What's your next invention in UAV propulsion? Innovation and the challenge of uncertainty

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Innovation is the name of the game, whether that game is war, or the market, or competition within an organization. Innovation is the process of discovering or developing what was previously unknown or even believed to be impossible. Surprise is an essential element of innovation. The innovator may be surprised (Wow! I didn't think that was possible.) and certainty the adversary will be surprised. The challenge of innovation is that both sides are engaged in the process, and neither side knows what will be the next innovation, either their own or their adversary's. This uncertainty about the future presents a major challenge in choosing a strategy for designing, developing, and managing new technologies.

Edward Luttwak stressed "the virtue of suboptimal but more rapid solutions that give less warning of the intent … and of suboptimal but inherently more resilient solutions …. This is why the scientist's natural pursuit of elegant solutions and the engineer's quest for optimality can often yield failure in the paradoxical realm of strategy."

"Do your best" is the motto of professionals in many fields, including of course engineering. But in the paradoxical realm of technological innovation, in conflict with an intelligent adversary, what does it mean to do your best?

This talk presents a response to that challenge, based on info-gap decision theory (Ben-Haim, 2006, 2010, 2018).

The search for ever better systems should guide the engineering designer. However, uncertainty, ignorance, and surprise diminish the importance of optimal designs.

The concept of an innovation dilemma assists in understanding and resolving the designer's challenge. An innovative and highly promising new design is less familiar than a more standard approach whose implications are more familiar. The innovation, while purportedly better than the standard approach, may be much worse due to uncertainty about the innovation. The resolution (never unambiguous) of the dilemma results from analysis of robustness to surprise (related to resilience, redundancy, flexibility, etc.) and is based on info-gap decision theory.

Info-gap theory provides decision-support tools for managing the challenges of design and decision under deep uncertainty. We discuss the method of robustly satisfying critical requirements as a tool for protecting against pernicious uncertainty.

These ideas will be illustrated with a simple example of designing propulsion for an autonomous aircraft for catching an evasive target. Deep uncertainty surrounds the evasive strategy and capability of the target. This presents substantial challenges to the designer of a UAV that must establish and maintain an effective distance from the target. The emphasis of the example is not on design details, but rather on the methodology by which alternative designs can be prioritized, in light of the uncertainty.

References

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Many more sources at: info-gap.com