TRANSACTIONSNASTPHL

ISSN 0115-8848 (print)
ISSN 2815-2042 (online)

https://transactions.nast.ph/

Vol. 44 (2022)
doi.org/10.57043/transnastphl.2022.2550

The Philippines' *Foresight 2050: Science for a Sustainable Future*—A Case of and Call for Systems Thinking

John L. Anderson

President
US National Academy of Engineering

ABSTRACT

Unexpected but inevitable surprises like a new bird flu or a category 5 typhoon can become too complex to be planned for using conventional techniques, even by the most informed and influential entities. To better engage with such complexity, more collaborative approaches are essential to reduce their detrimental consequences. This talk will provide some perspectives on how systems engineering can provide such capabilities, identify opportunities for systems thinking to guide foresight in shaping agile responses like resilient supply networks. It will review the US National Academy of Engineering's programs—centered on people, systems, and culture—that are taking on this challenge, and how making engineering more inclusive empowers positive results.

Keywords: systems approach, systems thinking, scenario planning, climate change, COVID-19 pandemic.

Correspondence:
John L. Anderson
JAnderson@nae.edu

Citation
Anderson JL 2022. The Philippines Foresight 2050: Science for a sustainable future—A case of and call for systems thinking. Transactions NAST PHL 44
doi.org/10.57043/transnastphl.2022.2550

Presented as plenary paper during the 44th Annual Scientific Meeting National Academy of Science and Technology Philippines on July 14, 2022.

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2550

Thank you for inviting me to speak at today's National Academy of Science and Technology (NAST) Philippines meeting. It is a pleasure to join you. Special thanks to Dr. Rhodora Azanza, NAST PHL President, for the invitation. I'm John Anderson, the President of the National Academy of Engineering of the United States (NAE). The NAE is part of the National Academies of Sciences, Engineering, and Medicine, which operates under an 1863 Congressional charter to advise the United States on science, engineering and health matters.

I am pleased to be able to share some ideas with you, even if only virtually due to the global pandemic. I extend my personal greetings to the Philippines' Department of Science and Technology (DOST) Secretary Fortunato T. de la Peña and commend him for his leadership. I also applaud NAST Philippines for completing the very important study, *Foresight 2050: Science for a Sustainable Future*.

Those of you here today have articulated a bold vision for the Philippines. Your 30-year foresight study, conducted in the midst of a pandemic, crosses myriad disciplines and identifies 12 key operational areas that will help you build a productive science and engineering culture. To paraphrase the 19th century Danish philosopher Søren Kierkegaard, "*life can only be understood backwards, but we must plan forwards.*" Your work is a case study of, and a call for, systems thinking—the subject I will be reflecting on today.

Like NAST, the NAE serves as an advisory function for the government and its public. It advises on matters, ranging from renewable energy, to the development of safe and resilient cities and towns, and to advances in medical devices that help save lives. We initiate and coordinate programs that promote a vibrant engineering profession and often engage with our sister organizations: the National Academy of Sciences and the National Academy of Medicine. We also work to raise the awareness of contributions of engineering to society and recognize outstanding achievements to encourage excellence and recruit talent to the engineering profession.

Looking ahead, as NAST and the NAE do in our advisory capacity, is an important and daunting task. As your plan makes clear, collaboration, research, and focused goals must be purposely pursued to achieve a future that is safe, healthy, and resilient. Such planning is needed.

You have considerable experience facing natural disasters such as typhoons, flooding, and earthquakes, and epidemics and pandemics. Now, a resurgence of Avian Flu tasks you with considering the most effective way to contain it spread. Such events are called *inevitable surprises*, and your country has invested heavily in dealing with them. In an effort to build resiliency in 2019, the Philippines bought *catastrophe insurance* through World Bank Catastrophe Bonds. You are steering responsive efforts with a focus on science.

Traditionally, the link between technical evidence-based recommendations and governmental policies and culture has been weakened in most countries. As we will discuss, strengthening their connections is an important way to use systems thinking to chart a path to the future.

In today's talk, I will provide an overview of systems thinking and share a few thoughts on how it can enable robust and resilient networks to deal with inevitable surprises.

