HUMAN SYSTEMS INTEGRATION
IN THE DESIGN OF COMPLEX SYSTEMS

Prof. Guy André Boy
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Fellow of the International Academy of Astronautics
INCOSE Fellow & HSI WG Chair
IEA Aerospace TC Chair
Senior Member of the ACM

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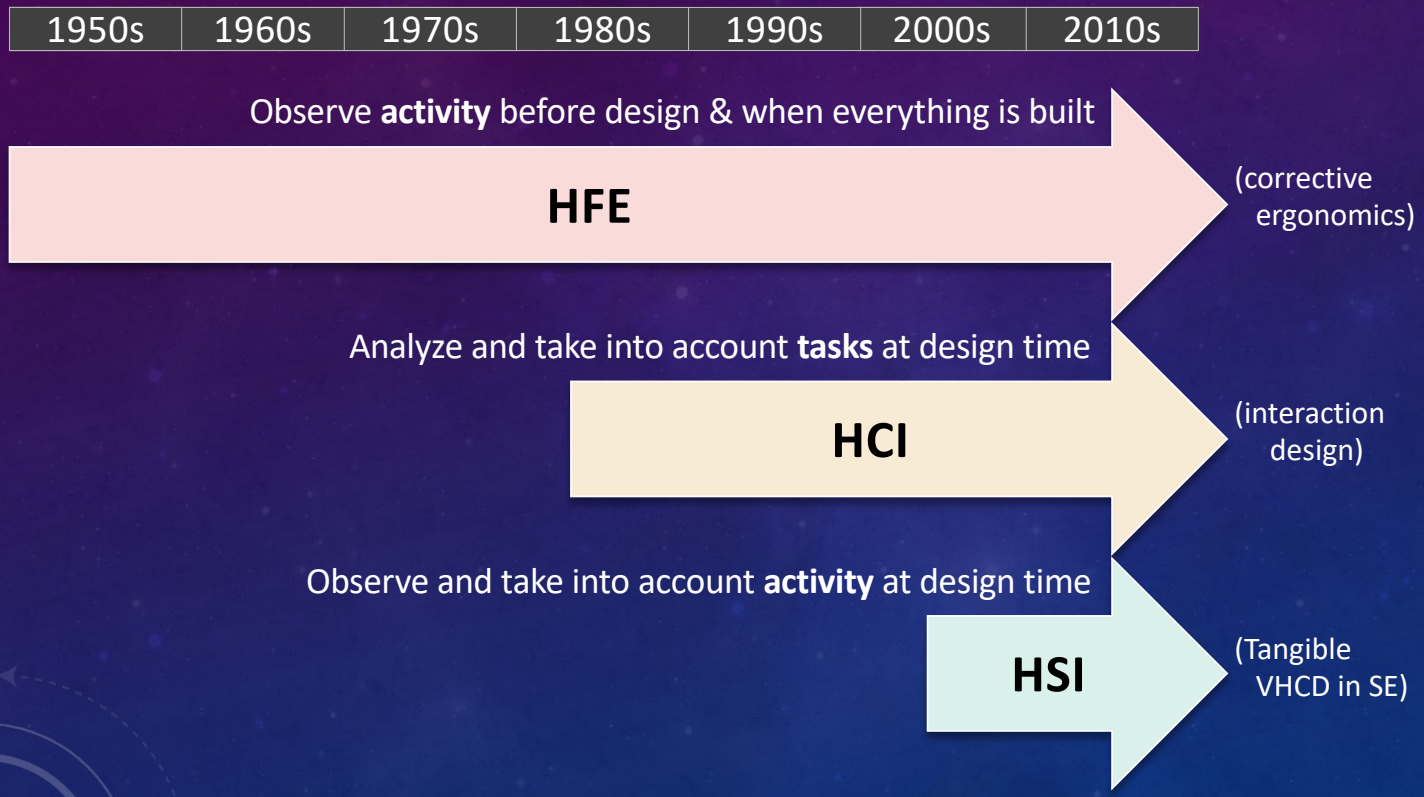
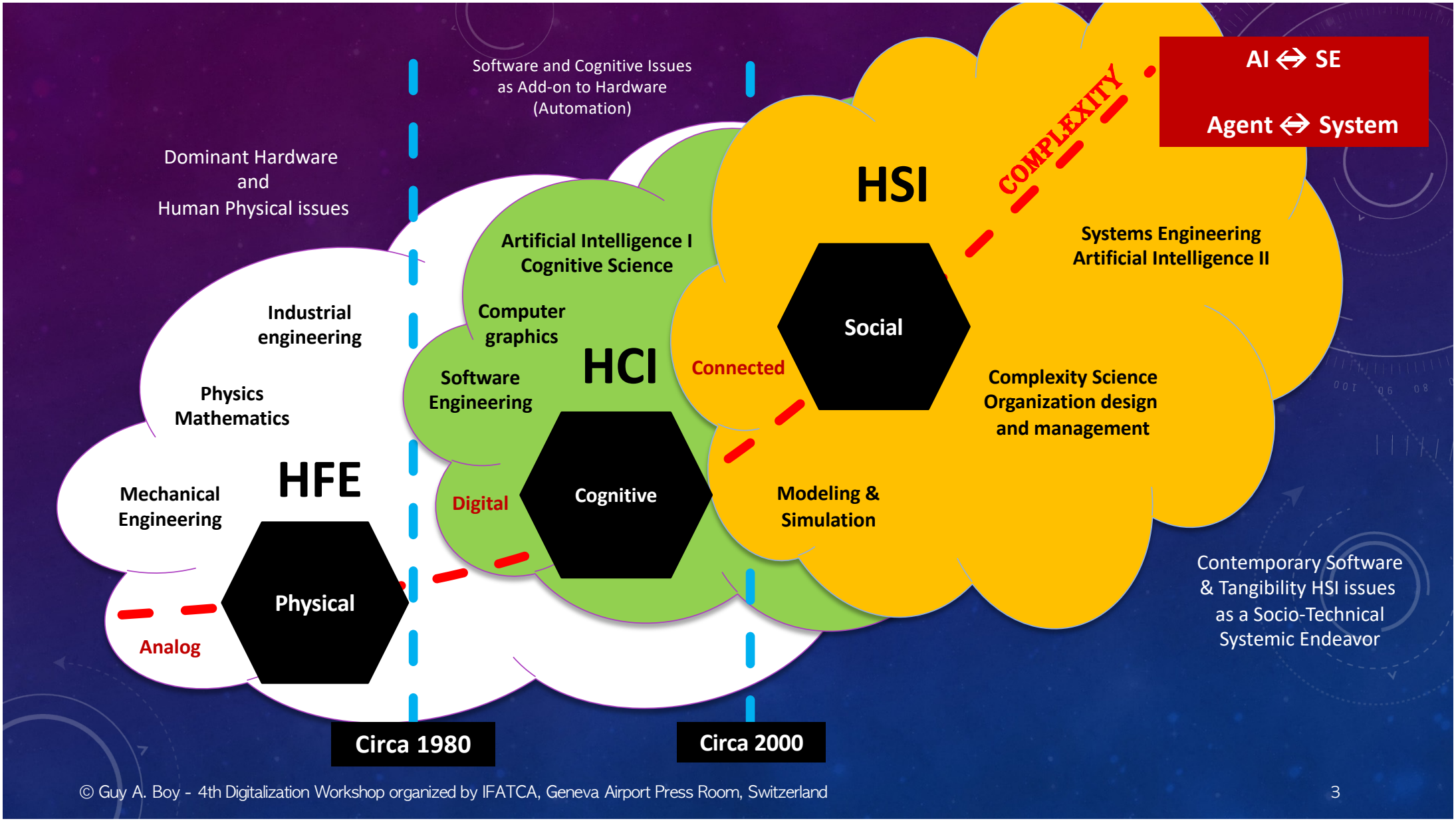
TASK VS. ACTIVITY

