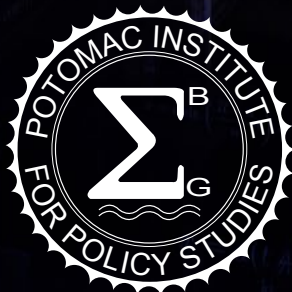


# THINK BIG

**BIG Science, BIG Opportunities,  
and BIG Ideas**

**December 2016**



**POTOMAC INSTITUTE FOR POLICY STUDIES**



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# INTRODUCTION

The election of a new president offers the country an opportunity to remake America with the innovation, inspiration, and leadership that has characterized us for two and a half centuries. America has always led the world in technology, new and big ideas, and a forward leaning approach to problems and challenges. Once again, it is time for the country to embrace BIG bold new projects and make America Great Again.

The priorities of the new Administration are to rebuild American infrastructure and reinvigorate the economy. Rather than return to the infrastructure and economy of the past, we should look to the future and think big. America's strengths in innovative science and technology will help us leap forward and maintain our economic strength and global leadership.

The Potomac Institute was founded over twenty years ago in a politically turbulent era – Newt Gingrich and the Republicans had just taken over Congress, written their Contract with America, and dissolved the Office of Technology Assessment (OTA) on the premise that it was too partisan when dealing with science and technology policy issues (a decision that has been much debated since). The Potomac Institute was founded to fill the role of a non-partisan, objective, and technically competent advisor to Congress and the Administration, regardless of party. The Institute was founded on the principles that 1) science should inform policy and 2) policy should foster the growth of science. Most importantly, the Institute anticipates emerging technologies and their associated policy implications, and uses this knowledge to guide investments toward shaping our desired future.

## **We urge the new Administration to develop policy based on the best available science.**

In policy-making, the best available science can take many forms – from technical and experimental data to economic data to social science research findings. Most important, however, is that policy be informed by the available information on potential impacts. Often policy-makers must make decisions based on incomplete or insufficient data – in those cases, we must use what is available and then support efforts to increase the available data. The concept of using science to inform policy should be non-partisan; data and evidence should form the basis of solid policy that all can agree on.

## **We urge the new Administration to foster the development of science and technology.**

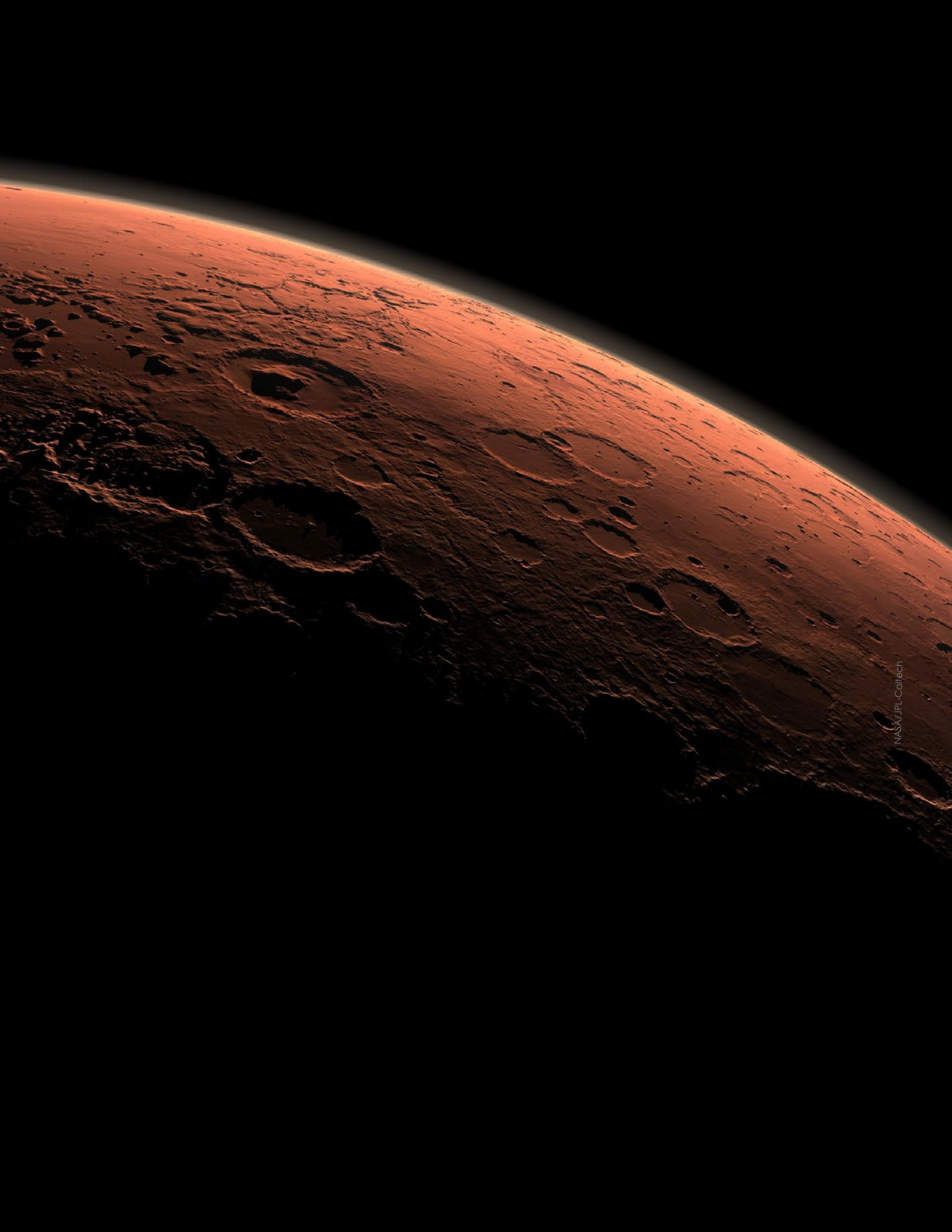
Economic development starts with good ideas and translation into products, and industry and government each have important roles in this process. If America leads the world in innovation, economic strength will follow, but to get there we have to focus on big ideas for the future rather

