

Multiscale Complex Systems Science and Engineering

- General Methodological Study
 - Applied Research

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Motivation and Challenge

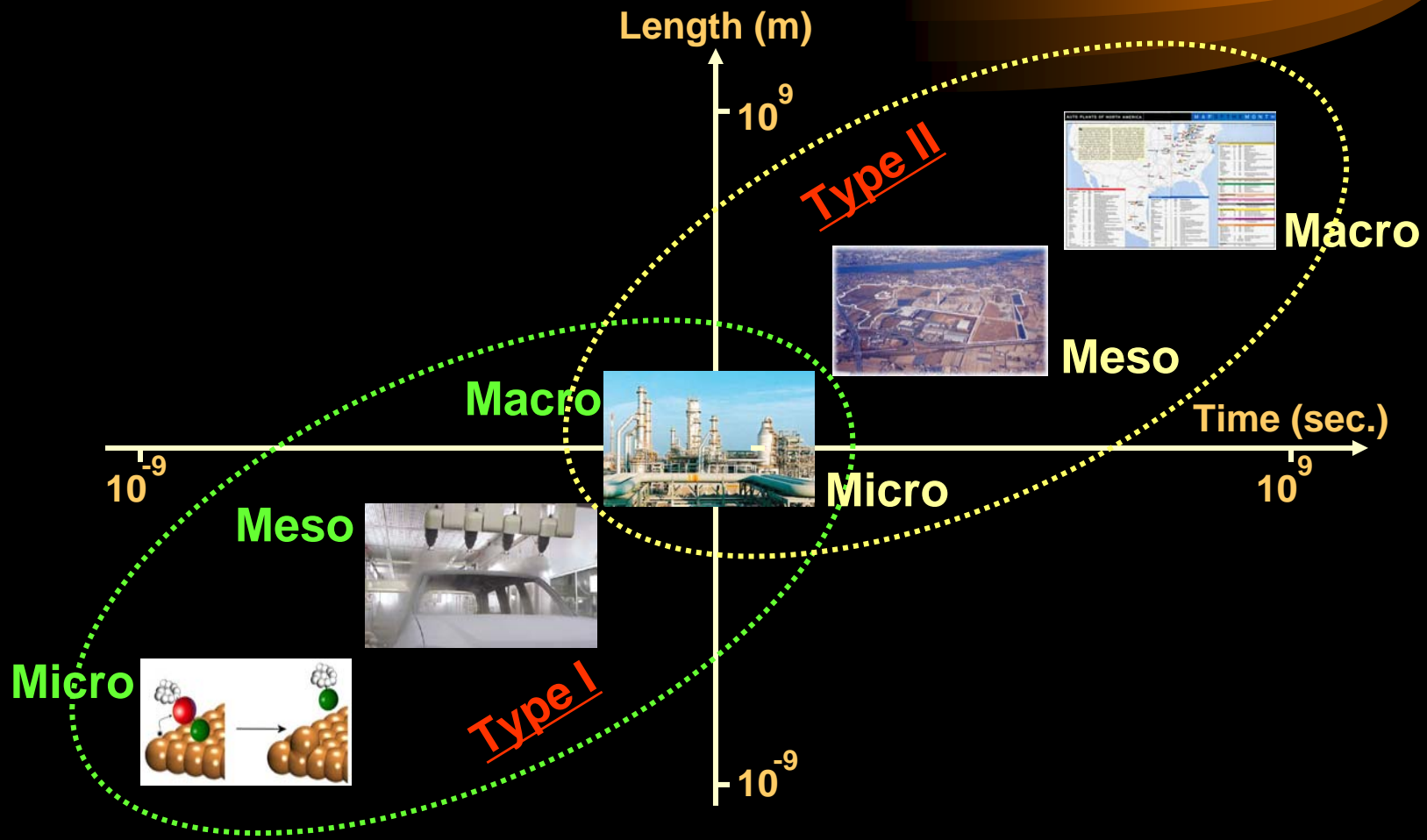
New Era of the Manufacturing Industries

- Process focused → Product centered

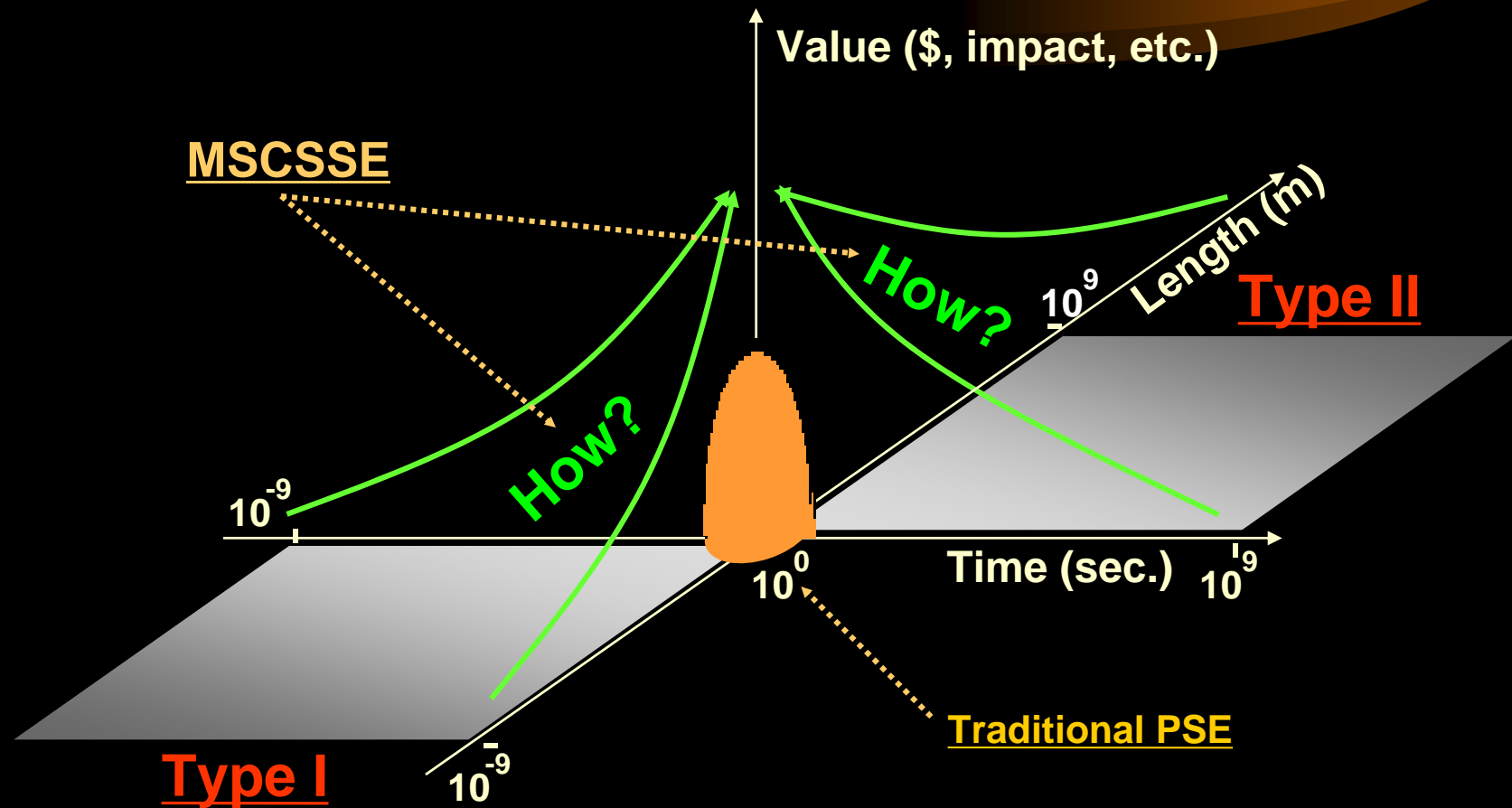
Complex Systems

- Inherent non-linearity
- Non-equilibrium interaction within the system
- Characterized by multiscale structures
- Extensive exchange of energy, material, and information within the system and with surroundings

Manufacturing Centered Study on Multiscale Complex Systems



Value-Added Multiscale Integration



Multiscale Complex Systems Engineering



General Need

- **Characterization and analysis of spatial and temporal aspects at different scales**
 - system modeling and simulation
- **Decision making with multi-objectives**
 - system design, control, and optimization
- **Coordination among system layers for global optimality**
- **Multidisciplinary approach**

Methodological Study

- **Developing unified theories, methodologies, and tools for system modeling, simulation, design, control, and optimization at the inter-, intra- levels**
- **Challenges**
