MEMO #25

PROMOTING ADVANCEMENTS IN SCIENCE, TECHNOLOGY, AND HIGHER EDUCATION: Increasing Government's Capacity to Manage Complex Policy Issues

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How can government use science and technology to keep the engine of innovation running through the 21st Century? Innovation is essential to a technological society. It produces economic growth, reduces debt, promotes civic stability, and helps to resolve the most pressing challenges that public officials face. Without innovation, economies stagnate, civility crumbles, and challenges accumulate.

Four policy initiatives are essential to the maintenance of a culture of innovation based on science and technology:

- Encourage people to understand science and technology, especially through the promotion of STEM education;
- Search for innovative solutions to policy challenges, especially those based in technology;
- Understand how technologies reshape the forms of governance that public officials use to manage complex policy issues; and
- Promote the rise of administrative systems with "nobody in charge."

Recommended Actions

1. **Understanding Science and Technology**

   An educated populace is essential to advances in technology, not just for the purposes of creating innovators, but for the enlightenment of the people served by them. Thomas Jefferson, an advocate of the Enlightenment, wrote a letter to George Wythe dated August 13, 1786, in which Jefferson stated that the most important pieces of legislation that office-holders could enact were those that provided "for the diffusion of knowledge among the people; no other sure foundation can be devised for the preservation of freedom, and happiness."

   The diffusion of knowledge is no less important today. Much of what modern science reveals seems counterintuitive. When in 1919 Robert Goddard proposed the use of rockets to reach the

Moon, editorial writers at the *New York Times* famously lampooned the proposal. The writers incorrectly observed that a rocket would not work in the vacuum of space because the device would have nothing against which to react. Goddard knew this to be false, having already conducted small propulsion experiments in a vacuum.

STEM education helps people separate scientific understanding from common experience. As this essay suggests, that education extends to the forms of governance associated with various technologies as well as to the basic science itself.

2. Technology and Policy

New technologies not only produce economic growth and personal comfort; they often provide fresh solutions to pressing policy challenges. For example, arms control agreements would not have been possible without advances in detection technology. During the early and most dangerous phases of the Cold War, national leaders like President Dwight Eisenhower sought methods for reducing atomic weapons proliferation and preventing a nuclear Pearl Harbor. Officials in the Soviet Union resisted the on-site inspections and aerial overflights that would make this possible. Imaging technologies, both ground and satellite-based, provided a workable alternative. The devices operated not just in the visual spectra but also through infrared and neutron-detecting means. Neutron technology allowed intelligence analysts to distinguish between prohibited multiple-warhead missiles and permitted single-warhead devices.

New technologies not only provide fresh solutions to policy challenges; they also force changes in the way policies are carried out. Few technologies illustrate this process better than the self-driving car. Through a series of prizes offered in the first decade of the 21st Century, officials at the Defense Advanced Research Projects Agency (DARPA) encouraged the development of self-driving cars. The purpose of the prizes was not to improve personal automobile safety, but to reduce the need to expose military convoy drivers to injury and death from roadside bombs.

The technology has profound implications for the ways in which public officials promote automobile safety. Since the appearance of the automobile, highway collisions in the United States have killed more Americans than have died in all the wars fought since the founding of the nation (roughly 3.6 million motor vehicle fatalities compared to 1.2 million deaths in service). Efforts to reduce traffic fatalities by conventional means have produced reductions in annual deaths of about 30 percent – seat belts, air bags, stricter enforcement of drunk-driving laws, and more traffic patrol.

Enter the self-driving car. The self-driving car is the quintessential GRIN technology, a robotic device programmed to behave intelligently without anyone immediately in charge. The acronym refers to innovations based in genetics, robotics, artificial intelligence and nano-technology. It is most frequently spelled GRN, with the "I" added to emphasize the artificial intelligence contained in robotics.

Fully developed, self-driving cars have the potential to reduce the occurrence of collisions to aircraft technology levels. (A May, 2016, Tesla fatality occurred in a car operating under assisted automatic control requiring driver participation.)

The potential for change is profound. Self-driving cars represent what various observers have characterized as a disruptive innovation. The technology has the power to alter traditional approaches to traffic safety, accident investigation and highway patrol. Additionally, it will change the way in which cars are bought, sold, parked, owned, and insured.

3. Reshaping Governance

Such changes embody one of the most significant lessons for persons formulating science and technology policy. Disruptive technologies produce their own forms of governance. Attempts to maintain new technologies within old forms are subject to inevitable frustration. New technologies produce new forms. The ability to anticipate those forms is essential to the encouragement of innovation.

The history of technology and administration shows how this works. The age of metal and associated weaponry helped to foment the paramilitary organization, with its emphasis upon division of work and strict hierarchy.

