HUMAN-SYSTEMS INTEGRATION WORKING GROUP

Human-Systems Integration: Unifying Human-Centered Design and Systems Engineering

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Current SE Handbook Contents

1. SE handbook scope
2. SE overview
3. Generic life cycle stages
4. Technical processes
5. Technical management processes
6. Agreement processes
7. Organizational project-enabling processes
8. Tailoring process and application of SE
9. Cross-cutting SE methods
10. **Specialty engineering activities**

Current SE Handbook Contents

10. Specialty engineering activities
    1. Affordability/cost effectiveness/life cycle costs analysis
    2. Electromagnetic compatibility
    3. Environmental engineering/impact analysis
    4. Interoperability analysis
    5. Logistics engineering
    6. Manufacturing and producibility analysis
    7. Mass properties engineering
    8. Reliability, availability and maintainability
    9. Resilience engineering
    10. System safety engineering
    11. System security engineering
    12. Training needs analysis
    13. **Usability analysis/human systems integration**
    14. Value engineering

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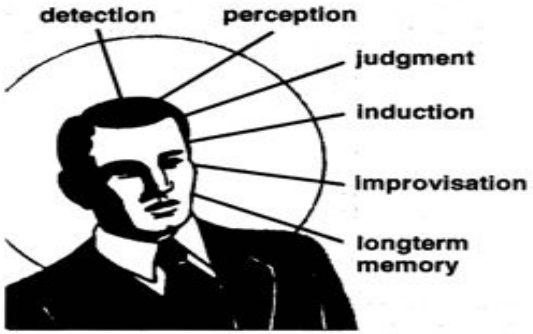
9. **Cross-cutting SE methods**
10. Specialty engineering activities

Current SE Handbook Contents

9. Cross-cutting SE methods

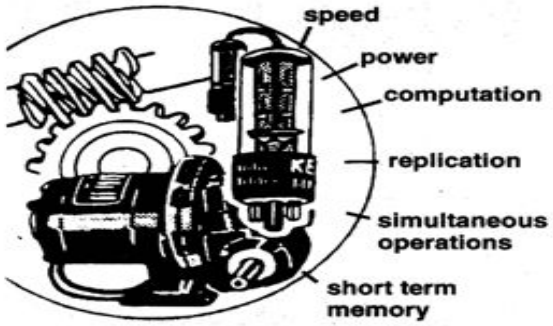
1. Modeling and simulation √
2. Model-based SE √
3. Function-based SE method √
4. Object-oriented SE method √
5. Prototyping √
6. Interface management √
7. Integrated product and process development √
8. Lean SE √
9. Agile SE √

HUMANS SURPASS MACHINES IN THE:



- Ability to detect small amounts of visual or acoustic energy
- Ability to perceive patterns of light or sound
- Ability to improvise and use flexible procedures
- Ability to store very large amounts of information for long periods and to recall relevant facts at the appropriate time
- Ability to reason inductively
- Ability to exercise judgment

MACHINES SURPASS HUMANS IN THE:

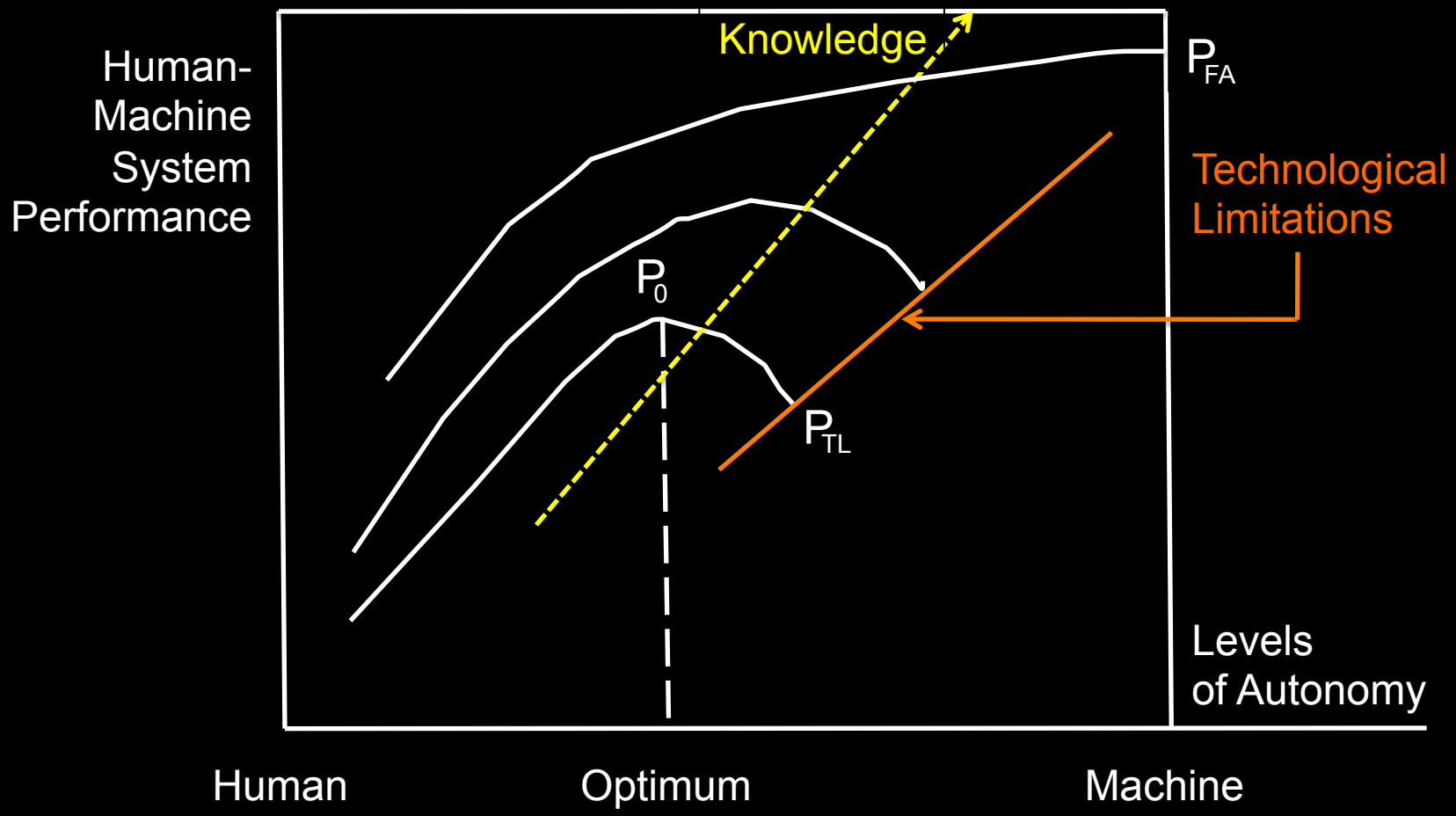


- Ability to respond quickly to control signals, and to apply great force smoothly and precisely
- Ability to perform repetitive, routine tasks
- Ability to store information briefly and then to erase it completely
- Ability to reason deductively, including computational ability
- Ability to handle highly complex operations, i.e., to do many different things at once.

The Fitts HABA-MABA (humans-are-better-at/machines-are-better-at) approach

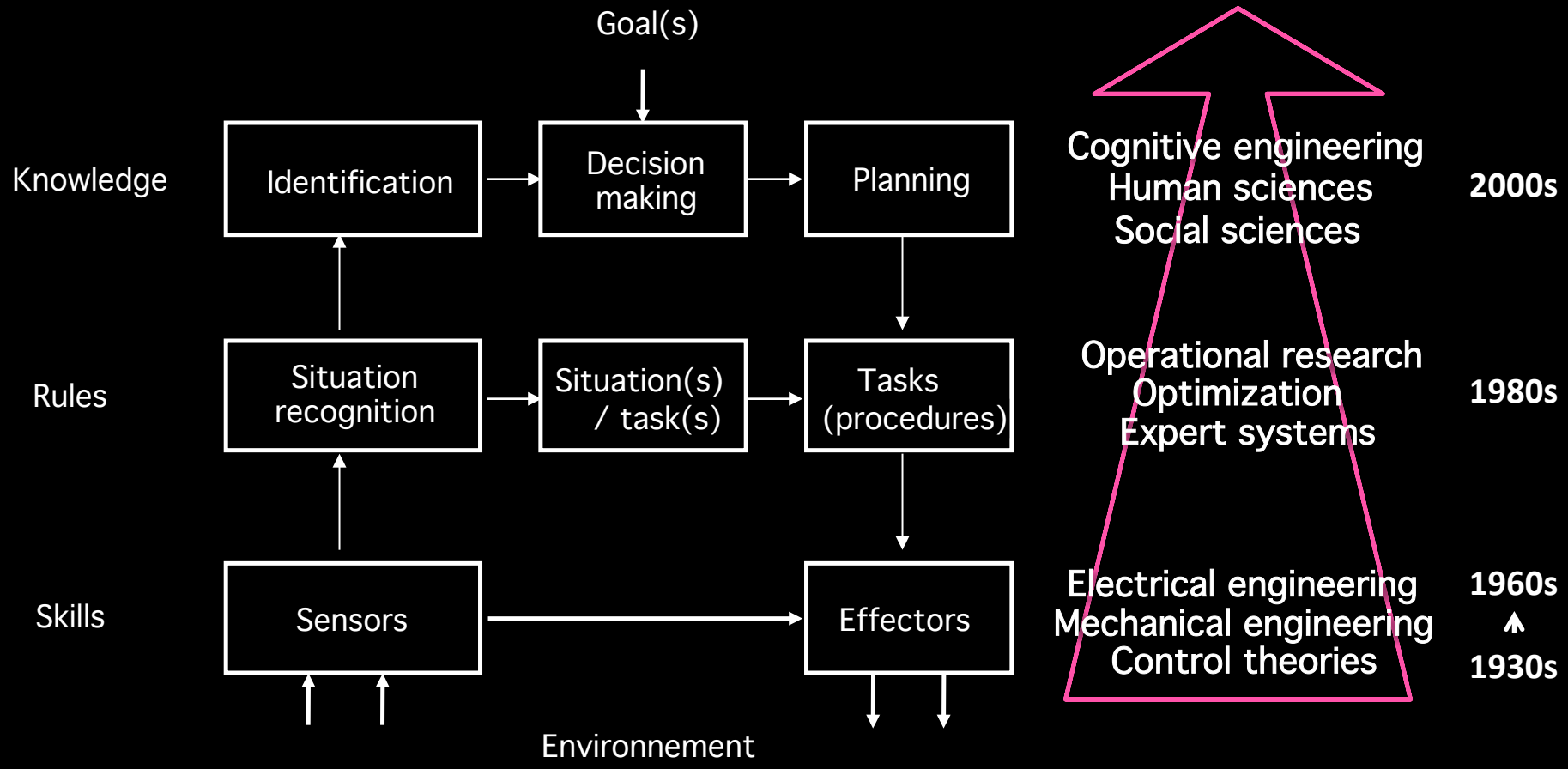
Fitts, P.M., ed. *Human Engineering for an Effective Air Navigation and Traffic Control System*. Washington, D.C.: National Research Council, 1951.