Departing from the 20th Century User-Interface Syndrome…



HFE: Human Factors and Ergonomics
HCI: Human Computer Interaction
VHCD: Virtual Human-Centered Design
HSI: Human Systems Integration
SE: Systems Engineering


Software and Cognitive Issues
as Add-on to Hardware
(Automation)
Dominant Hardware
and
Human Physical issues
AI ⇔ SE
Agent ⇔ System
COMPLEXITY
HSI
Artificial Intelligence I
Cognitive Science
Systems Engineering
Artificial Intelligence II
Industrial
engineering
Computer
graphics
Social
HCI
Connected
Software
Engineering
Physics
Mathematics
Complexity Science
Organization design
and management
HFE
Mechanical
Engineering
Digital
Cognitive
Modeling &
Simulation
Physical
Analog
Contemporary Software
& Tangibility HSI issues
as a Socio-Technical
Systemic Endeavor
Circa 1980
Circa 2000

PRODEC

A method for the design, evaluation, operations, and support of increasingly digitalized complex sociotechnical systems

WHAT IS A SYSTEM?

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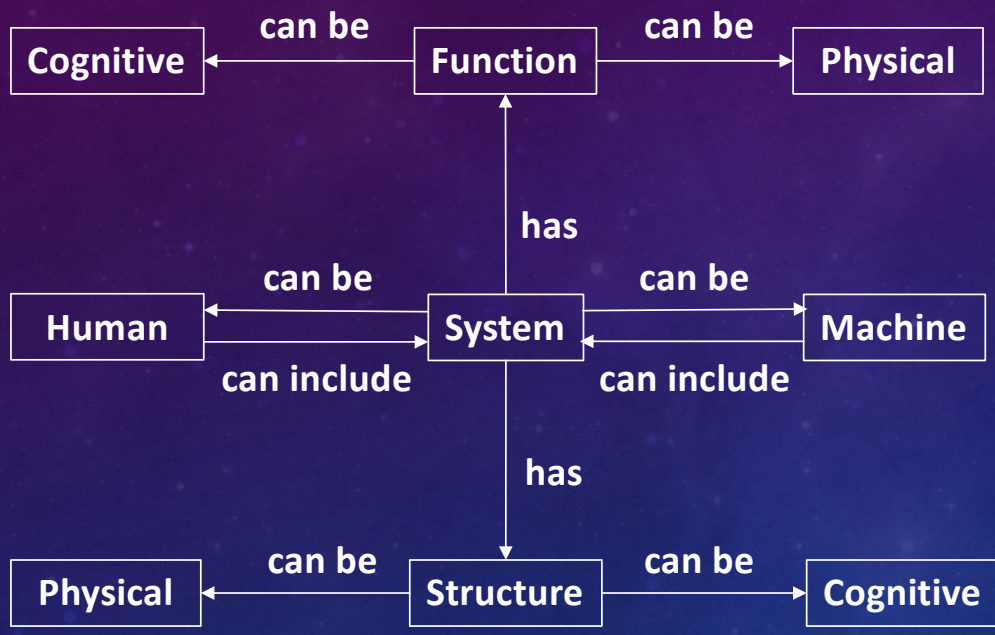
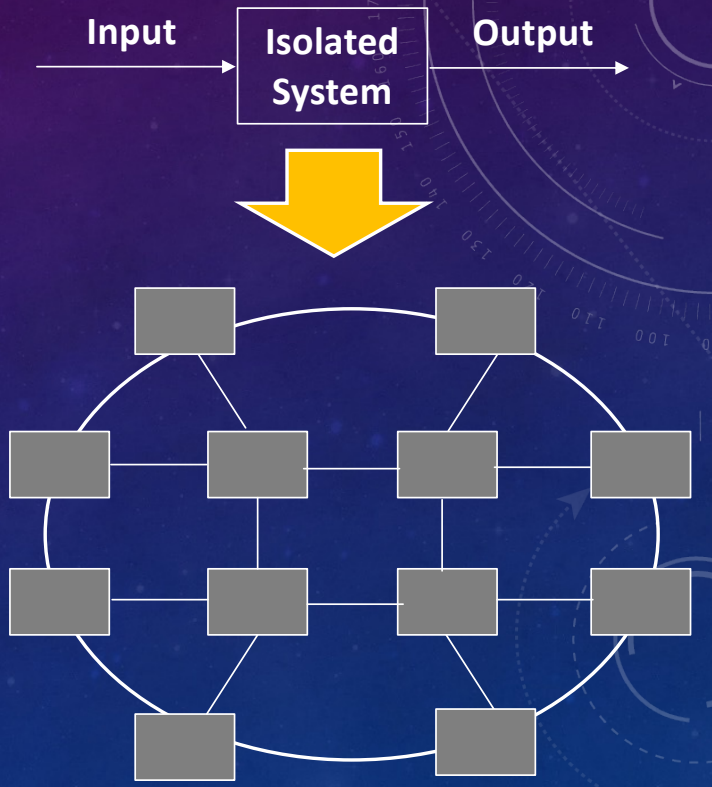


Systems include Humans and Machines…



Interconnected System of Systems

SYSTEM = STRUCTURE + FUNCTION

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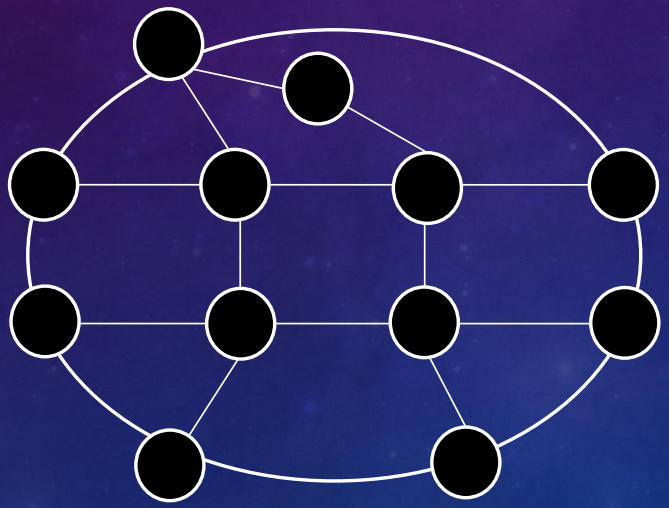
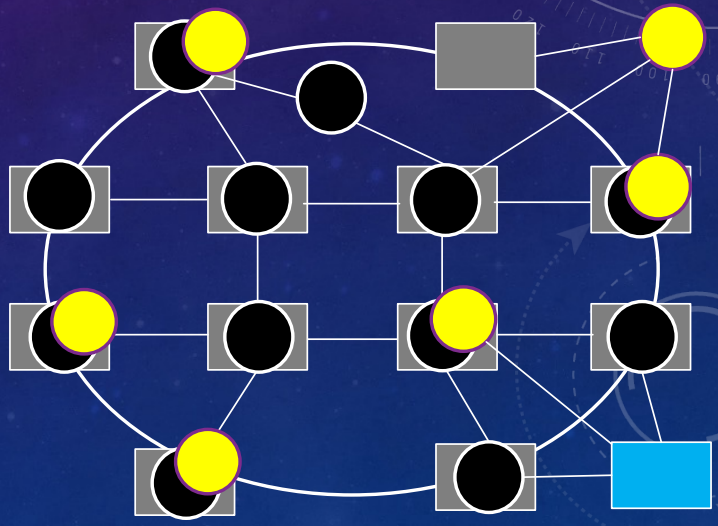
Emergent Structures

