Professor Derek Hitchins,

CEng, PhD, MSc, FIET, FCMI, Wg.Cdr., RAF, Retired.,

INCOSE Fellow, INCOSE Pioneer

Systems Scientist & Systems Anthropologist

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Semper Integritas

Systems Engineer Essentials:
7. Making Things Right
—*Vs*—
Making the Right Things
OR, Engineering Vs Systems Engineering.

"**We Engineers,** we make things *to specification.* Accurately. Certainly, no more and no less than the customer specifies. The things we make have to do a job, in a particular way, on demand, in synch and on time, etc. Obviously. So, let's face it, we *have* to, make things **right.**"

Well, uh, perhaps we should say *"design" things right. As engineers, we don't usually* <u>make</u> *the things, per se—we draw/design/calculate and specify, for artisans, mechanics, machinists, programmers, etc., to actually fabricate. But, of course, it's we engineers who make the choices and decisions.* **To ensure that things are made right.**

But, suppose the customer has a problem—a BIG problem—and has no idea how to solve it? Or has no confidence that their 'solution' will be the right/best one, or will even work.

This happens, rather more frequently than you might imagine. Notably, in the *civil engineering* domain. F'rinstance:—

A town council wants to demolish a dilapidated old chapel in a prime hill-top location, and they want a prestigious, landmark, iconic "something" of a building in its place. But, they don't know quite what that new icon should be/should look like. Yet, they want their new icon to be "better" than anyone else's…

What does the council do? They approach one or more, consulting architects. And they give the architects a brief. Not a specification. A brief. Which outlines their general ideas, and how the new icon should, somehow, "represent" the town, going forward; should "stand out" visually, whilst not offending against the general ambience of the area. But, no specifics.

And they then rely on the architects reputation, past performance and expertise to come up with one, or more, *innovative solutions*.

And it works. That's how Sydney got its magnificent Opera House. How London got the Gherkin and the Shard. How the Louvre got its iconic Glass Pyramids…And so on, around the World.

S imilarly, but in domains other than civil engineering, *that is how **Systems Engineering** may serve.* Like consulting architects—**<u>Systems Architects.</u>** To solve the customer's *social* problems… Yes, *social,* which would include societal, organizational, sociotechnical, sociopolitical, social ecosystem, enterprise, business, industry, socioeconomic, etc., etc. So, problems, but with a *social* element or implication… which goes to explain why **Systems Engineering invariably employs the Systems Approach (Ref A.)**

Hitchins' "Poached Egg" Diagram (Ref B)
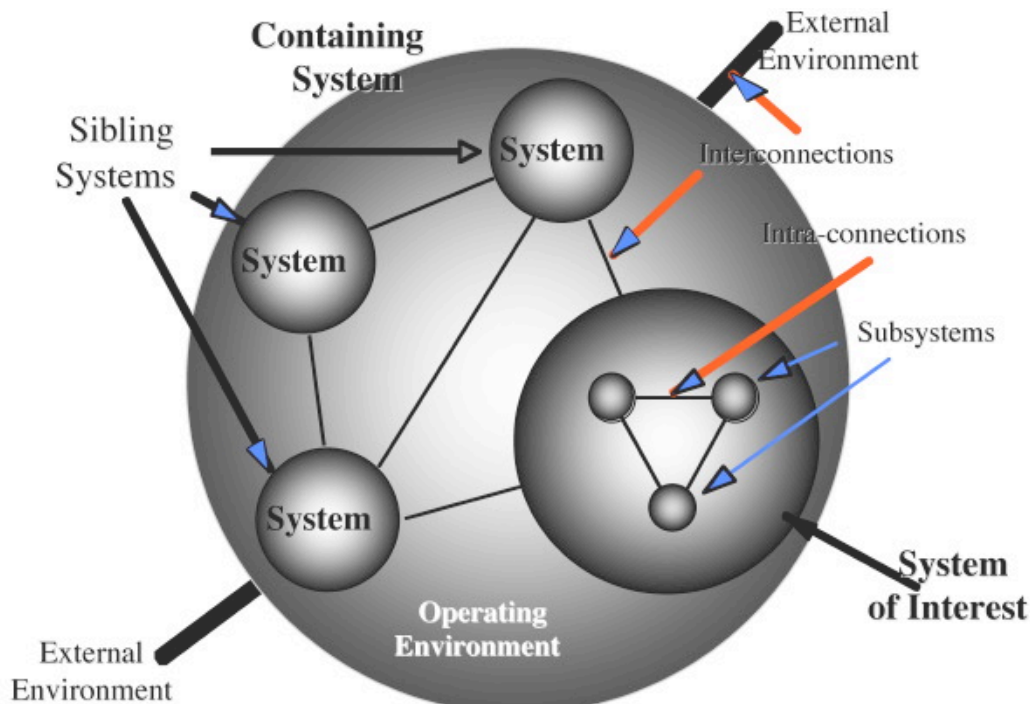
<u>Conceptualizing the *Systems Approach*</u>. A System of Interest (SOI), lower right, containing a number of intra-connected subsystems, exists in an Operating Environment, where the SOI and other <u>*open systems*</u> mutually interact, within a notional Containing System. An output from a subsystem of the SOI will affect both the SOI, and its interacting Sibling Systems—which will respond/reflect/reverberate/react to each other, the SOI, and its subsystems.