The age of industrialization produced the factory system, characterized by the assembly line and the stopwatch for timing the pace of production.

Modern record keeping allowed the advent of the bureau, giving prominence to governance systems based on rules, impersonality and a permanent career service.

Irrigation, dam building and spaceflight led to the project form of management, varying between its more traditional forms for construction projects to advanced versions like those developed for Project Apollo.

The Internet produced electronic government, allowing citizens to file their taxes online and obtain permits without visiting a real person.

These forms of governance often coexist alongside each other. Police and fire departments still utilize the paramilitary form. The factory system is alive on production lines, especially in countries that employ cheap labor to produce physical goods. Social Security and Medicare would not be possible without bureaus. The National Aeronautics and Space Administration uses large scale systems management to operate the International Space Station. Electronic government is everywhere.

The movement to new forms encourages policy innovation. Without the advantages gained from the establishment of bureaus one century ago, creation of the social welfare state would have been impossible. Its advocates would have remained mired in a governance system organized around political bosses in which offices were awarded for political loyalty and office-holders sought to enrich themselves with the spoils of government. Without the rise of project management, a modern alternative to bureaus, Americans would have never flown to the Moon.

Just as past forms of technology encouraged newer forms of governance, impending technologies will produce altered ones as well. Experts agree that the most technologically

advanced nations stand on the cusp of an era dominated by GRIN technologies. GRIN technologies will produce their own governance forms. It is as inevitable as the rising of the sun. Adjusting old forms of governance to fit new forms of technology will be one of the toughest challenges facing people who deal with innovation through science and technology.

4. Emerging Governance Forms

The shape of those forms is becoming more apparent. Not surprisingly, the shape tends to embody the nature of the technologies. GRIN technologies are characteristically smart, reliable, and typified by organizational systems with *nobody in charge*.

Smart systems refer to creations or processes in which the overall system is more intelligent than the parts that make it up. Scientists offer beehives as an example, characterizing the operation of the hive with a concept known as swarm theory. Individual bees are not very smart. Their collective behavior, however, produces an entity that is superior in intelligence to the elements within it.

Augmenting the nature of intelligence, the smart system is characterized by the absence of central control. No superior intelligence governs the behavior of the hive. Its intelligence emerges spontaneously when individual bees follow a few simple rules. In this case, nature and evolution produce the rules.

Similar characteristics govern the behavior of many human organizational forms. Markets and conventional auto transport systems operate this way. Individual producers and consumers participating in a free market create highly efficient supply and price decisions without any central planning body to resolve those matters. Automobile owners driving their own cars can create a smooth flow of freeway traffic without any central command mechanism.

People who believe that modern technologies require central control systems for daily operations are mistaken. Their ideas are as misplaced as those of zealots who believe that the operation of the universe requires a Creator to guide it. At least, that is what the advocates of new governance systems proclaim.

5. A Role for Governance

So, what is left for government to do? Some rules arise spontaneously, without anyone in charge. Left to their own devices, automobile drivers will naturally determine whether to drive on the right or left side of the road. It is in their self-interest to do so. Yet some rules can be centrally created. In the genetics field, natural process will produce beneficial genetic modifications if given enough time, but intelligent beings can speed up the process through gene-splicing and other techniques associated with biotechnology.

Suppose that a group of public officials wanted to create a new and less expensive method of space transportation. The officials could assign the task to a government field center, which could prepare a viable design and contract out the fabrication to an industrial firm. That would be a traditional approach.

Alternatively, officials could create a series of support mechanisms and incentives (such as an agreement to purchase new systems) that encourage entrepreneurs to build their own rockets and space ships. Such partnerships draw on natural processes present in the market place. The process requires no public official centrally in control of design and fabrication, but does require the creation of viable incentives.

This is the method used by the National Aeronautics and Space Administration (NASA) to create a successor to the space shuttle. It may be the method that pushes humans to Mars.

Sometimes the rules governing human arrangements arise spontaneously. More often, they require someone to devise and enforce them. A market, for example, requires processes for protecting property and enforcing contracts. The incentives for following the rules must be sufficiently strong to elicit compliance – in other words, the rules must work to everyone's advantage overall. Once in place, the system runs on its own. In that sense, the system requires no central governing body to achieve maximum efficiency.

Conclusion

To return to the first point, education is critical to these developments. Not only does an innovative society require a citizenry informed about science and technology, it requires leaders who understand the relationship between technology and governance forms. Those forms shift significantly as new innovations appear. Societies that succeed technologically are likely to be characterized not only by a strong emphasis upon education for science and technology, but by close collaboration between educators who teach STEM subjects and those who teach business, governance and the methods of innovation.

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