An introduction to Environment Systems and Decisions' Special Issue on Emerging Technologies

Benjamin D. Trump¹ · Danail Hristozov² · Igor Linkov¹

Published online: 15 May 2018

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Emerging and enabling technologies have the potential to revolutionize everything from industrial processes, to medical breakthroughs, to overall improvements in the standard of living. As has been frequently noted, however, these potential benefits must be weighed against considerations of risk, cost, and societal assent, among various other concerns (Linkov et al. 2018a). Many of these technologies, such as nanotechnology, synthetic biology, 3D printing, and geoen지니어ing, have potentially vast implications, making this reflective value judgment exercise all the more vital for policymakers, developers, and the general public (Cummings et al. 2017). Their inherent uncertainty, from the perspective of both potential risks and benefits, creates governance challenges that require regular reflection and coordinated response to address in a meaningful way (Rycroft et al. 2018; Trump 2017).

This Special Issue includes commentaries and research articles that reflect upon several emerging and key enabling technologies that are already having an impact upon daily life and scientific practice. They represent a diversity of opinions and backgrounds, yet all seek to address the critical question of uncertainty and risk facing these new technologies and technological opportunities. Although the emerging technologies field is vast, with many questions and opportunities for inquiry, these articles capture core concerns of how might we understand the risks and rewards these technologies pose to individual countries and societies at large and how might we better organize ourselves to address these technologies' challenges in the future.

Mampuy and Brom (2017) reflect upon key challenges of emerging biotechnologies, including the inherent tradeoffs between risk and benefit. They particularly reflect upon the

need for social embedding and argue that such social reflection should center upon "...which role we want technology to play in our lives." For biotechnology, this includes a wide spectrum of genetic modification, from older genetically modified organisms to modification via gene editing techniques such as CRISPR–Cas9. The authors conclude that such discussion will address broad questions of policy, regulation, and oversight that remain uncertain or unaddressed within various governments.

Linkov et al. (2018b) further acknowledges the risk/benefit divide by commenting upon a need for a collaborative, reflexive, and adaptive approach for risk governance to guide policymakers and key stakeholders in industry, academia, workers, and civil society. Building from reflections via a Society for Risk Analysis Policy Forum in Venice, Italy in March 2017, the authors offer insight into what such risk governance should look like and why emerging and key enabling technologies would be better suited to be governed under such a regime.

Finkel et al. (2018) offer an alternative approach known as solution-focused risk assessment (SFRA). Specifically, SFRA is argued as an approach that can better evaluate synthetic biology, which is difficult to assess under quantitative risk assessment processes that require robust sources of data to populate and execute. The authors contend that SFRA can help qualitatively evaluate synthetic biology products against conventional competitors. Specifically, this paper applies SFRA to synthetic biology options for dengue virus vector control, where genetically modified *Aedes aegypti* have recently been developed and used to reduce such populations in an effort to limit the transmission of dengue and other diseases.

MacIntyre et al. (2017) discuss how emerging technologies like synthetic biology, cyberthreats, and various other concerns present a new risk landscape for which there are few precedents, and are challenged by considerations of regulation and risk mitigation. Rapidly evolving patterns of technology convergence and proliferation of dual-use risks

✉ Benjamin D. Trump
Benjamin.d.trump@usace.army.mil

¹ US Army Engineer Research and Development Center,
Concord, MA, USA

² GreenDecision SRL, Venice, Italy

expose inadequate societal preparedness. The authors outline examples in the areas of biological weapons, antimicrobial resistance, laboratory security, and cybersecurity in health care. In this way, they conclude that new challenges in health security such as precision harm in medicine can no longer be addressed within the isolated vertical silo of health, but require cross-disciplinary solutions from other fields.

Cummings and Rosenthal (2018) review the public's formation of opinions related to geoengineering, which is broadly defined as the deliberate large-scale manipulation of an environmental process that affects the earth's climate. The authors seek to understand which factors contribute to or detract from public acceptance of geoengineering through robust path analytic modeling of public perceptions of geoengineering that may better serve the academic community and decision-makers. This study finds that familiarity, epistemic trust, preference for alternative solutions to climate change, and media consumption are interrelated in their influences on opinions toward geoengineering proposals and support for funding further geoengineering research.

The articles in this issue each seek to better understand a component of emerging technologies, their governance, and/or various considerations ranging from risk perception and communication to policymaking and value tradeoffs. The questions asked within each article are representative of the greater challenges to the emerging technologies' arena and will likely continue to be asked by various stakeholders on an international scale moving forward.

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