Interaction-Centred Design for Engineering A Resilient Human-AI Symbiotic Partnership:

DRDC RDDC

The Next Stage of Evolution

Ming Hou, PhD, FIEEE, FCAE

Defence Research and Development Canada

Department of National Defence, Canada

The Canadian Academy of Engineering, Fellows' Showcase Montreal, 27 May, 2025

Canada

National Defence

ASSIST

Industrial Revolutions: Transformations in How We Live, Work, and Socialize

CANADIAN ARMED FORCES

FORCES ARMÉES CANADIENNES

DRDC RDDC

Increased system complexity

Trailhead.com

1st: Mechanization Machine Power

1800s

Agrarian societies gave way to urbanization

Wiki Commons

2nd: Industrialization Electricity, Airplanes, Chemical Fertilizer, Mass Production, etc.

1900s

Ushered in the modern world

asc-csa.gc.ca

3rd: Digital Revolution Electronics, Internet, Automation, Information and Communication Technology, etc.

2000s

Embrace Globalization

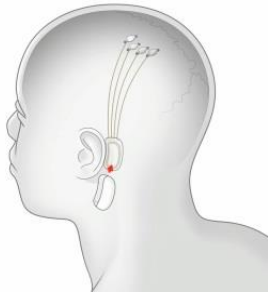
Caltech Science Exchange

4th: Human-Cyber-Physical Systems AI, Autonomy, IoT, Quantum Computing, Genetic Sequencing and Editing, Mixed Reality, Nuclear Fusion, Symbiosis Technologies, etc.

Today

Empowering Human

Productivity and Capability



www.geekwire.com

Increased human cognitive capacity

Issues of Human-AI/Autonomy Teaming

CANADIAN ARMED FORCES
FORCES ARMÉES CANADIENNES

DRDC
RDDC

1. AI Incompetency (under indeterministic conditions or with insufficient data)
2. Human and AI Bias
3. Cognitive Overload
4. Transparency and Explainability
5. Trust and Accountability
6. Legal and Ethical Challenges
7. Policy and Regulations
8. Human Systems Integration Processes, Verification and Validation

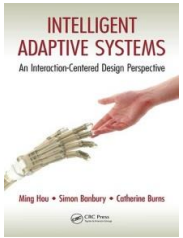
Understanding Strengths, Limitations, Benefits & Risks, and Roles & Responsibilities

Hou, et al., (2022). Frontiers of Brain-Inspired Autonomous Systems: How does the Defence R&D Drive Innovations? IEEE Systems, Man, and Cybernetics Magazine, 8(2) 8-20.
Puscas, I. (2022) Human-Machine Interfaces in Autonomous Weapon Systems: Considerations for Human Control, United Nations Institute for Disarmament Research.

Interactions during An Emergency

Human control mode from "on-the-loop" to "in-the-loop"

15 Jan 2009, US Airways Flt 1549 lost engine power after two minutes departed from LaGuardia Airport in New York. The pilot (Capt Sully) made a quick decision (100+ seconds) to land safely in the Hudson River and all 155 people survived.



Intelligent Adaptive Systems: An Interaction-Centered Design Perspective (Hou, Banbury, & Burns, 2014)

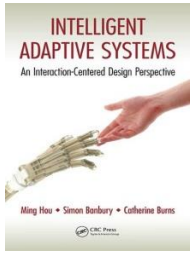
Need: Paradigm-Shift Design Strategy and Guidance

Technology – Centered
(1950')

Human/User – Centered
(1980')

Interaction – Centered
(2010')

H/UCD is not sufficient, problemic, or even harmful for the design of complex safety/ mission-critical socio-technical systems



Vicente, K. (1990), Coherence- and Correspondence Driven Work Domains: Implications for Systems Design, Behaviour & Information Technology, 9(6), 493-502.

