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Engineering Diplomacy: An Underutilized Tool in Foreign Policy

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IN recent years science has played a renewed role in the broader U.S. foreign policy tool kit. The term *science diplomacy* often elicits images of cooperation in basic research or academic exchanges. However, across a range of fields, other critical elements of science diplomacy—namely, the many and varied engineering disciplines—are often implicit, or merely taken for granted, when, in reality, they make possible the infrastructure for human civilization. The fundamental role of engineering in modern science diplomacy should not be overlooked. The intended objectives of engineering for diplomacy with other nations—developed and developing—can be as varied as supporting education and research capacity, exchanging faculty and students, and "building bridges" via partnerships to implement engineering and technology-related projects. Such activities have increasingly characterized recent programs at the U.S. Department of State and the U.S. Agency for International Development.

Modern engineering projects, highly interdisciplinary and using a multifaceted thinking process, can greatly contribute to economic progress and the bridging of differences between countries. Engineering can be characterized by two main features: a systems orientation and "design under constraints."

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"Engineering is about systems. The frontier[s] of engineering today are in tiny systems on the one hand and in macro systems on the other," describes Charles Vest, president of the U.S. National Academy of Engineering (NAE). The NAE's 2004 study, *The Engineer of 2020: Visions of Engineering in the New Century*, calls attention to the need for a "systems-based interdisciplinary" orientation in engineering research and education to address current global issues. The study concludes that the professional context for engineers in the future requires "the systems perspective and system-based approaches. . . . [This] needs openness to interdisciplinary efforts with non-engineering disciplines such as social science and business."

An operational definition of engineering is "design under constraint," which is attributed to William Wulf, former NAE president. In designing systems, engineers are "constrained by nature, by cost, by concerns of safety, reliability, environmental impact, manufacturability, maintainability, and many other such 'ilities.'" Waldemar Karwowski expanded on this concept in a 2005 paper in Ergonomics by addressing what he believes twenty-first century societies expect: design and management of systems that satisfy human compatibility requirements. Human Systems Integration methodologies allow the design and operation of a variety of natural and artificial products, processes, and living environments.

The NAE has had extensive discussions on the vital role of engineers in tackling and, hopefully, solving major global issues. In a seminal 2008 study, the NAE identified specific grand challenges, or opportunities, that await engineering solutions. The fourteen grand challenges cover the broad realms of human concern—sustainability, health, vulnerability, and joy of living—and include, for instance, providing access to clean water, making solar energy economical, and restoring and improving urban infrastructure. The study concludes: "Applying the rules of reason, the findings of science, the aesthetics of art, and the spark of creative imagination, engineers will continue the tradition of forging a better future."

Engineering activities are already well integrated into many formal, government-to-government agreements and memoranda for cooperation between the United States and other countries. Outside the government, many laboratories, universities, and private sector companies have even more extensive science and engineering relationships that complement official diplomacy.

Given the challenges facing foreign policy makers and diplomats in this broader context, engineering diplomacy, a key component of science diplomacy, could and should have a higher profile. It is in reaching out beyond the traditional state actors and building confidence between countries where engineering diplomacy has great potential and should be a major part of ongoing and future activities in diplomacy.

This is especially true in parts of the Middle East where engineers play important roles in cultural and political structures. For example, Diego Gambetta and Steffen Hertog showed in a 2007 study of Middle East and North African educational systems that engineering is considered one of the most prestigious subjects. In Iran, which has been a central focus for the U.S. foreign policy community, Supreme Leader Ayatollah Ali Khamenei declared in a 2005 speech that Iran's "most talented students have always studied at our technical colleges. . . . As far back as I remember, the most intelligent and most dynamic students were always admitted to various engineering colleges and similar centers of higher education." Given this prominence and respect, engineering and engineers provide a potentially influential community with which to work when developing broader diplomatic overtures.

Engineering Diplomacy Projects

Although the types of engineering-related confidence-building measures described in the following examples may be applied in many parts of the world, in this context they are focused on central Asia, the Caucasus, and the Middle East, where the United States has a strategic interest in either reducing tensions or developing links with key countries. These politically uncontroversial examples also share similar characteristics, including

- having a humanitarian focus (i.e., improving safety, health, and environmental conditions);
- being technology neutral (i.e., from the public domain, no need for transferring sophisticated technology, equipment, etc.);
- using systems-based capacity building (i.e., creating the thought processes and instilling the needed framework for "mindfulness" in system operations);
- being people-centric (i.e., the primary beneficiaries are ordinary people);
- being concrete (i.e., practical, short-term, and result oriented);
- targeting practitioners (i.e., focus is on operators, pilots, etc.);
- being mutually respectful and in partnership (i.e., not being condescending or infringing on the independence of the collaborating countries and associated professionals); and
- using interdisciplinary knowledge.

