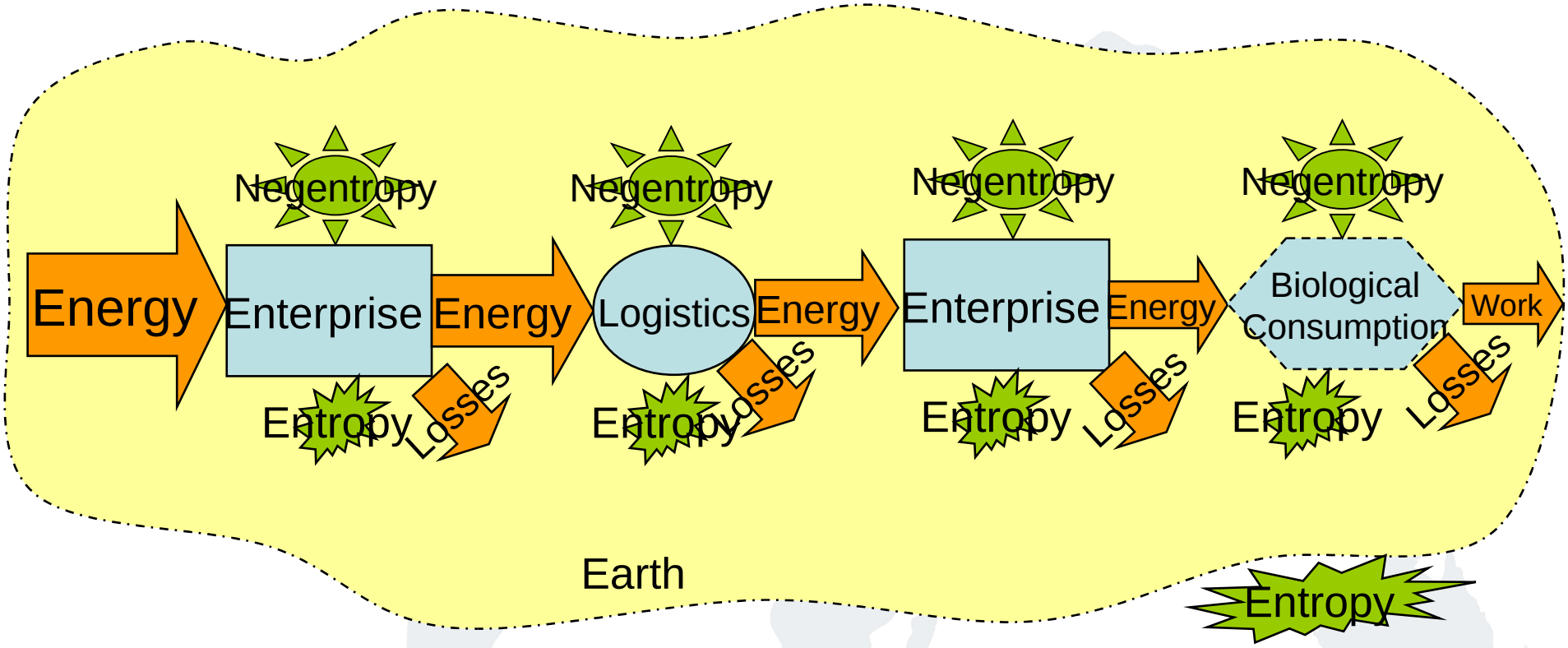
The enterprise black box: Energy Chain