"Open Systems exchange energy, information and material with their environment, *and adapt* to the interchanges."

"**W**e _Systems Engineers,_ we solve customers' problems. **Comprehensively**. _We create **viable, lasting solutions that are compatible with, and adapt to, their operating environment as it continually changes.**_"

We explore the customer's problem in depth, including the future Operational Environment for the Solution System…
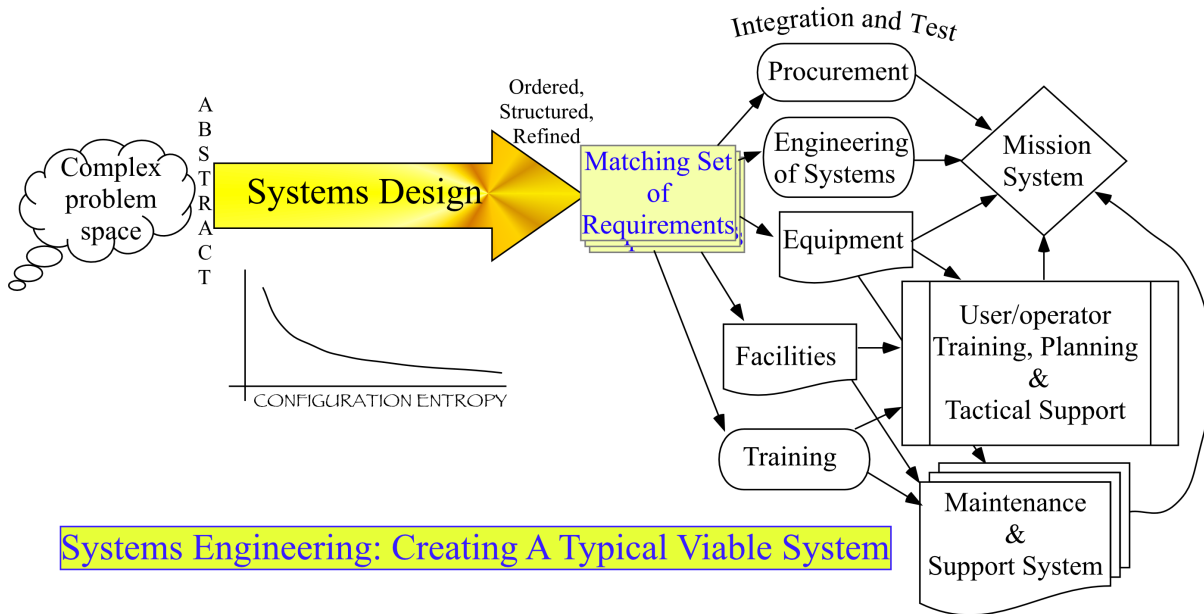
• looking for symptoms, threats, attitudes, opportunities, siblings, etc., that characterize the problem,* and…

• creating a variety of potential solutions and comparing them extensively, using, _inter alia,_ Operations Research, to find…

• ..the **optimum**, that best solves/resolves or dissolves the problem and relieves all symptoms but, at the same time…

• ..is compatible, and viable, in the ever-changing operating environment, with its inherent risks, threats, options and opportunities.

* _supplanting stakeholders_

We undertake comprehensive systems design and create a full, _complete, matched-set of requirement specifications for the whole solution system…_ …which may comprise a number of interacting, discrete facilities—see figure overpage.

• We instantiate and integrate the various parts to commission a comprehensive solution to the customer's problem

• We support the customer, undertaking continual system redesign and necessary update throughout the Solution System's operating lifecycle.

Integration and Test

Procurement

Engineering of Systems

Mission System

Ordered, Structured, Refined

A B S T R A C T

Complex problem space

Systems Design

Matching Set of Requirements

Equipment

User/operator Training, Planning & Tactical Support

Facilities

Training

Maintenance & Support System

CONFIGURATION ENTROPY

Systems Engineering: Creating A Typical Viable System

Systems Engineering creates more than the Mission System. It may also create, e.g., Maintenance & Support, User Support Systems, etc.−see right-hand column−without which the Mission System will not remain viable in operation.