 - ✓ **Uncertainty (about information, conception, knowledge, etc.)**
 - ✓ **Interaction complexity (b/w time/length scales and among subsystems)**
 - ✓ **Computational efficiency**

Applied Research Areas



- **Type I -- Scales and sequence: $\sim 10^0 \searrow 10^{-?} \nearrow \sim 10^0$**
 - **Surface coating:**
 - ✓ **Polymeric coating**
 - ✓ **Metal surface finishing**
 - **Biomedical systems:**
 - ✓ **Dynamic Metabolic Flux Analysis for tissue systems**
 - ✓ **Cancer tumor growth and treatment**

Applied Research (cont'd)



- **Type I – Scales and sequence: $\sim 10^0 \searrow 10^{-?} \nearrow \sim 10^0$**
 - **Chemical plant security**
 - ✓ **Process security focused**
 - **Process Integration**
 - ✓ **Integration of process design and control**
- **Type II -- Scales and sequence: $\sim 10^0 \nearrow 10^{+?} \searrow \sim 10^0$**
 - **Industrial sustainability**
 - ✓ **Industrial zone focused**
 - ✓ **Industry specific**

Current Real Players

Length

10^{-9} m

10^6 m

10^{-9} sec

Time

10^9 sec



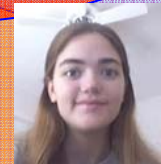
Surface Coating



Systems Biology



Process Security



Sys. Theory



Multiscale Complex

Integrated Prod. & Proc. Sys. Eng.



Environmental Sustainability