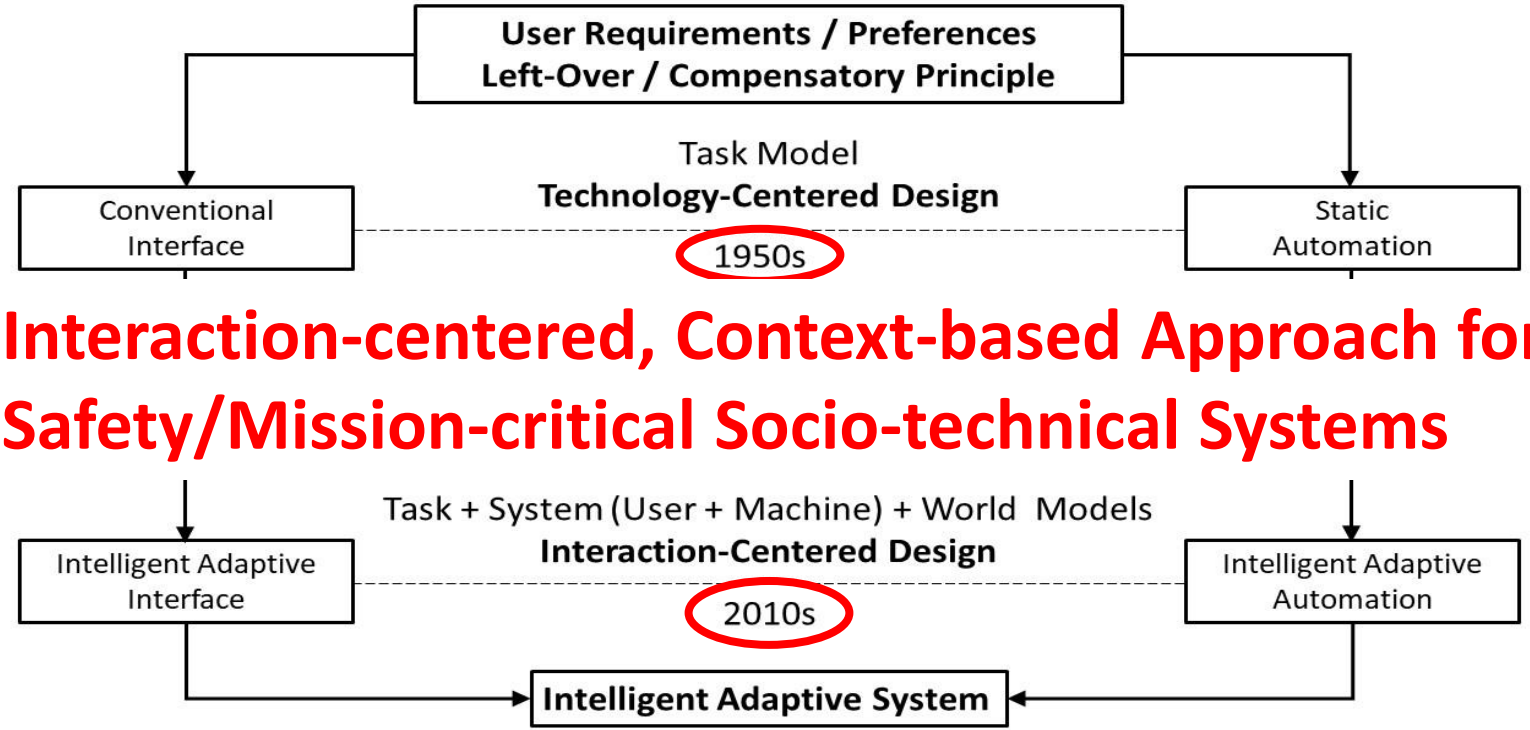
Norman, D. (2005), Human-Centered Design Considered Harmful, Interactions, 12 (4), 14-19.

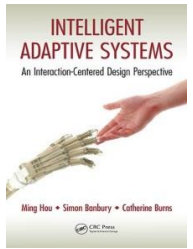
Hou, Banbury, Burns, (2014), Intelligent Adaptive Systems: An Interaction-Centered Design Perspective.

Puscas, I. (2022), Human-Machine Interfaces in Autonomous Weapon Systems: Considerations for Human Control, United Nations Institute for Disarmament Research.

