Human Systems Integration: the Digital Twin Support

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Greening MOC?

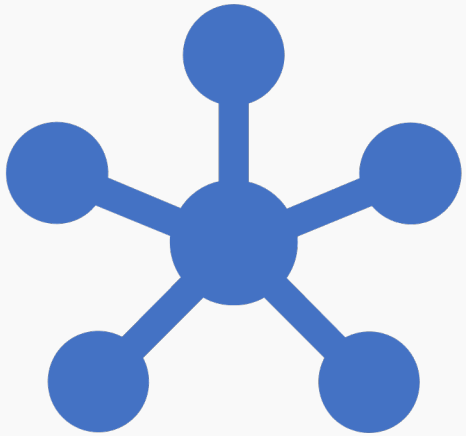
MOC: **Maintenance in Operational Condition**

Environmental impact

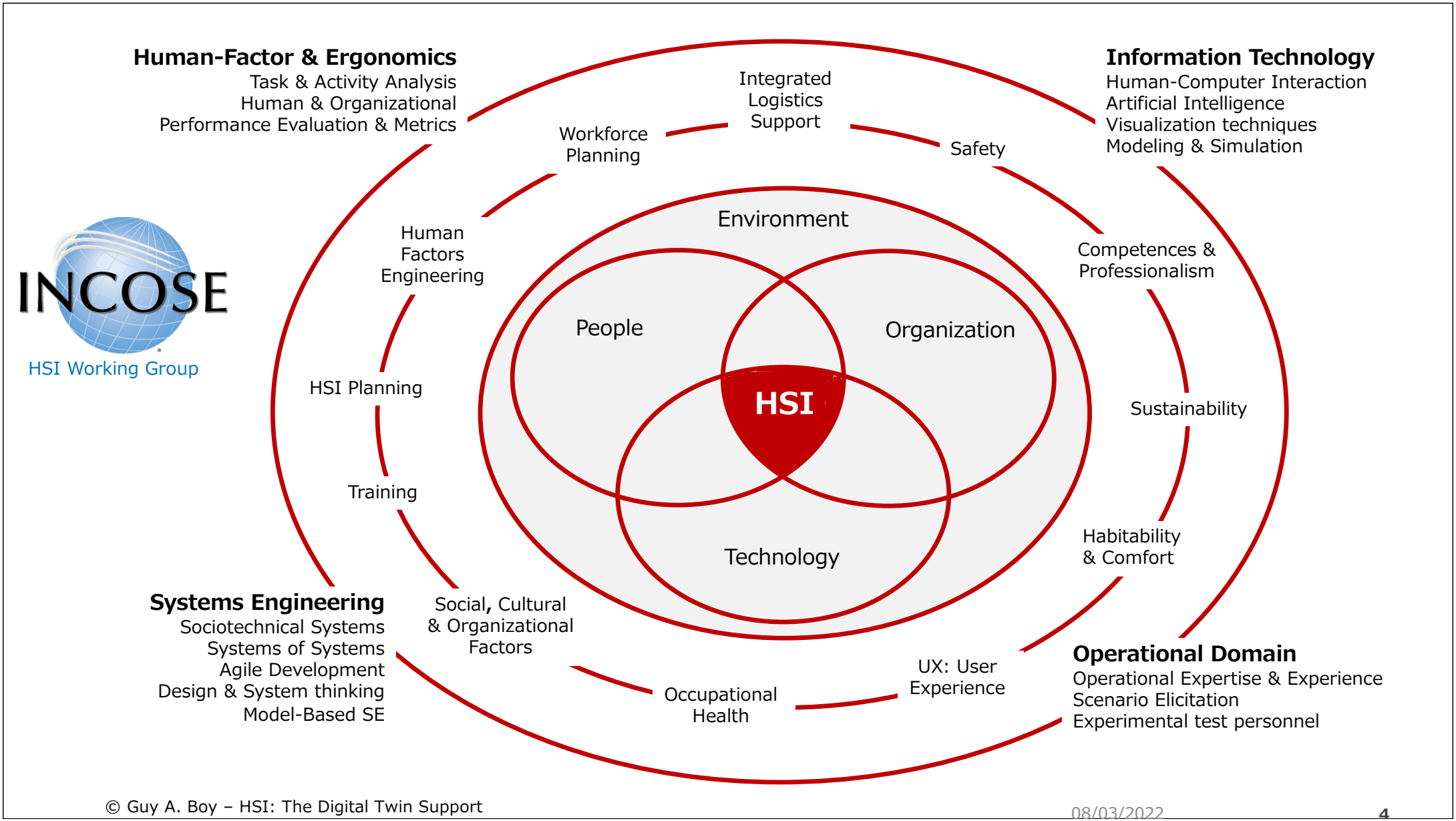
business continuity → work + travel → costs + pollution

lack of sustainability → unnecessary replacement + waste

How to avoid this?



