Professor Derek Hitchins,
CEng, PhD, MSc, FIET, FCMI, Wg.Cdr., RAF, Retired.,
INCOSE Pioneer
Systems Scientist & Systems Anthropologist
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sit vis vobiscum

System Engineer Essentials: 4. The *Principles* of Systems Engineering

So far in this mini-series of briefs—*System Engineer Essentials*—we have reviewed:—

- SEE1. ***Emergence,*** Reality, Importance & Value
- SEE2. Systems Design ***Methodology,***
- SEE3. *Pyramid Secure* ***Architecture Framework…***

In this, the 4th brief, we shall review four fundamental principles, tenets & beliefs, **A** to **D** below, that imbue Systems Engineering with its unique capabilities. Starting with, perhaps, the most challenging:—

A. The Systems Approach. (Ref A)

The **Systems Approach** was conceived in the 1950s and introduced by many disciplines, including: psychology, soci-

ology, anthropology, economics, political science, ecology, jurisprudence, *systems thinking* and ***systems engineering***

> *"The **systems approach** is not a technique; it is a way of thinking. about the ways in which **human organizations** work, change and **interact with their environments**. It is **interdisciplinary** and is essentially an approach to **problem solving and decision-making."***
>
> *Charles West Churchman 1913 –2004*
> *US Systems Scientist & Philosopher*

The Systems Approach, then, is concerned with solving problems associated with dynamic human organizations interacting with their ever-changing environments.

Which suggests, *inter alia,* that we should present a customer's requirement in the form of a *problem*, and then proceed to solve the problem by designing and creating a complete, *optimal solution system* as it *interacts* with its anticipated *operational environment*.

To address the Systems Approach *practically* I derived a Generic Reference Model (GRM) (Ref A), purporting to 'describe' any system. The GRM includes a ***Function Management Model,***[1] reflecting the notion that all systems are, in effect, open and interacting dynamically with others, and adapting to the interchange.

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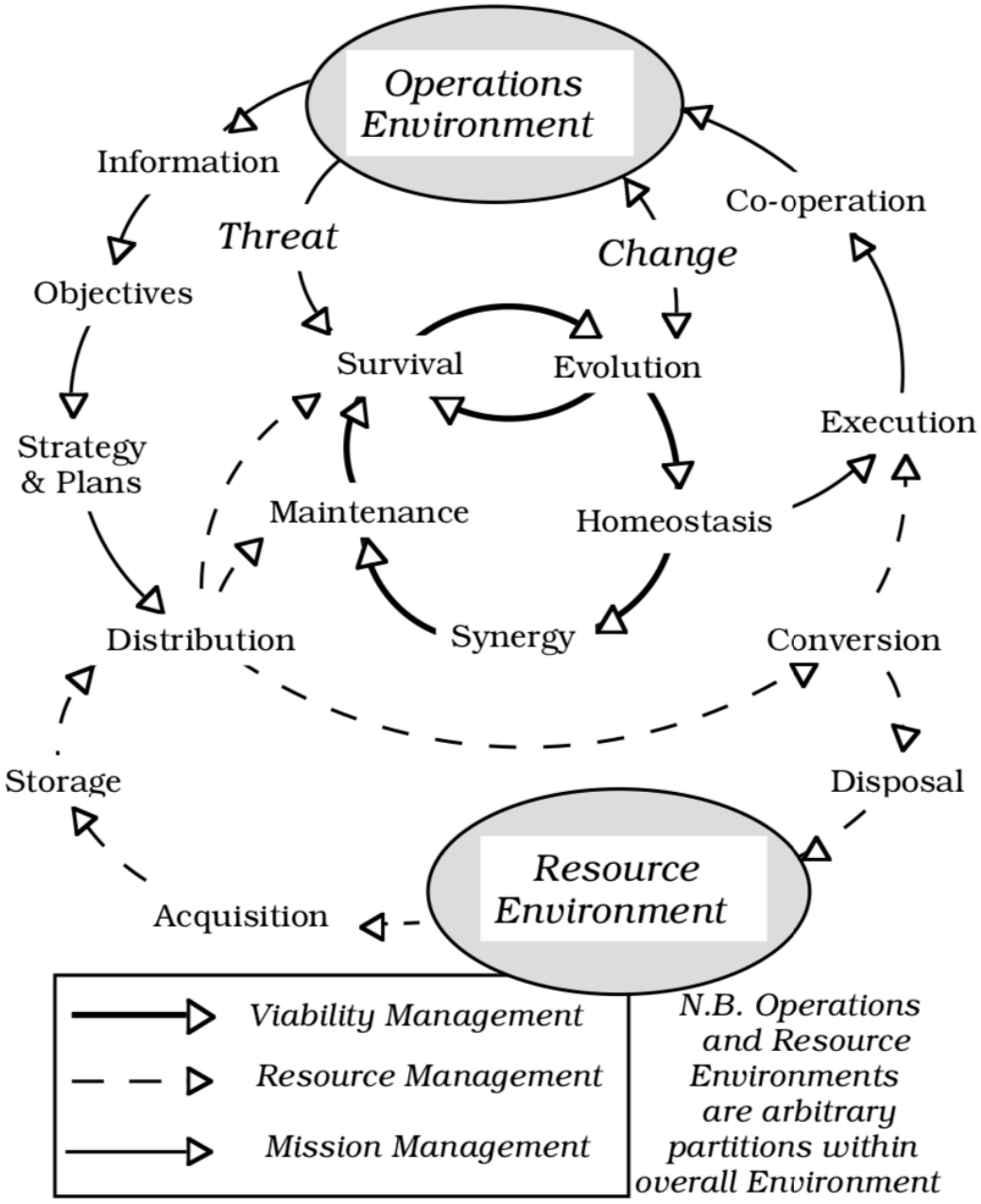
[1] **The GRM, with its Function Management Model, gave rise directly to Hitchins' Viable Systems Model—see video at Ref. C—which is similarly consistent with West Churchman's Systems Approach. HVSM is a powerful method for the realization of viable and autonomous systems**