Automation / Autonomy Diagram



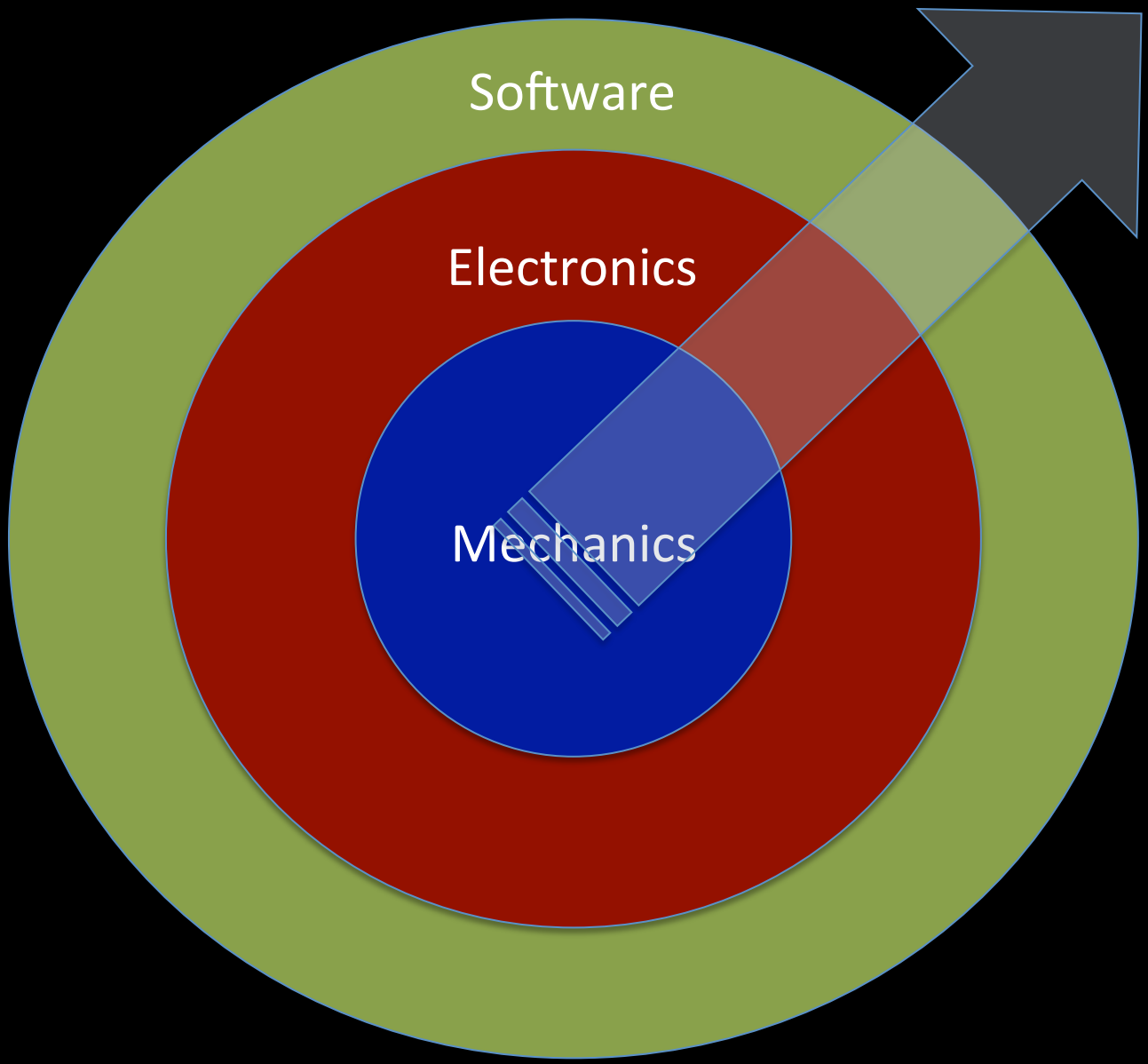
Automation evolution…

Automation evolution and **emergence of contributing disciplines**
(Rasmussen's model)



20th century

From Hardware to Software



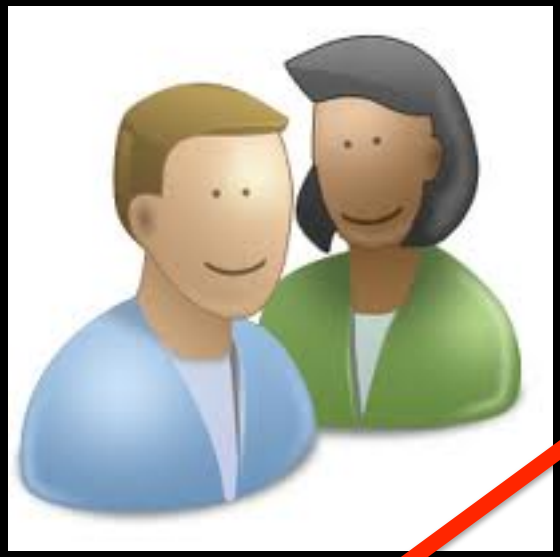
Incremental Accumulation of Artificial Functions into Structure

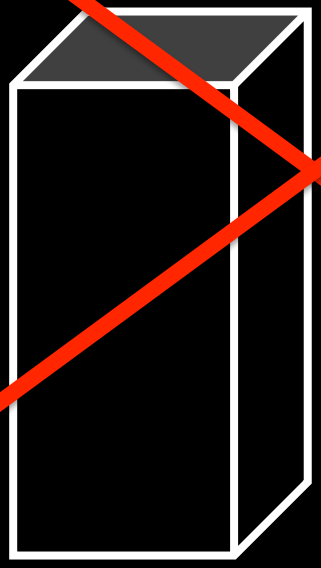
…

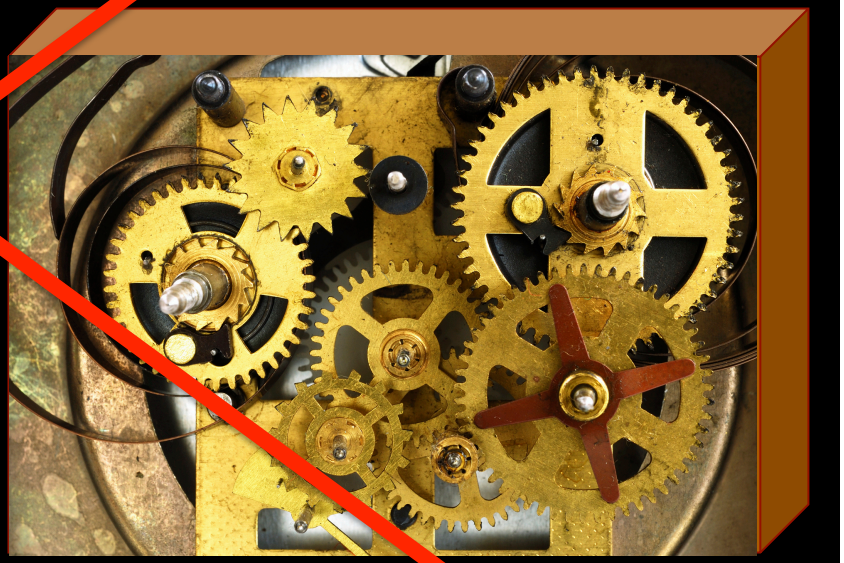
Automation & HCI

Why HFE ?