What is Human Systems Integration (HSI)?

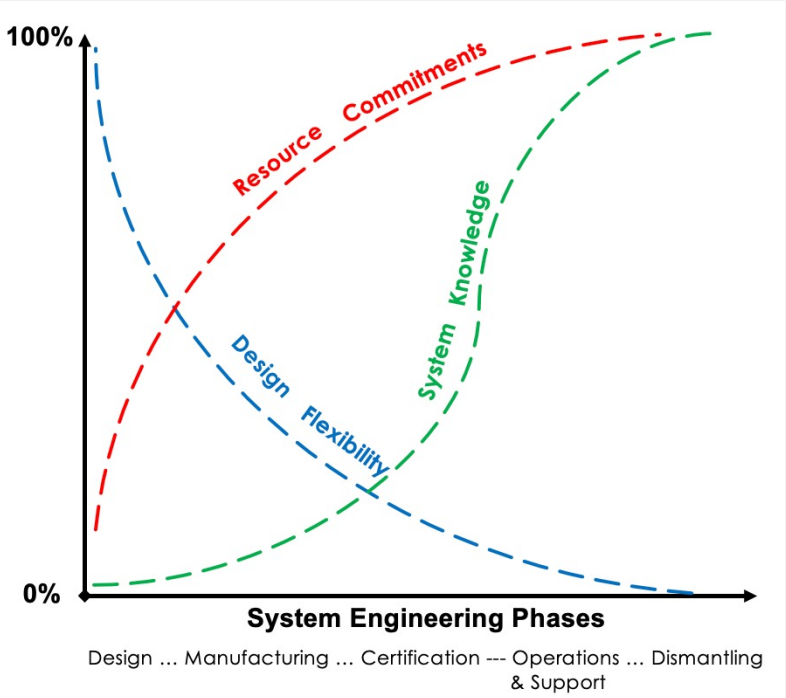


Integration

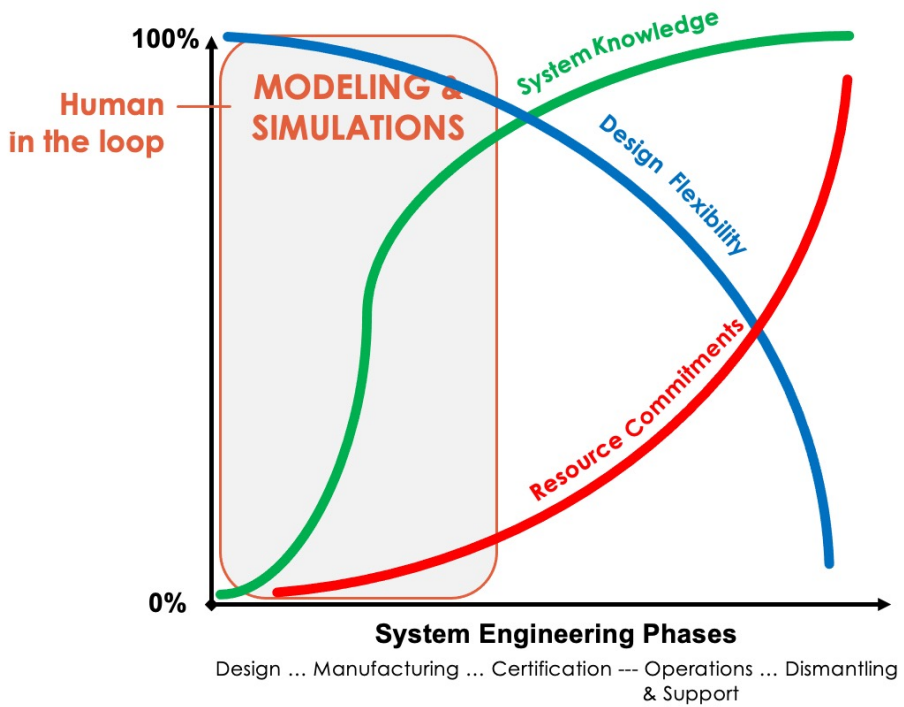
from the early stages of design

Life-Cycled Human Systems Integration

Technology-centered

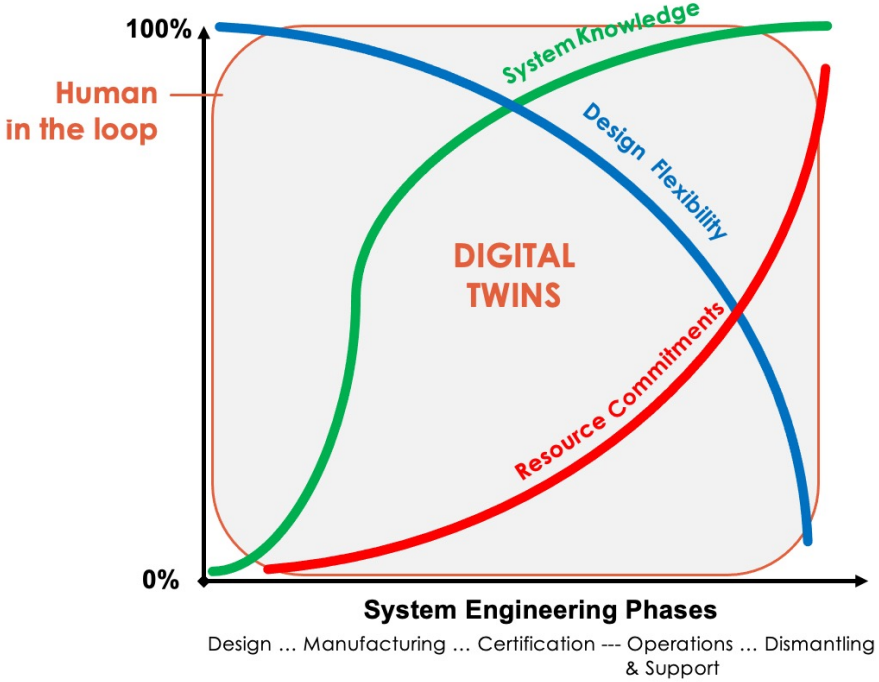


Human-centered



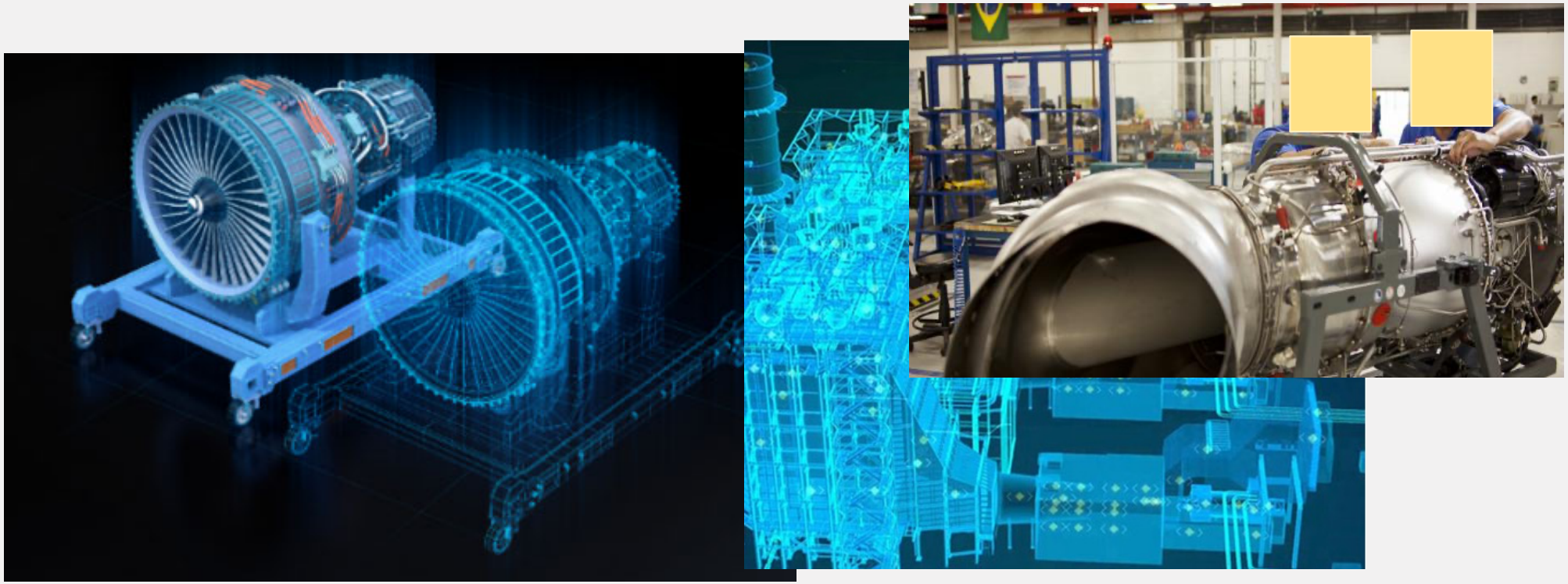
Digital Twins

- Expanding HITLS
  - During the whole life cycle
  - *"what if?"*
- Vivid documentation
  - *Integration of experience feedback*
  - *Organizational memory*
- DTs as virtual assistants
  - *Multi-agent collaboration*
  - *Mediators for collaborative work*



Digital twin for helicopter engine diagnostic and repair system

Human-Centered Design of a Digital Twin for Helicopter Engine Maintenance



SCENARIO : AS-IS

A pilot of the French Air Force at the Toulon base wants to start his NH90 helicopter.

Unfortunately, it emits strange noises.

He calls the technician on base to help him start it up as soon as possible so that he can go on mission.

The technician called the engineer in charge of the NH90's engines in Tarnos and told him that he could not start the aircraft because it had an engine slamming problem.

