The notion of 'Systems of Systems' should be abandoned

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This talk aims to provide offer our key argument for why the notion of a "*system of systems*" is inadequate for its aim and should be replaced with a more adequate conception. That message is based both on our key theoretical insights into the notion of '*System of Systems*' and our empirically experiences that started in the 1990's, with the doctrine change of the Swedish Defence, and continued with the emergence of digital businesses from the late 1990's to the present day.

Both these and many other contexts, for example airlines and transportation, healthcare and the financial institutions, military operations and various facets of digital business practices, manifest an emergence of increased *interconnectness* and *changeability* of physical, virtual and organisational entities, giving rise to an *aggregated behaviour* of these entities which is perceived as unpredicted and sometimes undesirable, such as the recent financial crisis. In order to understand and possibly influence the behaviour of a dynamic aggregate, constituted by interacting entities, the notion of '*System of Systems*' (SoS) was proposed in the 1990's (e.g. Maier, 1998 ; Sage & Cuppan, 2001; DeLaurentis, 2005; Jamshidi, 2008; Luzeaux & Ruault, 2010) and has today its own journal, the '*International Journal of System of Systems Engineering*'. A chief motive stems from the perceived success of the notion of the '*system*' as such, and the various practical systems tools that have been advanced since the Second World War.

While the notion of a '*system*' as such, regarded as a whole manifesting characteristics that cannot be observed in its parts, originates as early as in the writings of Aristotle, it is its re-emergence in the 20th century that has led to various methodological advancements. L. von Bertalanffy (1901-1972) often considered the father of 'General Systems Theory' (von Bertalanffy, 1968, 1972; Hammond, 2003) – which offers conceptions that are not very general or theoretical – re-introduced the old Aristotelian notion that a '*whole is more than the sum of its parts*'. While von Bertalanffy was motivated by problems in biology (ibid.), i.e. how to understand the behaviour of a living organism, the chief proposition of the notion of a system (i.e. emergent characteristics of a whole) was re-interpreted (e.g. Simon, 1962; Morin, 1977; Le Moigne, 1990; Klir, 1991; Holland 2006) and absorbed by various other disciplines (Hamond, 2003), both in basic sciences – i.e. physics, chemistry, biology, psychology, sociology and economics – and particularly in the so-called applied sciences – i.e. operations research (e.g. Ackoff et al., 1957), systems analysis (e.g. Checkland, 1978; Miser & Quade, 1985), systems engineering (e.g. Hall, 1962,), and various domains of social analysis and planning (e.g. Forrester, 196; Churchman, 1971, 1979, Ackoff, 1981, Checkland 1981; Ulrich, 1983, 1987) and more recently management of economic organizations (e.g. Milgrom & Roberts, 1995; Porter & Siggelkow, 2008). The success of the *systems conception* applied to human affairs – whether they be military, industrial and business, or public – has been manifested many times in practice: e.g. the establishment of the 'airlift', after the Berlin Wall was erected by the Soviet powers in 1961, which at its peak required a start and landing of a supply aircraft at the West Berlin airport every 90 seconds; or the construction and despatch of space shuttles to the moon, along with many other interventions.

It is then not so odd that the proposed notion of a '*system of systems*' has attracted the attention and interest of those concerned with domains where *numerous* man-made entities – be they physical, virtual, organisational – interact and generate a joint behaviour that challenges our understanding and influence

(e.g. Jamshidi, 2008); for example the expansion of health care from the provision of pure medical diagnoses and treatment of an individual conducted by a single physician to situations that include various dietary, mental, social, physical and economic facilities and their specialist actors, all formed in a temporary and dynamic network with the common end of helping an individual. The key message of systems thinking – i.e. that the interaction of parts (components) generates a global behaviour that cannot be derived from any of its parts alone – is often regarded as highly pertinent also for those contexts where numerous entities (for example military aircraft and military submarines), initially regarded as having their own identities interact in a manner to produce an outcome that none of them could achieve on its own.

However, the notion of a *system*, being based on the biotic root-metaphor of an *organism* (e.g. von Bertalanffy 1968, 1972; Checkland 1981; Hamond, 2003), assumes that a system's parts are all perfectly aligned with its overall purpose, and therefore a system's constituting parts are regarded to be fully subordinated to the whole of which it is a part – as is the case with organs in the human body: the heart, lungs or kidneys make sense only in the context of the human body and lack thus any meaningful identity that is independent of its whole, i.e. when taken outside of the human body. Now, the very specific contribution and peculiarity of the notion of a system also makes the notion of a 'system of systems' an antinomy, or a contradiction, in the sense of the expression "*a married bachelor*". This is so as a system, per definition, cannot consist of other systems, it can only be constituted by system *parts* that unlike the systems as such, lack their own independent identity. This ontological antinomy is unfortunately disregarded in the current *System of Systems* discourse (e.g. Jamshidi, 2008), which we regard as a dangerous tendency, as a key assumption of the notion of a *System of Systems* may generate conceptions and perceptions that fail the very need that originated the use of that notion, namely to perceive and conceive complexities that emerge from a number of entities posing their own identities, and interacting with each other thereby producing emergent global characteristics. A tragic example of such a failure is the recent disaster of the Germanwings Flight 9525, bound from Barcelona to Dusseldorf, where the co-pilot deliberately flew the Airbus A 320 into a mountainside in the French Alps causing the death of 150 people – clearly, assuming that the co-pilot of an aircraft lacks his or her own identity, being part of the larger system, deviates from the actual empirical experience and thereby exercises a dangerous reductionism.

Our position is that the notion of a *System of Systems* should be dismissed as such, and other notions should instead be advanced to address the empirical challenge at hand. To that end we are in the process of exploring two such alternative notions (Haftor & Kurti, 2014): the notions of an *assemblage* (DeLanda, 2006) and the notion of *encaptic relations* (Dooyeweerd, 1997). To exemplify the latter, a small rock in a bird's gizzard may assume a function in the bird's digestive process. The rock is not a part of the bird, rather it assumes a passive function and the rock can exist without the bird yet it cannot perform the same digestive function without the bird. In such whole-whole relation, one whole is governed or obeys one kind of norms or laws while the other whole is governed or obeys another kind of norms or laws; this means that there is a significant difference in the nature of the two entities and therefore these should be conceived in terms of *encaptic relations*.

The ontological antinomy inherent in the notion of a 'System of Systems' also generates epistemological and ethical concerns. Epistemologically speaking, the experience of whole-whole relations suggests that novel processes of conception are required in order generate knowledge thereof. The modernist ambition of perfect and valid knowledge seems untenable, rather we have to accept the aspiration of feasible knowledge (Simon, 1957; Churchman 1971; Le Moigne 1994, 1995) together with critical reflections upon its limitations (Churchman, 1971; Ulrich, 1983, 1987). Morally speaking, the key question is who is responsible in and for situations where numerous whole-and-whole relations, between both human and non-human entities, generate emergent behaviour that may have undesirable and indeed harmful consequences (Floridi, 2013)?

Clearly, more important research needs to be done to produce conceptions that may support our understanding of situations where numerous wholes interact with each other and generate emergent characteristics. The key message here is that the current notion of 'System of Systems' should be abandoned due to its inherent antinomy, and alternative conceptions should be advanced to overcome its limitations.

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