Emergent Functions

Overlapping Functions of Functions



Interconnected Functions of Functions



Interconnected Structures of Structures

SYSTEM = STRUCTURE + FUNCTION

ATM SYSTEMS OF SYSTEMS

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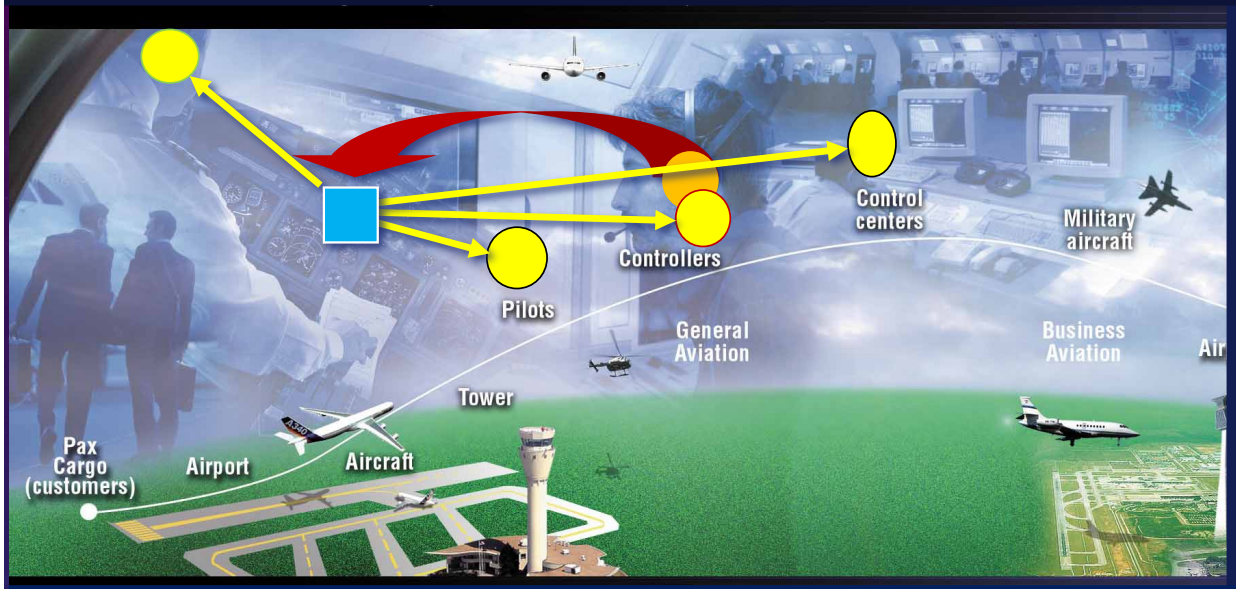


Machine cognitive function

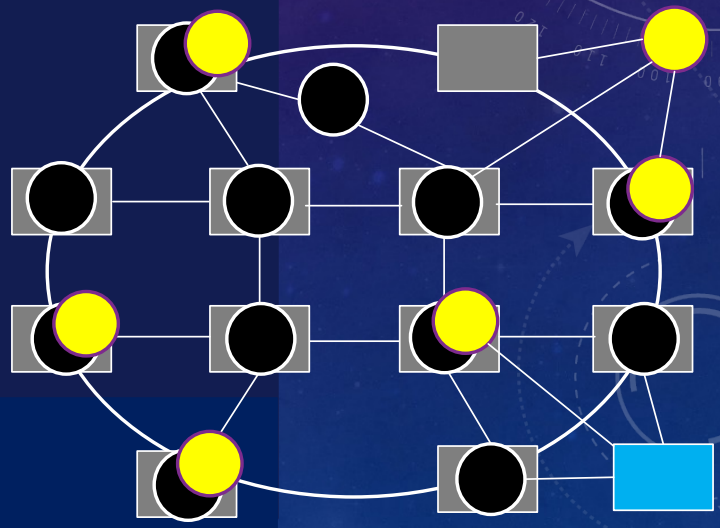
Human cognitive function

PAUSA: Authority Sharing in the Air Space (2006-2008: France; 9 Partners)