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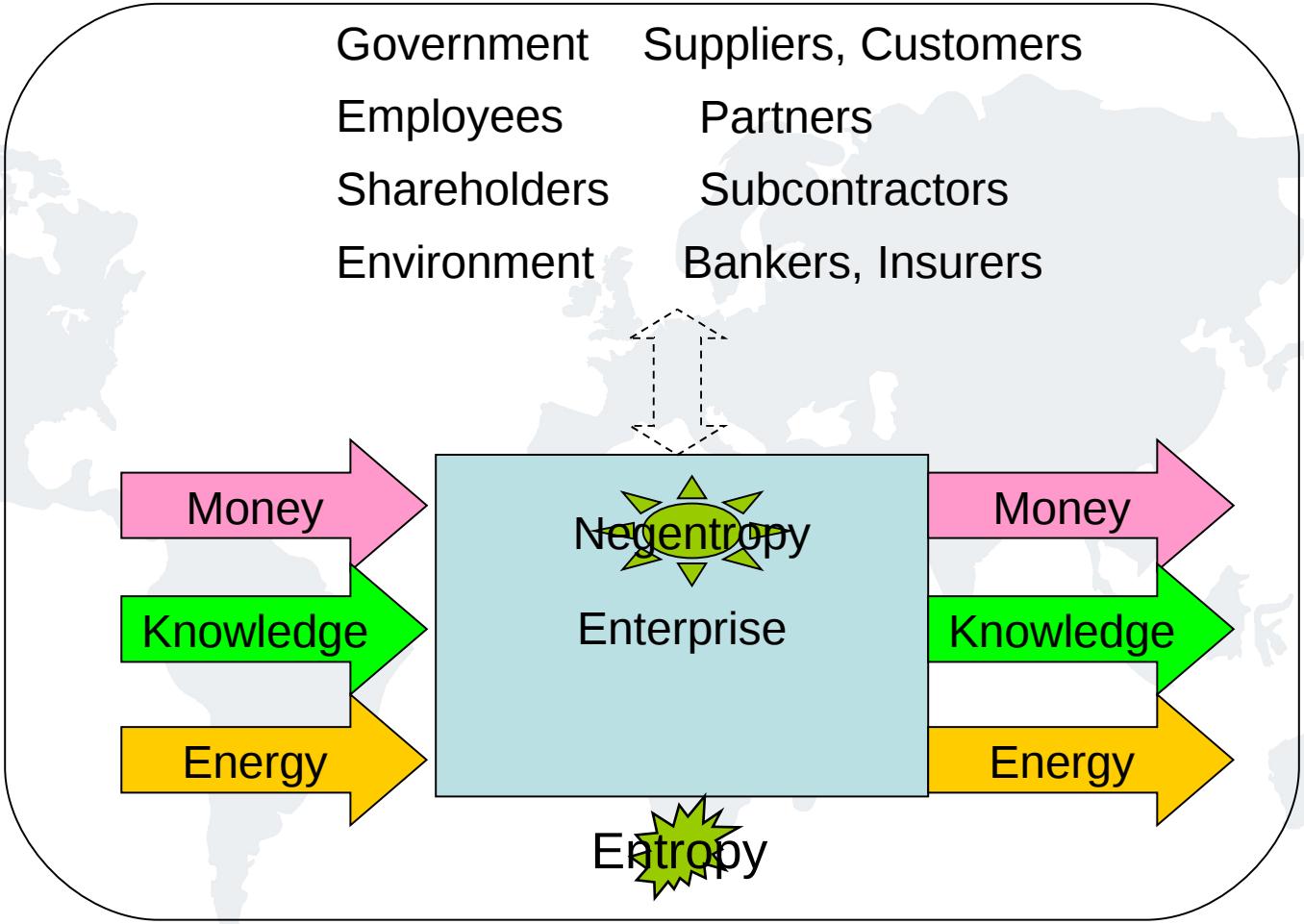