User Interface





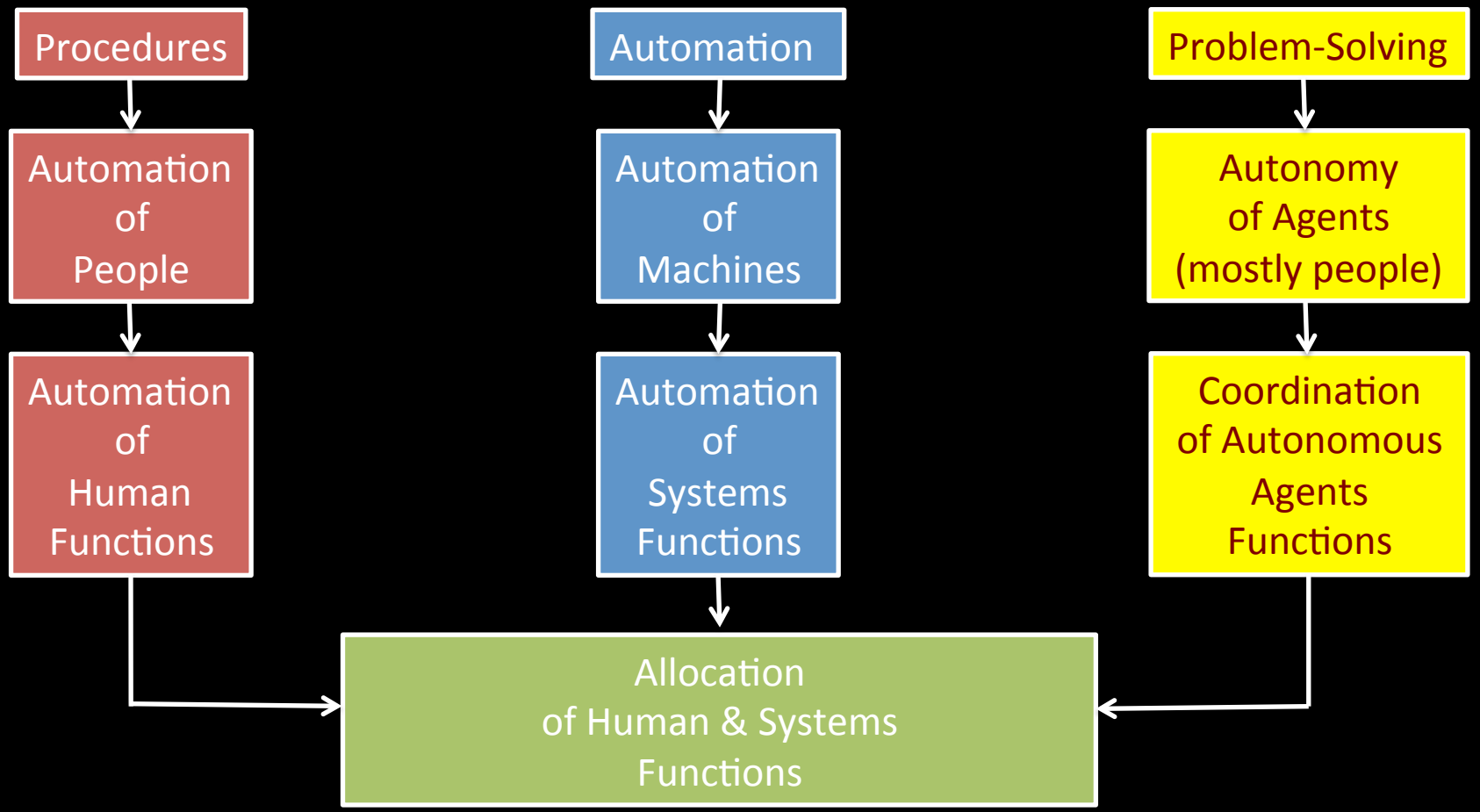


Human Factors

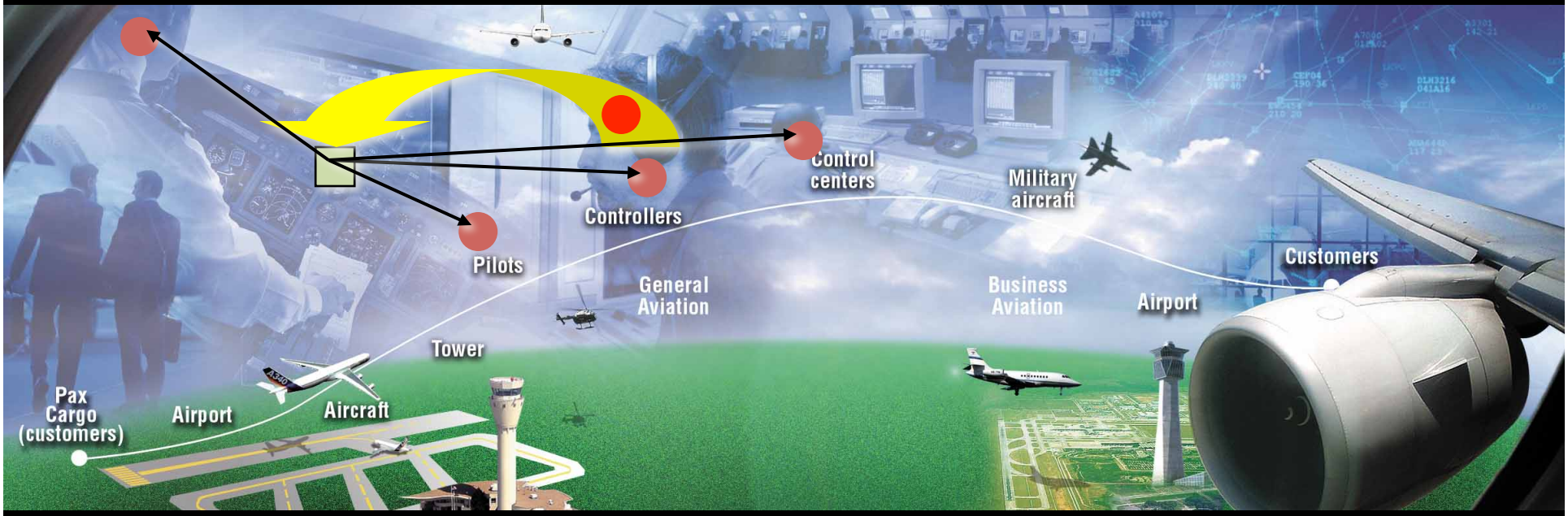
Ergonomics

Engineering

Automation vs. Autonomy



Air Traffic Management…
… a multi-agent system



Machine cognitive function

Human cognitive function

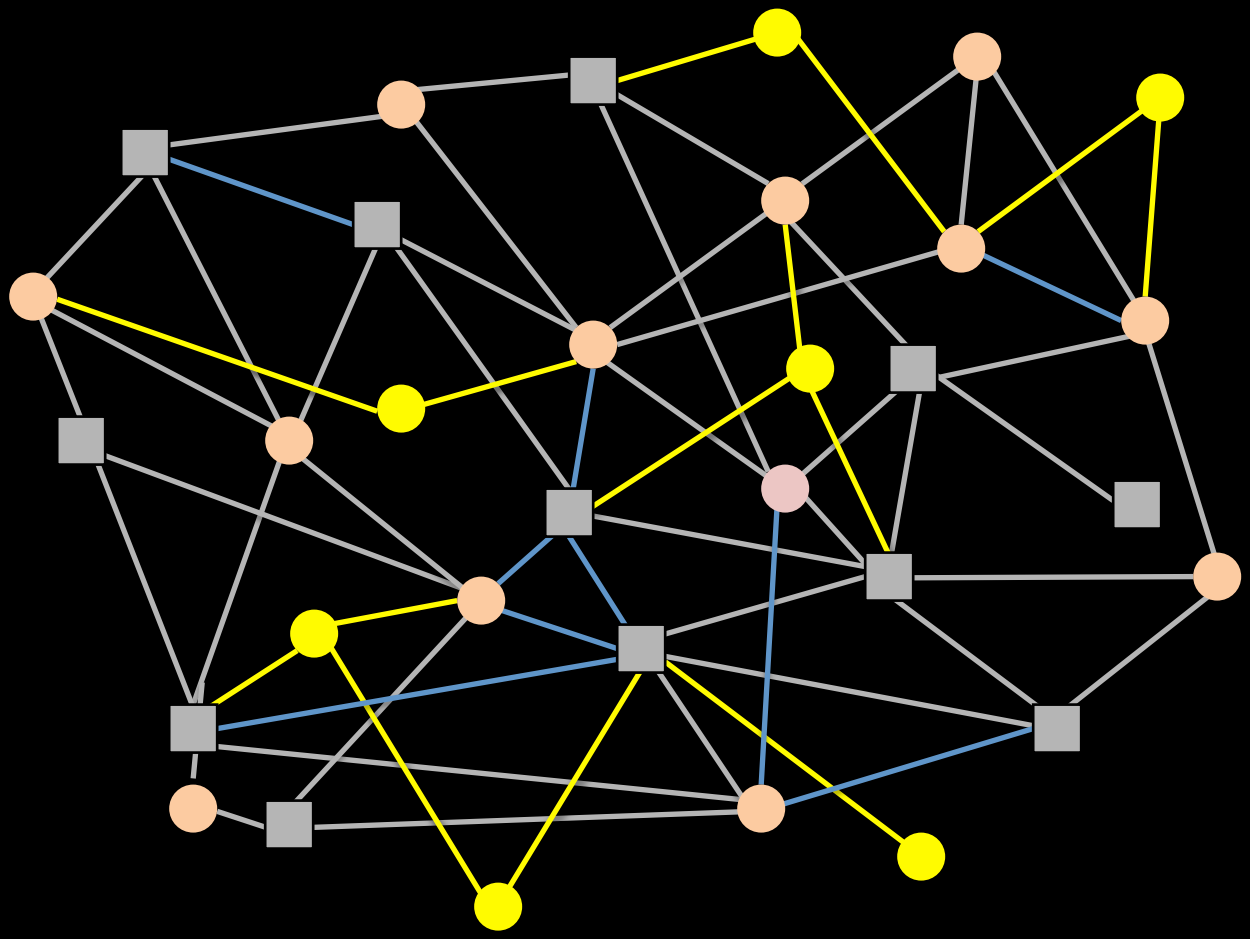
How do we identify emergent cognitive functions?

Multi-agent systems properties…

Separability
a crucial issue

Complexity
in connections
as well as
in agents
themselves

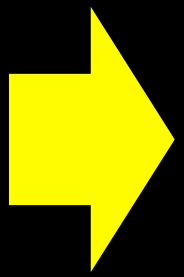
Emergent functions and
the **maturity**
issue



… therefore, this is a living organism

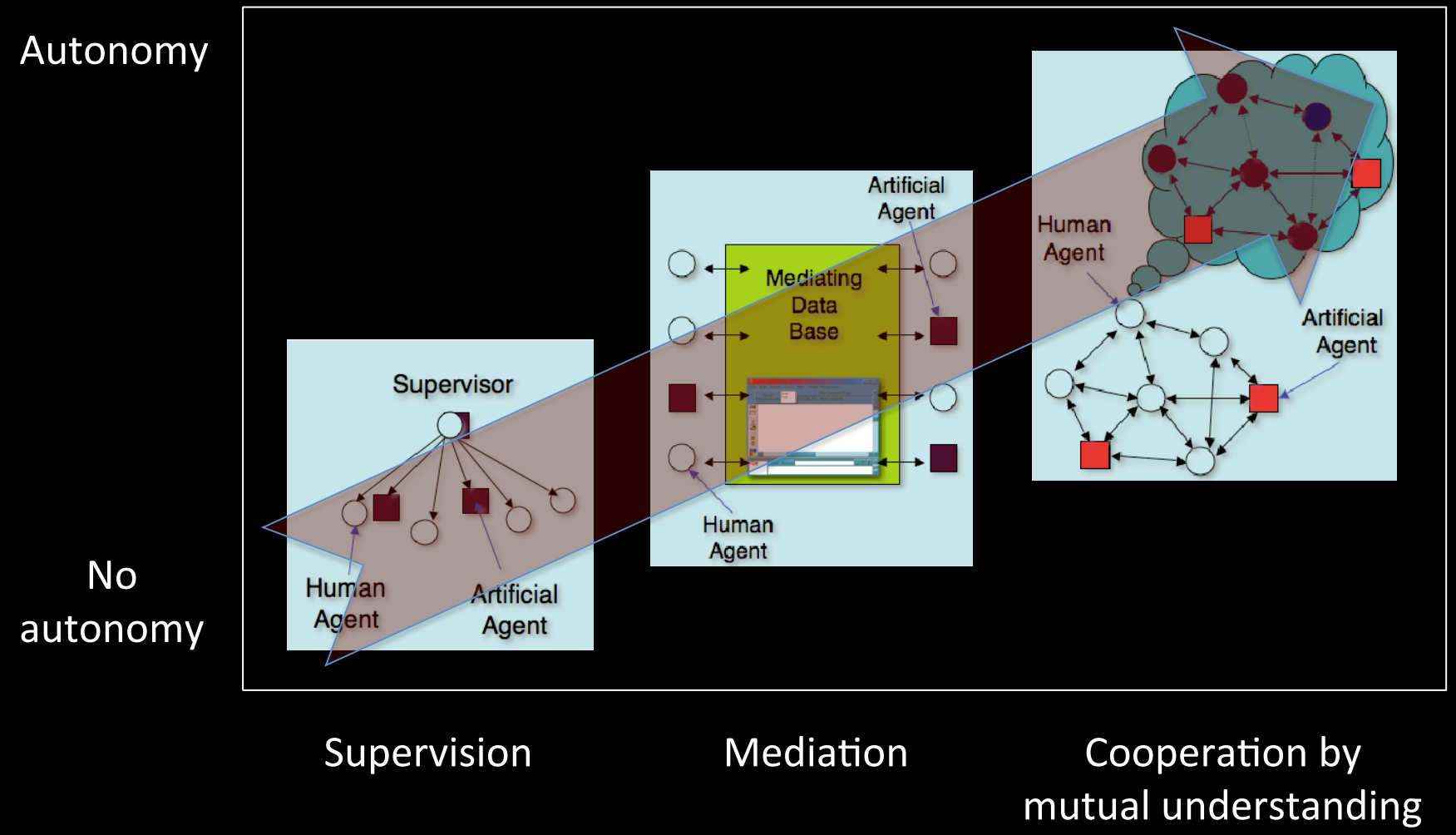
Therefore, the problem is …

- not to be stated within the cockpit only
- but in the multi-agent environment
- and taking into account ATM complexity



e.g., self-separation
human & systems orchestration
looking for models of interaction

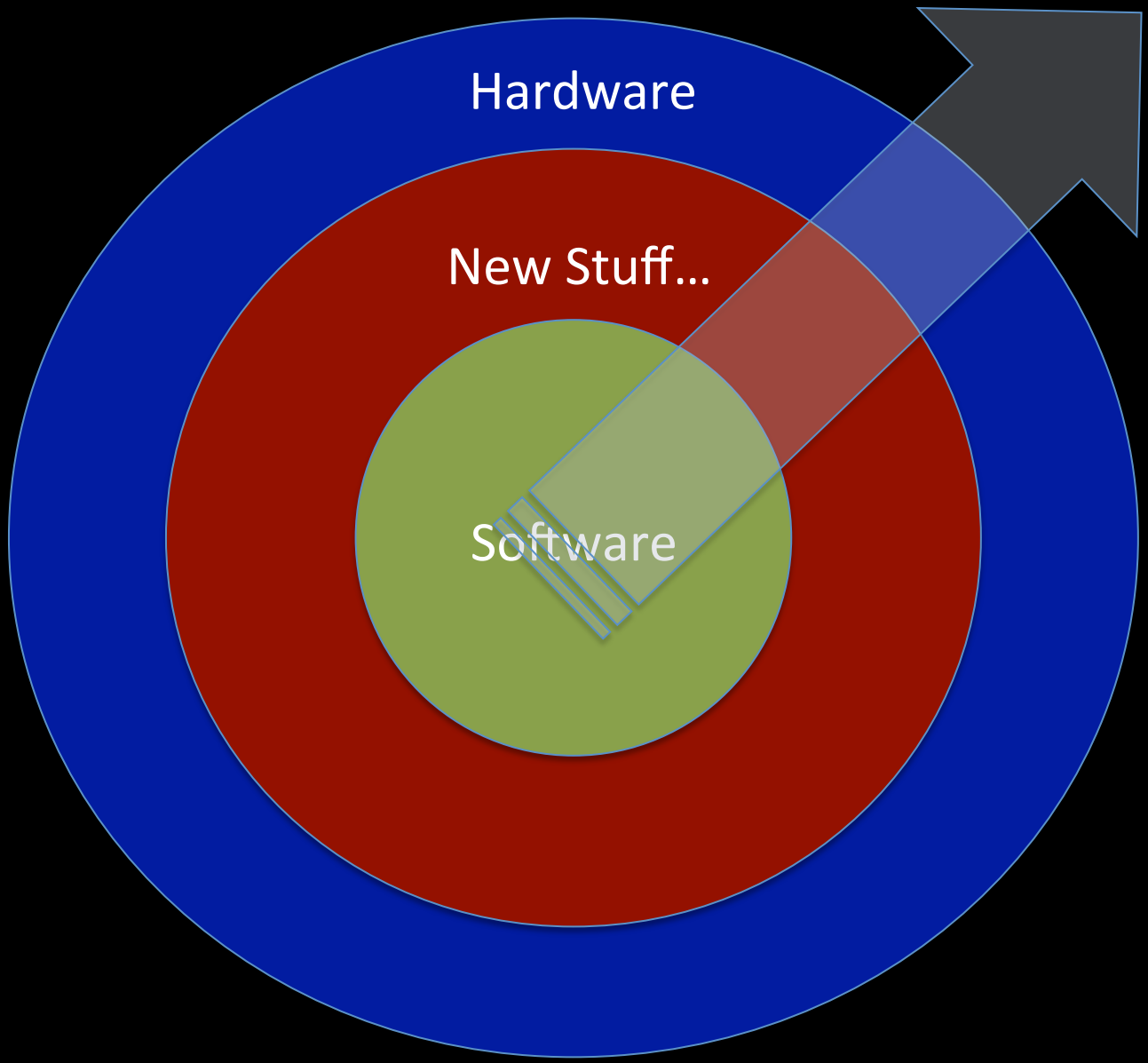
Models of interaction…



Virtual engineering…

21st century

From Software to Hardware



Modeling
Simulation
Connectivity
Orchestration
3D Printing
…

Tangible Interactive Systems (TISs)

Tangible: What do we mean?

