New Principles for Human- Robot Team Design and Development

Makingworkworthdoing:Panelevent withSocio-TechnicalSystems Roundtable

Shankar Sankaran and Helen Hughes

HARTCoN – ARC Industrial Transformation Hub for Human-Robot Teaming for Sustainable and Resilient Construction

Thursday 25th June 2026

Acknowledgment of Country

We would like to acknowledge the Gadigal people of the Eora Nation upon whose ancestral lands our City campus now stands. We would also like to pay respect to the Elders both past and present, acknowledging them as the traditional custodians of knowledge for this land.

We would further like to acknowledge the traditional custodians of the various ancestral lands from which our other attendees join us today, and to pay respects to those Elders past and present.

Meet the Team

Prof Shankar Sankaran

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Prof Helen Hughes

Organisational Psychologist, Behaviour Lab,
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AI Ethicist and AI Designer,
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Teaming with Robots and AI

New STS Principles in Theory and Practice

25 June, 2026

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Overview

1. What is a socioteachnical system (STS)
2. Why do STS principles proposed earlier have to be reconsidered today?
3. Research conducted to look at the past and forsee the future.
4. Propose Modified and New STS principles for our projects.
5. Demonstrate an application
6. Discuss

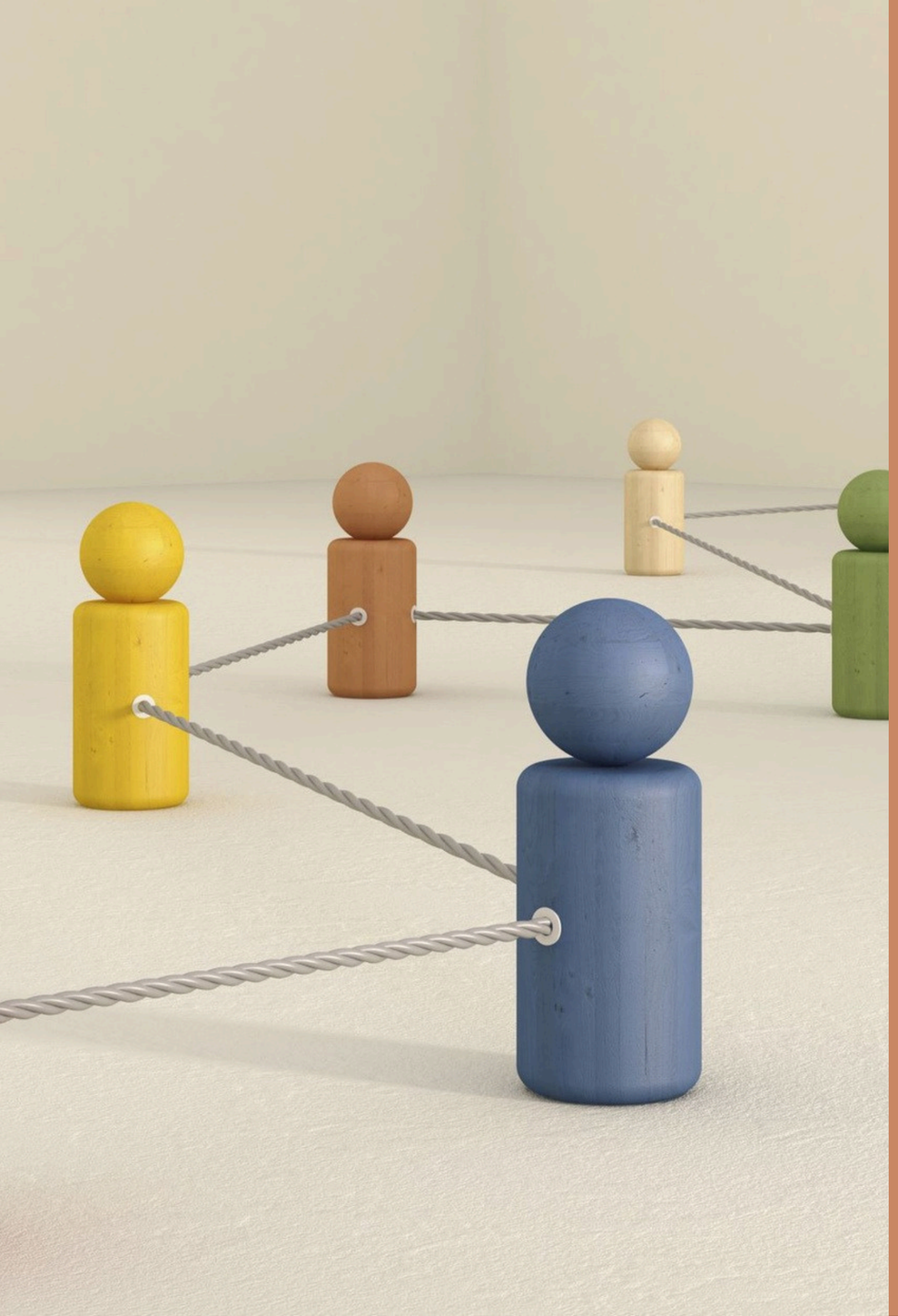
What is a socio technical system (STS)
Knox 2024, Abbas & Michael (2025)