The engineer at Tarnos goes to his simulation software. He selects the defective aircraft and runs a simulation to try it out. Lacking the information to find the maintenance problem, the engineer is forced to travel to get more information needed for the simulation.

He finds the cause, which is the engine. After several simulations, he finds a solution and how to repair the failure using the software.

He calls the technicians in Toulon to give them the procedure to repair the failure.

During the break, the engineer talks about it to his colleagues and one of them said that he had the same problem a month ago.

Benefits	Limitations
We have access to several devices on a single software	We do not have access to the old maintenance schemes
Devices that can be repaired remotely	Sometimes the user does not describe the failure well.
Human experience that is very rich	To have the history of the personnel who carried out the maintenance.

SCENARIO : TO-BE

An air force pilot from Toulon base wants to start his NH90 helicopter.

Unfortunately, the helicopter makes strange noises.

He calls the base technician to help him to start it as soon as possible so that he can leave on mission.

The technician called the engineer in charge of the NH90 engines in Tarnos and told him that he could not start the helicopter because it had an engine slamming problem.

The Tarnos engineer consults his simulation software. He selects the faulty aircraft and chooses the engine model in order to have all the past maintenance on it and to see if a similar case has been encountered in order to solve it quickly.

By selecting the engine model, he finds 1,000 maintenances already performed on this engine and 500 WHAT-IF simulations.

He types in the search bar "engine slam" to get a similar case to go faster and not repeat the simulations, but there are no results.

He then tries other keywords such as "strange noise", still no existing solution. He then runs a few simulations and fixes the problem and saves it. Later, he discovers that the problem exists under the name of "cast connecting rod" realized by his colleague Jones.

Benefits	Limitations
Access to old maintenance plans	Management of a large number of similar maintenance cases.
Access to the maintenance personnel who performed the task	Sometimes difficult to find a maintenance case that matches the current problem.

THE PRODEC METHOD

Procedural scenarios (stories)