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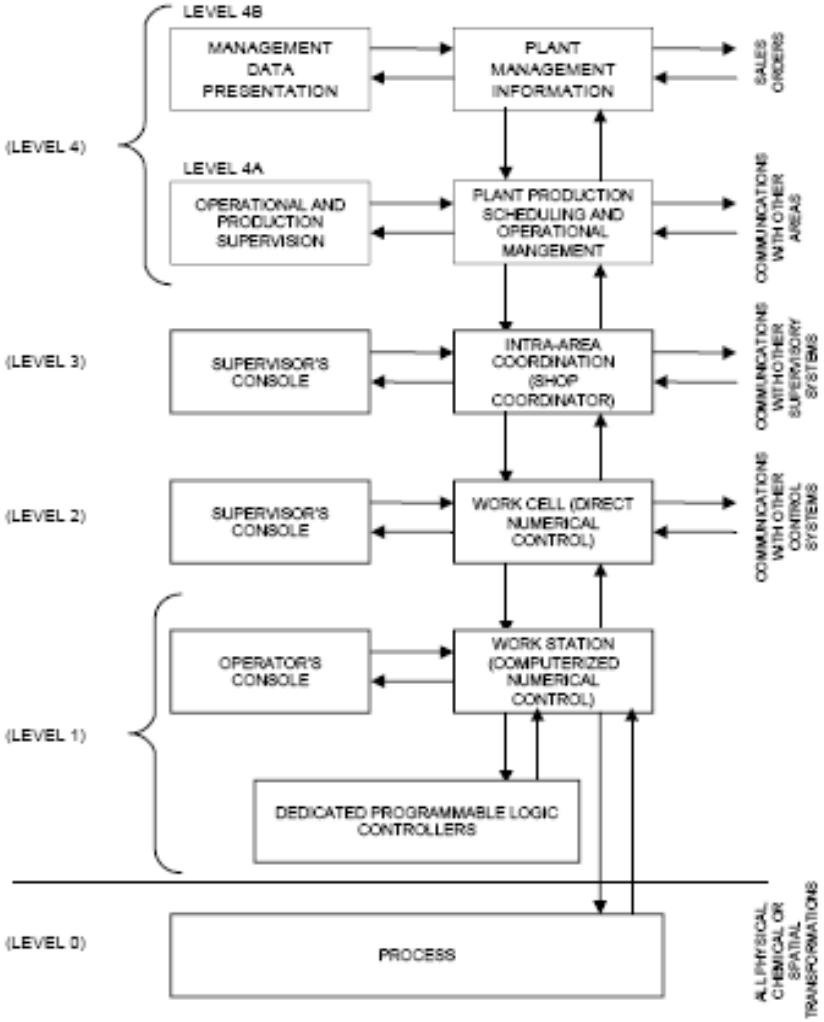
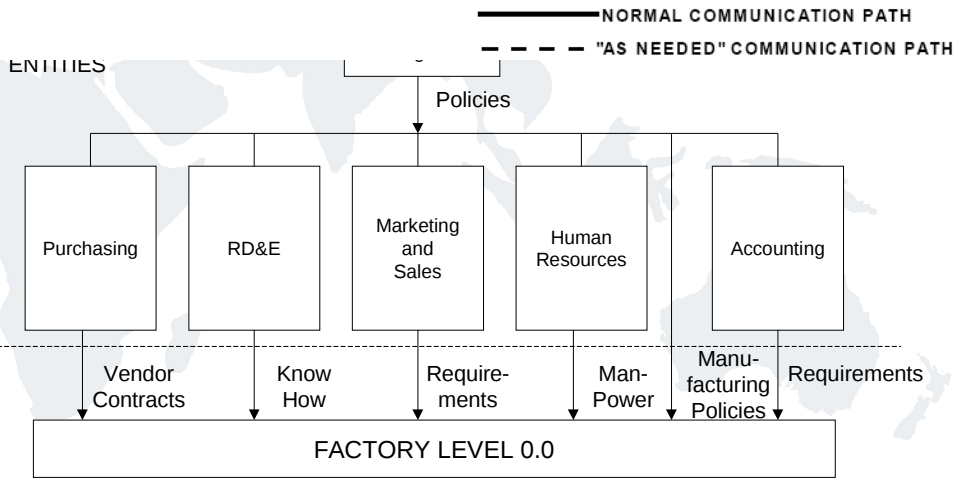
Opening the black box: Examples of enterprise structures (from PRM)