Something is tangible when it is **graspable**
in the **physical** sense,
but also in the **figurative** sense.

Tangibility…

Integration
Innovation
Complexity
Flexibility
Maturity
Stability
Sustainability

Boy, G.A. (2016). Tangible Interactive Systems: Grasping the Real World with Computers. Springer, U.K. ISBN 978-3-319-30270-6.

TISs in Air Traffic Management…

Flying in the early 21st century, in high density traffic, requires new competencies and TISs capable of handling **complexity** of the overall organization.

➡ **Complexity Science**

Discover, model and use

Emergent Properties and Behaviors

What is at stake?

- 1956: birth of Artificial Intelligence (AI)
  - AI is about Cognition
  - Aeronautics is about Cognition vs. Physics
- Drones as Autonomous Robots ≠ Automation
  - What is Autonomy?
  - Open World vs. Close World…
- More Autonomy → More Coordination!

TISs in Air Traffic Management…

Air Show vs. Flock of birds

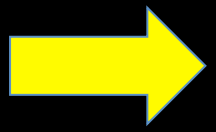
Automation

Manual & Automatic Control

Autonomy

Protection Envelopes ← **TISs**

Two main types of TIS

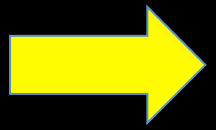


Low Level TIS for low level control

autopilot

collision avoidance and automated recovery

…

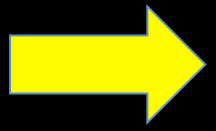


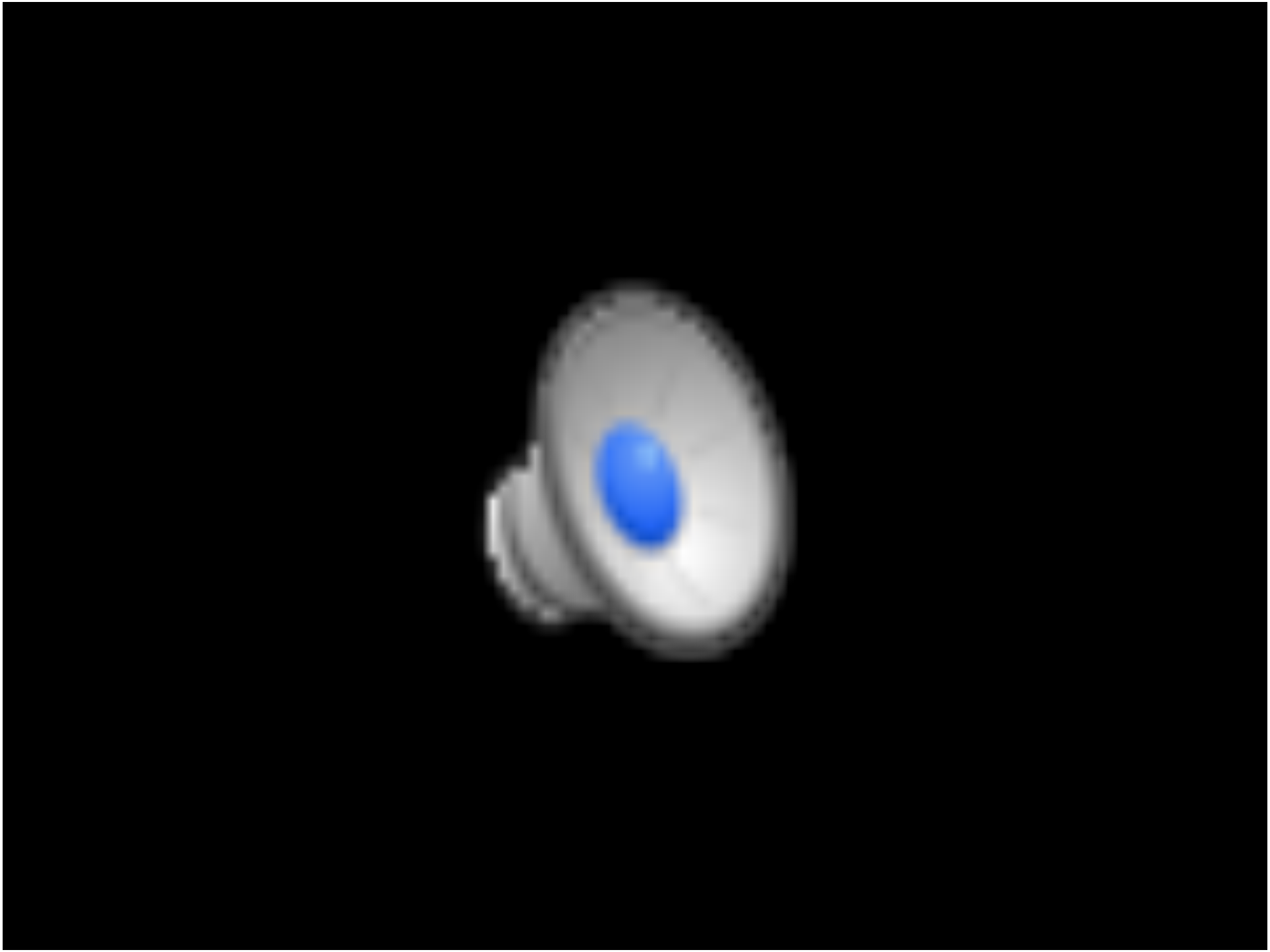
High Level TIS for high level management

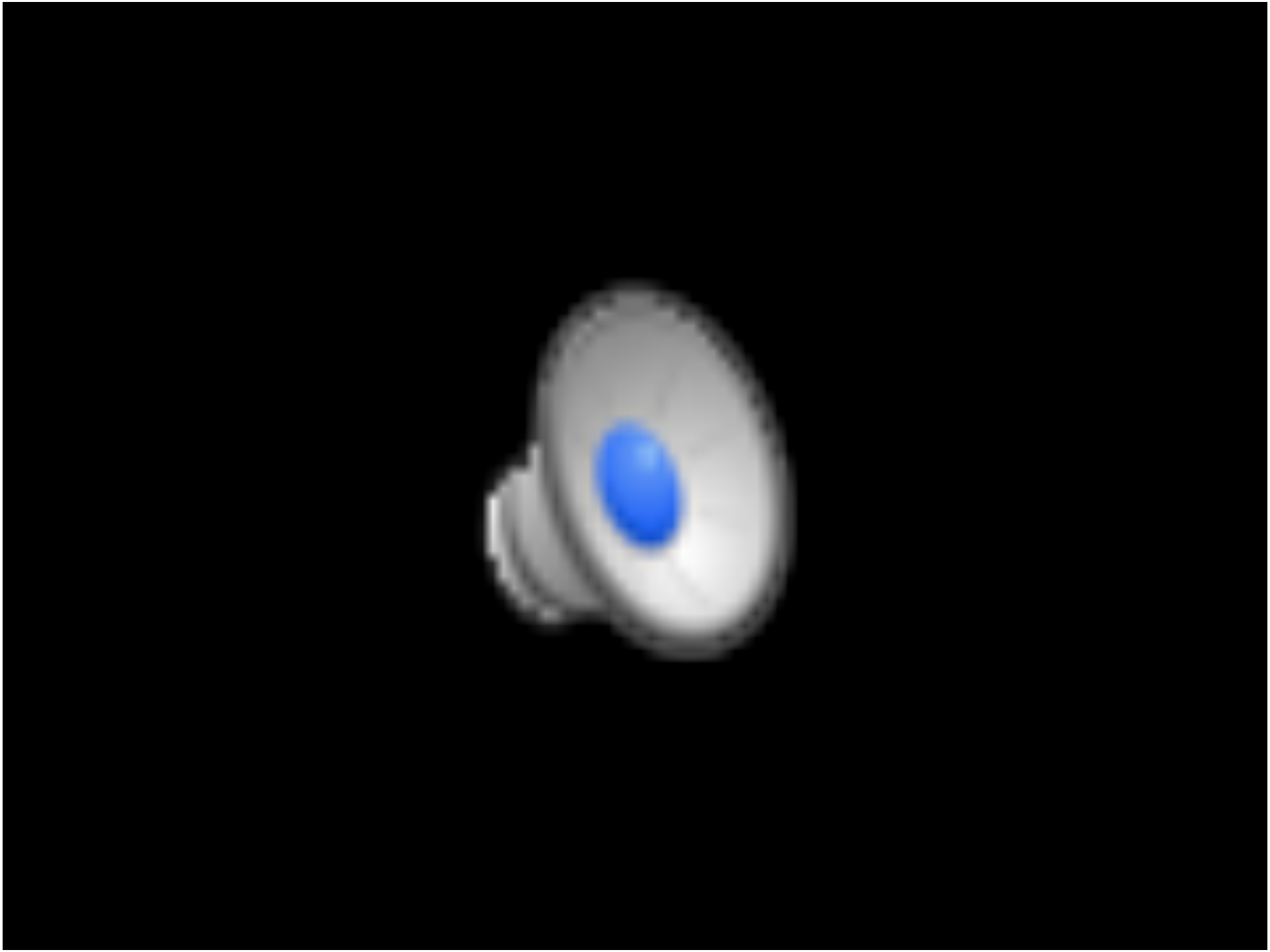
FMS

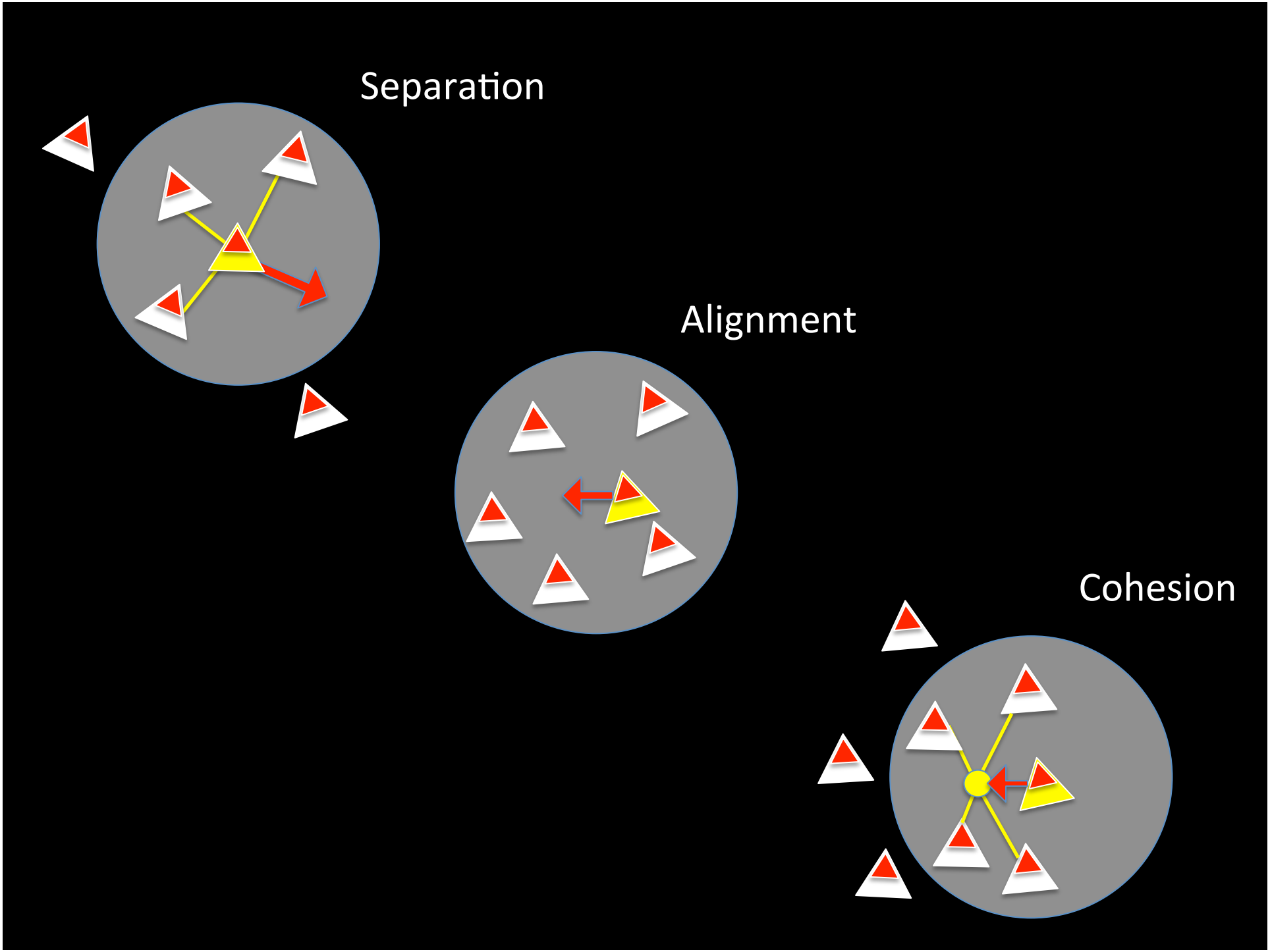
4D dynamic planning (traffic, weather, …)