Search for emergent functions and structures

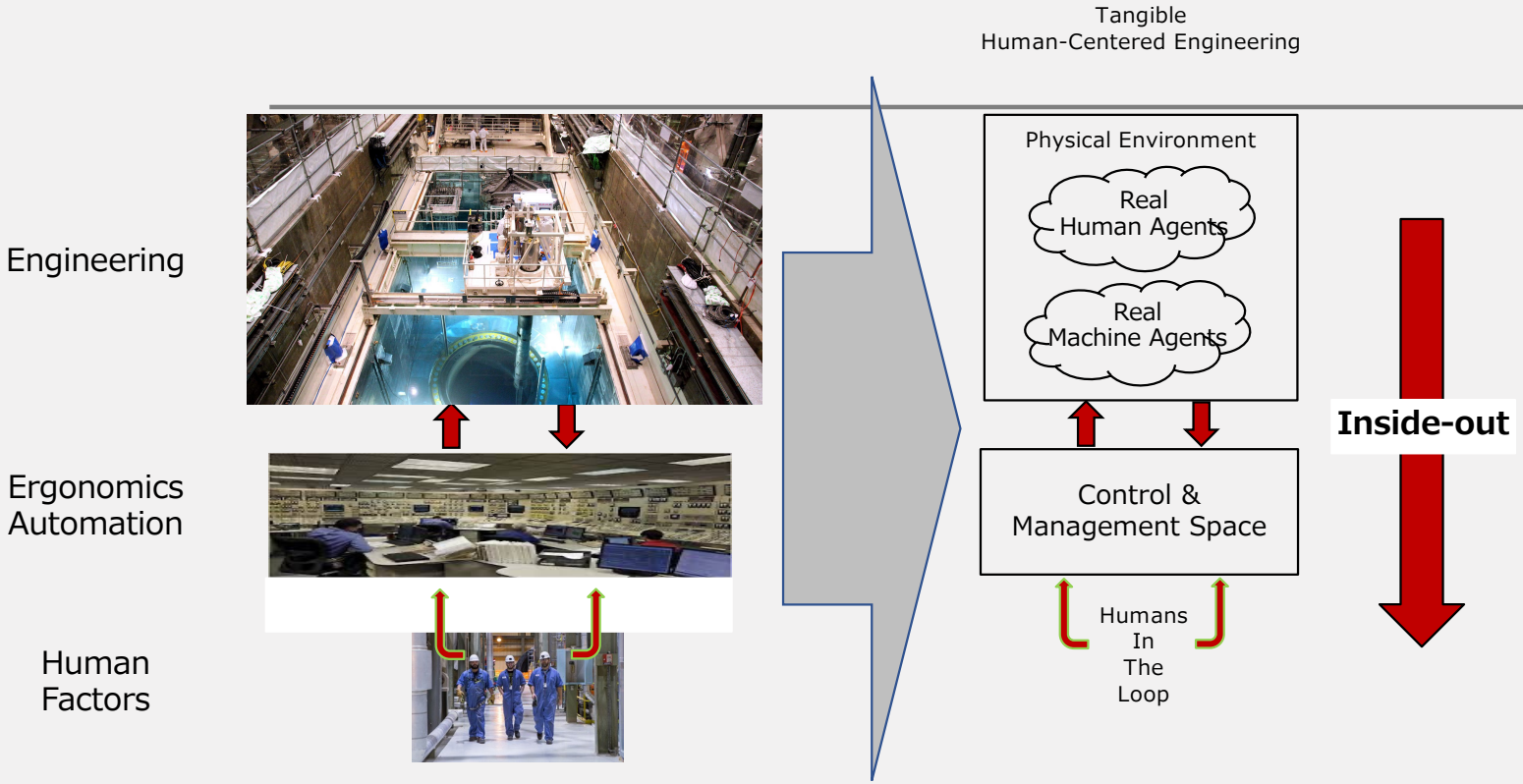
Declarative scenarios (configurations)