Emergent Structures

Emergent Functions

Overlapping Functions of Functions



Interconnected Structures of Structures

SYSTEMS OF SYSTEMS PROPERTIES

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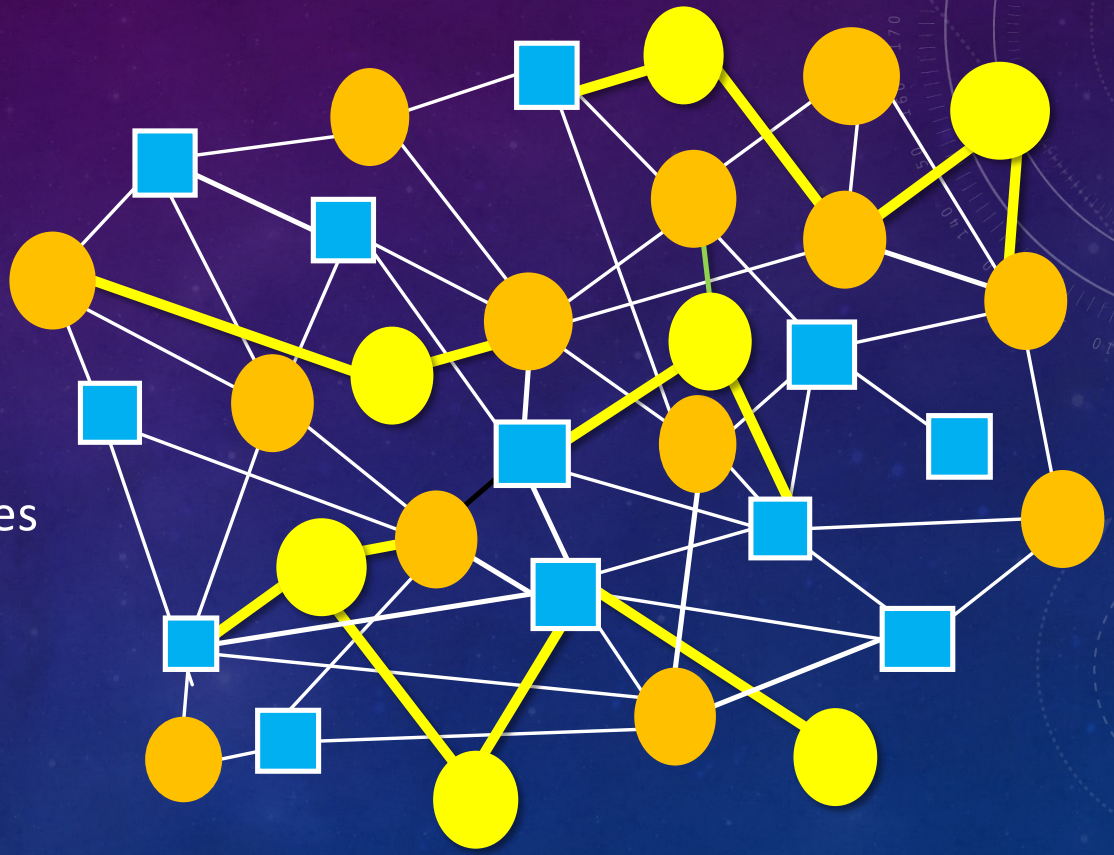
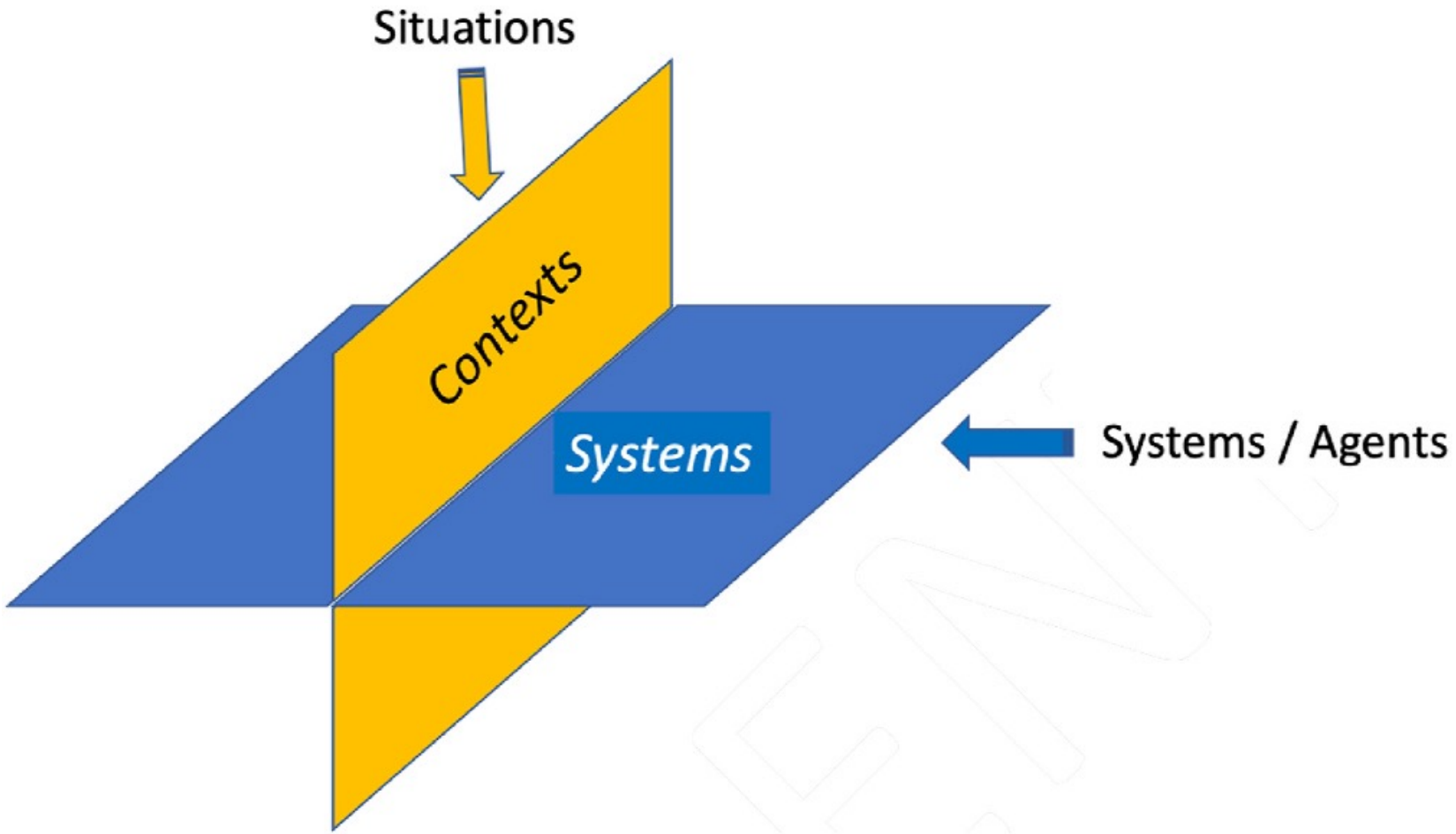
Separability
a crucial issue

Complexity
in connections
as well as
in agents/systems themselves

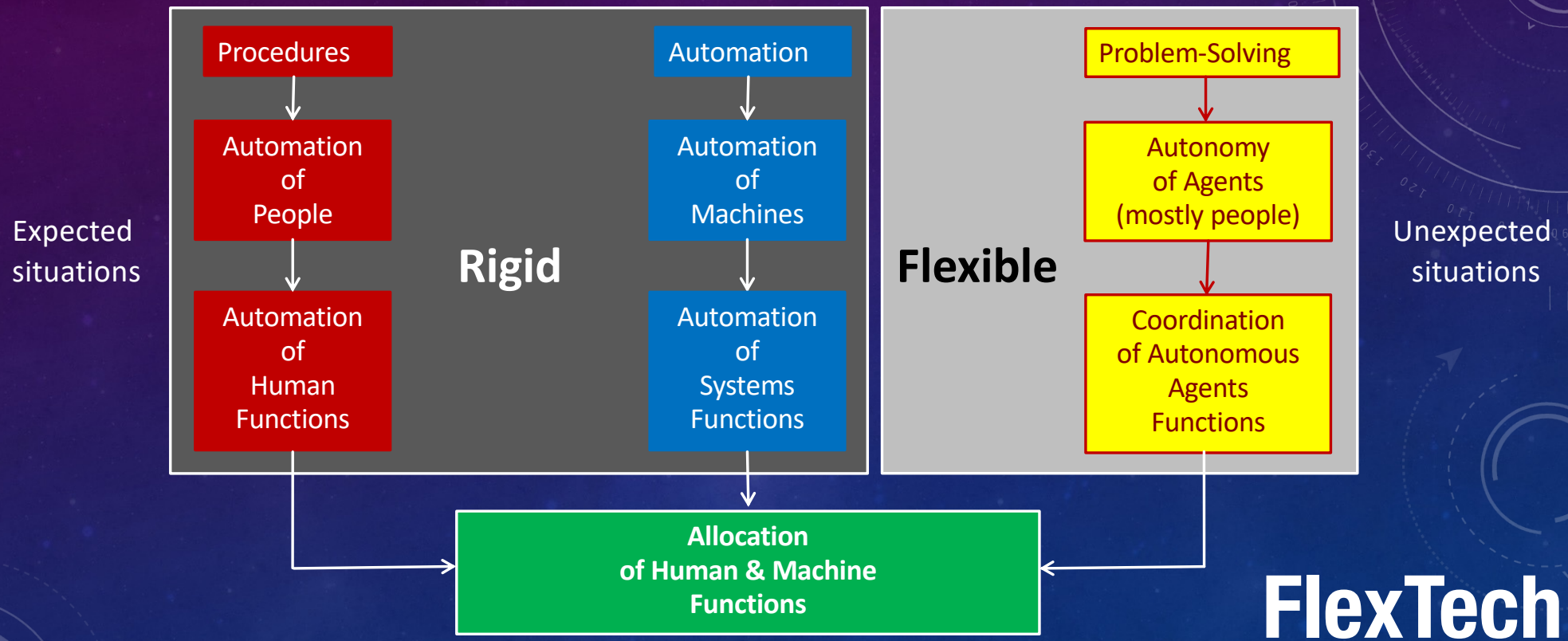
Emergent functions,
Coordination rules
and
the **maturity** issue