…





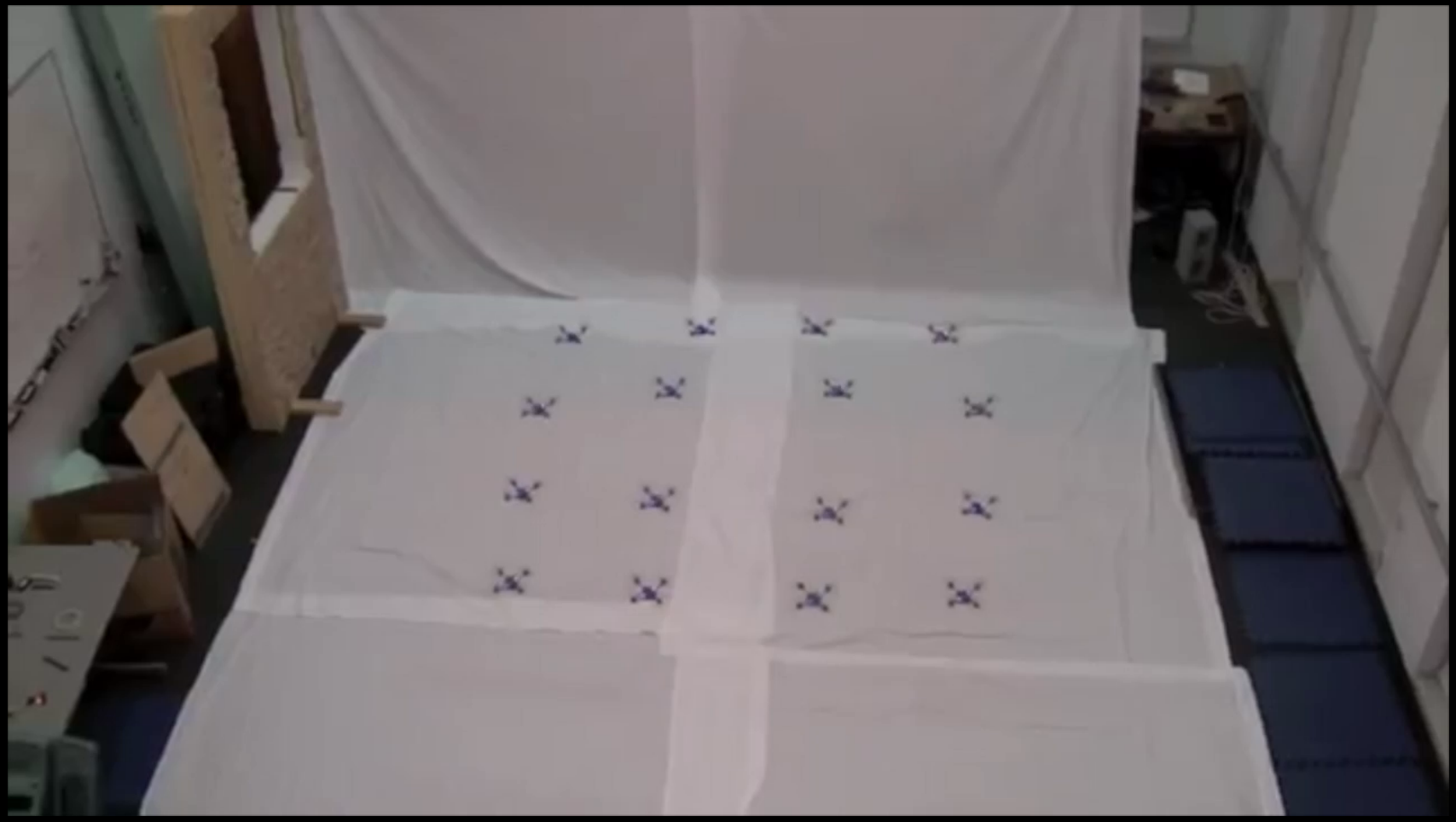



Separation
Alignment
Cohesion

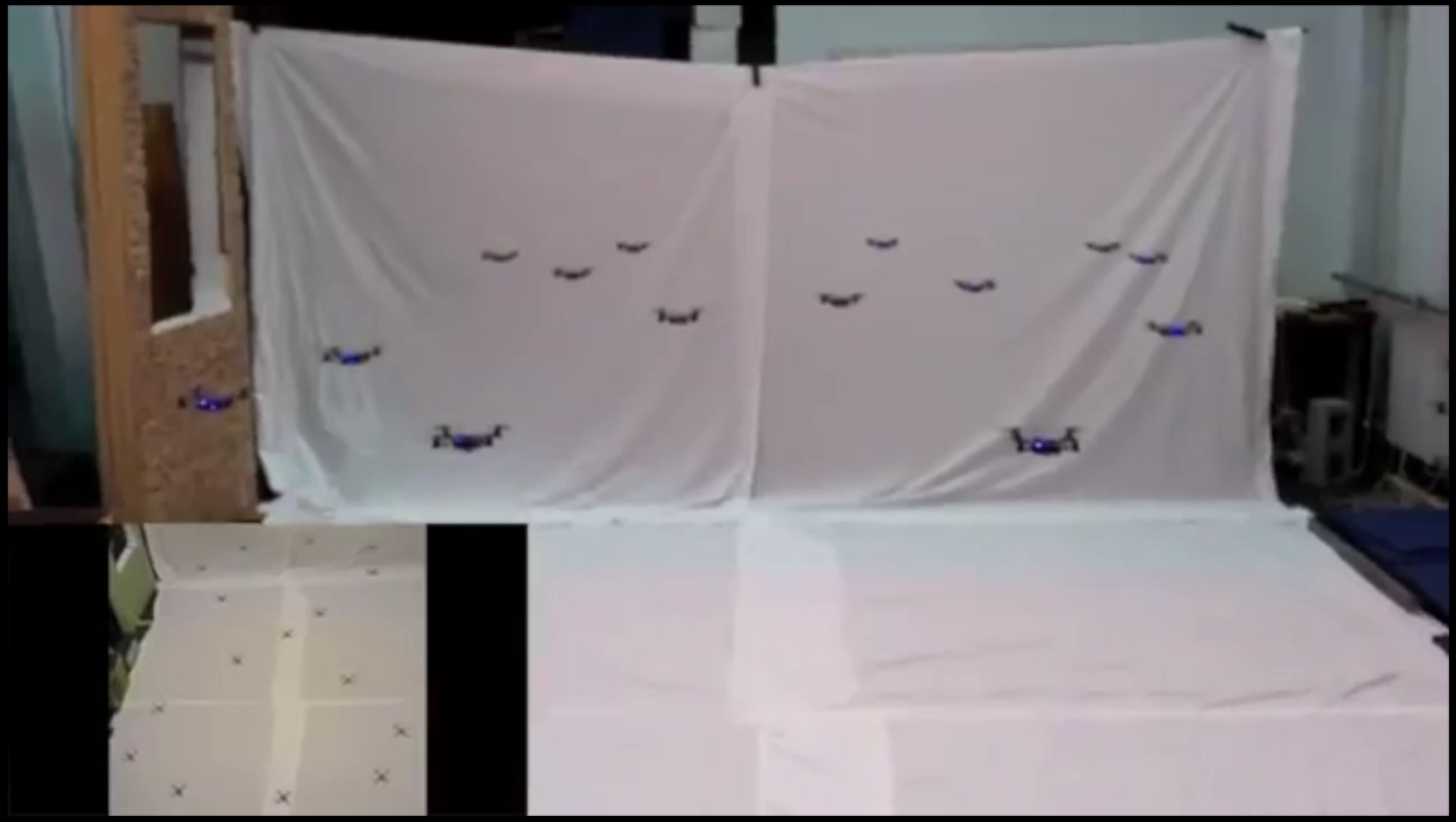
Simple formation

More complex formation

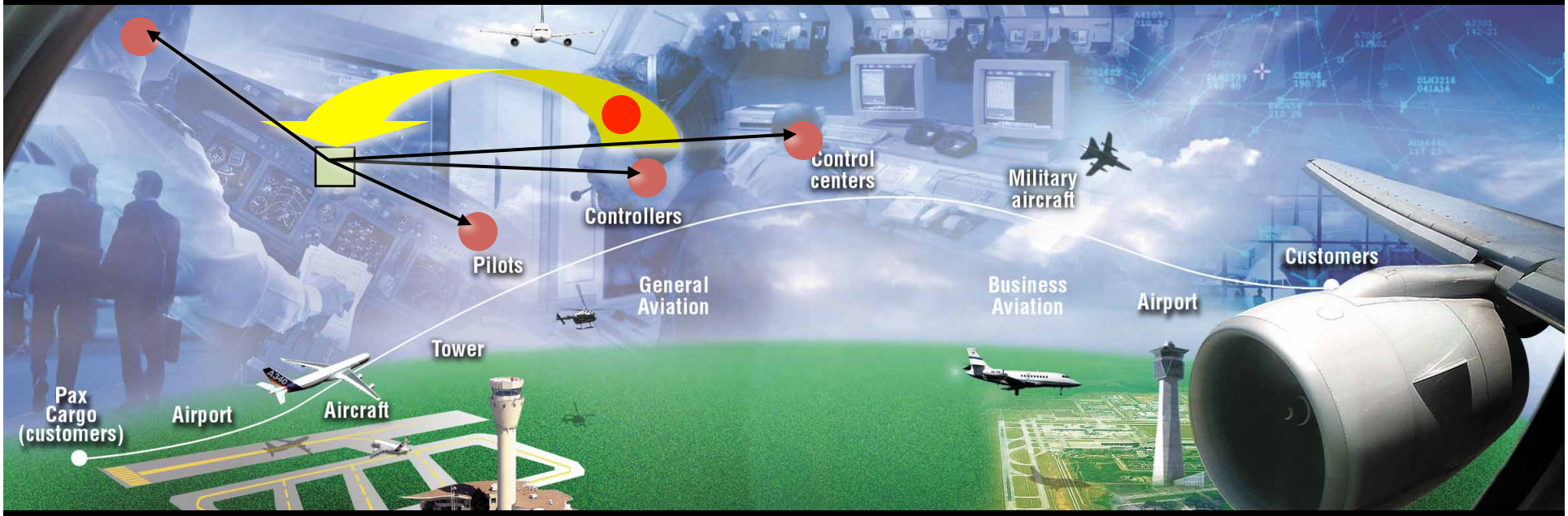
Even more complex formation



Crossing trajectories



TISs in Air Traffic Management…



- Machine cognitive function (TIO)
- Human cognitive function

Disciplinary Evolution

Human Factors and Ergonomics (Human-Machine Interfaces)