From virtual HCD to tangible engineering

Integration

From purpose to means

From means to purpose



20th century approach

Engineering, Ergonomics, HCI & Automation

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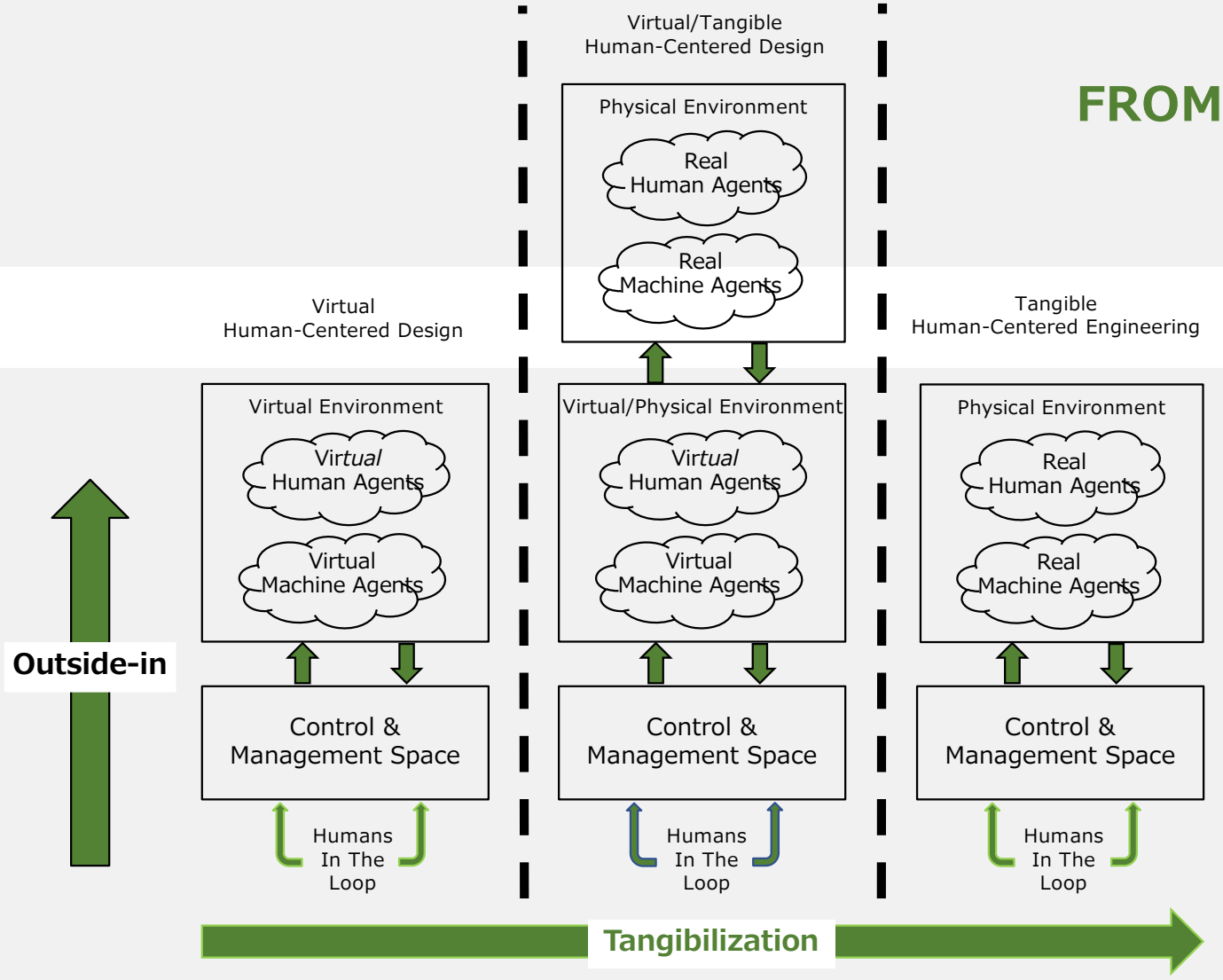
FROM PURPOSE TO MEANS



21st century approach

HSI

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Tangibility: systemic attributes

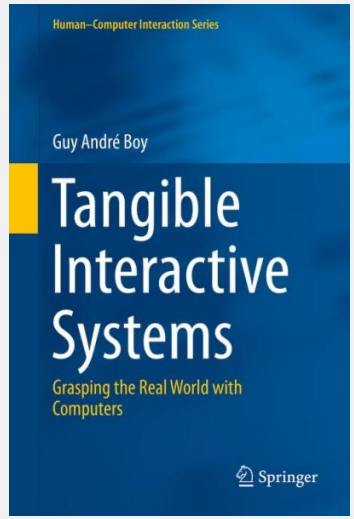
Complexity → separability, interconnectivity, collaboration, trust, ⋯