STS recognizes that organizations are composed of *people* and *technology* that are interrelated

Both people and the technology affect each other and how they operate together(Trist & Bamforth 1951).

The goal of STS is to optimize the relationship between the organization's *social system*, its people and the technology (*technical system*) used to produce output.

An organization will only achieve optimal functionality if its social and technological systems are designed to fit the demands of each other and *their environment*.



Study Rationale

- Traditional STS principles propose joint optimization of social & technical systems.
- Human-Robot Teams (HRTs) pose unique challenges.
  - Such as autonomy shifts, shared models, trust, and awareness.
- Goal: Extend STS to guide effective HRT design.

What we found

Framework of 34 STS principles organized in 7 themes guides HRT design and development.

8 new principles address unique challenges of AI-enhanced human-robot team dynamics.

Framework bridges traditional STS theory with emerging HRT field for practical application.

Methodology - Collaborative Review Approach

Context: HRT as multi-disciplinary, intelligent, multi-teams comprising human and robot members or agents (with embodied AI)

Focus: Design & Development of a HRT System

Literature Review

- Identifyall STS principles from different scholars
- Check and sort principles
- Develop a comprehensive spreadsheet for review

STS Review

- ***INDIVIDUALLY Review STS principles* criteria**
  - Scorecard on ‘How well do these principles fit (relevance)
  - How do*es* each principle relate to HRT design and development
  - What’s missing: Identify gaps for NEW principles not in the list

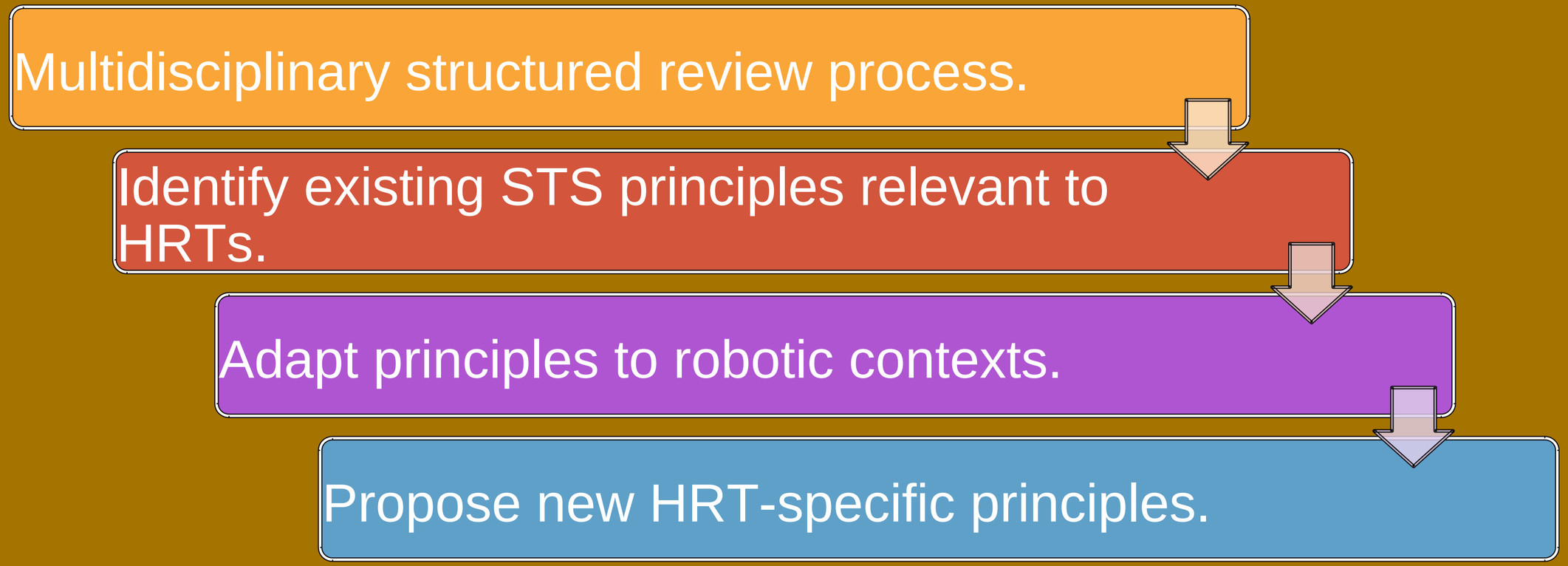
Collaborative STS discussions

- Review and establish common understanding of each STS principles
- Discuss principles to be used: As is, needs to be modified, or not relevant to HRT design and development
- Discuss what new principles are needed
- Reviewing the team ‘how well are we doing in current STS principles’