The Function Management Model, Figure 1, addressed Churchman's Systems Approach, in that it assumed that all systems were open, such that functions within the system-of-interest were being influenced by one another

Generic Reference Model: Function Management.
Figure 1. Ref B.



Mission Management pursues the Purpose of the Solution System. Resource Management provisions spares & expendables. And Viability Management protects, maintains and repairs the physical structures (not shown) that 'enable' the functions. Together, these three "maintain the aim…"

and by external factors, and *vice versa.* This requires the internal functions to be managed in such a way as to maintain the *purpose, or goal,* of the Solution System. Hence, Mission Management—see Figure.

The Function Management Model, representing the Solution System, is seen in Figure 1 interacting with both Operations and Resource Environments. Each of these is open and replete with information, threats and opportunities, requiring the Solution System, as it fulfills its purpose/pursues its goal in the ever-changing environment, to continually review its objectives, strategies and plans. In accordance with Churchman's Systems Approach.

Any associated Systems Design will necessarily incorporate features, facilities & capabilities that the Solution System needs to prosecute its mission and remain viable through the challenges of its particular Operational and Resource Environments. Moreover, since those Environments will be continually changing, those Systems Designs, and consequent Solution Systems will require <u>continual re-optimizing/updating throughout their future operation/life-cycle.</u> And that's the Systems Approach, too!

Holistic Synthesis

Holistic Synthesis describes the "ethic" of the Systems Engineer *and* of Systems Engineering *as a discipline*. This ethic embraces two SE Principles in the one expression:

B. **Holism**. The theory that parts of a whole are in intimate interconnection, such that they cannot exist independently of the

whole, or cannot be understood without reference to the whole, which is thus regarded as greater than the sum of its parts.

Term coined by J.C. Smuts in the 1920s to designate the tendency in Nature to produce organized 'wholes' (bodies or organisms) from the ordered grouping of units.

C. **Synthesis**. The combination of components or elements to form a connected, *unified whole.*

Oxford Dictionary of English

Taken together as *holistic synthesis,* they describe the process of systems engineering as one of synthesizing the whole system from its functional parts without any Cartesian reduction, analysis, decomposition, etc., at any stage.

> ***System***. *An open set of complementary, interacting, parts with properties, capabilities and behaviors emerging both from the parts and their interactions to synthesize a complex, organized, unified whole of material or immaterial things.*
>
> *Derek Hitchins*

Complementary parts combine in such a way as to enhance or emphasize the qualities of each other. *Interacting* parts act in such a way as to have an effect on each other. Together, *complementary* and *interacting* promote synergy & emergence.

> *In systems design, parts identified by analysis of the function(s) to be performed by the whole are not put together like unchangeable pieces of a jigsaw puzzle; they are designed to fit each other so as to work together harmoniously as well as efficiently and effectively.*

Ackoff, Russel L. and Emery F.E.… (1972)
On Purposeful Systems,
Aldine-Atherton, Chicago

D. Organicism

Organicism is the doctrine that human societies ought to be considered alive and naturally ordered, much like a living organism, with organic elements as dynamic components of a dynamic system. Societies 'behave' like organisms: conception, birth, lifecycle, death, replacement.

Organicism is related to holism, and is similarly incompatible with reductionism.

*The **organismic analogy** compares the different parts of society to the organs of an organism. The organism is able to live, reproduce and function through the organized system of its several parts and organs.*

Herbert Spencer (1820-1903)

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See follow-up brief:—

SEE5. S.E. Principles in Practice

Don Del *April 20*

References.

A. West Churchman, C., 1979, *The Systems Approach,* Dell Pub. Co. Rev.
B. Hitchins D.K., 1992, *Putting Systems To Work,*[2] Wiley, Chichester. (Possibly out of print, but see footnote)
C. Hitchins, D. K., 2015, *"Systems & Systems Engineering - Viable Systems Model,"* https://youtu.be/-dwzb_NN4II

[2] **http://systems.hitchins.net/profs-stuff/profs-books/putting-systems-to-work/e-putting-systemstowork.pdf**