Improving Offshore Platform Safety in the Persian Gulf and Caspian Sea

The future of the fossil fuel industry requires exploiting deepwater offshore oil and gas fields. According to the International Energy Agency, about 30 percent of the world's oil production comes from offshore projects, and that amount is expected to grow. In addition to more deepwater drilling in the Gulf of Mexico, the practice is expected to increase in the Mediterranean, Black Sea, Caspian Sea, Persian Gulf, and the North Slope of Alaska, as well as off the coasts of China, India, Brazil, and Angola. This presents potential rivalries and challenges, but also opportunities.

While the explosion of the BP Deepwater Horizon offshore platform in the Gulf of Mexico on April 20, 2010, which killed eleven workers and caused one of the largest recorded oil spills in the world, was one of the worst environmental disasters in the history of North America, the Persian Gulf and the Caspian Sea areas have also suffered similar calamities.

On October 2, 1980, an exploratory well blew out in the Persian Gulf for eight days and cost the lives of nineteen men. The resulting spill threatened the neighboring countries of Saudi Arabia, Qatar, Bahrain, and the United Arab Emirates. In 1983 Iran's Nowruz oil field in the Persian Gulf was involved in several oil pollution incidents. Less than a decade later, catastrophic large-scale events took place in the Persian Gulf during and after the 1991 Gulf War. Between 0.5 and 1 million tons of oil were released into the coastal waters. Azerbaijan has also suffered a major oil platform blowout in 2008 and oil spills in the Caspian Sea that have seriously contaminated coastal waters and beaches on the Iranian side.

The lessons learned from the Deepwater Horizon accident are of paramount importance to the offshore platforms of the Persian Gulf, whether they belong to Iran or to member states of the Gulf Cooperation Council. In the Caspian Sea, for example, Kazakhstan's Kashgan field in the northeastern Caspian is the world's largest oil field discovered since 1968 and shares geological commonalities with the Macondo Well reservoir involved in the Deepwater Horizon disaster. Major reports by the Presidential Spill Commission in January 2011 and the National Academy of Engineering/National Research Council Committee (of which the author was a member) in December 2011 analyzed and captured these lessons, examining the importance of safety culture; how technologies, such as blowout preventers, performed; and practices involved in the probable causes of the explosion. To avoid future occurrences of such events, the analyses further identified available technologies, industry best practices and standards, and other measures in the United States and around the world related to oil and gas deepwater exploratory drilling and well completion.

Companies and stakeholder countries engaging in offshore drilling should proactively, voluntarily, and cooperatively address the institutionalization of safety culture at all levels—from the rig to higher levels of organizations to governmental regulatory agencies. Additionally, such initiatives should seek to balance national sovereignty over territorial waters with international responsibility to neighboring countries, thereby incentivizing countries to engage in a mutually beneficial practice of engineering diplomacy. By-products of such safety centric confidence-building collaborative efforts could be better relations and more efficient communication between countries.

Improving Nuclear Safety and Sustainability in the Caucasus and Central Asia

The safety of nuclear power plants transcends national borders, as radioactive fallout does not recognize victims by nationality, creed, religion, race, or even the content of their character, and so, as nuclear physicist Alvin Weinberg said, "a nuclear accident anywhere is a nuclear accident everywhere." Never in the history of humankind have the activities of a relatively small group of people—those involved in the running of a nuclear power plant—in one country have the potential to affect the livelihood of large populations in neighboring countries or regions.

On March 11, 2011, a series of catastrophic events triggered the Fukushima Daiichi Nuclear Power Plant crisis in northern Japan. While tragic in their own right, the monstrous 9.0 magnitude earthquake and ensuing powerful tsunami also led to the unprecedented "secondary" and "tertiary" anthropogenic disasters of reactor meltdown, fire, and radiation release. This created regional concerns about potential fallout and medium- to long-range transport of radioactive material. It was later discovered that the root causes of this human-made disaster were a nearly nonexistent independent nuclear regulatory oversight system in Japan and the ineffective or woefully weak safety culture of the utility—Tokyo Electric Power Company, or TEPCO.

On December 7, 1988, Armenia experienced a devastating 6.8 magnitude earthquake. The quake caused a prolonged shutdown resulting from a controversial debate about the safety and future of the Metsamor Nuclear Power Plant, which supplies approximately 40 percent of Armenia's electricity, because of an exposed vulnerability. A massive 7.2 magnitude earthquake again struck the region on October 23, 2011, near eastern Turkey, with tremors recorded throughout Armenia and felt in the capital, Yerevan.

