Preface

"Are you a psychologist, a philosopher, or an engineer?" This is the question several people, who I met during the last three decades, repeatedly asked me. For sure, I have an engineering background, mostly automatic control, computer science, and aerospace engineering. Therefore, I am supposed to do tangible engineering. Incidentally in the early 1980s, I started working on the two-crewman cockpits and the fly-by-wire technology. I was research scientist at ONERA (the French Aerospace Research Administration) working with flight test pilots and engineers at Airbus.[1] The problem was for us to certify commercial transport aircraft with two crewmen instead of three. The FAA rules required us to take into account human factors. Very few specifications were provided in the FAA Rules PART 25 Appendix D (a little bit more than half a page—see P25-D in the reference list). They were described in the form of criteria for determining minimum flight crew, and more specifically 10 workload factors such as accessibility to flight instruments and controls, number, urgency, and complexity of operating procedures, mental and physical efforts, systems monitoring, degree of automation, communication and navigation workload, emergency workload management, and crewmember incapacitation.

We then studied human factors and ergonomics. Our first attempt was centered on physiological measures, such as ECG[2] and EEG.[3] Indeed, engineers liked "objective" measures! We could measure electric physiological signals coming from people, in this case pilots. However, the main problem was the interpretation of these signals. Interpretation is always subjective because it requires opinions and judgments from experts. Physiologists were able to provide models, but these models were very context dependent and did not provide meaningful-enough explanations of what was really going on when pilots were flying and, at the same time, trying to manage a failure recovery process (e.g., engine failure). We then decided to use methods that were based on subjective assessment from the start. A good example

[1] Called *Airbus Industrie* at that time.

[2] Electrocardiogram.

[3] Electroencephalogram.

is the Cooper-Harper workload assessment method that pilots had to learn in order to self-assess their own workload on a 1-to-10 subjective scale (Cooper and Harper 1969). Pilots' subjective assessments were correlated to workload subjective assessments of an observer located in the cockpit on the jump seat behind them. This approach worked perfectly. This was when I decided to formally attend psychology classes at the University of Toulouse. I learned cognitive psychology, got deeply interested in cognitive science and artificial intelligence, and actively participated in the making of cognitive engineering and human-centered design (HCD) since then (Boy 2003, 2011).

Tangibility: From the User Interface View to the Systems View

Thus, for the last four decades, I learned how and modestly contributed to articulate engineering with human and social sciences when designing life-critical systems,[4] more specifically aerospace systems. After a few years of practice, I understood that human factors were discovered too late during the life cycle of a product to be taken into account seriously. What human factors specialists produced for a long time was mostly informative for training, but cosmetic and not really effective for design. They contributed to the design of user interfaces and operational procedures to improve human adaptation to engineered systems. Since the 1980s, user interfaces became almost exclusively supported by computers and software. Consequently, Human-Computer Interaction (HCI) progressively became the inevitable solution to increasingly computerized Human-Machine Systems (HMS).

The **HCI-HMS distinction** is major. The early conference series on Human-Machine Interaction and Artificial Intelligence in Aerospace was renamed Human-Computer Interaction in Aeronautics (HCI-Aero) in 1998. The term "machine" was used in the HMS community to denote a mechanical system. Pilots were interacting with mechanical devices (e.g., maneuvering the yoke that was mechanically linked to the flight control surfaces of the aircraft). Today, when we talk about an **interactive cockpit**, we mean interacting with computers using a graphical "point-and-click" display system (i.e., pilots interact with a software that itself interacts with the flight control mechanisms). When I first heard about the term "interactive cockpits," I asked: "weren't aircraft cockpits interactive before?" Indeed, pilots were used to interact with mechanical surfaces of the aircraft directly and physically through mechanical control devices. Today with the fly-by-wire, pilots interact with computers that themselves interact with the mechanical systems of the aircraft.

[4] Life-critical systems (LCSs) are defined as an integrated set of people and interactive systems that have three main emerging properties, i.e., safety, efficiency and comfort. For example, aircraft, power plants, cars, hospitals, houses and cities are LCSs. New types of LCSs involve security because they are software-based networked and open to the world with little protection. For example, when you loose your smartphone, you realize how life-critical it is. We created this kind of LCS. Consequently, we also created the need to deal with their specific life-criticality. This is a complexity issue because emerging LCS issues are very hard to discovered before use time.