than trying to return to the successes of the past. The science and technology investment priorities the Institute has identified for the next Administration include:


- **America's Future Infrastructure:** Major public investments to achieve great things are a hallmark of American history; we went to the Moon, built an atomic bomb, built an interstate highway system, and created the internet. When we set big goals and invest in the science and technology needed to achieve them, the benefits are enormous. We need revolutionary new infrastructure projects to drive America forward, not just fix what is broken.
- **Fostering American Industry Leadership:** The U.S. needs a strategic national industrial policy to drive economic development and preserve industries that are vital to national security. This industrial policy should focus on fostering American innovation, helping American companies stay competitive in a global marketplace, and protecting intellectual property (IP).
- **Revolutionizing Medicine:** Advances in genetics, precision medicine, sensors, and big data analytics hold great promise to revolutionize human health. The costs and inefficiencies of the American health care system could be vastly improved by leveraging technology, putting more power in the hands of patients, and adapting the medical workforce.
- **Climate Engineering:** We can use science to engineer our way out of the climate challenge. The fields of biotechnology and climate engineering promise immense benefits but also represent unprecedented power to shape the world around us, in ways we may not yet fully understand. The government plays an important role in fostering innovative research and ensuring responsible development of biotechnologies.

Innovation in science and technology are the keys to American economic strength and national security. We will not lead the world by investing in old technology, old infrastructure, and old ways of doing business. The way to maintain America's leadership and keep our country and economy strong is to think big.





NASA/JPL-Caltech



**“I welcome and seek your ideas, but do not bring me small ideas; bring me big ideas to match our future.”**

***Arnold Schwarzenegger***

# AMERICA'S FUTURE-STRUCTURE

The new Administration has identified infrastructure projects as a top priority. We must not merely rebuild or fix our current infrastructure; rather, we must reimagine the infrastructure of the future and invest in the technologies and businesses to achieve that future. The country has a unique opportunity to imagine and build a new America – to be the world leader in infrastructure innovation. Major infrastructure projects of the past, from the National Highway System to the commercial aviation system, have launched new industries and driven major economic development. America's future will be a world of autonomous vehicles, universal access to information, and unlimited energy. To reach this future, we need an innovative infrastructure investment plan.

Our Future-Structure will include:

- **Autonomous vehicles** that free humans from driving, accidents, and vastly reduce the costs of travel. Automated flying vehicles will revolutionize both commercial and personal travel.
- **Ultra high-speed internet access** will be a universal right and will be available to the entire population just as fresh water is a national mandate, today. Entire new industries and intellectual freedoms will be born out of universal access to mankind's knowledge base.
- **Super high-speed travel** will usher in a new age of trade and transportation. Vast distances will be covered in minutes via ultra high-speed trains, super-sonic planes, and hyper-loop cargo systems.
- **Inexpensive energy** will become a reality through new methods of generating and storing energy, not via a new grid but by eliminating the grid. Every home, vehicle, and electronic device will generate its own power from the vast energy provided by natural forces. Large, nationwide energy grids will become obsolete.
- **Education will be revolutionized** when we put an iPad in the hands of every child in the country, giving them access to the world's knowledge and customized, self-paced learning. The next generation will know more and be more enabled than ever before.
- **Deep-space exploration** and colonization will become possible, and eventually routine. The U.S. will become the global hub for space travel.

