[Extended Abstract]

Systems Intelligence Thinking as Engineering Philosophy

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1. SYSTEMS INTELLIGENCE

As human beings we are always engaged and embedded in a context and in the process of becoming. We have to operate inside complex interconnected wholes that involve feedback mechanisms and emergence. The key word is relationality. Remarkably, human beings have capabilities to make use of such complex and emergent wholes in their environments even as they unfold. Hämäläinen and Saarinen have suggested that it is useful to conceptualize this set of capabilities as *systems intelligence.*

Systems intelligence was introduced in 2004 by Raimo P. Hämäläinen, an engineering professor, and Esa Saarinen, a philosopher, in an article entitled "Systems Intelligence: connecting engineering thinking with human sensitivities" [1]. The basic idea was to establish an integrated framework to account for impact-seeking and solution-focused action in the process of its emergence, something the authors considered to be essential to engineering thinking.

Engineering thinking, conceived in terms of systems intelligence, does not reduce to intelligence *of* systems or to intelligence about any other from-outside identifiable objects. This is more radical than might seem. Much of engineering thinking appears to be about systems-as-identifiable-objects, and it is tempting to see engineering brilliance to be about the handling, regulating and controlling of such systems. There seems to be an objectival fundament built into the very essence of engineering thinking, one that depicts the engineer to be an expert of envisioning and implementing control over thing-like complex system-objects.

The systems intelligence perspective of Hämäläinen and Saarinen shows how inadequate such a perspective of engineering thinking is. To be sure, engineering thinking involves rational control over making object-like systems work, but at the same time also much more than that. In engineering thinking, the systems intelligence perspective emphasizes, it is critical to recognize the subjectival and sensitivity-based dimensions of the human endowment as an integral part of what makes engineering thinking *itself* work. Engineering thinking, contrary to what might be thought *prima facie*, does not reduce to objectivism, narrow rationalism or controllism over object-like systems.

The systems intelligence perspective approaches the human condition as an ongoing engagement with holistic systems. Holistic systems are "complex wholes which have properties that emerge from the functioning of parts many features of which are due to their connectivity, modes of interaction and mutual interplay" [2]. As Hämäläinen and Saarinen emphasize, the human understanding of the whole and its effects on us is always partial and biased, and yet we have to act [3]. As Hämäläinen and Saarinen put it, "instead of getting taken aback because of uncertainty, instead of becoming mesmerized when facing the complexities of a system, the call of Systems Intelligence is a soft but confident battle-cry for action." [4]

Systems intelligence emerges from the three fundamentals of the human condition, i.e. (i) the contextuality of the human engagament (ii) the complexity of any context, and (iii) the necessity to act. It is the subject's ability to engage fruitfully and successfully with the complex and holistic systems of her environment that the systems intelligence perspective wants to highlight. As Hämäläinen and Saarinen put it, "This fundamental capacity is action-oriented and adaptive, holistic, contextual and relational, and links the subject to her environment as an ongoing course of progression. It amounts to an ability to connect with the complex interconnected feedback mechanisms and pattern structures of the environment from the point of view of *what works.*" [2].

As pointed out repeatedly by Hämäläinen and Saarinen, a key feature of systems intelligence is that the subject need not be in a position to describe or conceptualize the system in which she is acting intelligently. For an adequate understanding of engineering thinking, this point is critically important to appreciate. It runs counter to what one might assume on the basis of the strong rationalism and objectivism of much of engineering thinking.

On the face of it, engineering thinking is about objectivity, rationality and about being explicit. To be sure, all those characteristics might hold true of the outcomes that result from engineering thinking. Yet engineering thinking itself is too much engaged in *action in the present moment* and in the *commitment to drive improvement*, to hold back its creative forces because of the lack of objectivity, rationality or explicitness. After all, for the engineer, the primary focus is to make something work now, as opposed to providing a rational, objective representation of something that worked upon some previous time. An engineering science might benefit from hindsight but engineering thinking itself looks primarily to the future. It seeks the next stage whereupon something gets improved.

Again this is in line with how things ought to be from the point of view of systems intelligence. Systems intelligence, as Hämäläinen and Saarinen emphasize, is not intelligence with respect to some predetermined and fixed, ontologically prior systems only. What the relevant system is, is a matter of choice and interpretation. In this sense "the systems approach begins with philosophy", as C. West Churchman once put it [5]. And engineering thinking begins with systems intelligence.