Analysis of STS Principles Discussion

- Label each principle and sorted into groups
- Synthesize and merge the grouped STS principles (existing principles as stated by scholars (generic): Used as is, Adapted, Omitted.
- Analyze the gaps from discussions -> what new STS principles are needed for the context of HRT design and development
- State and describe new STS principles for design and development of HRTs
- Review full list of STS principles relevant to the design and development of HRTs
- Thematically grouped all the adapted and new principles

Methodology – Collaborative Review



Adapting Existing STS Principles

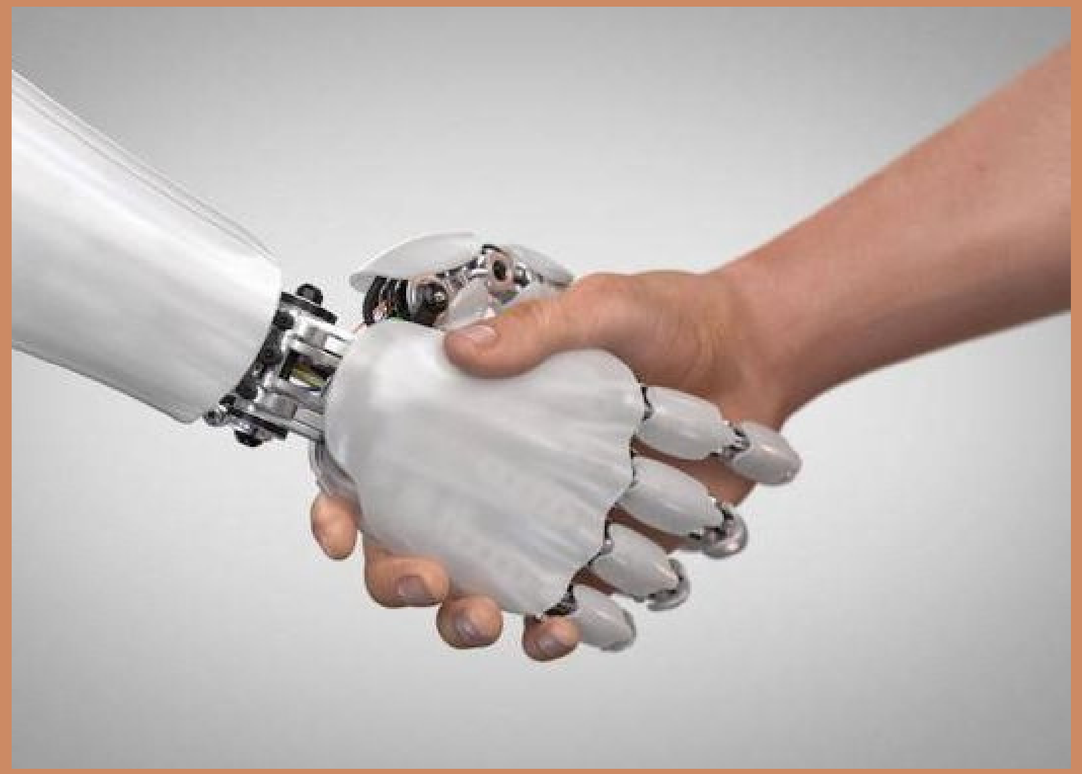
- Joint optimization: real-time collaboration.
- Responsible autonomy: humans + robots share decisions.
- Minimal critical specification: rules evolve dynamically.
- Participative design: end-users involved in design.

For details, see Table1inthe article(Ang, Sankaran & Liu, 2025) summarizing 26 STS principles that were eventually selected as relevant for the HRT context.