Maturity → TRLs & HRLs & ORLs

Flexibility (design & operations) → safety nodes, reversibility, FlexTech, ⋯

Stability/Resilience → passive vs. active, resilience, crisis management, ⋯

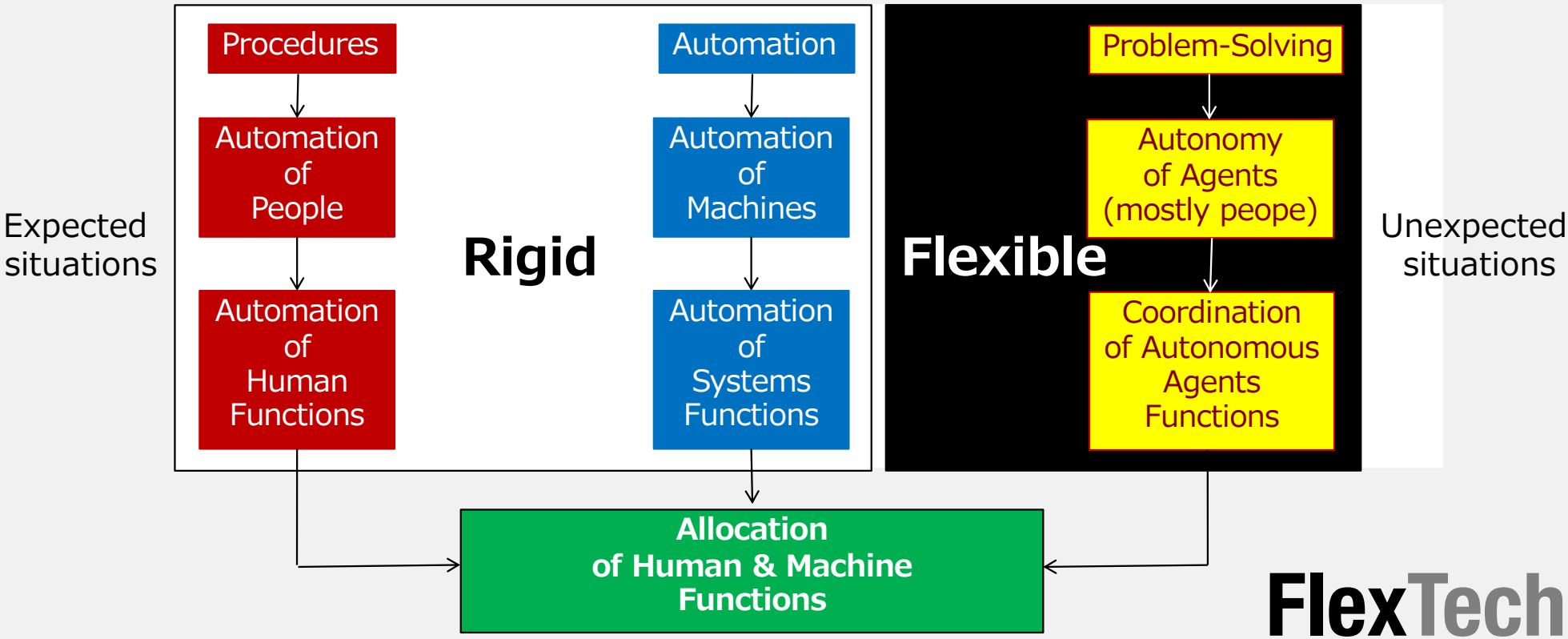
Sustainability → design rationale, knowledge management, ⋯



+ Social Factors

Shared situation awareness
Cooperative decision-making
Harmonized risk taking
Trust and collaboration

From rigid automation to flexible autonomy



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FlexTech HSI education

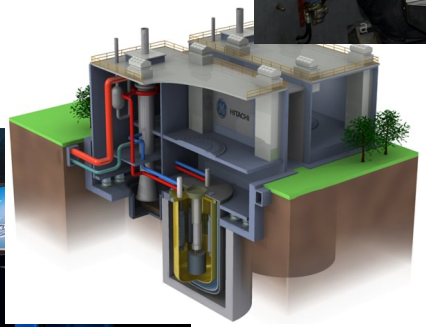
CentraleSupélec & ESTIA & ISAE-SUPAERO

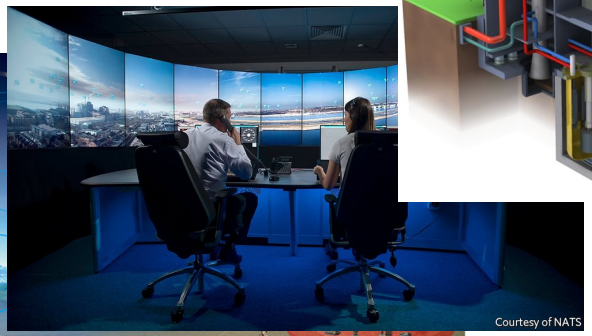
3rd year engineering school & Master

150 étudiants (2020-21 & 2021-22)

4 x 8 small projects

4 Ph.D. students





A few take-aways

We live in a digital world → **tangibility** is a crucial contemporary issue

Single-agent ergonomics is not enough → **Socio-ergonomics**

Human-machine teaming → what **new human roles**?

Rigid automation is what we know → **Flexible autonomy** is what we need to make

How do we deal with the unexpected? → **problem-solving support**

From means to purpose (people adapt) → **From purpose to means** (machines adapt)

Collaborative work requires **education**, **openness**, **empathy** and **enthusiasm**!