When comparing systems intelligence with systems thinking, Hämäläinen and Saarinen have suggested that systems thinking easily falls victim to what could be called *the trap of modelling* resulting in a description focus rather than action focus [6]. The systems intelligence perspective stresses the latter. It acknowledges the immense usefulness of the objectifying apparatus of systems thinking while at the same time taking seriously the dimension of human sensitivity.

Here it is particularly important to observe that engineering thinking, as a drive towards solutions and improvements, owes much of its success to the right kind of management of ignorance and uncertainty in the context at hand. Likewise, acknowledging the nature of productive action *in the presence of uncertainty* is the key to appreciating chief insights of systems intelligence. If much of the time we cannot know what the systems are and still manage to live successfully in the middle of them, surely this is an important capability!

One fundamental nature of the human life is that it involves engagement. Indeed, the call for *living successfully with emergent and interconnected wholes* is there even when one cannot identify objectively the wholes in question. “In a paradigmatic case, the systems that humans are intelligent in and with, are not ‘thing-like’. “ “Some of the relevant systems are out there to be depicted, modelled, analysed and represented. Some other are not.” “Systems intelligence reaches out to a productive interplay with systems irrespective of the epistemic status of those systems.” [4]

This highlights an often overlooked feature of engineering thinking. While celebrated for its control of systems and abilities to produce ingenious end-systems, engineering thinking at its authentic best is something other than its end-products. Engineering thinking is fundamentally an orientation to one’s enviroment from the point of view of improvement, rationality and action. The question of the availability of models and representations is only secondary. Engineering thinking, in other words, is systems intelligence. It combines the sensitive, passionate, instinctual, pre-rational and subjective aspects of the human endowment with cognitive, rational and objectivity-related epistemology in the service of improvement with the means that are available.

2. PHILOSOPHY OF ENGINEERING VS: ENGINEERING PHILOSOPHY

There is an important distinction to be drawn between philosophy of engineering and engineering philosophy. The former looks at engineering from a philosopher’s perspective [7]. Standing outside the actual practice, it reflects and contemplates on engineering, conceptualizes important aspects of it and calls into question some background premises previously unnoticed inside the practice. It operates in the dimension of the conceptual, and its project is to make something that is implicit to become explicit. It can shed light on many significant issues the practitioners themselves might have overlooked. Philosophy of engineering is essentially what results when the methodologies and concepts of philosophy as an academic discipline are applied to the field of engineering.

Engineering philosophy and engineering thinking, on the other hand, are something quite different. By engineering philosophy we refer to the mindset and general orientation of an agent that seeks out an improvement in some identified part of her environment with a conviction that an improvement-generating solution to a problem at hand does exist, as well as possibility of working out the improved state of affairs. An engineering philosophy might not be explicit or articulated. It might involve instincts, feelings and aspirations and might rely heavily on human sensibilities as well as on objective knowledge. It might not impress an academic philosopher as being “philosophy” in the first place. It is out there to change the world for the better, and everything else is secondary, including the legitimacy of the improvement-attempt in question.

As a mindset of systematic impact-seeking action, engineering philosophy reigns far beyond the field of pure engineering. Indeed it is useful to think engineering as comprising a distinct and fundamental way of approaching the world. Engineering philosophy means looking at the world with the conviction that rationality-based and incremental steps can be taken in order to produce improvement. Essentially an optimistic philosophy, it amounts to looking how to cause, using the apt words of Billy V. Koen, “the best change in a poorly understood situation within the available resources” [8].

The distinction between explanatory sciences and design sciences, as articulated by Herbert Simon [9], is useful here. Explanatory sciences are occupied with accurately describing the world. Most sciences as well as much of traditional philosophy fall within this category. For design sciences, accurate description is only one means to something truly important. The aim of design sciences is to produce a desirable change. Applicability of a theory, model or artifact is the measure of its usefulness, not its accuracy. It is a “science of making things better.” Engineering is perhaps one of the purest forms of design sciences when understood as Koen suggests as an occupation to generate the best change in a poorly understood situation within he available resources. Engineers are not concerned with knowledge per se, but with a sort of *design knowledge* [10], knowledge through which a desirable change in the human environment can be made [11].