→ HFE experts correct engineering productions

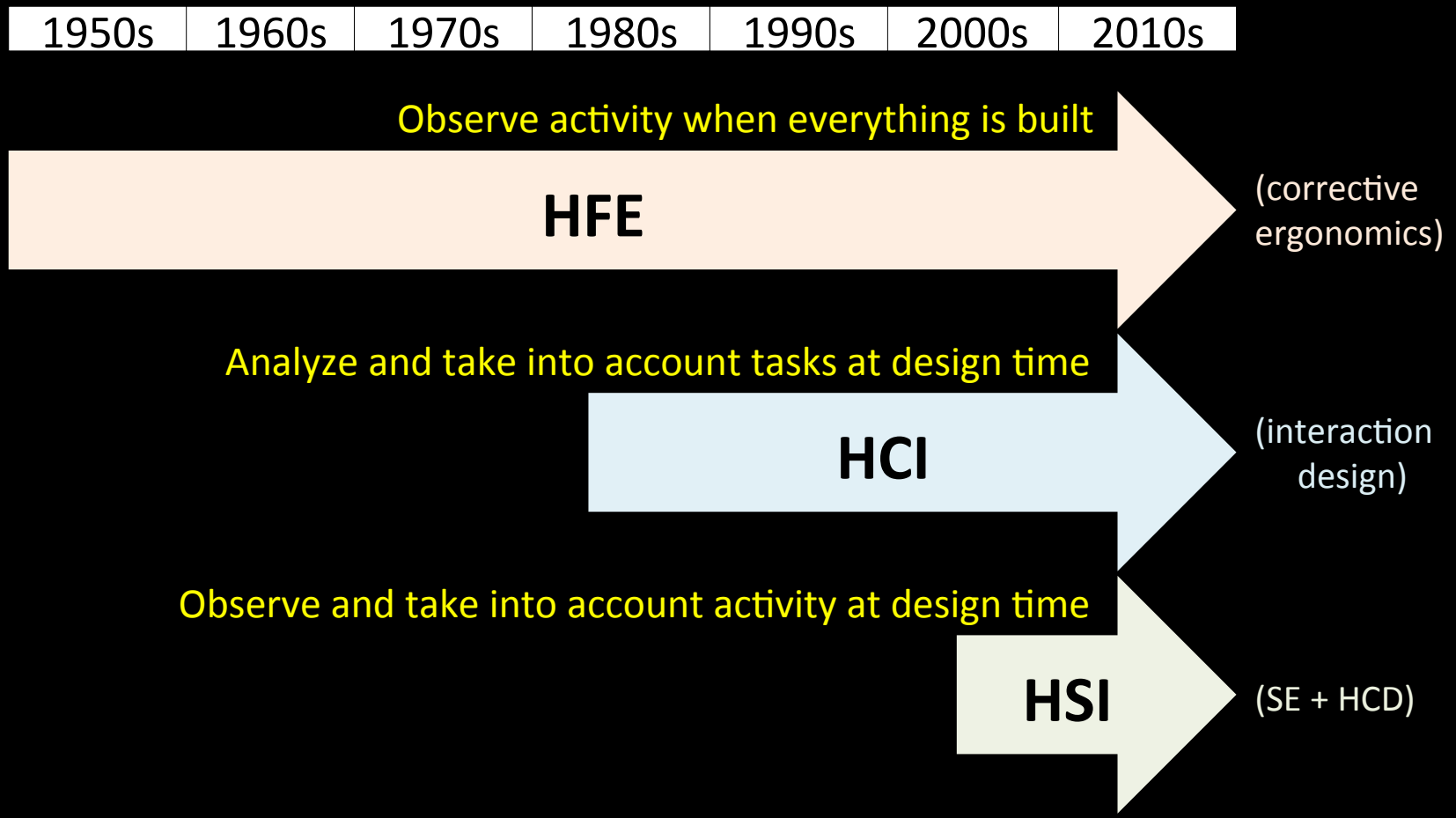
Human-Computer Interaction

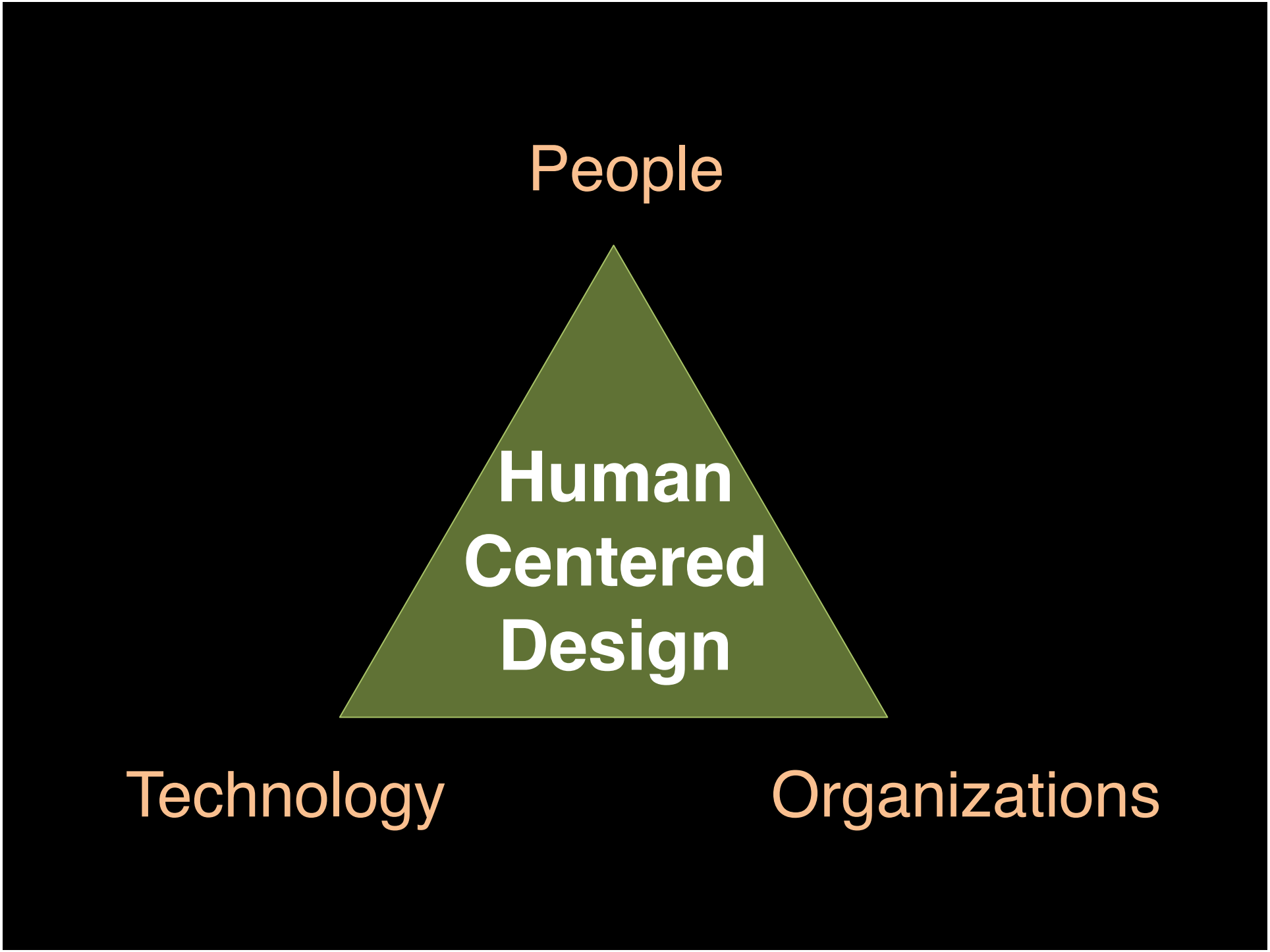
→ From corrective ergonomics to interaction design