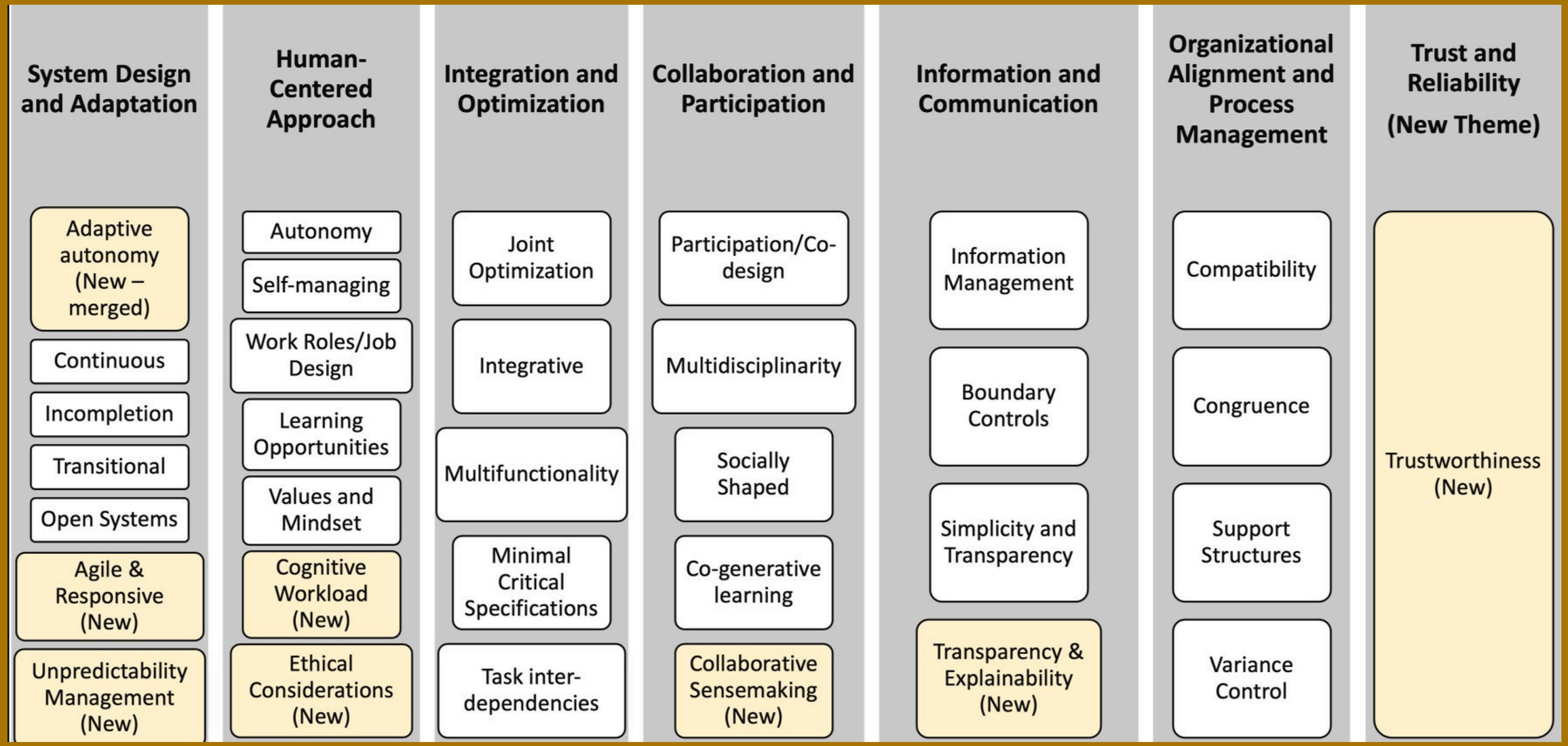
New STS Principles for HRT Design and Development