As a leading representative of Simon’s design sciences an engineer, however, is also an artist. The “making of the better” might not follow any scientifically respectable methodology. The way an engineer generates a solution might be highly idiosyncratic. It might only apply to the context at hand and for reasons that cannot be identified. While at first sight perhaps surprising, this is how things should be, according to systems intelligence thinking. As pointed out by Hämäläinen and Saarinen repeatedly, an agent can maneuver intelligently and successfully in systems she cannot comprehend scientifically. Once again, the point is success in action rather than in the methodologically correct representation or scientific legitimacy of that action.

The history of engineering shows that science is a tremendous instrument where it can be applied. Instrumentality is the key – the core value for engineer thinking. This leads to the use of science as an instrument. But it is a serious mistake to believe that this exhausts the available resources of an engineer who wants to *make things work.*

There is a relativistic dimension to engineering thinking in the engineer’s mindset. Might not an improvement upon a system serve the cause of the bad and the interest of the evil? Might not the focus be upon a system that should not be improved? Absolutely! A pressing theme for philosophy of engineering is the illumination of some of the value elements involved in the adopted practices and technologies. In engineering thinking, the value of improvement and of instrumentality is one that is relative to a given context and a particular set of parameters that define what the relevant improvement is. Engineering thinking does not assume absolutely given criteria for improvement or what counts as better.

Again this is in line with how things ought to be from the point of view of systems intelligence. Systems intelligence, as Hämäläinen and Saarinen emphasize, is not intelligence with respect to some predetermined and fixed, ontologically prior systems only. What the relevant system is, is a matter of choice and interpretation.

3. APPLYING SYSTEMS INTELLIGENCE

The systems intelligence perspective has been applied to a number of themes across a number of disciplines. The following examples hopefully illustrate the usefulness of the concept and how natural it is as a framework of explicating engineering philosophy.

In discussing the industrial future of Finland, J. T. Bergqvist, the former member of the executive board of Nokia, identifies *superproductivity* as a key component in the new strategic paradigm for the country's industrial endeavours [12]. Superproductivity occurs whenever a non-linear productivity gain is reached through an innovation – whether this innovation is related to business models or value chains (e.g. Ikea), products (e.g. machineroom-less elevator of Kone) or to the business process (e.g. Wal-Mart). Bergqvist argues that a company works as a system constituted of people whose mutual interaction has a greatly amplified effect on energy creation and innovation capability. Therefore creating the right kind of atmosphere is the key prerequisite for superproductivity. This atmosphere is built up in day-to-day social encounters through often trivial looking interaction patterns, like listening and giving space to other people's opinions, begging your pardon after having hurt somebody, encouraging people or celebrating even small advances.

In his essay [13], Martin Westerlund gives an articulation of the theory of constraints of Eliyahu Goldratt, an "intuitive yet highly capable tool to address shortcomings in efficiency" in organizations and other human systems. According to the theory of constraints every system is equipped with at least one constraint and by identifying these constraints and by focusing our efforts of improvement on them the system can be elevated to new level of performance [14]. Westerlund argues that the perspective of systems intelligence with its holistic and change-seeking focus could complement theory of constraints by helping to identify and utilize the *trigger points* of a system, trigger point being "the constraint or catalyst that acts as the most crucial inhibitor or most potential activator, respectively, of enhancement". Systems intelligent person "automatically perceives a system as a field of opportunities – that is, an environment with certain trigger points the leverage potential of which he seeks to unleash".

Environmental issues is the area where engineering thinking and systems intelligence are most urgently needed. Environmentally sustainable policies and technological challenges are typically holistic and complex, and characterized by the imperative to act. Change can be done in a constructive mode by employing systems intelligence. Environmental issues typically embed conflicting criteria and interests. It is essential and systems intelligent to shift the focus from "reactive and conflict driven thinking" into "self encouraged co-operation and positive trust" through defining a common goal and innovative ways to reach it [15]. On a more general level systems intelligent approach to environmental leadership calls for a "co-operative, inclusive and systemic approach" [16]. It acknowledges the fact that most large-scale systems are extremely resilient to change attempts which do not take into account the forces and interconnections within the system. Therefore these implicitly confrontational and dualistic change attempts from the outside usually fail no matter how much pressure or even brute force is used. Instead, "successful change takes place – and successful leaders operate – from within the prevailing systems, utilizing the values, dynamics and feedback connections of the systems to achieve sometimes gradual, sometimes rapid changes with relatively little effort." In this spirit, systems intelligence and engineering thinking join forces in the vital and noble aim of creating sustainable environmental leadership.

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