

FlexTech-2

Toward Human Systems Integration Maturity

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Abstract

The FlexTech Chair has successfully contributed to the discipline of human systems integration (HSI) in the niche of increasingly autonomous systems. This unfinished contribution deserves to be followed up by a new chair program called FlexTech-2. FlexTech-2 will focus on five key objectives:

- (1) training FlexTech staff in HSI management and leadership;
- (2) conducting appropriate research efforts with industrial partners;
- (3) teaching courses at program member schools and beyond;
- (4) publishing in top-level journals and conferences;
- (5) continuing to lead HSI globally within the industry, academic community, and the best professional associations.

This white paper presents the current background, objectives, expected means, expenses, budget, governance, research and industrial projects, and valuable references.

Background

FlexTech-1 (2019-2024) produced three significant outcomes:

- (1) Consolidated relationships with the industrial sector in aerospace, defense, oil-and-gas, aviation, railways, and health (Armée de l'Air et de l'Espace, Thales, Dassault, SAFRAN, CS Group, TotalEnergies, SNCF, SAMU) (<https://www.flextechchair.org/research.html>).
- (2) Significant exposure to the world through proactive participation in global committees and several international conference organizations (INCOSE, IEA, and ACM) and publications in major conferences and journals, as well as the publication of three internationally acclaimed books on HSI (<https://www.flextechchair.org/publications.html>).
- (3) An HSI course (45 hours) that includes HSI fundamentals and real-world small projects in cooperation with appropriate industries and governmental agencies – this course has been given to four primary engineering schools (CentraleSupélec, ESTIA, and ISAE-SUPAERO) and a business school (ESCP) (<https://www.flextechchair.org/education.html>).

In addition, the FlexTech-1 network, noticeable events, and team continue to develop:

- (<https://www.flextechchair.org/community.html>)
- (<https://www.flextechchair.org/events.html>)
- (<https://www.flextechchair.org/people.html>)

Research Strategy Proposal

FlexTech-2 chair project responds to the INCOSE and various governmental agencies and private industries to set up a Human Systems Integration (HSI) approach for complex sociotechnical systems. HSI developments are now intimately associated with digital engineering issues. To circumscribe the project, three research tracks are targeted: (1) Society 5.0; (2) Human-AI Teaming; (3) Engineering Design for the Unexpected.

Track 1. Society 5.0. The evolution of systems engineering and engineering design in digital engineering (Industry 4.0) toward considering people and organizations during the whole life cycle of sociotechnical systems. FlexTech-1 chair produced the PRODEC method that needs to be consolidated and expanded to more advanced activity and structure/function analyses, human-in-the-loop simulation setups, formal systemic representations, and crisper HSI transdisciplinary approaches.

Track 2. Human-AI Teaming. Following the expansion of artificial intelligence (AI) research and practice, HSI must be developed in symbiosis with current AI4SE and SE4AI frameworks, supporting the design and development of sociotechnical systems of systems investigated with the support of multi-agent representations, where agents are human, organizational, and technological entities. HSI metrics such as trust, collaboration, and operational performance will be primarily considered within various systemic frameworks, including supervision, mediation, and cooperation.

Track 3. Engineering Design for the Unexpected. Until recently, technology was developed for many expected situations, i.e., we automated using rigid procedures and algorithms. Handling unexpected situations requires different kinds of methods and tools (FlexTech) that foster problem-solving in real-time, involving various kinds of expertise to be coordinated. Dealing with the unexpected will be investigated from three perspectives: technology, organizations, and people (the TOP model). A categorization of unexpected situations as an ontology will be developed and validated.

FlexTech-2 chair **objectives**

First, the FlexTech-2 chair will aim to conduct transdisciplinary research to meet the current needs of a FlexTech entity that can be technological, organizational, and/or human. Human Systems Integration (HSI) researchers and practitioners must know this important question. Moreover, this situation is crucial because HSI researchers must work with industrial partners, so their understanding of real-world HSI issues must greatly increase. The project aims to fill these gaps with an innovative and transdisciplinary approach. The chair will organize three international and regular national events and encourage researchers to publish their work, articles, and books in

HSI-related fields. The chair will foster the integration of three major fields: systems engineering, human factors and ergonomics, and computer science/information technology. FlexTech-2 chair will continue expanding its research scientists, professors, PhD, and post-doc team.

Regarding **teaching**, the FlexTech-2 chair will continue to develop HSI courses. We created an unprecedented course available for students at various university levels, including Bachelor, Master, and PhD. This course is designed to train engineering and management students in HSI to develop a common language, encourage transdisciplinary practice, and meet the objectives of HSI implementation and use. Regarding valorization and knowledge transfer, the chair will aim to develop methods and tools to support industrial HSI, specifically in increasingly autonomous systems. These methods and tools will be available in open access.