Hou, Wang, Fang, Farrell (2023), Interaction-Centered Design: An Enduring Strategy and Methodology for Complex Socio-Technical Systems. Chapter 12, Handbook on Human-Machine Systems: State-of-the-art and Research Challenges.

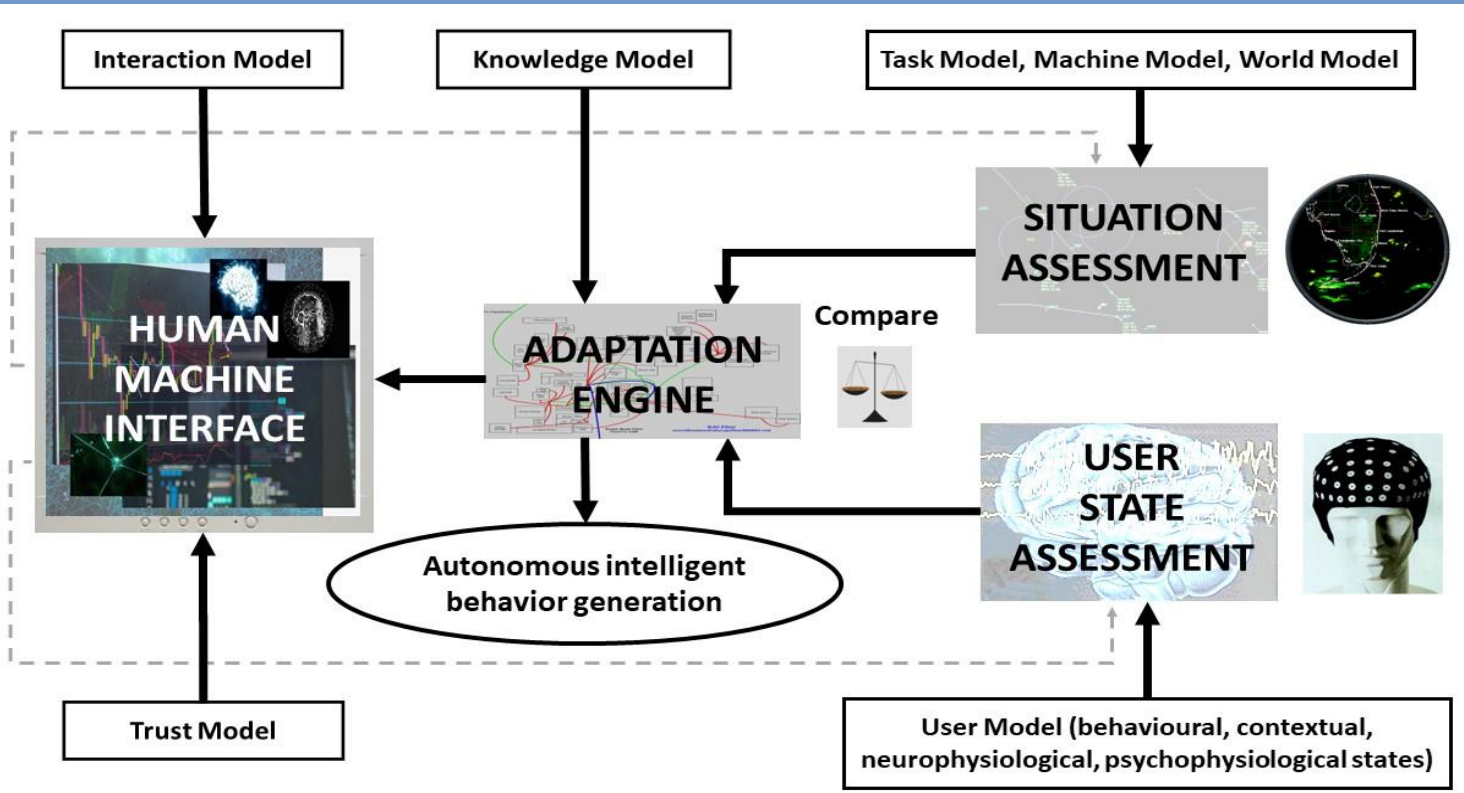
Evolutionary Stages of Systems Design Strategy

