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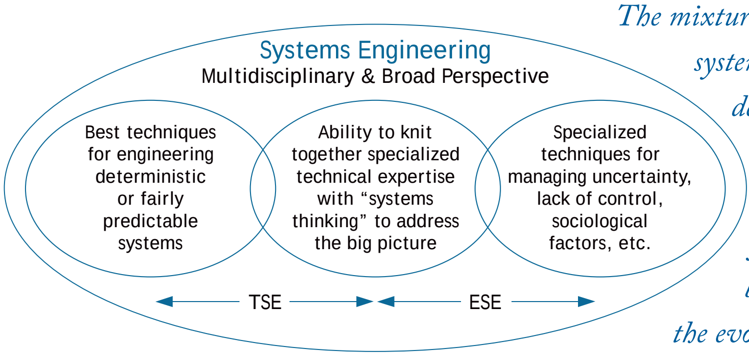
Evolving Complex Adaptive Systems and Systems Engineering



The mixture of traditional systems engineering (TSE) and enterprise systems engineering (ESE) capabilities should be tailored depending on the circumstances. While applying best practice TSE capabilities isn't easy (or all that common), it's relatively well understood (e.g., SEI's CMMI framework) compared to the community's grasp of how to best do ESE. This paper explores some aspects of ESE and the evolution of complex adaptive systems.

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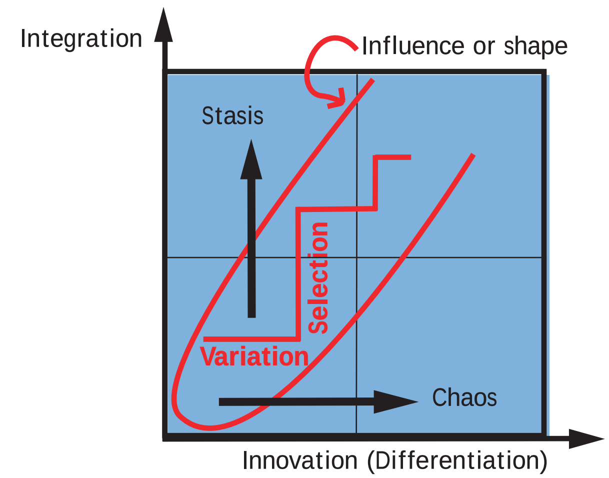

References:
- *Gharajedaghi, Jamshid, Systems Thinking—Managing Chaos and Complexity.*
- *Axelrod & Cohen, Harnessing Complexity—Organizational Implications of a Scientific Frontier.*

It's been hypothesized that complex adaptive systems theory may be able to inform how to do enterprise systems engineering. This theory states that complex systems evolve based on the principles of variation (generating viable options), shaping (influencing the evolutionary environment), and selection ("pruning" the resulting evolving system). The implication is that such systems cannot be fully specified and engineered "from the top down." They will respond like an ecosystem subject to natural selection and demonstrate emergent behavior, evolving in ways that are not completely predicable.

To grasp the bridge between natural selection and systems engineering of man-made systems, think about today's World Wide Web. Its current state is the result of evolution very much like natural selection, and its evolution is still ongoing. We've seen bursts of variation (e.g., the dot com boom) and periods of rapid selection (the dot com bust). Influencing factors include regulatory policy, the availability (or not) of venture capital, and the invention of new technology (e.g., Web 2.0). Survival is determined by market competition, and long-term success by the ability to adapt to change.

We need to exercise care when applying these principles to the government acquisition environment. The variation and selection that drive commercial information technology represent an environment with a high percentage of failures. The venture capital process maintains an unforgiving, milestone-driven demand for demonstrable results, as well as a "fail early" methodology. These represent a considerably different culture compared to the government acquisition community. Government acquisition is itself a complex adaptive system (a large, multi-stakeholder enterprise) that has evolved over many years and will not easily or quickly change. We need to recognize its nature; understand how far it is likely to go at any point in time; take into account the various motivations, incentives, and limitations of the stakeholders; and then introduce techniques from World Wide Web lessons learned accordingly.

One approach may involve experimentation—creating venues where end-users can interact with prototypes to explore "marketplace reaction" without the commitment of a formal new program start. The hard part is creating effective transition mechanisms to move experimental "winners" to supported, fielded capabilities. This often takes time and concerted, creative effort by a government manager who becomes convinced of the advantages of pushing the boundaries.

Another potential approach is to identify key individuals who are respected and trusted as peer leaders among the user community. Working with these people and getting them to help craft a candidate solution and then declare it as good to the rest of their community can go a long way toward achieving "marketplace acceptance" without having to fully exercise the marketplace itself.

It is often crucial to maintain continual contact with the user community to help rapidly implement capability improvements even after fielding. A capability "thrown over the wall" to the user is much more likely to suffer from stasis and be passed by as conditions change, which they will. Taking (and making) every opportunity to observe and experience the users' domain best enables systems engineers to act, even in a limited way, as a surrogate for anticipating marketplace reaction to various possibilities—an advantage regardless of the approach being tried.

If a system (or component of a system) is expected to face constant conditions during its lifetime, then it can be optimized for those conditions. However, other circumstances demand that more thought be given to adaptability. This is where design precepts such as standards-based layered architectures, separation of data from business rules, modular designs, carefully chosen convergence layers (e.g., the Internet Protocol "hourglass"), and exposure of data (and metadata) become important. Building composable (and re-composable) capability is another approach to achieve cost-effective adaptability, with mash-ups and service-oriented architectures being two currently favored technical (and associated governance) methods for doing so.

Finally, it is useful to think about the value of building options into designs. If there are future extensions that can be envisioned up front, given when they might be needed, the likelihood of needing them, and the cost of extending the design compared to a new replacement in the future, is it worth spending extra money on the initial design to facilitate future options (i.e., build in the design "hooks")? As an example, consider the forethought that caused the designers of the George Washington Bridge over the Hudson River between New York and New Jersey to build the original structure capable of supporting a second level of roadway when the need for its capacity was many years in the future.

In conclusion, while ESE best practices are not fully understood, thinking about enterprise issues in the context of evolving complex adaptive systems can open our eyes to new ways to achieve mission success.

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