Therefore, the concept of interaction shifted from human-mechanical systems interaction to human-computer interaction.

Consequently, we need to be careful when we talk about interactivity. Human-computer interaction is not only a matter of cognition, but also a matter of tangibility. We are facing the paradox of information overload and information access as well as loosing the sense of physical things. This is why tangibility has become a central focus of current socio-technical evolution.

HCI was born during the early 1980s as a specific branch of computer science. The Special Interest Group on Computer-Human Interaction (SIGCHI) of the Association for Computing Machinery (ACM) created a famous conference series called CHI (Conference on Human Factors in Computing Systems). The first CHI conference was held in Gaithersburg, Maryland, USA in 1982. It was, and still is, a **design** conference more than anything else. CHI focuses on the design of human-centered computing systems (i.e., the whole thing is a computer, even cell phones that populated CHI conferences since the late 1990s). However, **domains**, such as nuclear power plants, aircraft, spacecraft, and other mechanical systems where software was progressively embedded, were never well integrated in the CHI community. For a long time, most HCI solutions and methods were developed with office automation in mind. Today, even if HCI diversified in various application domains, tangibility is still only focused on user interfaces, and not on large complex socio-technical systems.

The concept of user interface is already a concept of the past when it is considered as an add-on. I explained in my previous book (Boy 2013) that systems were designed and developed from **inside-out** (i.e., technological means are engineered without taking into account people who will use them; consequently, when they are fully developed, artifacts such as user interfaces and operational procedures need to be designed and developed). This was the necessary approach of the twentieth century, where engineered systems required human factors and ergonomics specialists to be usable. Since the beginning of the twentieth century, modeling and simulation capabilities enable the development of virtual prototypes that can be tested by appropriate end users. Consequently, systems can be designed from **outside-in** (i.e., usage purposes can be designed taking into account people who will use them from the beginning; people's activity can be tested; emerging behaviors can be discovered and seriously considered in the design process; user interfaces and operational procedures are integrating components of the system from the beginning). Inside-out engineering was about developing technological means requiring user interface development in the end to finally find out technology capabilities and usefulness purposes. Outside-in design is about purposes from the beginning and integration of appropriate technology to fulfill them, involving the participation of potential end users. This is what HCD is about.

User interface and automation are concepts of the twentieth-century bridging the gap between technology-centered engineering and users.

Virtual engineering and tangibility are concepts of twenty-first century bridging the gap between human-centered design, systems engineering, and people.

When I wrote this book, I also started to be in charge of the Human-Systems Integration Working Group of INCOSE.[5] Indeed, systems engineering and human-systems integration, coming from two different approaches (i.e., technology-centered engineering and HCD, respectively), developed independently. I was looking for an integration of these two approaches.

Many colleagues have encouraged and collaborated in my efforts to develop and demonstrate the value of tangibility in virtual engineering and human-centered design of current interactive systems. I am indebted to Mike Conroy, Ondrej Doule, Nikki Hoier, Christophe Kolski, Jason Miller, Jen Narkevicius, and Lucas Stephane for active discussions and provision of helpful comments on this integration. I also want to thank all my students and research scientists at the School of Human-Centered Design, Innovation and Art of Florida Institute of Technology, and NASA Kennedy Space Center who directly or indirectly helped me in shaping the concept of tangible interactive systems developed in this book.

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References

Boy GA (2003) (ed) L'Ingénierie Cognitive: interaction Homme-Machine et Cognition (The French handbook of cognitive engineering). Hermes Sciences, Lavoisier

Boy GA (2011) (ed) Handbook of human-machine interaction: a human-centered design approach. Ashgate, UK. ISBN 978-0-7546-7580-8

Boy GA (2013) Orchestrating human-centered design. Springer, London

Cooper G, Harper R (1969) The use of pilot rating in the evaluation of aircraft handling qualities. Technical report TN D-5153, NASA

P25-D. Part 25: airworthiness standards: transport category airplanes, Appendix D to Part 25, page 163. Docket No. 5066, 29 FR 18291, 24 Dec 1964; as amended by Amdt. 25–3, 30 FR 6067, 29 Apr 1965

[5] International Council on Systems Engineering.

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