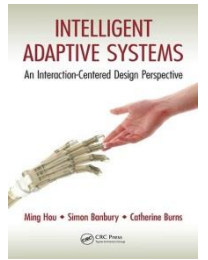




Intelligent Adaptive Systems: An Interaction-Centered Design Perspective (Hou, Banbury, Burns, 2014, 2021)

Evolutionary Design Strategy for Intelligent Adaptive System (IAS)





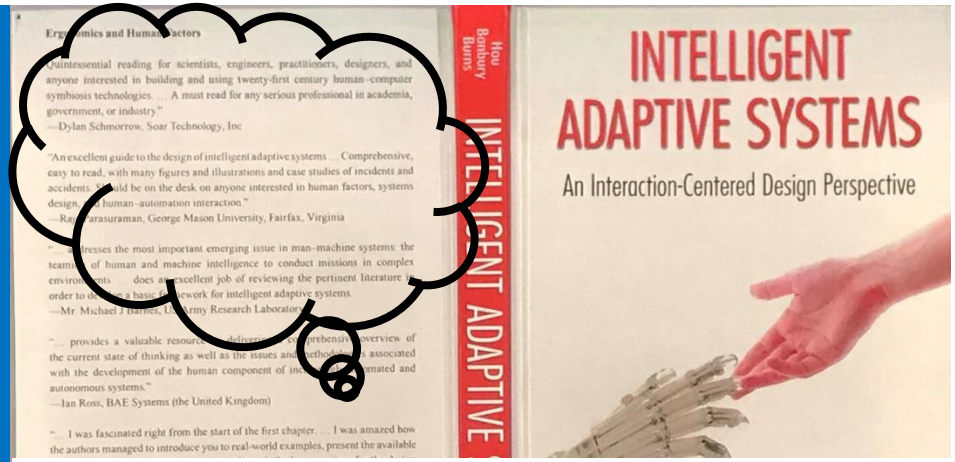
Hou, Wang, Fang, Farrell (2023), Interaction-Centered Design: An Enduring Strategy and Methodology for Complex Socio-Technical Systems. Chapter 12, Handbook on Human-Machine Systems: State-of-the-art and Research Challenges.

Peer Reviewed, Field Validated, and Organization Adopted

for A Collaborative Partnership (Human-AI/Autonomy Team)

"… Setting the agenda for the coming years as Human Factors practitioners grapple with the demands that IAS will make on its operators and a clear statement of the importance of collaboration and partnership between Human and AI, and outlining how this can be achieved through interaction (centred) design …"

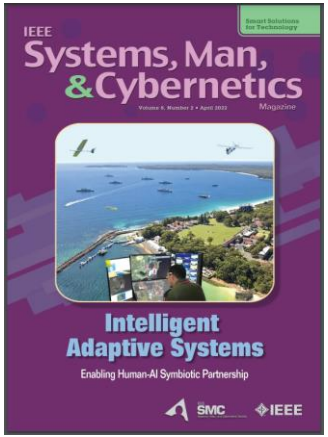
Book Review: Intelligent Adaptive Systems. Prof C. Baber, University of Birmingham, Ergonomics, 2017, Vol. 60, No.10, 1458-1459.