… therefore, this is a living organism


Situations
Contexts
Systems
Systems / Agents

FROM RIGID AUTOMATION TO FLEXIBLE AUTONOMY



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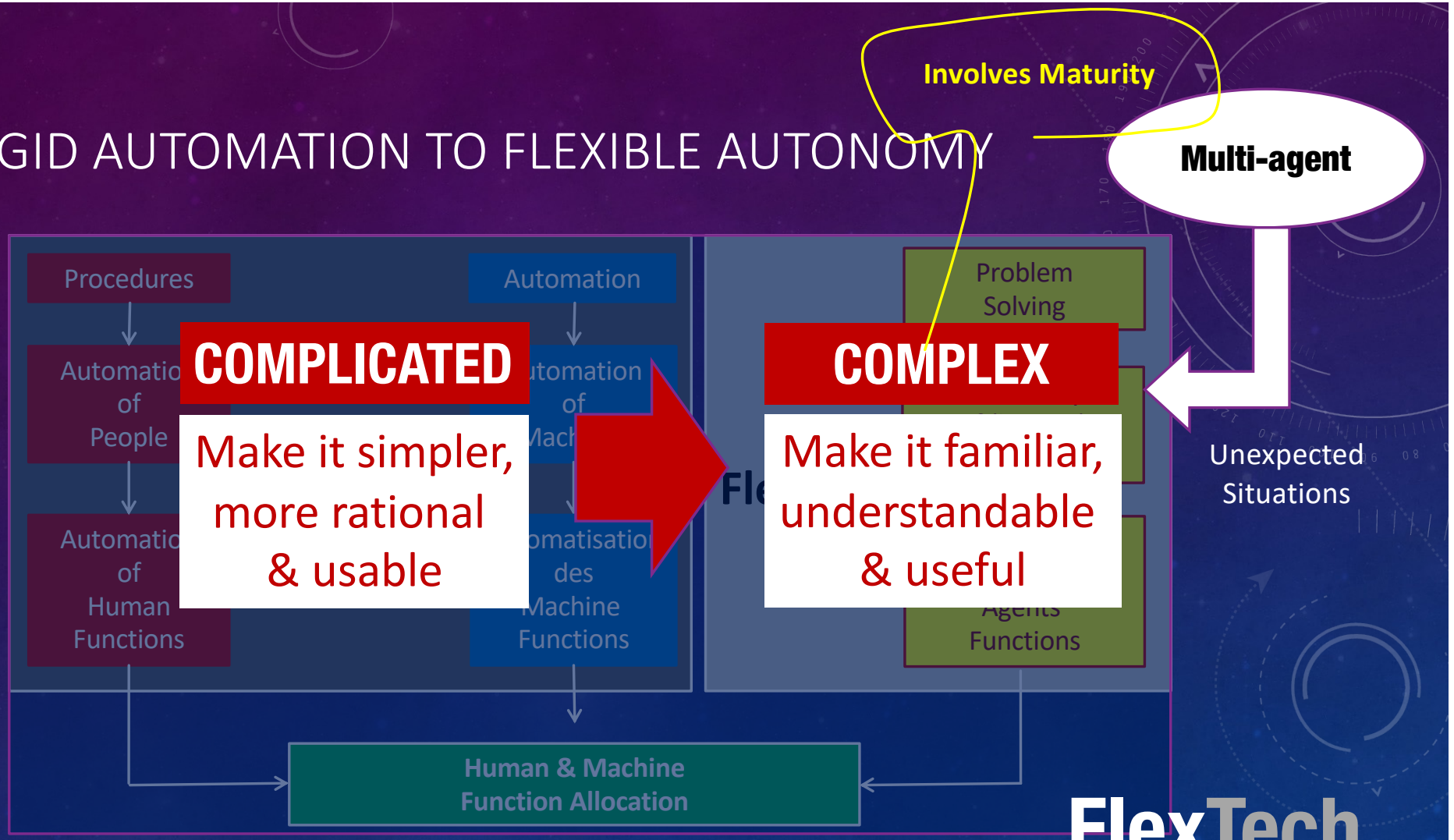
FROM RIGID AUTOMATION TO FLEXIBLE AUTONOMY



https://www.sciencedirect.com/science/article/pii/S0160791X23001033

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READINESS LEVELS

Technology (TRL)

Human (HRL)

HRL	Description
1	Relevant human capabilities, limitations, and basic human performance issues and risks identified
2	Human-focused concept of operations defined and human performance design principles established
3	Analyses of human operational, environmental, functional, cognitive, and physical needs completed, based on proof of concept
4	Modeling, part-task testing, and trade studies of user interface design concepts completed
5	User evaluation of prototypes in mission-relevant simulations completed to inform design
6	Human-system interfaces fully matured as influenced by human performance analyses, metrics, prototyping, and high-fidelity simulations
7	Human-system interfaces fully tested and verified in operational environment with system hardware and software and representative users
8	Total human-system performance fully tested, validated, and approved in mission operations, using completed system hardware and software and representative users
9	System successfully used in operations across the operational envelope with systematic monitoring of human-system performance

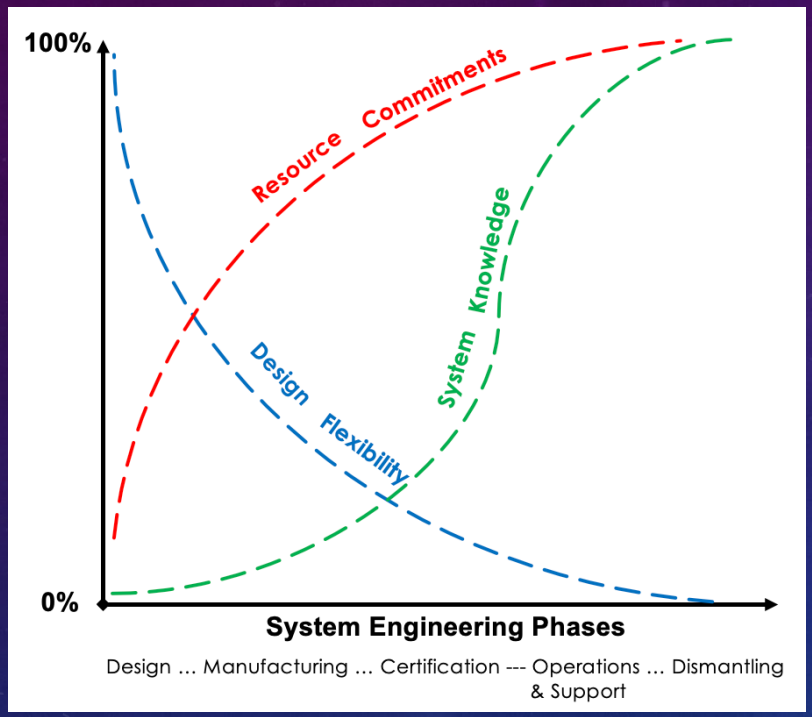
Organization (ORL)

ORL-0	First principles where potential organizational models are explored.
ORL-1	Goal-oriented research that requires making choices from first principles to practical fully digital organizational setups
ORL-2	Proof of principle development, and active R&D is started in a virtual environment
ORL-3	Virtual agile organizational prototype development and first HITLS (virtual HCD)
ORL-4	Proof of organizational concept development using concrete scenario-based design from fully virtual to more tangible environments
ORL-5	Assessing organization capability in terms of authority sharing (responsibility, accountability and control), trust, collaboration and coordination, for example
ORL-6	Real-world use-case tests in a wider variety of situations - tangibilization continues
ORL-7	Practical integration with respect to criteria such as safety, efficiency and comfort, at various levels of granularity of the organization – tangibilization continues
ORL-8	Readiness for effective implementation on a real site (fully tangible) based on personnel feedback for deployment approval
ORL-9	Deployment involving both personnel and real machines