Throughout I offer my thoughts on how the inclusion of men and women from a range of backgrounds—what we call diversity—can strengthen the capacity for systems thinking in all aspects of important national planning work.

Systems Thinking

Theodore von Kármán, considered the father of Aeronautical Engineering, characterized engineering as follows: "Engineers create the world that never has been." Creating systems that are robust and resilient is a central activity and distinguishing feature of engineering.

A century of scholarship in systems analysis has produced ways to study better relationships and apply patterns to better understanding a problem. Efforts to address natural disasters illustrates some major challenges that can benefit from a systems thinking approach.

I'll begin by paraphrasing Thomas O'Rourke, member of the US National Academy of Engineering and professor at Cornell [University].

Within the past 20 years, the world has witnessed the 2004 Sumatra-Andaman and the 2011 Tohoku earthquakes and tsunamis, the 2010 earthquake off the coast of Chile, and the 2010 and 2011 Canterbury,

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2550

New Zealand earthquake sequence; three of these earthquakes are among the largest six ever recorded. In the United States, Hurricanes Katrina, Sandy, Harvey, Maria, and Irma are the country's five most expensive hurricanes in history—all in the past 17 years and three of them in the same year. Instead of being rare events, mega-disasters due to both man-made and natural causes are being experienced with greater frequency.

The severity and far-ranging consequences of these events are establishing a new normal through natural disasters, and a corresponding challenge to the engineering profession to help develop the resilient infrastructure needed to reduce their impact and speed up recovery.

Engineers must view resilience as both a social and technical problem. Infrastructure policy and progress must address the combined social and technical dimensions of infrastructure including interdependencies among the physical, social, and economic systems that communities depend on.

For these reasons, optimal solutions to complex problems cannot be developed in isolation.

Diversity of thought is critical input to rational and effective decision-making, and thus central to good leadership: technical, social, and political leadership. Individuals of different backgrounds have different perspectives on a problem and on routes to solutions. In short, one of the most important aspects of systems thinking is applying correct mental modes. Historically, we may have prepared many times for a catastrophic event, but modes of thinking and operation that worked in the past are not always sufficient, or appropriate, to address inevitable surprises in the present.

Along with new mental models, systems thinking calls for the opposite of working in isolation. In any complex system there are multiple stakeholders and decision-makers, with differing opinions on pinpointing the problem and how to address it. Their perspectives contribute to a systems understanding of the problem, which is necessary to develop an effective systems approach to it.

Consider, for example, the case study of workers responding to hurricane Maria in the Caribbean nation Dominica. After the category 5 hurricane, residents were drinking from unsafe and untreated water supplies, their homes had been destroyed, and their mental health was challenged. Considering how to approach the complexities of water, sanitation, and health outcomes, members of local, national, and international groups came together. But they could not agree on a first step to tackle the problem.

They had clear goals but carrying out post disaster recovery is complex. There may be guidebooks on how to safeguard residents and rebuild infrastructure, but in the aftermath of an inevitable surprise like a natural disaster, the time constraints and levers of stress are great. And actions often have consequences in both linear and parallel processes. Decision-makers need a way and mindset to effectively assemble inputs from multiple local stakeholders, and take action rather than each group dictating a course for everyone based on their own perspective.

In both disaster planning and recovery, systems thinking requires acknowledging that there are no perfect solutions because responses will impact other parts of the system. The goal is to become more effective in the totality of the problem, the systems approach facilitates that effectiveness.

Most important, systems thinking has a critical cultural and people component to it. As I noted earlier, its application is based on an understanding of relationships, a commitment to multiple perspectives, and an awareness of boundaries. An international group—even one with considerable experience in handling disaster recovery elsewhere—is not equipped to effectively handle recovery in a specific locale without building such relationships and understanding the local culture.

The NAE seeks to advance the practice of applying systems thinking to societal problems. Drawing on evidence-based research and analysis, the NAE provides guidance for improving health and safety, maintaining and raising the standard of living, and expanding education and workforce opportunities for all. We seek to engage support and promote the inclusion of people from multiple disciplines and cultures in the engineering design process. We include culture because the successful engineers must recognize a responsibility, beyond the individual and the technical work we do.