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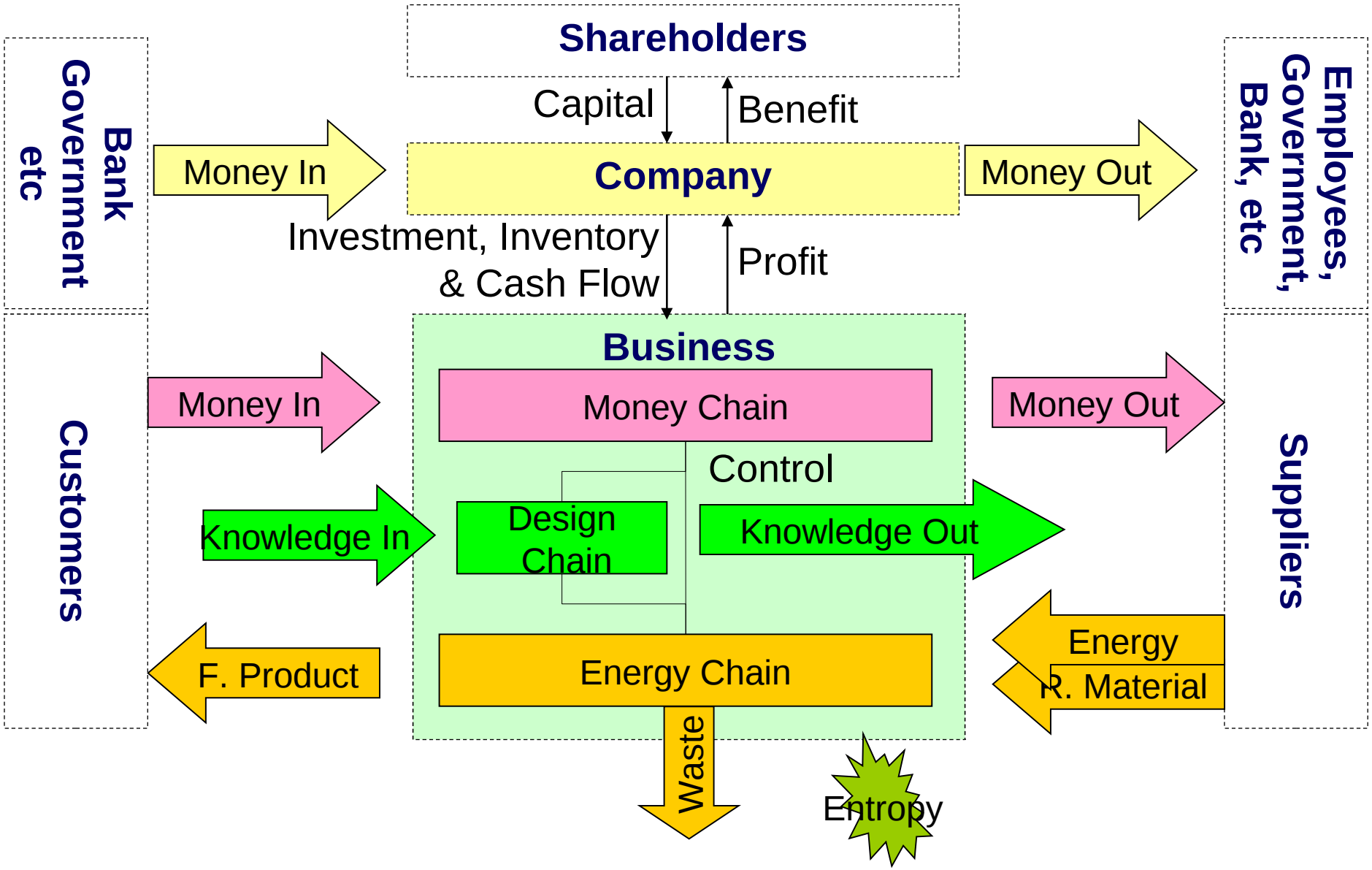
Opening the black box: High level interactions



Enterprise entropy

- **Many different forms of energy**
  - Thermal, chemical, Electrical, Radiant, Nuclear, Magnetic, Elastic, Acoustic, Gravitational…
- **Many different forms of entropy**
  - Human resource: inefficiency, errors, tiredness, aging, illness, discontent ..
  - Equipment resource: wear & tear, inefficiency, breakdown...
  - Material & energy resource: waste, energetic balance, uselessness (decreasing relevancy)…
- **High entropy may satisfy short term financial goals**
  - Earth system feedback loops will correct or eliminate offenders

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Information, IT and Enterprise

- **There are no Information System**
  - Information is part of the system, of the enterprise
  - Not the attribute of a separate enterprise component
- **IT just adds to other information media**
  - From people's memory, paper files, couriers, telephone, pneumatic tubes, human brain, analog computers, mechanical marvels…
  - …To electronic data storage devices, networks, and computers
- **IT makes possible more interactions, more complexity, more knowledge, less entropy**