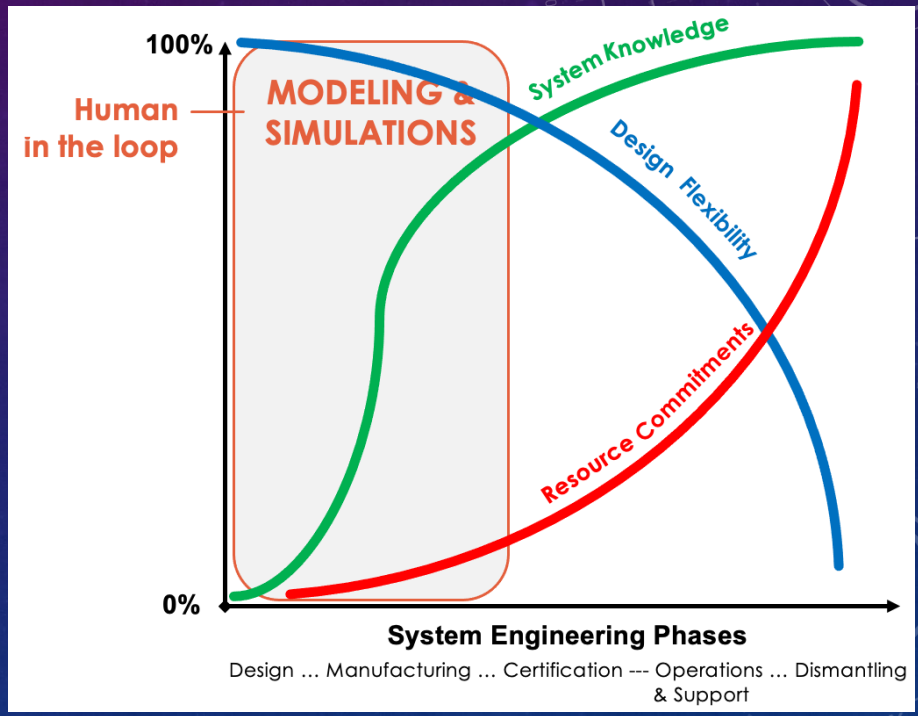
https://www.sciencedirect.com/science/article/pii/S0160791X23001033