Together, these constitute the Solution System, comprising "complementary, interacting parts, synthesizing a complex organized whole." See corresponding organizational chart, following…

*O*f course, as with engineers, we may not actually make or manufacture anything. Instead, we carefully specify what has to be made/synthesized/organized/ instituted. And, when these activities have taken place, we bring the many and various parts together in an operational environment, real or simulated, to ensure inter-operability, adaptability, compatibility and viability.

To ensure that we have, indeed,
… _made the right things!_
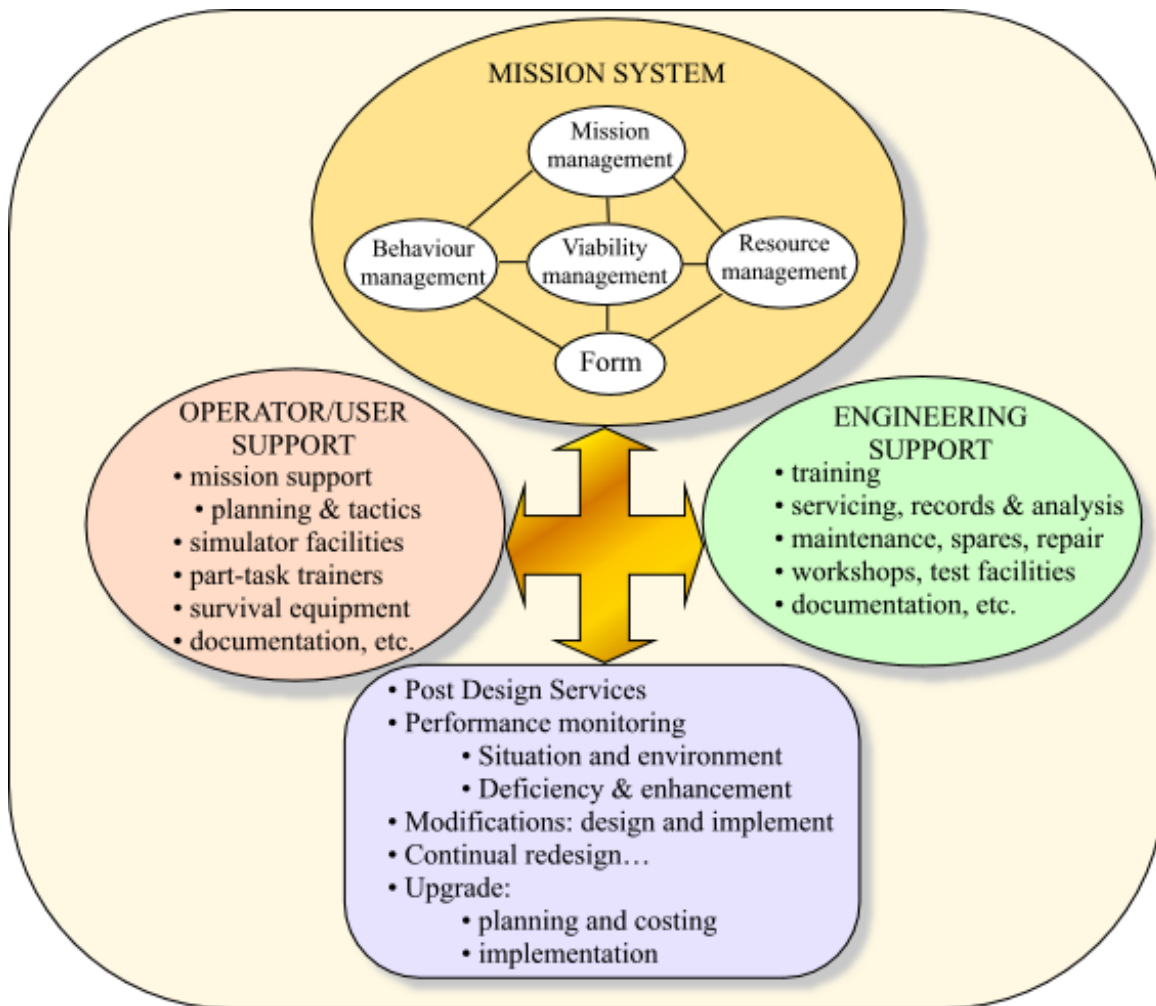
The whole is a Thru-Life, Autonomous Organization. The Mission System could be a military weapon system, a manufacturing organization, an industrial complex, a new hospital/prison/airport, a tidal-stream energy barrage, waste disposal facility, Intelligence System, new school/university department/supermarket, etc., etc. There is an underlying pattern to all of these, and many more…which renders them appropriate for Systems Engineering, with its innovative, complexity-managing holistic synthesis.

Don Del   'July 24

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