## RECOMMENDATION

**America needs an infrastructure investment plan for the future.** We must leap ahead of current infrastructure systems to meet the technology-enabled demands of the next 50 to 100 years – and beyond. With a mandate to “rebuild America,” the new Administration has an opportunity to radically transform America's infrastructure and ensure our status as the world's economic and technology leader. Let's embrace the future, not rebuild the past.

## Autonomous Vehicles

The future of transportation is autonomous vehicles, both on the road and in the sky. This previously unimaginable future has arrived, but the technology is outpacing government action and the country's infrastructure. The benefits of autonomous transportation for personal and commercial transportation are enormous. We need an infrastructure plan to support and take advantage of autonomous technology, not a fix for the roads of the past.



Autonomous vehicles will revolutionize American society in the near and long-term.

- **Autonomous vehicles will drive America's economy.** Autonomous vehicles are an imminent future technology, but it is also this future that should be embraced. The McKinsey Global Institute estimates that the overall economic potential from autonomous vehicle technology will be as high as \$1.9 trillion annually by 2025. Morgan Stanley estimates that autonomous vehicles will contribute \$1.3 trillion in annual savings to the U.S. economy by increasing productivity.
- **Autonomous vehicles will increase efficiency.** In the near future, autonomous trucks, buses, cars, and drones will operate across the country. Logistics of the cross-country transportation of goods, the productive utilization of a commuter's time, and the near-instantaneous delivery of items purchased online are just some of the ways that autonomous vehicles will boost efficiency. Self-driving vehicles can provide a competitive edge for the U.S.
- **Transportation will be safer than ever.** Autonomous vehicles eliminate human error. Autonomous vehicles can also provide immediate reactions to real-time information about traffic, road conditions, and weather, far beyond the capacities of human beings. McKinsey estimates a 90 percent decrease in accidents, saving the U.S. \$180 billion annually in repair and healthcare bills alone.

## RECOMMENDATION

**The President's infrastructure plans must foster the growth of autonomous vehicles.** The technology of autonomous vehicles is already here and represents significant potential for economic growth and jumpstarting new industries. The Federal government must invest now in the infrastructure needed for autonomous vehicles. Stakeholders from the auto industry, suppliers, regulators, and related industries such as transport and logistics, insurance, and health care should be consulted to create a national plan for autonomous vehicles. The Department of Transportation and other federal agencies should incorporate plans for autonomous vehicles into all surface transportation infrastructure projects. The Federal Aviation Administration must provide new regulations and guidance documents to establish a National Spaceway System for the safe development of drones and flying vehicles.

## Internet

Low-cost, high-speed internet access for every American will be essential for basic living in the future. As technology continues to permeate every facet of our life, it is essential that our connection to devices be fast, secure, and available to all. High-speed connections for every individual, every project, and every device will be a key enabler for other future infrastructures, including energy, education, and autonomous transportation. Universal access to the internet will allow entire new industries to emerge and significantly impact our economy. The democratization of knowledge resulting from this connectedness will have profound impacts on American society; lack of access to information will no longer be a barrier to success.

American society will be built on the world's best internet infrastructure.

- **Internet must become a public utility**, distributed and regulated like electricity, gas, and water. In the near future, high-speed access will be viewed as a universal right. Staying connected will be just as essential to life as food, shelter, and water.
- The **Internet of Things (IoT)** will be enabled by increased bandwidth, providing the backbone of America's future infrastructure.
- Creating **new internet architectures** will enable the flexibility to deploy different networks for specific purposes, or to protect sensitive government, military, or critical infrastructure systems. Physically distinct and multiple internets are needed in these areas to keep our networks safe.

### RECOMMENDATION

**The new Administration should work with industry to ensure all Americans have universal, affordable access to high-speed internet.** The government must regulate and protect internet infrastructure given its importance to our society and security. The Federal Communications Commission should classify the internet as a public utility. Congress should draft a bill that provides minimum standards on all internet services and makes high-speed internet affordable for all Americans. The bill should include funding to purchase unused fiber from commercial providers and to install new fiber where necessary. It must also include a directive to create physically distinct internets for critical services.



## Super High-Speed Travel

Future high-speed travel will allow coast-to-coast travel in less than an hour, over land or by air. This will impact both human travel as well as freight, and will be a key driver for the U.S. economy. Achieving unprecedented speeds will require investment in big infrastructure and big science. Just as the Transcontinental Railroad and Interstate Highway System revolutionized transportation – and therefore industry – in the respective times in which they were built, ultra high-speed travel will revolutionize the future of American transportation and enable new industries to emerge.

Land and air-based super high-speed travel will revolutionize travel and our economy.