LIFE-CYCLED HUMAN SYSTEMS INTEGRATION…

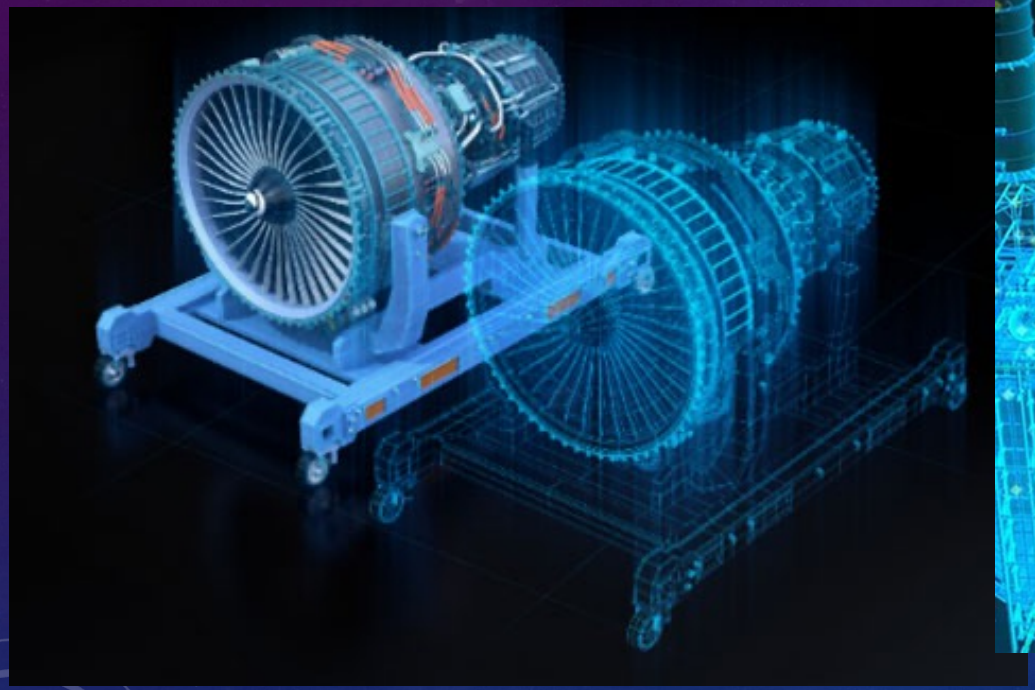
Technology-centered

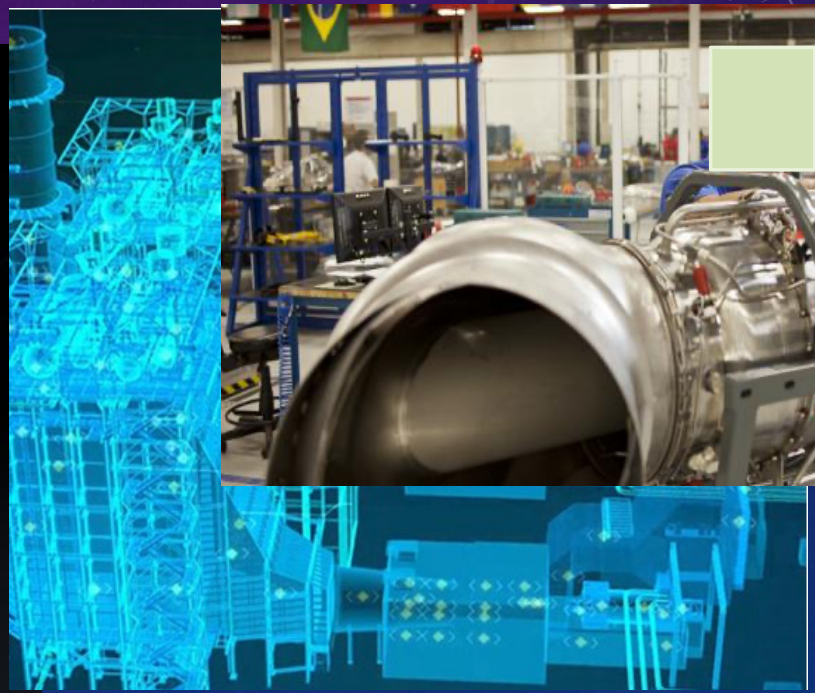


Human-centered



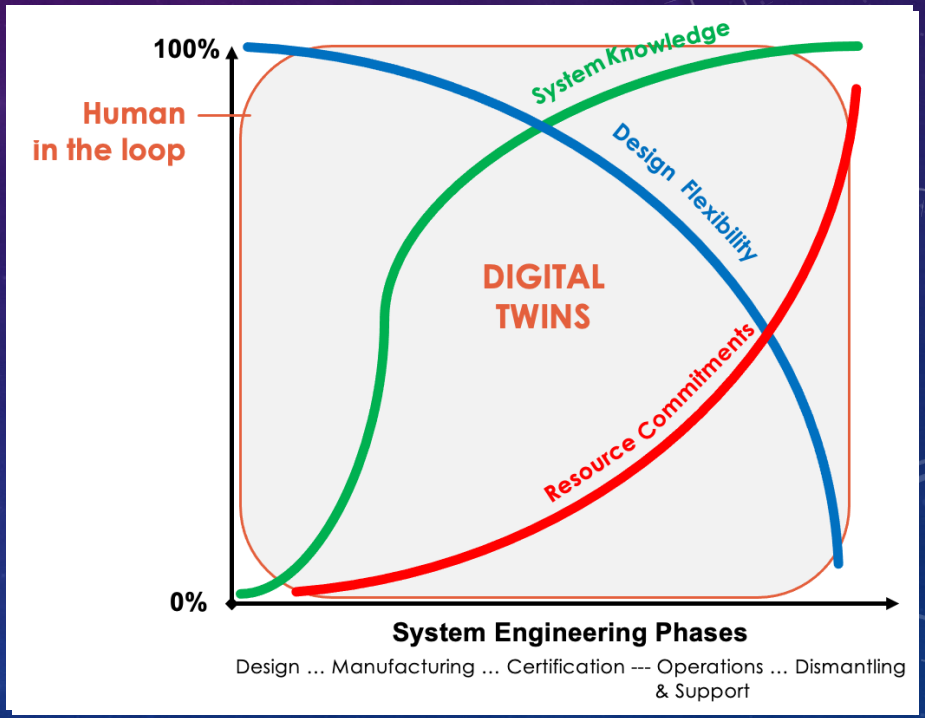
HUMAN-CENTERED DESIGN OF A DIGITAL TWIN FOR HELICOPTER ENGINE MAINTENANCE





DIGITAL TWINS

- Extending human-in-the-loop simulations
  - Throughout the life cycle
  - “what if?”
- Active documentation
  - Integration of experience feedback
  - Organizational memory
- Digital twins as virtual assistants
  - Collaborative multi-agents systems
  - Mediators for collaborative work



