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sit vis vobiscum

Systems Engineer Essentials —*1. Emergence!!*

What every Systems Engineer should understand…

First, what <u>does</u> a Systems Engineer do? Well, that should be self-evident, surely—his discipline is Systems Engineering (Applied Systems Science), his rôle as a Systems Engineer is to create, with others, viable Systems Solutions to complex issues/problematic situations, with the Systems Approach as his watchword and employing the Systems Design Methodology. And…of course, he will understand Emergence…

Some engineers—have a problem with the concept of emergence/emergent properties. It's due to their training—that what they give to the customer should be what the customer asked for—no more, no less.

So much so, that I have had students telling me flat out that I don't know what I'm talking about, and walking out of class, and off the course, rather than *even entertain* the notion of emergence. Which is a shame, not only because they are misguided, but because they miss so much in their engineering (sic!). And would, inevitably, make inadequate systems engineers…

But…let's start at the beginning. What is emergence? Well, it is evident in the **system paradigm**:—

> *"A system is…an open set of complementary, interacting parts, with properties, capabilities and behaviors <u>emerging</u> both from the parts and from their interactions to synthesize a complex, organized whole of material or immaterial things."*

So, properties, capabilities and behaviors 'emerge' from a system. But, can they also 'emerge' from an engineered artifact…?

Let's start with a definition of emergent properties that would suit engineers:—

"Those properties of a system as a whole which cannot be ascribed completely to any of its individual component parts,"

Archetypal examples might include, say:
- *self awareness from the human brain;*
- *a picture emerging from a jig-saw puzzle.*
- *anguish and joy in equal measures, emerging from Rachmaninov's 2nd piano concerto,…*

But, for would-be systems engineers/systems designers, consider the…

<p style="text-align:center">**..<u>Emergent Properties of a Car</u>…**</p>

- **Physical properties**, such as coefficient of drag, emissions, recycle-ability
- **Functional properties,** such as carrying capacity, top speed, braking distance
- **Temporal properties,** those that change or remain constant, such as rust-resistance, times between servicing, lifetime
- **Aesthetic properties,** such as elegance, comfort, style
- **Behavioral properties,** such as responsiveness, handling, ride.
- **Value properties,** such as cost, fuel consumption, resource utilization

There is a slight snag, of course. The typical automobile/car is properly viewed as an *artifact,* a manmade 'tool' for a human to use, rather than a system. However, put a driver in the driving seat, start her up, and together with car plus driver plus road—we have a viable, autonomous sociotechnical system. And, notice, that nearly all the emergent properties presume that the vehicle is/has been operating in a representative environment…

Oh! And finally, an exercise for all you budding systems engineers/systems designers. In your imagination, see if you can enhance any one of the above Emergent Properties (EPs) of a Car *(viable, autonomous sociotechnical system)* **without** *detracting from any other EPs.* After all, that's one of the things a systems designer would seek to do…

And, for those of you who disagree with all of the above 'nonsense? I'm not surprised…but you are **wrong!** **Again!**

Don Del   *March 2024*