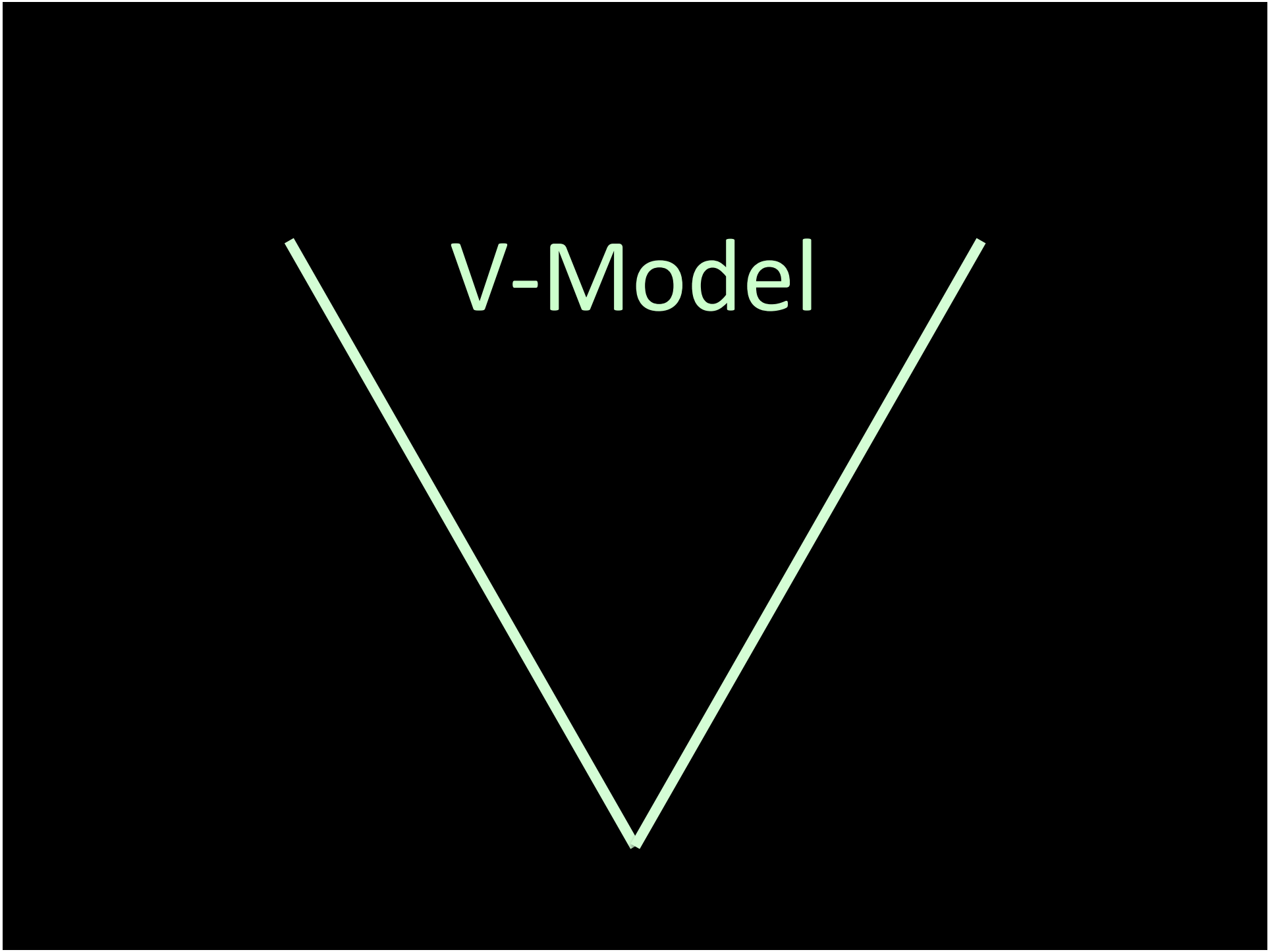
Human-Systems Integration

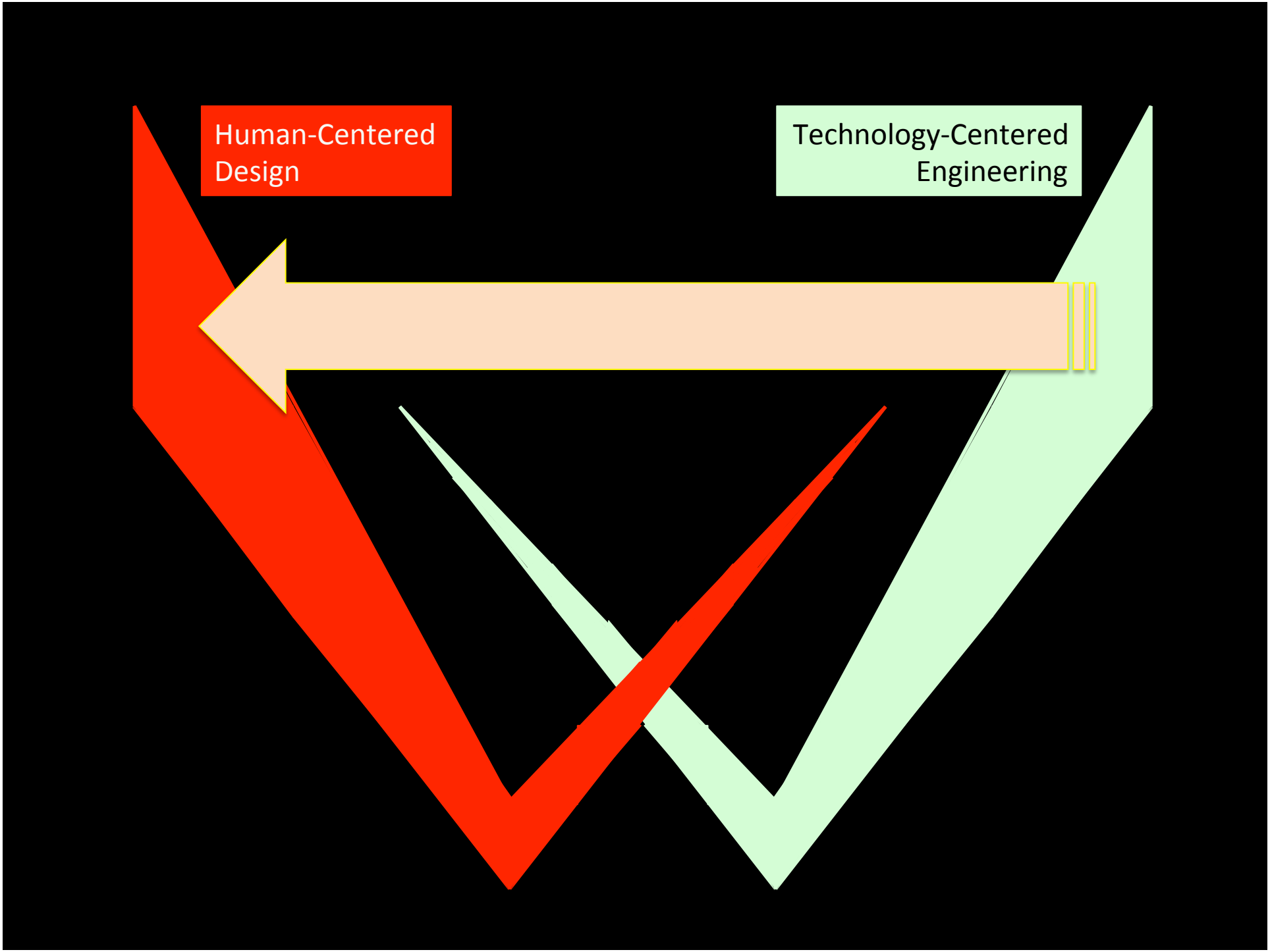
→ Systems engineering and HCD combined

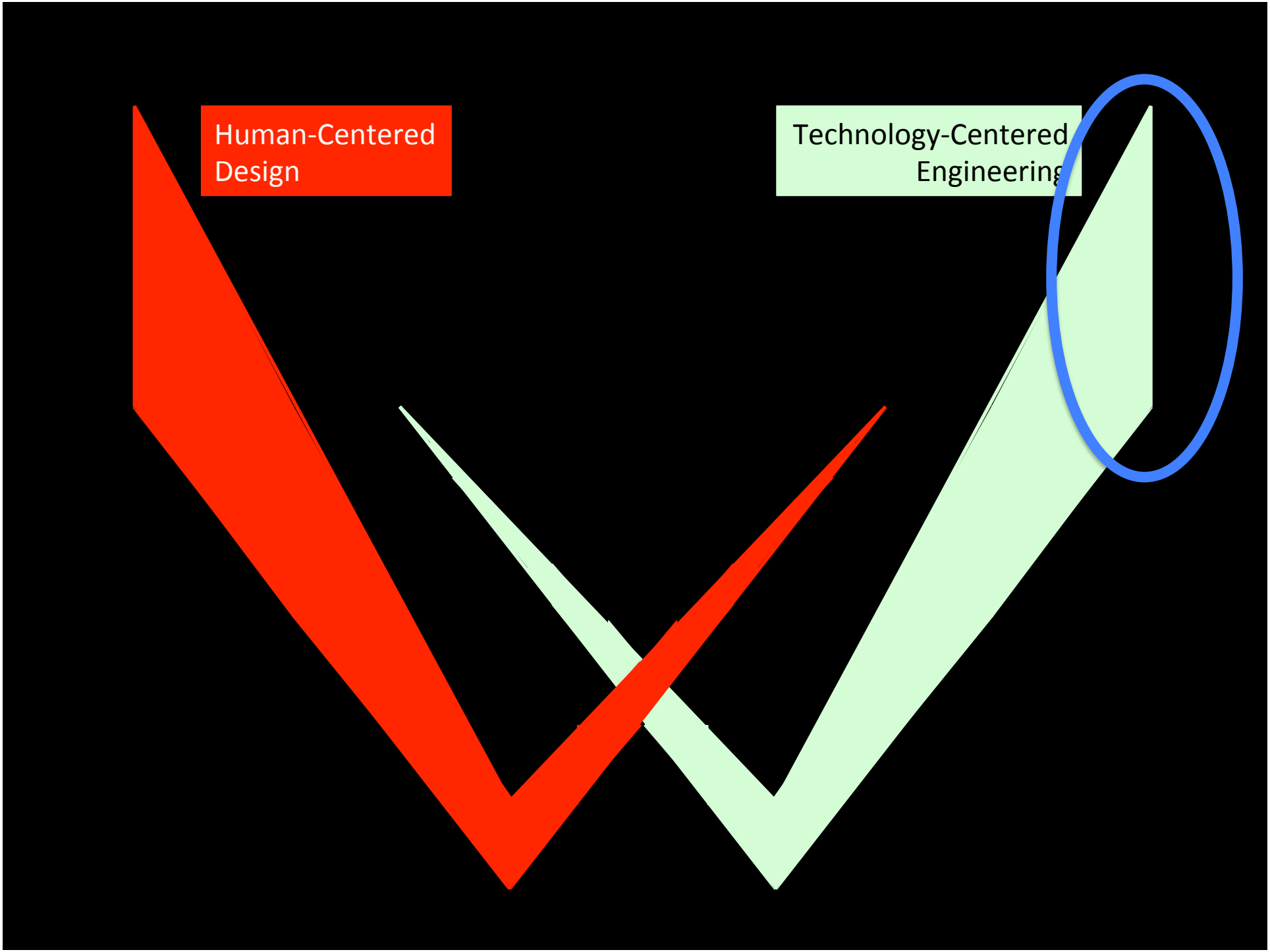
Task vs. Activity

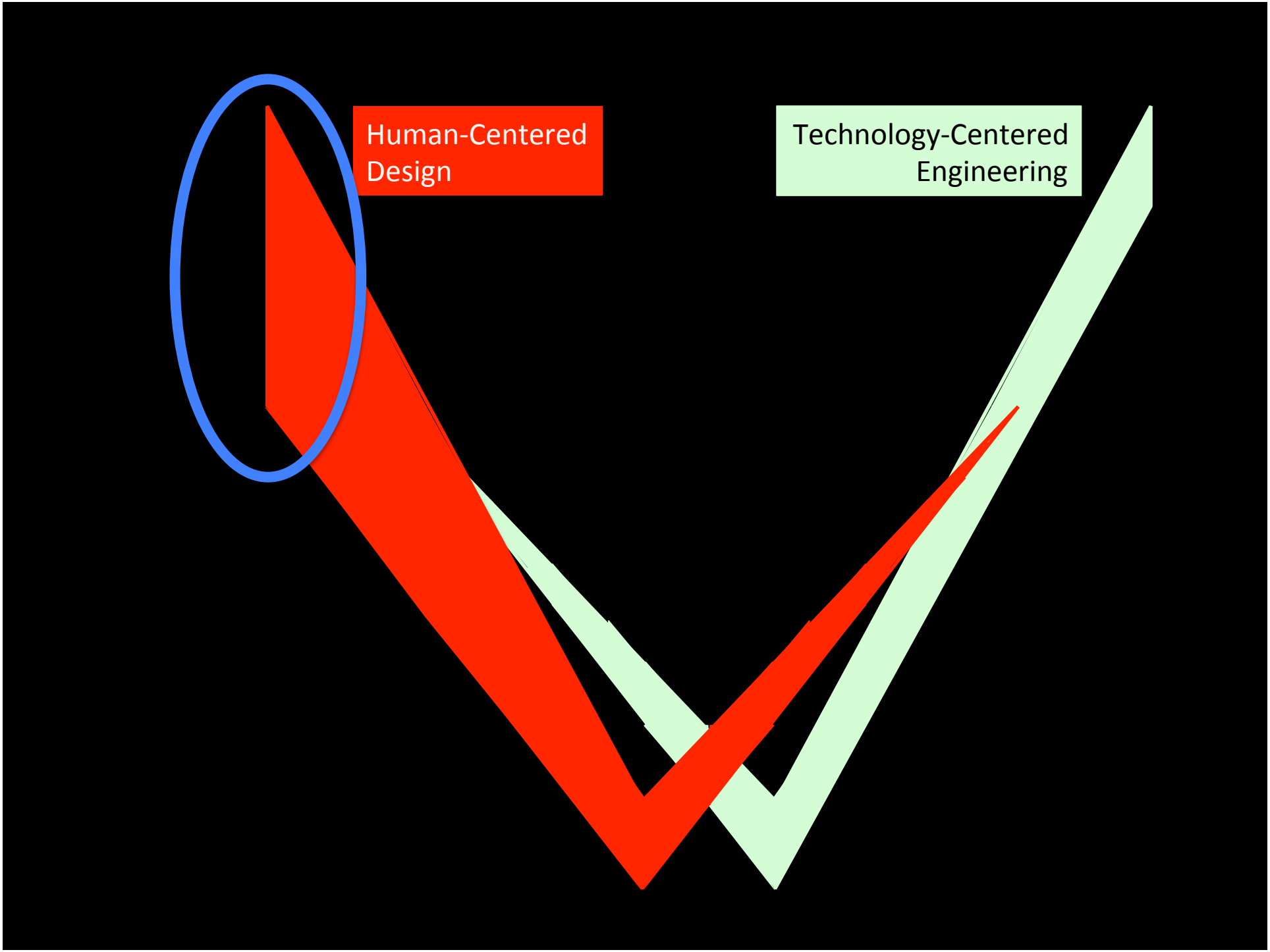



People
Human Centered Design
Technology
Organizations


V-Model


Human-Centered Design
Technology-Centered Engineering


Human-Centered
Design
Technology-Centered
Engineering


Human-Centered
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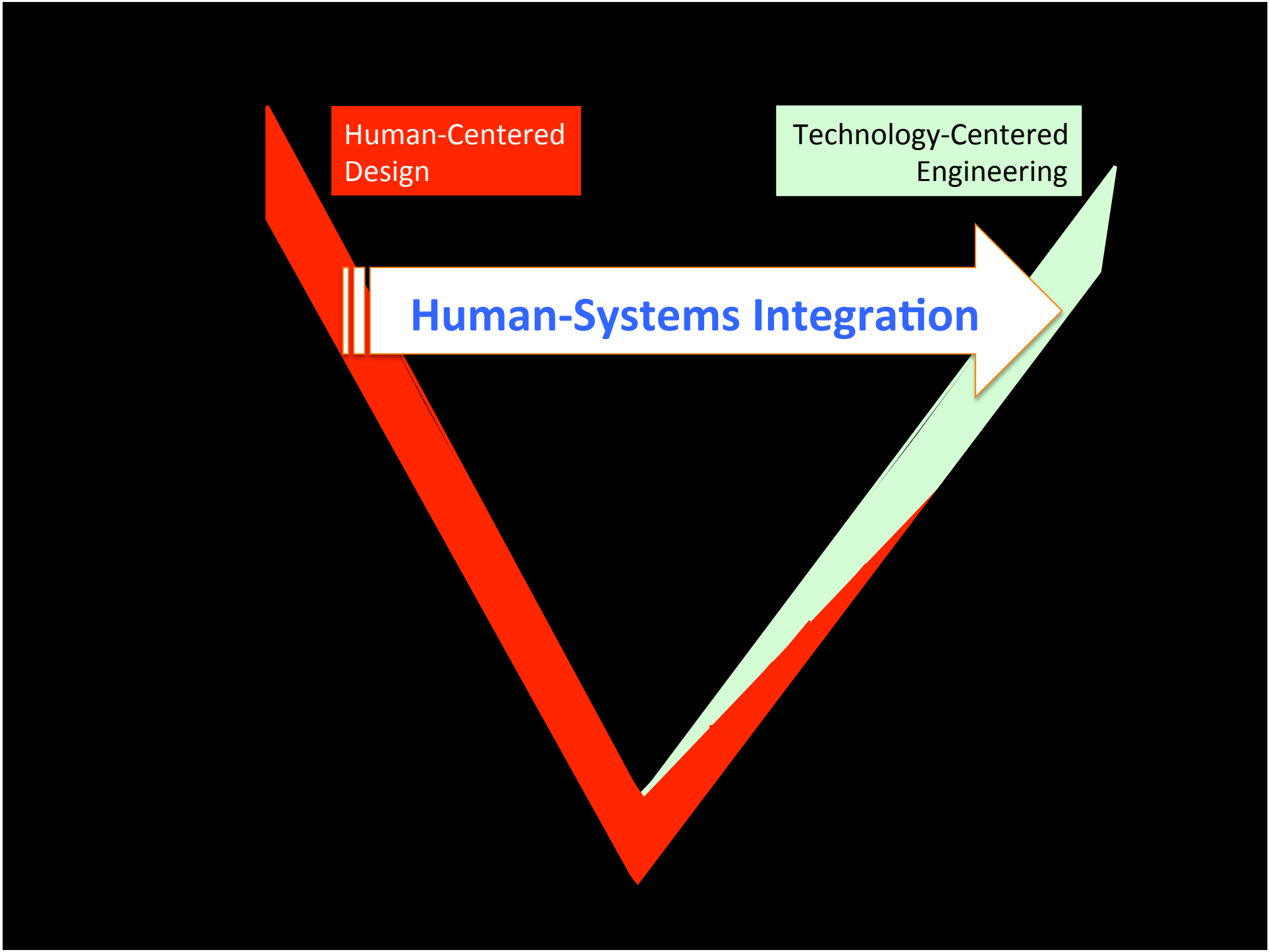
Human-Centered Design
Technology-Centered Engineering
Human-Systems Integration