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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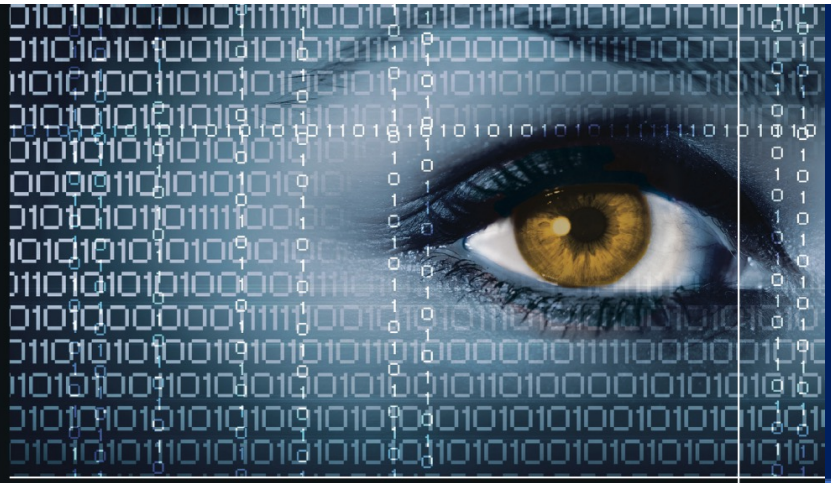
HUMAN-SYSTEMS INTEGRATION

Guy Andre Boy

CRC Press



HUMAN-SYSTEMS INTEGRATION

From Virtual to Tangible

Guy Andre Boy

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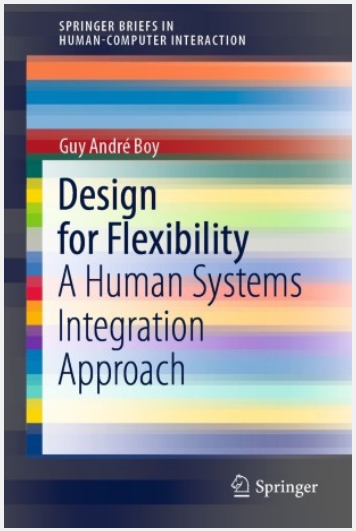
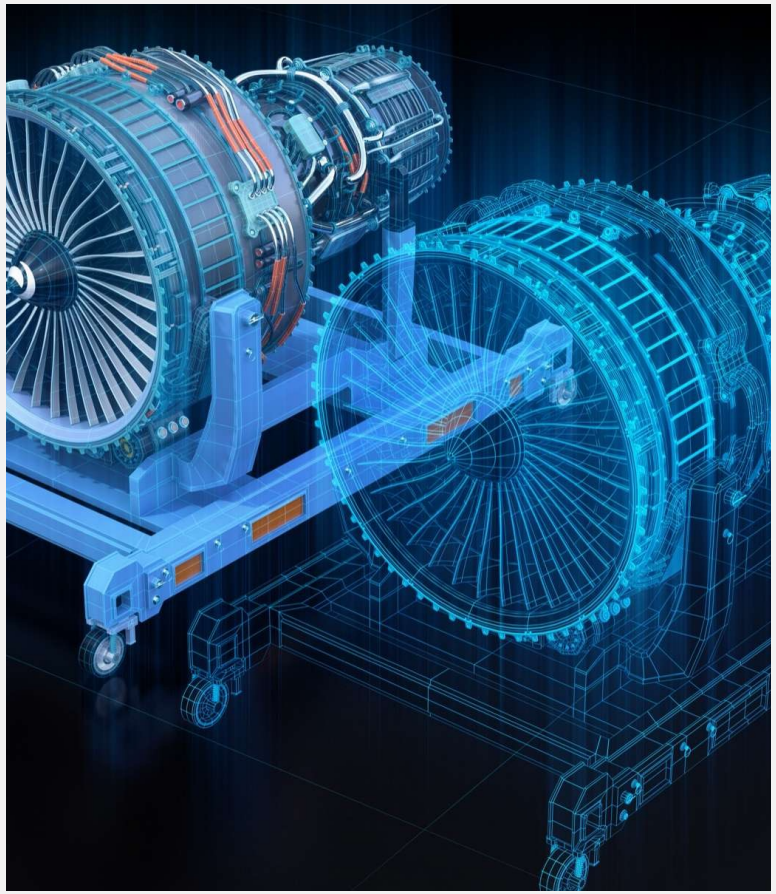
… and the last one!





Thank you!

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