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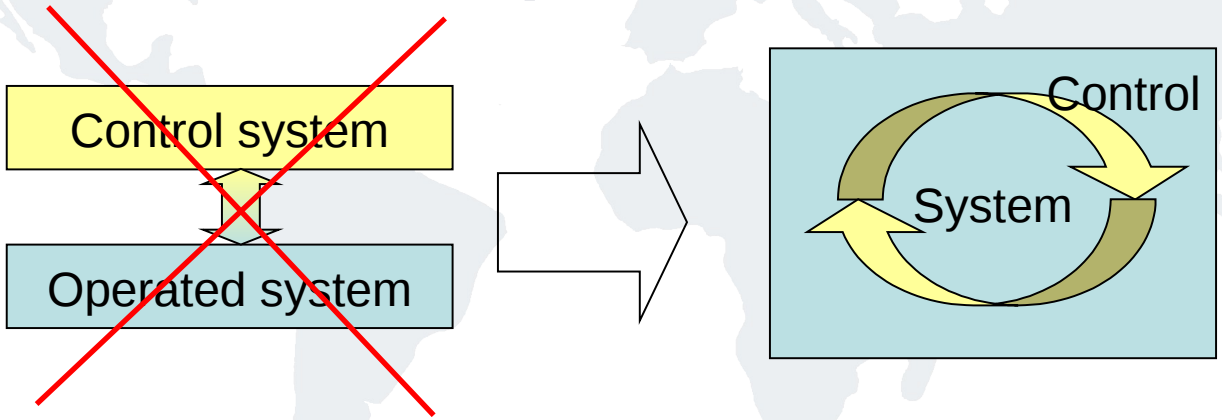
Enterprise System Control

- **Enterprise is a complex, adaptive system**
  - Many components interactions
  - Many feedback loops
  - Enterprise control is like Process control
- **Control is not separate**



- **ISA88 Equipment Entity Concept**

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Why an enterprise architecture?

- **Entropy is impacted by knowledge, organization, information**
- **EA helps for**
  - Understanding: describes enterprise spatiotemporal aspects (structures and interactions)
  - Defining target improvements: design changes
  - Monitoring achieved improvements: follow-up with changes implementation and effectiveness

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Why an Enterprise Architecture?

- **It is Architecture effort**
  - Unlike construction business, it is an ongoing activity in a living organism like an Enterprise
  - Drafts AS-IS and prospective TO-BE
  - Plan and monitor the construction / Changes
- **Enterprise is essentially a “virtual entity”**
  - Mainly informational
  - Buildings and facilities are merely a facet
- **Pitfalls**
  - EA too often IT focused
  - Top-down, prescriptive approaches can kill the system by negating its complexity

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Enterprise Architecture Modelling Frameworks

- **EA relies on Models**
  - Express knowledge – relate to entropy…
- **Many EA frameworks**
  - PERA, CIMOSA, Zachman, TOGAF, FEAF, IAF…
  - Strong IT focus
  - High level meta-models, do not contradict more practical models like ISA88/ISA95

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ISA88/95 manufacturing architecture framework

- **How ISA88/95 fit in EA**
  - EA frameworks address the whole enterprise
    - This concept is well documented for describing the virtual, informational part of the enterprise
  - Manufacturing architecture is a sub part of EA
    - Manufacturing is much more complex, needs “information translation” from its physical nature.
  - Information / System gap is harder to close!
    - ISA88/95 helps to depict, understand and control the manufacturing reality
  - The next slide gives the big picture of an integrated ISA88/95 manufacturing architecture framework