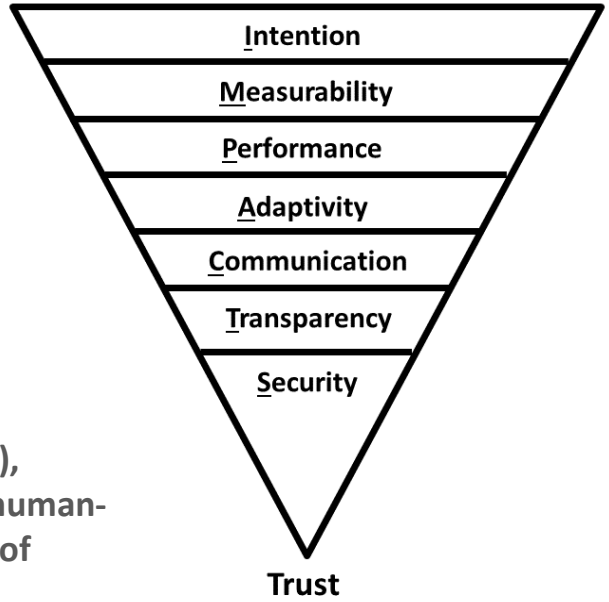


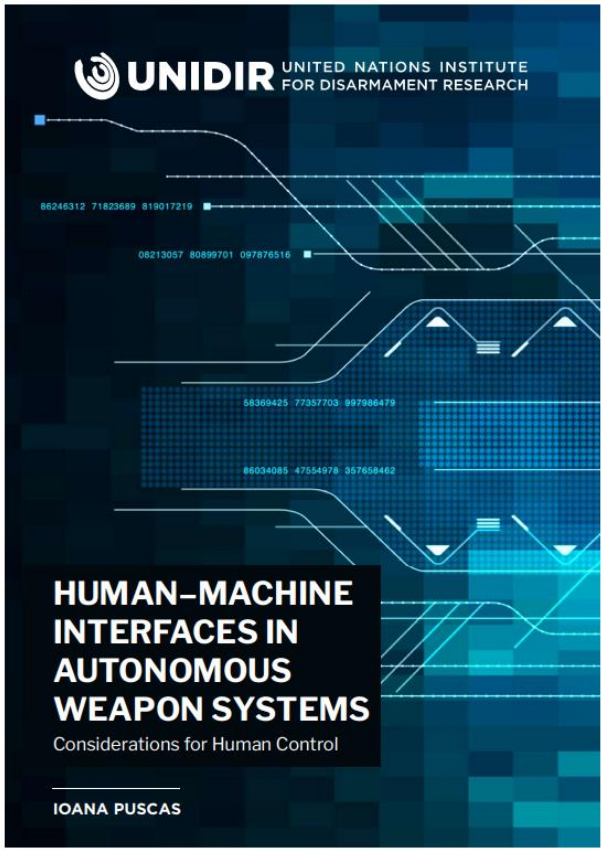
A must read for any serious professional in academia, government, or industry, interested in building and using 21st century human-computer symbiosis technologies …

Dr. D. Schmorrow, President & CEO, Soar Technology, Inc., former DARPA Executive

IMPACTS: A Trust Model for Collaborative Symbiosis







Hou, Ho, & Dunwoody (2021), IMPACTS: A trust model for human-autonomy teaming, Journal of Human-Intelligent Systems Integration, 3, 79–97.

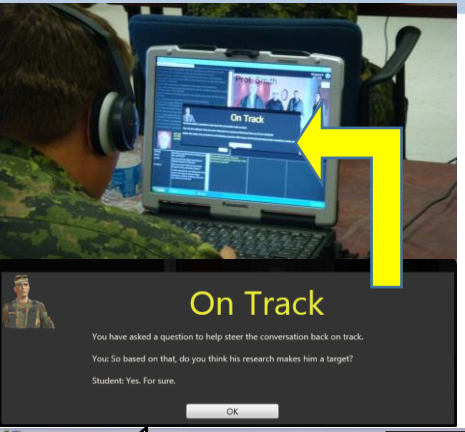
Puscas, I. (2022), Human-Machine Interfaces in Autonomous Weapon Systems: Considerations for Human Control, United Nations Institute for Disarmament Research.