HSI development **locks** are currently linked to change management blocks regarding digital culture appropriation and adaptation. Engineering has been developed and used from the inside out, i.e., developing technology first and dealing with human factors after. HSI promoted the outside-in, i.e., designing and developing digital prototypes where human activity can be tested before making major commitments, keeping design flexibility as much as possible, and learning about the sociotechnical system being designed and operated as early as possible. Locks can be alleviated by expanding technology readiness levels (TRL) to human and organizational readiness levels (HRL and ORL).

Operational Objectives

FlexTech-2 objectives are:

- (1) Training staff in the management and mastery of HSI:
 - a. Two educators and researchers have been identified (one at CentraleSupélec and one at ESTIA) to follow intensive training in HSI leadership. This training is foreseen during the first two years of FlexTech-2 to ensure these two leaders will replace the current Chair Holder in 2026.
 - b. This training will be done in cooperation with FlexTech-2 academic and industrial partners.
 - c. The current HSI course will be incrementally transferred to CentraleSupélec and ESTIA leaders.
 - d. An active search for research contracts will be done as a cooperation between the current chairholder and the two increasingly autonomous leaders and in coordination with industrial member representatives.
- (2) Conducting appropriate research efforts with industrial partners:
 - a. Priority will be given to working with FlexTech-2 industrial members.
 - b. An intensive effort will be made in proposal writing together with European partners. The European Commission and industry will be targeted.
- (3) Teaching courses at program member schools and beyond:
 - a. Continue current teaching efforts at CentraleSupélec and ESTIA.

- b. Continue the HSI course within the Master shared between CentraleSupélec and ESCP Business School.
 - c. Continue the HSI course and develop research efforts together with ISAE-SUPAERO.
 - d. Open up HSI training to other university organizations and develop online HSI engineering training.
 - e. Organize the Human-AI Teaming Spring School in 2024 or 2025.
- (4) Publishing in top-level journals and conferences:
- a. Lead and Publish the Handbook of Sociotechnical Systems: An HSI Approach (currently 47 chapters to be assembled).
 - b. Publish articles in various high-standard journals (Impact factors > 2).
 - c. Give keynotes, webinars, and talks at major conferences and institutions.
- (5) Leading HSI globally within the best industry and academic associations:
- a. Continue leading INCOSE HSI Working Group worldwide.
 - b. Continue leading the Aerospace Technical Committee (TC) at the International Ergonomics Association and develop their HSI TC.
 - c. Connect HSI to ACM SIGCHI (Association for Computing Machinery – Special Interest Group on Computer-Human Interaction).
 - d. Organize the INCOSE-IEA HSI2024 conference in Jeju, Korea, in August 2024.

Potential Members

We continue with FlexTech-1 members that are: Armée de l’Air et de l’Espace; Thales; CS Group; Ingenuity and SNCF; and clients that are TotalEnergies; Safran; DGA.

New members can be: SOPRA-STERIA; Dassault Systèmes; Dassault Aviation. Avec des clients: CNES; Communauté d’Agglomération du Pays Basque; European Commission; Ministère de la Santé.

Means, expenses, and budget

FlexTech-2 anticipated means are:

- (1) Gifts from the members: 100 KEUR each per year = 500 KEUR for five years; counting on four members, we should plan on 2 MEUR for five years.
- (2) Research contracts (based on what we got during FlexTech-1): 1 MEUR for 5 years.
- (3) Research contracts with the European Commission: 1 MEUR for five years.

Altogether, we could plan on 4 MEUR for 5 years for the whole FlexTech-2 enterprise.

Expenses are mainly spent on personnel:

- (1) Chair Holder: on five years (considering the replacement of the current chairholder by two junior chairholders): 500 KEUR.
- (2) Assistants and Postdocs (6): $6 \times 50 \times 5 = 1,3$ MEUR.
- (3) Administrative management: 500 KEUR.
- (4) Travel expenses (national and international, including outreach): 500 KEUR.

(5) Software and modeling/simulation facilities: 400 KEUR.

Governance

CentraleSupélec and ESTIA will oversee the FlexTech-2 Chair in an equal manner.

The first chairholder will be Prof. Guy André Boy, Professor and Chair of the Science Board of ESTIA and Visiting Professor at CentraleSupélec. Prof. Boy will coach his or her replacement in the leadership of FlexTech-2.

Both research and education duties will be allocated within the CentraleSupélec-ESTIA partnership. Development efforts will be shared between CentraleSupélec and ESTIA (e.g., new members, new contracts, new staff).

XXX will handle the financial entry flow and share funding in an equal manner between the two institutions.

A scientific and industrial committee will be set up. It will include representatives from the chair members and external personalities.

A strategic committee and operations committee will be set up to include chair members' representatives.

Projects

There will be Ph.D. and Masters research projects with industrial and institutional members supporting Ph.D. and Masters students and their supervisors.

Research contracts will be with FlexTech-2 members and external bodies (industry and government).

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