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figure 9

Manufacturing Architecture Dimensions

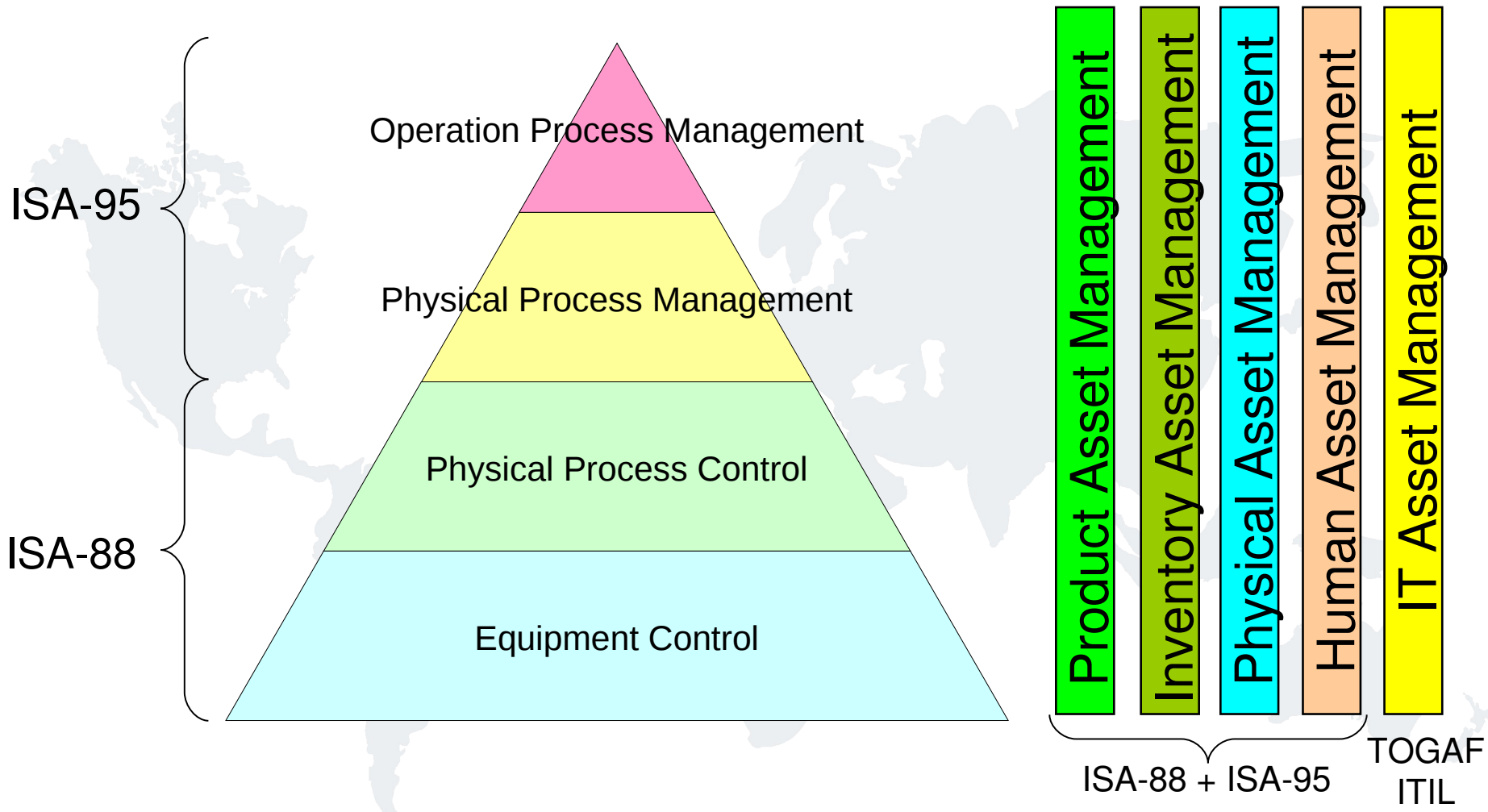

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figure 10

Ongoing Manufacturing Architecture

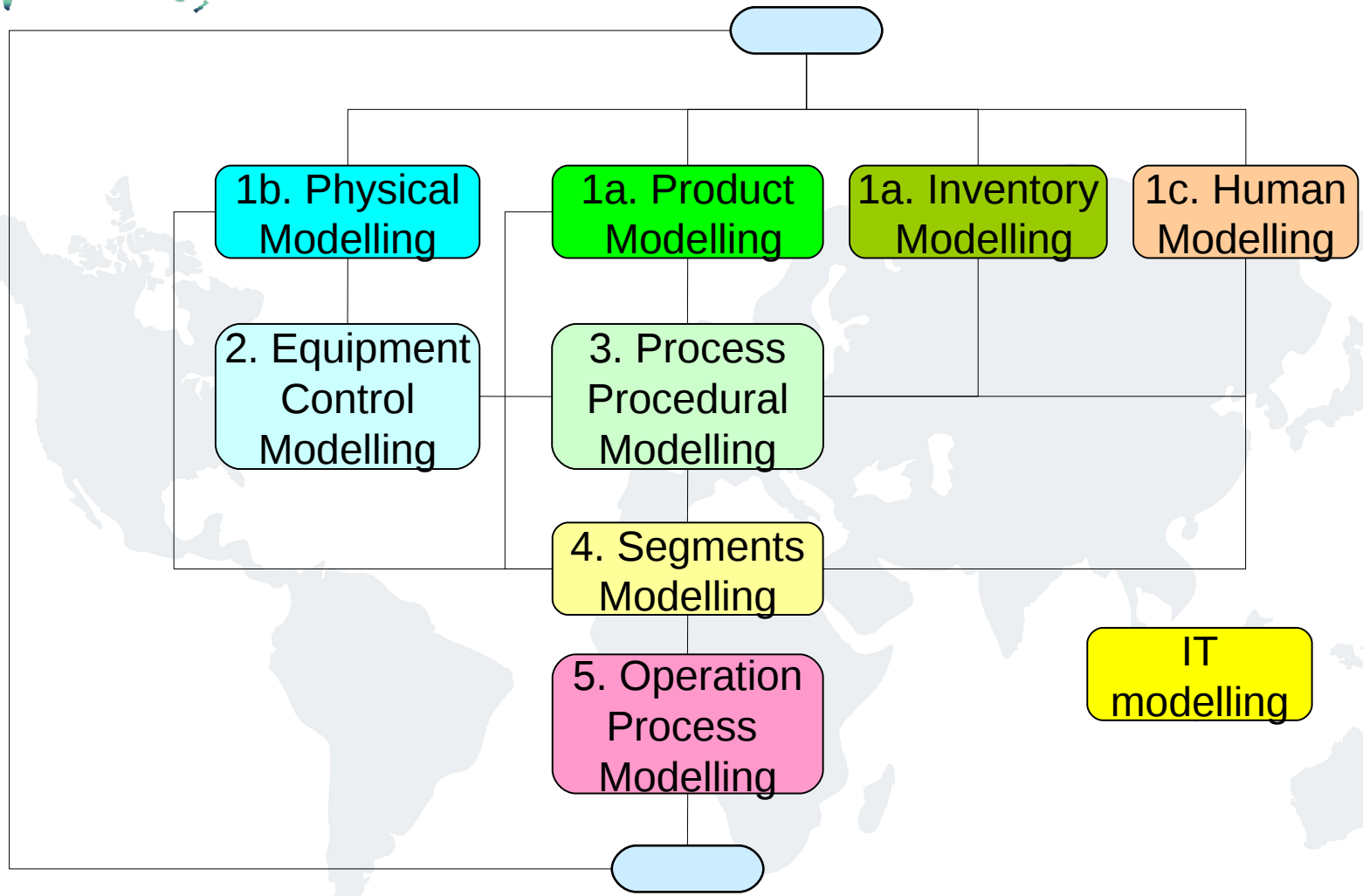

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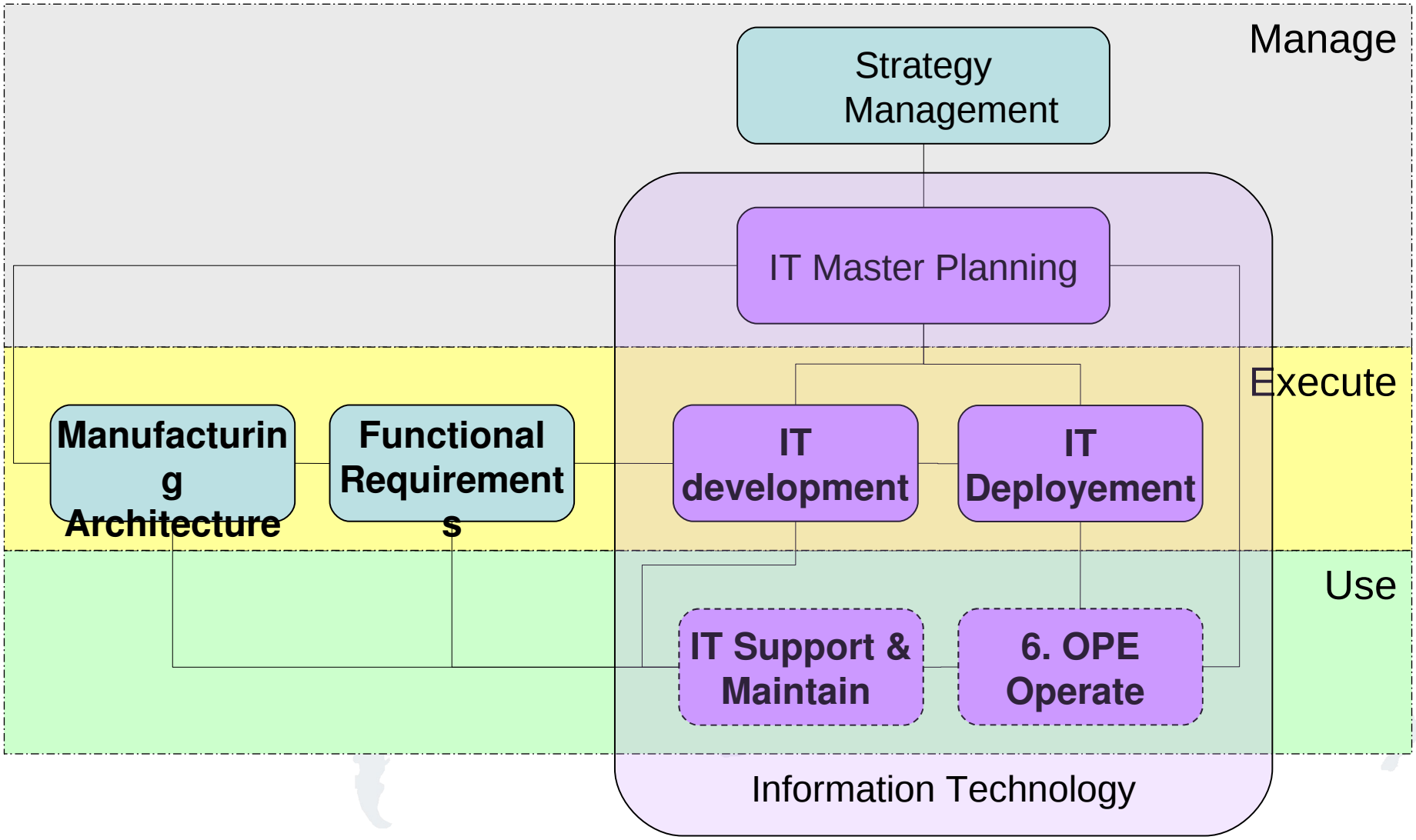
figure 11

Business/IT Convergence Processes



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Wrap up

- **Entropy is a basic behaviour of nature**
  - Ongoing disorder - Arrow of time – Ignorance
- **Enterprises obey to physical laws**
  - Complex, open Earth subsystems, subject to Entropy and Chaos
  - Living organism: React by reorganizing, adapting itself permanently
  - Information is its intimate, intrinsic component
- **Enterprise Architecture**
  - Manages ongoing enterprise construction, Enables IT convergence
  - Manufacturing architecture is more complex, needs “translation”
  - ISA88 and ISA95 are good candidate to support MA
- **Entropy is the indicator of smartness**
  - Should drive negentropic IT development.
  - Working on measuring methods…

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The 10 commandments of Systemic

1. Preserve variety
2. Do not "open" regulatory loops
3. Look for the points of amplification
4. Re-establish equilibriums through decentralization
5. Know how to maintain constraints
6. Differentiate to integrate better
7. To evolve, allow aggression
8. Prefer objectives to detailed programming
9. Know how to use operating energy
10. Respect response times

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Questions?

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