1st Canadian Intelligent Tutoring System (ITS)

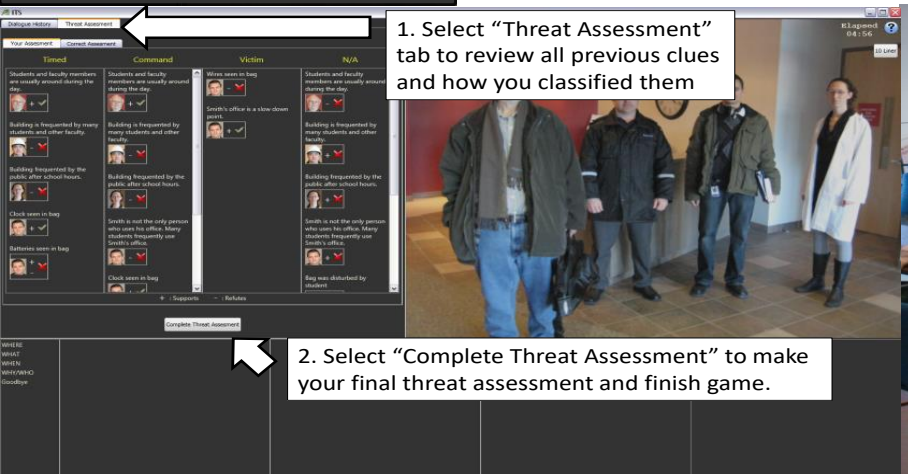
ASSISTANT DEPUTY MINISTER (DEFENCE RESEARCH AND DEVELOPMENT CANADA)

CANADIAN ARMED FORCES
FORCES ARMÉES CANADIENNES

DRDC
RDDC



- **Students can question virtual witnesses and receive real-time and adaptive instructions (from intelligent tutor) based on their response and performance to learning context in Improvised Explosive Device (IED) disposal scenarios.**
- **Improved efficiency, effectiveness (94%), and reduced cost for CAF Counter-IED disposal operator training course.**
- **Patent application filed in Canada and US.**



National Defence / Défense nationale

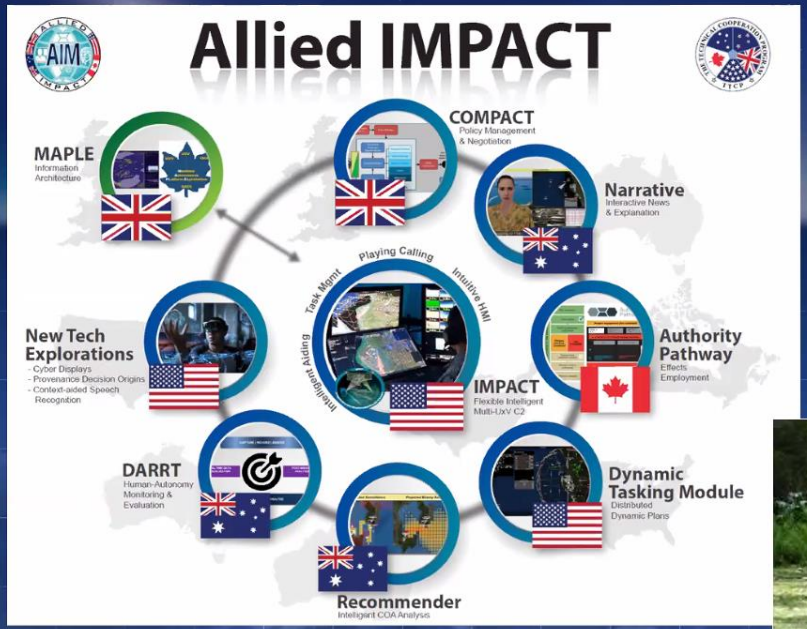
ASSISTANT DEPUTY MINISTER (DEFENCE RESEARCH AND DEVELOPMENT CANADA)

1st Canadian Unmanned Aircraft System Command & Control Center

International Autonomy Strategic Challenge Joint Exercise

PARTNERSHIPS

Human-Autonomy Teaming



Praised by the Commander of US AFRL at the Plenary of 2021 Human Factors and Ergonomics Society Annual Conference

Take Away

Given difficulty in designing fully fail-proof AI-enabled socio-technical systems,

how to benefit from the evolution and advancement of Systems Design Methodology (e.g., ICD)

and ensure safe, responsible, and trustworthy Human-AI Symbiotic Collaboration for maximized mission effectiveness, public acceptance, and positive societal impacts ?