HCD as a core discipline…

- Understand principles of HSI
  - Function allocation (TIS)
  - Interaction models
  - Context models…
- Systems and design thinking
  - Complexity analysis
  - Organization design and management
  - Life-critical system properties…
- Tools for HCD
  - Modeling and prototyping
  - Human-in-the-loop simulations
  - Advanced interaction media...

Current SE Handbook Contents

9. Cross-cutting SE methods

1. Modeling and simulation √
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7. Integrated product and process development √
8. Lean SE √
9. Agile SE √


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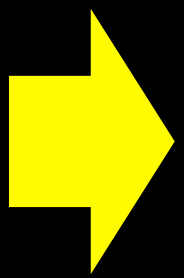
What we are looking for …

- not short-term responses
- but intrinsic principles
- and sustainable solutions



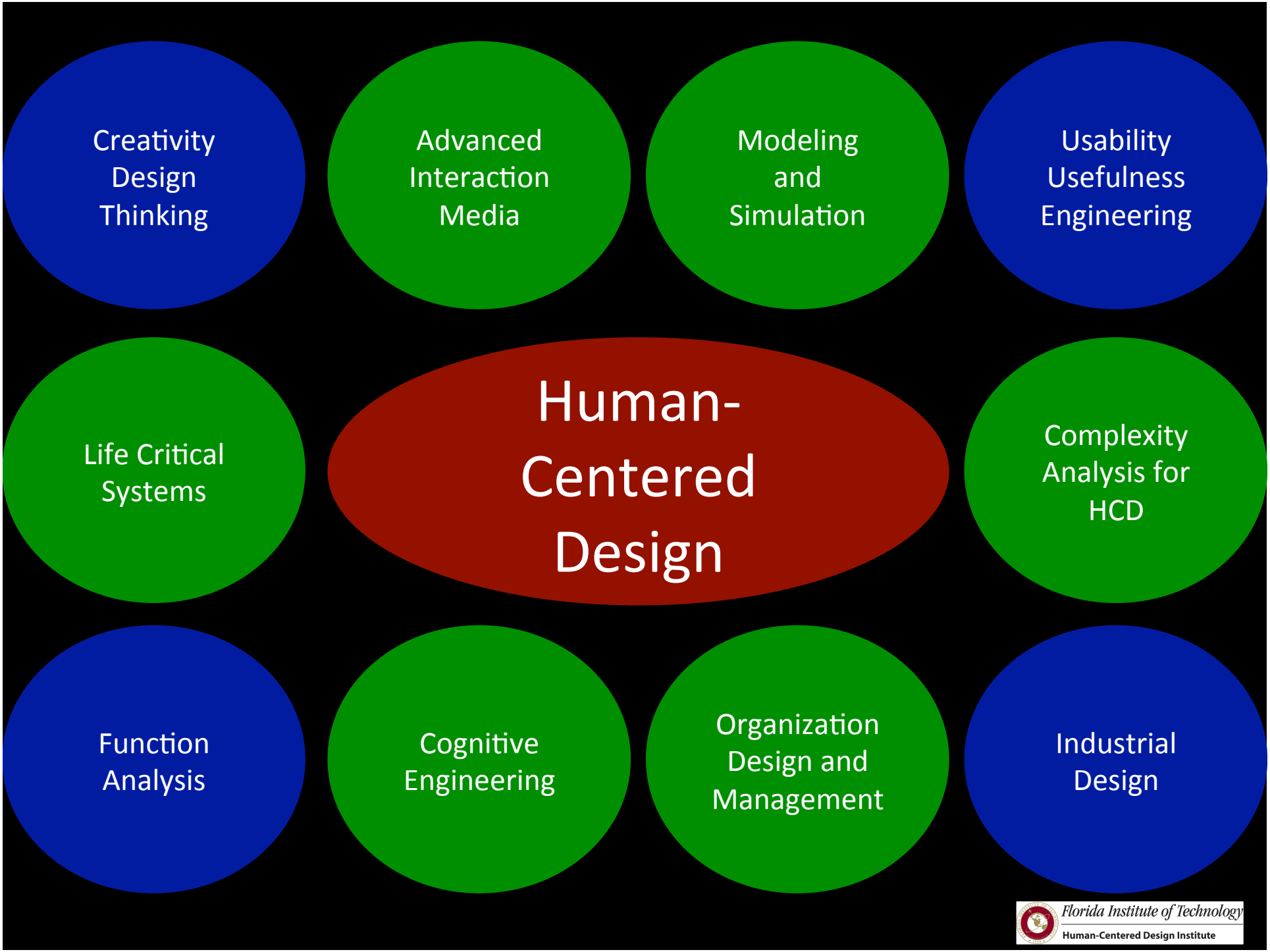
engineering and design evolution
new technological possibilities
familiarity with complex systems

Organize Creativity Spaces…

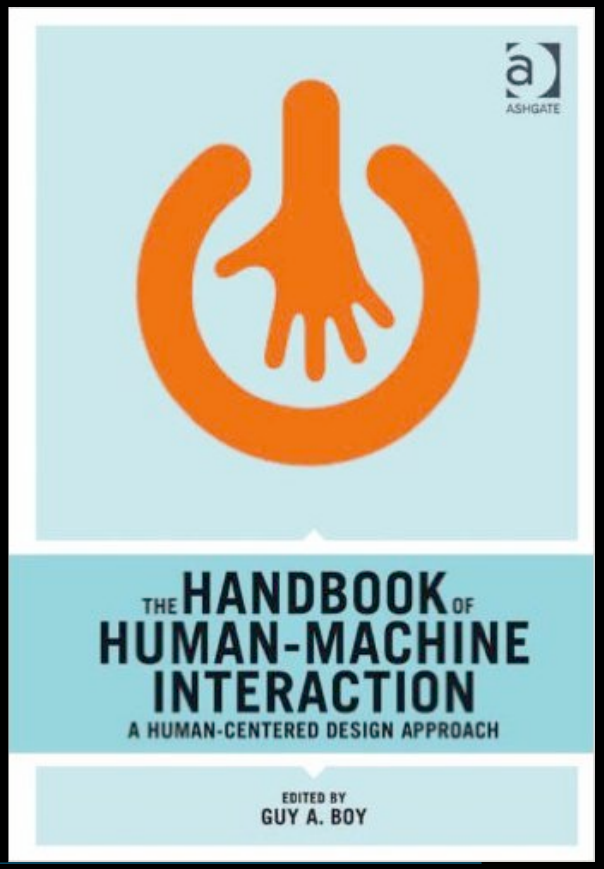
Recommendations for HCD

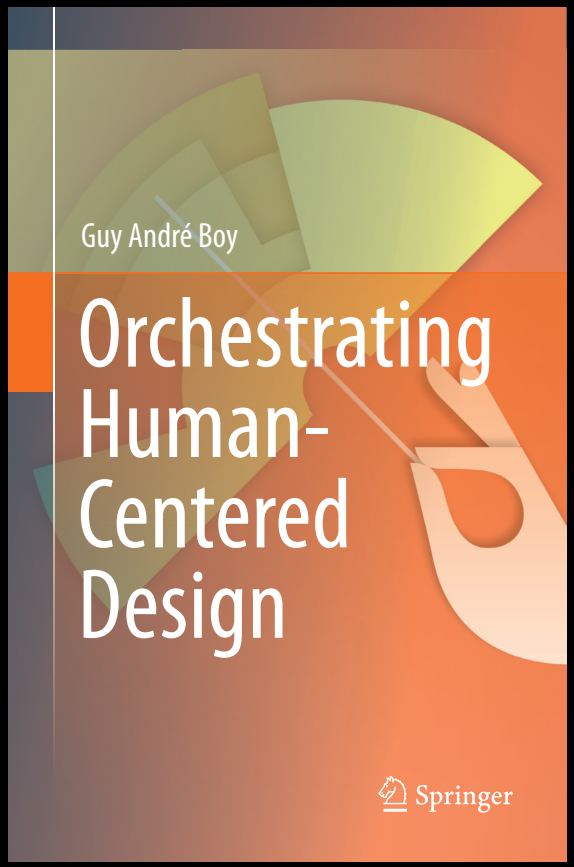
1. Concepts of operation and scenario development
2. Task analyses
3. Function allocation between humans and systems
4. Allocation of roles and responsibilities among humans
5. Iterative conceptual design and prototyping
6. Empirical testing, e.g., human-in-the-loop, testing with representative population, or model-based assessment of human-system performance
7. In-situ monitoring of human-system performance during flight

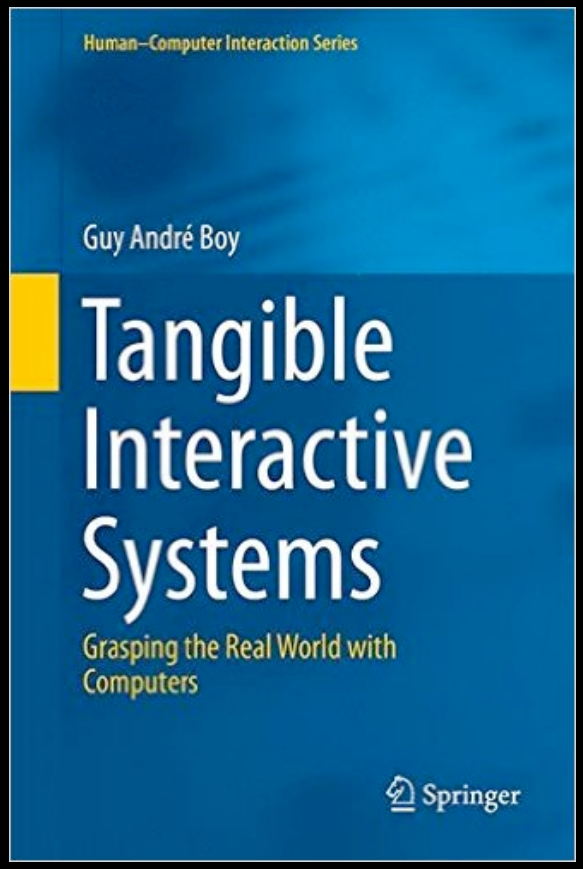
NASA Human-Systems Integration Practitioner's Guide. Nov. 2015


Creativity Design Thinking
Advanced Interaction Media
Modeling and Simulation
Usability Usefulness Engineering
Life Critical Systems
Human-Centered Design
Complexity Analysis for HCD
Function Analysis
Cognitive Engineering
Organization Design and Management
Industrial Design
Florida Institute of Technology
Human-Centered Design Institute

You want to know more…







HCDIA graduate school…

Thank you!