These examples illustrate that extreme natural disasters can trigger rare, but nonetheless probable, events with severe safety implications. It is therefore imperative that barriers to safety culture-related problems and their adverse impacts on plant safety operate effectively 365 days a year, 24 hours a day. Incidents such as Fukushima, and other disasters like Chernobyl, should spur the collection, analysis, and dissemination of knowledge about seismic safety, as well as general nuclear engineering, throughout the global nuclear community. Sharing these lessons can be immensely valuable in efforts to enhance the safety of nuclear power plants worldwide by providing the most up-to-date guidance on actions to take before, during, and after earthquakes.

Such efforts should welcome openness and transparency to help countries develop regional and international cooperation among nuclear-powered countries and their neighbors. For instance, after the Fukushima incident, certain countries in the Central Asian and the Caucasus regions have demonstrated heightened sensitivity and expressed concerns about safety and the vulnerability of Metsamor. The recent public dispute between the Azerbaijani president, Ilham Aliyev, and the Armenian president, Serzh Sargsyan, over their diametrically different positions on the safety of Metsamor, in front of more than fifty world leaders at the Nuclear Security Summit in Seoul on March 27, 2012, is a further testament to the importance and urgency of this matter. Again, such engineering diplomacy initiatives incentivize neighboring countries to engage by focusing on issues of mutual concern that benefit from cooperative problem-solving, resulting in interactions that could lead to better relationships.

Improving Civil Aviation Safety in Iran

Iran has one of the worst civil aviation safety records in the world, with 10 percent of world aircraft hull losses at a rate of 1.5 fatal accidents per year. Two major crashes involving Tupolev and Ilyushin aircrafts in July 2009 killed a total of 184 people. Iran's most recent aviation accident involved a Boeing 727 carrying 105 passengers and crew that crashed on January 9, 2011, in the suburbs of the city of Orumiyeh, killing at least 77 people and injuring 27 more.

Many Iranian officials have long blamed the West, especially the United States, for many of the country's air crashes. These officials single out U.S. sanctions that prevent upgrades to the country's aging aircraft fleet and the obsolete equipment in the country's air traffic control system as the primary cause for the high accident rate and the generally degraded state of aviation safety. Although sanctions do play a significant role, Iran's civil aviation sector suffers from multiple problems, only some of which are related to equipment and hardware. In fact, most crashes involved Russian-made aircraft, which were not affected by the U.S. sanctions. Iran's aviation safety issues include, but are not limited to, poor maintenance and repair practices; lack of modern aviation safety technology, know-how, and training; lax or inadequate safety regulations; unclear regulatory oversight; sporadic enforcement; and lack of institutionalized, interdisciplinary, and standard accident investigation procedures. It is noteworthy that the January 2011 crash, the fourth fatal air crash in Iran over the last two and a half years, resulted in the impeachment and removal of Iran's transportation minister, Hamid Behbahani, who reportedly employed managers with poor knowledge of aviation and allowed the use of dilapidated planes.

During the last decade, representatives of the nongovernmental U.S. National Academies conducted a series of collaborative activities with their Iranian counterparts in such fields as public health, nutrition, environmental protection, and earthquake research and seismic safety. Aviation safety is another potential area where increased interactions between technical experts—engineering diplomacy—could help build trust while addressing important safety concerns to improve civil aviation safety in Iran through the Safety Management System and Human Systems Integration training. The primary objective of an aviation safety collaborative project is to bring together cognizant U.S., European, and Iranian policy makers and professionals from public and private sectors to share their knowledge and experiences (with *no* need, at least initially, for any part or equipment transfer).

This case illustrates how engineering diplomacy can offer an apolitical and sustainable alternative for countries with poor diplomatic ties to engage one another, such as the West with Iran. The overall outcome serves two desirable and mutually reinforcing goals: in the short-term it will save lives and boost relations between the West and Iran, and in the long run it could eventually lead to modernization of Iran's civil aviation industry.

Conclusion

As Thomas Jefferson wished, "I hope that our wisdom will grow with our power, and teach us that the less we use our power the greater it will be," engineering diplomacy is about using a country's wisdom and its best minds over its brute force. It is about using systems-oriented, proactive vision and innovative initiatives requiring engagement, collaboration, and negotiation instead of shortsighted policies of isolation, containment, sanctions, and gunboat diplomacy. Engineers are mostly trained to be mindful of "constraints" while generally searching and settling for an "optimal" solution, which may not necessarily be the "best" or "ideal" solution to a given problem. This optimization process is a key ingredient for appreciating the limitations of diplomacy while taking full advantage of its potential. SD