FROM MEANS TO PURPOSE

Engineering

Ergonomics
Automation

Factors
Human

Tangible
Traditional Engineering

Physical Environment

Real
Human agents

Real
Machine agents

Space for
Control & Management

Humans
in
the
Loop

Inside-out

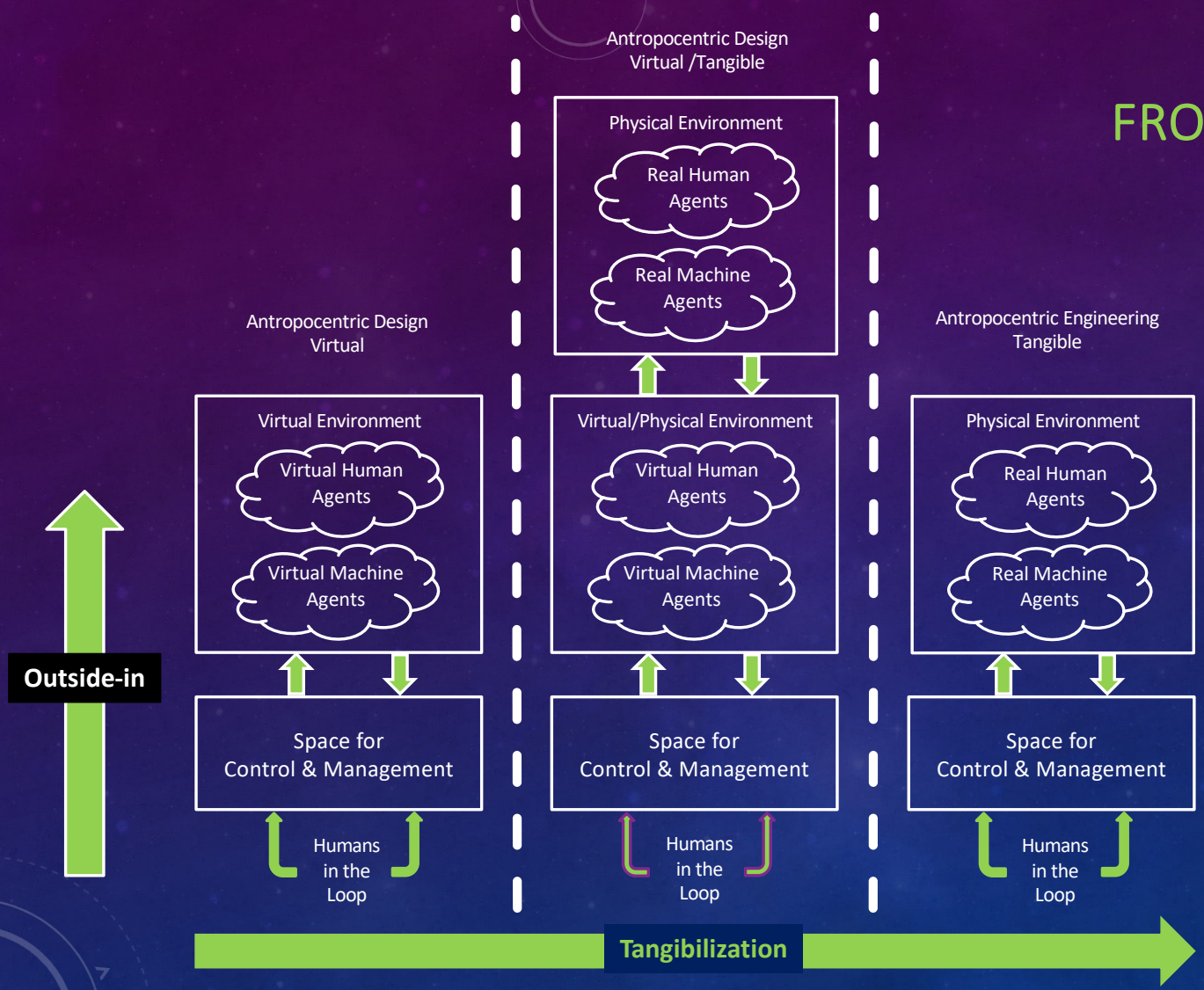
20TH CENTURY APPROACH

Engineering,
Ergonomics,
HCI &
Automation

FROM PURPOSE TO MEANS

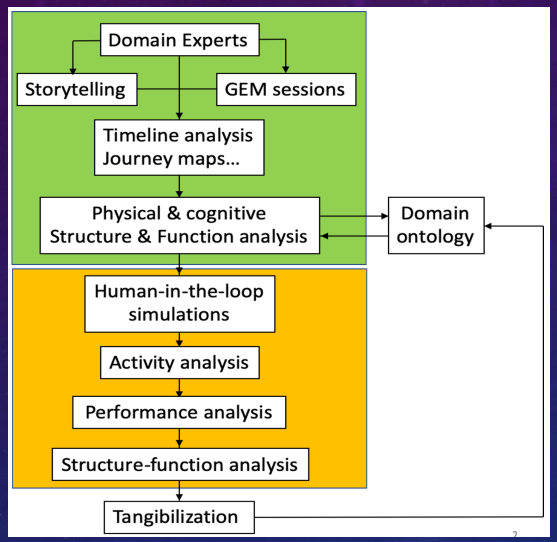
21ST CENTURY APPROACH

HSI



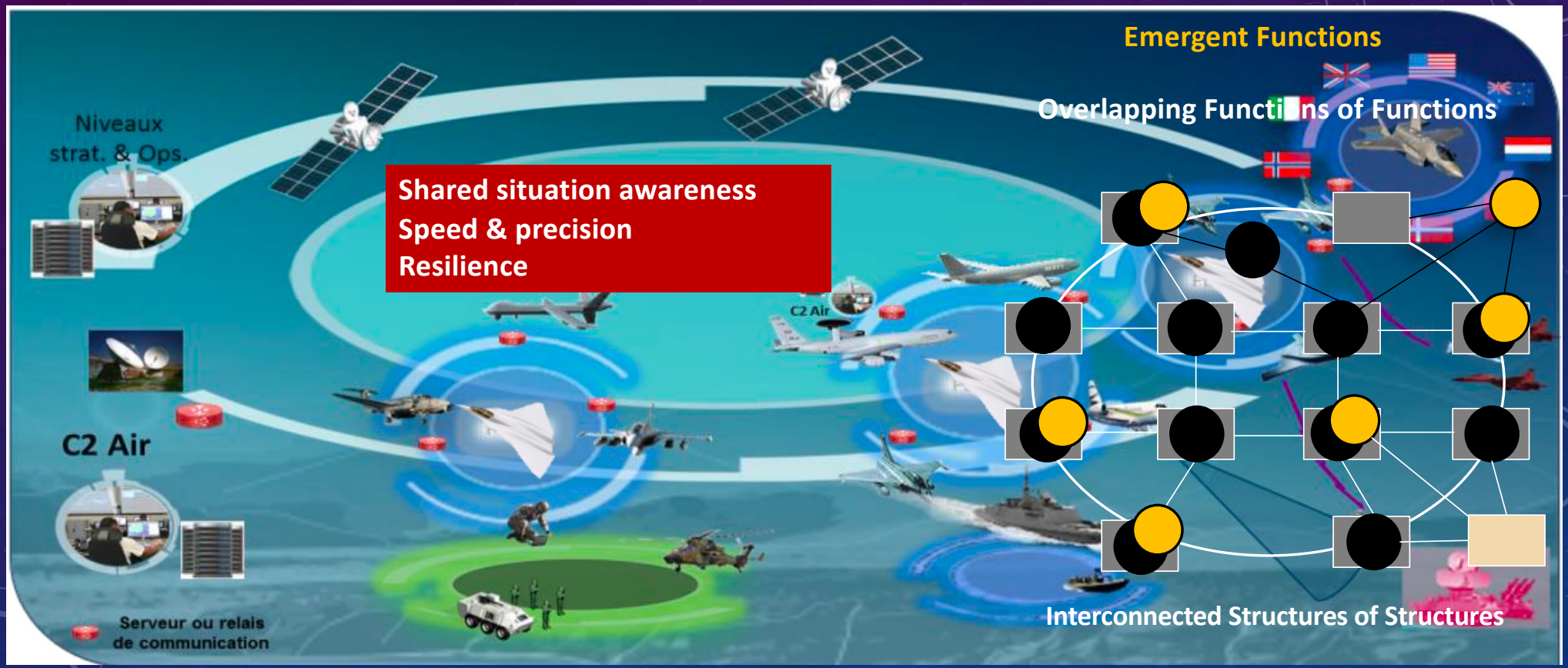
OFF-SHORE MULTI-AGENT TELEROBOTIC SYSTEMS

PRODEC method combined with human-in-the-loop digital simulation

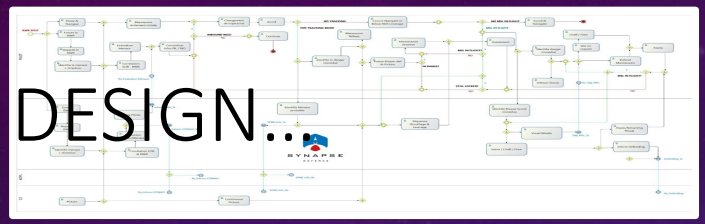


Tangibilisation

FUTURE COMBAT AIR SYSTEM (FCAS)



SCENARIO-BASED DESIGN…



PRODEC

VIRTUAL PROTOTYPES…

Tangibility metrics

HUMAN-IN-THE-LOOP SIMULATION…

Activity analysis

Emergent function discovery

This book is a follow-up of previous contributions in Human-Centered Design and practice in the development of virtual prototypes that requires progressive operational tangibility toward Human-Systems Integration (HSI). The book discusses flexibility in design and operations, tangibility of software-intensive systems, virtual human-centered design, increasingly-autonomous complex systems, Human-Factors and Ergonomics of sociotechnical systems, and systems of systems integration.

This is an attempt to better formalize a systemic approach to HSI. Good HSI is a matter of maturity… it takes time to mature. It takes time for a human being to become autonomous, and then mature! HSI is a matter of human-machine teaming, where human-machine cooperation and coordination are crucial. We cannot think engineering design without considering people and organizations that go with it. We also cannot think new technology, new organizations and new jobs without considering change management, especially in digital organizations.

The book will be of interest to industry, academia, those involved with systems engineering, human factors and the broader public.

Features:

- Discusses flexibility in design and operations of complex systems
- Offers tangibility of software-intensive systems
- Presents virtual human-centered design
- Covers autonomous complex systems
- Provides human factors and ergonomics of sociotechnical systems

About the Author:

Guy André Boy is one of the pioneers and a world leader in the study and applications of human centered design and human systems integration. He is also the Chair of INCOSE Human Systems Integration Working Group worldwide.

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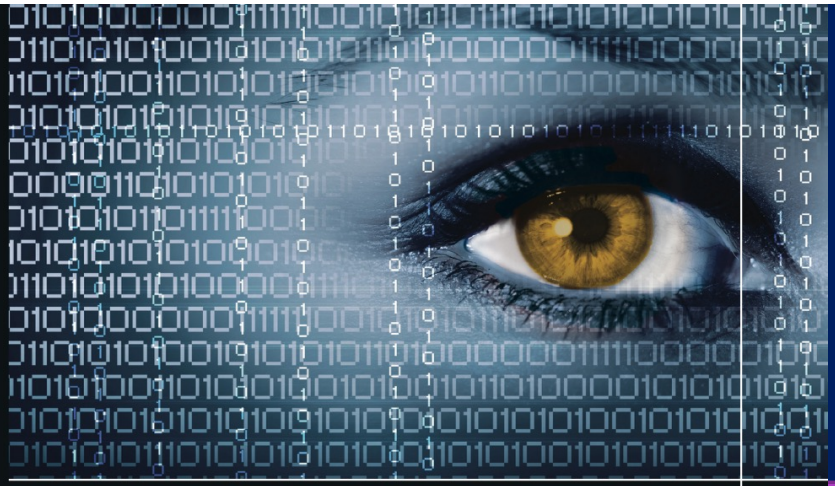
HUMAN-SYSTEMS INTEGRATION

Guy Andre Boy

CRC Press



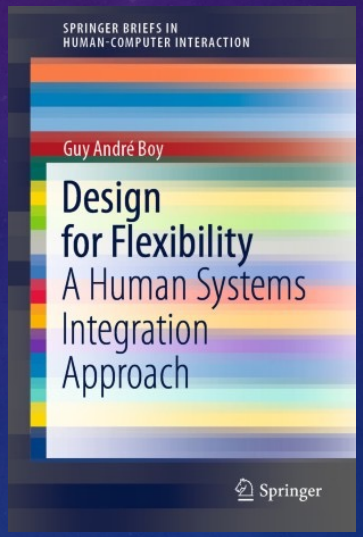
HUMAN-SYSTEMS INTEGRATION

From Virtual to Tangible

Guy Andre Boy

CRC Press
Taylor & Francis Group

… and another one!



HANDBOOK OF SOCIOTECHNICAL SYSTEMS

A HUMAN SYSTEMS INTEGRATION APPROACH

- To appear by the end of 2024/beginning of 2025
- 48 chapters
- 16 countries

Is the machine a partner or a Tool?

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International Industrial Spring School 2024

Human-AI Teaming

A Human Systems Integration Approach

29-31 May 2024 - Radisson Blu, Biarritz, Basque Country, France

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Lecturers

Prof. Guy André Boy
Dr. Mica Endsley
Prof. Gudela Grote
Dr. So Young Kim
Dr. Tom McDermott
Prof. Philippe Palanque
Dr. Dr. Norbert Streitz

https://www.flextechchair.org/FTSpringSchool2024/about.html

Future Integrated Automation in Aviation

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THANK YOU FOR YOUR ATTENTION!

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