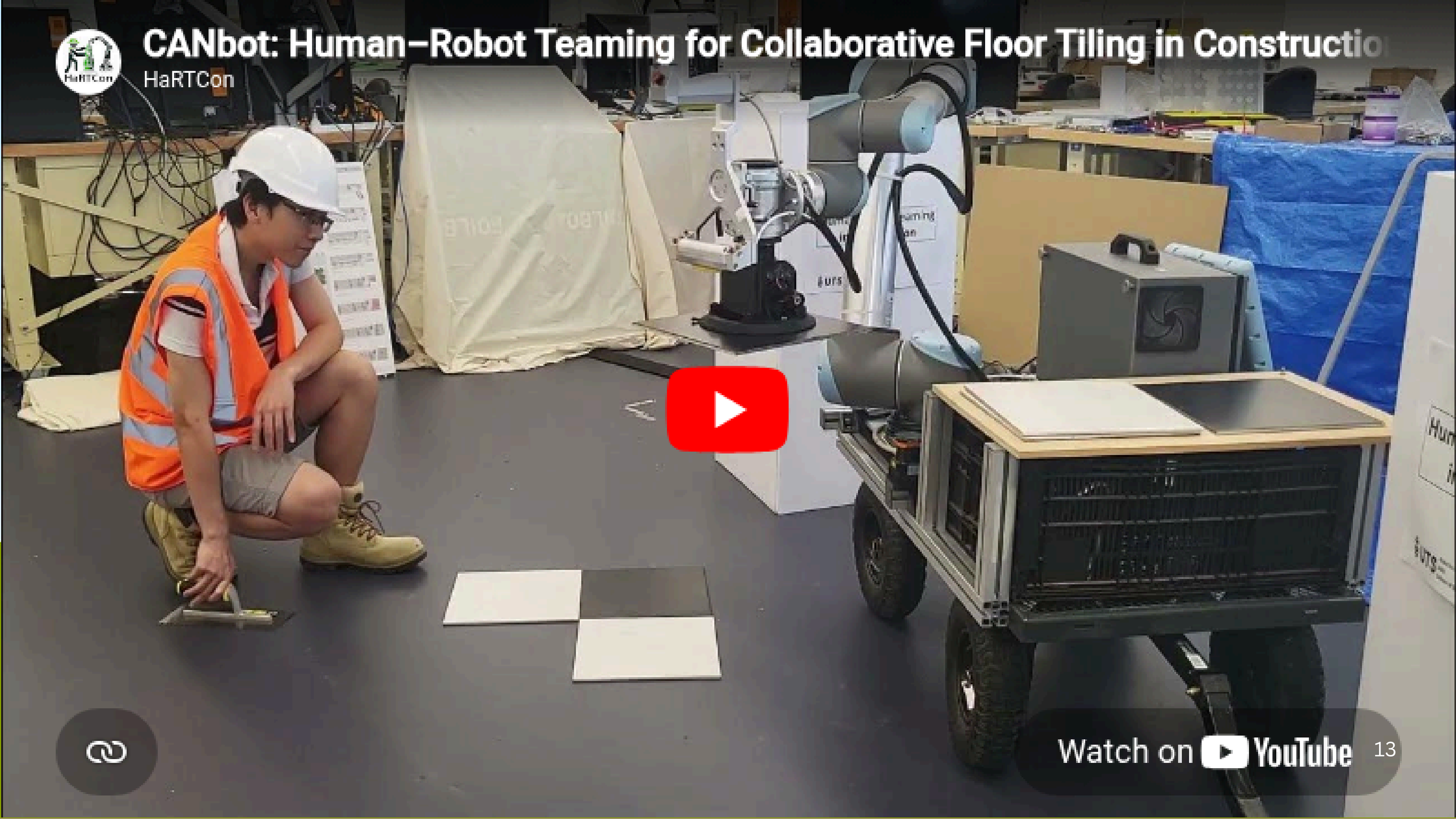
Table 2. New STS Principles for HRT design and development.

	New STS Principle	Brief STS Description
27	Adaptive Autonomy	Dynamic bidirectional adjustment of autonomy, task-based flexibility, responsive system.
28	Agile & Responsive	Iterative design, state-of-the-art knowledge, proactive approach, future thinking.
29	Cognitive Workload	Manage cognitive challenges, reduce burden, complement human abilities.
30	Collaborative Sensemaking	Mutual understanding, shared mental models, anticipatory strategies.
31	Ethical Considerations	Incorporate ethical guidelines, address AI-related concerns in HRTs, build trust.
32	Transparency and Explainability	Address "black box" problem, promote understanding, inform decision-making. Understandable AI processes, enable validation.
33	Trustworthiness	Design for mutual trust, multi-perspective trust, reliable HRT systems.
34	Unpredictability Management	Address inscrutable AI-based decision-making in HRTs, human oversight, handle unexpected situations.



STS themes, principles and relevance to HRT development




CANbot: Human–Robot Teaming for Collaborative Floor Tiling in Constructio
HaRTCon
Watch on YouTube


Let's Discuss

Further Readings

Ang, K. C., Sankaran, S., & Liu, D. (2025). Advancing sociotechnical systems theory: New principles for human-robot team design and development. Applied Ergonomics, 129, 104604.

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Ang, K. C., Sankaran, S., Liu, D., & Shrestha, P. (2023, January). From Lab to Field: A Sociotechnical Systems View of the Organizational Cycle for Intelligent Robotics Technologies Ideation, Planning, Design, Development and Deployment. In Proceedings of the 40th International Symposium on Automation and Robotics in Construction. International Association for Automation and Robotics in Construction (IAARC).