# Why co-adaptation is mandatory in extreme environment human-system integration and co-evolution modelling?

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Can we define a valid and generic theoretical framework for modeling and simulation based on a co-integrative approach to analyze, model, design and deploy human-machine systems that are reliable, stable and adaptive in this extreme environments?

The development and the more and more intensive usage of devices aimed at enhancing the human operational capacities, implies the design of safety frameworks for the development and the spreading of efficient and reliable human-machine systems. This is particularly mandatory when this human-machine system must maintain a level of operational efficiency in extreme environment applications related to health, defense and aerospace fields.
Thus, in these contexts, the main issue is to validate and certified through formal approaches the Human-Systems Integration engineering methods aimed at developing systems that are correct by construction, safe, reliable, and adaptable.
The currently developed systems mainly rely on the adaptation capacity of the human. However, the interactions modes tend to thicken the limit between the technical and the biological systems. The currently more and more widespread technologies such as implantable biotechnological nano-systems, ubiquitous artificial intelligence, biomimetic prothesis tends to reinforce this last trend.
By the way, this convergence is hard to reach due to the difference in nature of the involved systems. The technical system, generally considered as a Cyber-Physical System (CPS), is mainly developed using a techno-centered approach relying on the regulation loop concept. This involves implicitly to consider the interaction with the human as an additional regulation loop making the Human in-the-Loop approach a natural way of thinking in a CPS context. This reductionist point of view leads naturally to design human-system interaction following a CPS paradigm. However, inter and intra human interactions have not the same nature. According to [Chauvet], these human interactions are non-local and non-symmetric whereas the physical and the cyber interaction are mainly local and symmetric. Even if the spreading of theoretical computer science model focused on emergent properties and self-organisation is increasing, they are still few used in a human-machine system context.

According to this, it is clear that a rethink of artificial system design is becoming mandatory. The considerations on the different natures of interactions naturally lead to the concept of Bio-Cyber-Physical systems [Fass]. The next step is now to define a co-integrative approach for the development and the design of human-machine systems where the human and the machine are no longer considered as independent system that must interact but are design as a whole unique system defined by its own shape, structure and dynamics. Such designed system can then fulfill its function with an extended stability domain and with the ability to adapt to the possibly high variations of the operational constraints. This co-adaptation ability is supported by the whole system including adaptation skills on both sides (Human AND Machine). The goal of this paper is to sketch this approach and illustrates the relevance of the co-adaptation in extreme environments.