Change sometimes happens rapidly. In planning preparedness for and recovery from inevitable surprises,

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2550

such as natural disasters,cultural, ethical, social, and environmental responsibility must be incorporated in the practices of good engineering.

To tackle complex problems, our objectives include working with other disciplines— such as the social and behavioral sciences—that are often not considered in engineering analysis and design. Appreciating social dynamics can be a great aid for engineers to avoid unintended negative consequences of innovative ideas and designs.

The NAE makes a point of engaging business, government, academia and other groups in applying complex systems engineering concepts across various engineer interests and goals. We embrace partnerships with experts in different fields and engage with colleagues across the globe, particularly as the frequency and magnitude of disasters and other surprises are growing worldwide. The number of such events has risen significantly during recent time, I mentioned a number of them earlier.

This observed increase could be due in part to better reporting, but the United Nations (UN) suggests that it is mostly due to a significant rise in climate-related disasters. In any case, it is clear that new tools are needed to help plan for and respond to national disasters.

NAE Efforts involving Systems Approach

I would like to briefly discuss two examples of work by the US National Academies involving a systems approach to national and global problems. Climate change and its impact are a global issue, and especially important in regions with a large coastal area, as noted in *Foresight 2050*.

On climate change

The US National Academies of Sciences, Engineering, and Medicine have led studies related to climate change over several decades, aimed at understanding, preparing for, and limiting future climate change. Climate change, its impacts and ways to mitigate it, represent a system of systems.

The three major goals of our work on climate change: first, define actions necessary to significantly mitigate global climate change; secondly, design path towards decarbonization of the energy system itself; and thirdly, engineer the transition to a low carbon economy.

Systems thinking approaches are needed, trade-offs will be essential, and personal sacrifices will be necessary—and this should all be done with great respect for social equity among the world's citizens.

On protecting coastal areas

United States learned a painful lesson about system interdependencies in the human-made disaster, the 2010 oil spill in the Gulf of Mexico. The explosion of the Deepwater Horizon oil drilling rig led to the death of 11 workers on the rig and the spillage, directly into the Gulf waters, of 140 million gallons of crude oil and other contaminants. The spill has affected the region's border in the Gulf of Mexico for the past 15 years. How did it happen?

First, there existed inadequate systems level thinking in planning and operations. Secondly, inadequate redundancy to allow for human error was introduced into the model. Thirdly, failure to observe operational processes led to the disaster. And finally, a lack of community engagement prevented recovery in the best sense.

The corporation British Petroleum (BP) agreed on a settlement to pay 21 billion US dollars to help restore the ecosystem of the Gulf of Mexico, restore the economy of the region, and fund an ongoing study of offshore energy production in the gulf. A portion of the BP settlement provides funding for a 30-year program called the Gulf Research Program at the National Academies in the United States. The program's mission includes improving the welfare of the coastal residents, protecting the gulf environment, and preventing future disasters resulting from energy production in the gulf.

Because the Philippines has a large coastal responsibility, I encourage you—with the voice of US experience—to investigate the activities of the Gulf Research Program to see if they might inform your thinking about disaster prevention and system resilience.

A systems approach based on simulation, optimization, and multi-objective analyses has great potential in providing appropriate support through effective disaster management with the dimensions of local culture included. Rigorous systems thinking methods can contribute to improve plans and designs for complex large-scale systems.

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2550

The combination of knowledge of the available analytical tools and understanding when each is appropriate, and skill in applying them to practical problems with input from a diverse group yields a method that is both mathematical and intuitive.

The Philippines Foresight 2050 and Nexus Scenarios

The Foresight 2050 plan represents the hopes and needs of the millions of people who call the Philippines home to ensure their sustainable future. It also sets a path forward for stronger STEM education to build a technical workforce of the future, to help tackle complex problems like healthcare, shelter, transportation, and to develop a strong research and development enterprise.

The number of Philippine residents who are vulnerable to flooding, earthquakes, typhoons, and mudslides is far reaching. Nine million residents have been impacted by a disaster in the past five years, more than 40% have had their home damaged as a result, and 38% reported they would have difficulty recovering from a national disaster. While many people own their home, probably very few have any type of home insurance or life insurance to help recover.

Systems thinking and scenario planning can significantly improve preparedness for natural and manmade disasters. Achievement of a sustainable society also requires equal concern for a balance among the environment, the economy, and social equity.

As we have all learned since 2020, epidemics and pandemics are also examples of inevitable surprise—events that are difficult or impossible to predict.

E. coli can spread from a back porch lunch gathering to contaminate a country. The recent avian flu problems in the Philippines illustrate what my colleagues and I have called nexus scenarios. They point to pervasive incidents that can become recurrent and ruinous to families, lives, and the economy. In addition to causing widespread and sometimes fatal illness, the coronavirus pandemic induces many supply chain setbacks that have made global recovery more difficult.

A recurring flaw in disaster responses is that when facing a complex problem the tendency is to revert to the tactics used in the previous emergency rather than tailoring their response to a new situation. For instance, COVID-19 had its fair share of comparisons to the influenza pandemic a century earlier, but its tendency to mutate so fast and spread so quickly around the globe places it in a different category.

Nexus scenarios such as COVID-19 or the avian flu create a confluence of disparate time, horizons, competencies, cultures, and perspectives. They require a critical capability to simultaneously look to the past, reliable evidence or what has succeeded, and what has failed, while weighing unique demands of the present and, importantly, equipping ourselves for future surprises.

The resulting trade-offs guide engineering design and eventually political decisions. For example, lockdowns in quarantine significantly mitigate the spread of the pandemic, but they also damage the economy, and with it, the livelihood and mental health of many citizens of all ages.

What is impressive about the global response to COVID-19 is the multipronged approach employed to mitigate its impact and address public health. First, its rapid political action by most countries to reduce disease transmission nationally and globally. Secondly, there is accelerated research, development, and manufacturing of protective personal equipment, and also of diagnostics. And thirdly, the rapid development and massive production and distribution of vaccines, on a timescale never seen before. The vaccine story of COVID-19 is a classic reminder of the importance of a strong research and development infrastructure.

The MRA platform for vaccines was developed over 20 years before COVID-19 appeared, this is a grand advertisement for investment in STEM education, the workforce, and research and development. The fortunate among us can be thankful for the many science and engineering contribution that allowed us to continue our livelihood in the face of the pandemic.

Engineering and Its Role in Innovation and Technology

I would like to conclude with some comments about engineering and its role in innovation and technology. We usually see the term “science and technology” in ordering that seems to imply the scientific discoveries magically leap to develop new technologies. Of course, this is not true: engineering bridges the gap, technology is the result of both engineering and science. In fact, sometimes engineering leads to the technology without scientific understanding, thus stimulating scientific research into why something works.

The perspectives of science and engineering are not the same, though they depend on each other. The linear model of science, that engineers take scientific discoveries to solve problems and create new things is oversimplified and inaccurate. Sometimes engineering activities, for example, disaster preparedness recovery or space exploration cannot wait for scientific discovery.

Conceiving of engineering simply as applied science distorts the synergistic relationship of scientific knowledge and engineering practice, implying that engineers wait for science to lead the way. Engineering responds to wants and needs, not simply to the discoveries of scientists. And it often works at the cutting edge in a way that basic science cannot, leading the way well before scientific understanding catches up.

In my remarks today, I hope I have conveyed the role of engineering and systems thinking, both in relation to science and technology, and in efforts to prepare for and address inevitable surprises. The synergy between engineering and science will play a fundamental role in advancing the 12 key operational areas specified in Foresight 2050.

I strongly encourage you to promote investment in higher education of your young citizens, in both engineering and science, it will pay great rewards. As you plan for the future, I hope you will continue to consider the inner relations between decisions and goals— the essence of the engineering method— and the critical role of systems thinking in understanding and responding to disasters and other inevitable surprises.

I thank you for the invitation to address the 44th Annual Scientific Meeting of the National Academy of Science and Technology, Philippines. I extend my best wishes for an exciting forum ahead!