- **Hyperloop** transport propels pod-like vehicles through a near-vacuum tube and is capable of speeds faster than current commercial aircraft. It is quiet, autonomous, and highly energy efficient, and can be used to transport both freight and passengers. The external structure's solar panel roof will produce net energy that could be sold to electrical grids or consumers to recuperate additional costs.
- **Commercial supersonic and hypersonic flights** will reduce long-distance domestic and international travel times by orders of magnitude. In today's globalized world, the speed of international travel is frustratingly inefficient. In the early days of commercial air travel, the U.S. government invested in the infrastructure needed to build airports and design air traffic control systems to ensure safe and accessible air travel. High-speed air travel is technically mature; infrastructure investment is needed to integrate these flights into the existing commercial aviation system.

### RECOMMENDATION

**The new Administration should launch a major infrastructure project in high-speed commercial travel.** The government should partner with industry to facilitate the development of these technologies and subsidize the building of the infrastructure necessary for its success. A public-private partnership would see these futuristic transportation methods become commercially viable within the next decade, thereby boosting the U.S. economy and making America the world leader in transportation.



## Energy

The U.S. must fundamentally redesign its energy infrastructure to provide all Americans secure, reliable, low-cost, unlimited energy. To achieve this, we must not fix or even rebuild our national grid; rather, we need to end our dependence on it for energy. New methods of generating and storing energy will enable every home, vehicle, person and electronic device to power itself.

America's electric grid, on which every other aspect of critical infrastructure depends, is highly vulnerable. Any of the following could decimate the system: direct physical attacks, cyber warfare, and natural or manmade EMPs (electromagnetic pulses). The electric grid is antiquated, originally designed with the aim of electrifying the country, but without consideration of the risks of physical or cyber attacks of modernity. Today, we must reimagine and redesign energy infrastructure based on decentralization and user-based energy generation.

A reimagined energy infrastructure, based on household or community-based microgrids, will be the backbone of America's future.

- **Independence from the national grid** will be achieved by turning every house into its own power generation and storage unit. Individuals will be responsible for their own energy consumption and unused energy can be sold as a commodity or shared within a neighborhood microgrid.
- **Unlimited, almost-free energy** will be available to all Americans in a user-generated system. The cost of renewable energy technology is steadily declining. Installation into every device and every household will soon become standard.
- **Security and reliability** will be ensured through the decentralization of the energy grid. The decentralization and volume of micro and individual grids will make the system less vulnerable to terrorist attacks.

### RECOMMENDATION

**The U.S. government must develop an energy infrastructure plan that goes beyond fixing and securing the current grid and that prepares for the future.** The government needs to support research into next-generation batteries and renewable energy technologies. Subsidies should be provided to companies developing renewable energy technology and self-powering devices. Grants should be offered to citizens installing technology to make their homes and neighborhoods independent from the national grid. To improve security, funds should be diverted from upgrading the national grid to creating microgrids for neighborhoods and municipalities.



## Education

America must reimagine its education system for the digital age. Technological advances will enable every child to receive an individualized education, armed with mankind's complete knowledge base and enabled as no previous generation has been. Instead of physical schools and libraries, personal electronic devices and free high-speed internet access will be the required infrastructure for the future of education. Personalized education will begin in the home, as soon as a child is able to hold an iPad. Customized digital lessons will allow school-age children to be challenged and reach their full potential. A reimagined education system for a digital future will allow students to innovate rather than simply learn.



- **The role of teachers will fundamentally change.** Traditional approaches in which one instructor teaches a classroom of 30 students of varying skill levels will become obsolete.
- **A virtual library** with full access to the world's knowledge base will be provided to learners of all ages. Funding for physical books should instead go toward technological infrastructure and learning resource databases. Unlimited access to humankind's accumulated knowledge will transform education from memorization and fact-regurgitation to critical thinking and innovation.
- **Redesigned curricula and evaluation procedures** will create a new system for personalized education. Core curricula should be modernized to include courses in programming, engineering, and critical thinking from the beginning of grade school. Standardized testing will become obsolete, as students are continuously evaluated in real time. Evaluation of the system, an individual's progress, or a population's performance will be automated. Adjustments to the pace and curriculum to meet the needs of individual students will be in real time.

## RECOMMENDATION

**The next Administration must set a new vision and plan for education that starts in early childhood and uses modern technology to personalize learning.** Personal electronic devices and high-speed internet access will form the backbone of education infrastructure in the future. Technology outfitted with educational software must be provided to every child in America before they reach grade school. Public schools must be equipped with technology that can accommodate digital learning that occurs both at home and at school. The Federal government should work with educators and industry to develop educational software and curricula capable of delivering personalized education.

## Space

America must become the global hub for all space tourism, deep-space exploration and colonization ventures. The future of American space exploration is manned, deep-space missions within our galaxy and beyond. Building the infrastructure for this future is a challenge that can only be met by the best minds from government, industry, and universities. American-led colonization will push the boundaries of science and engineering, and ensure the long-term survival of the human race.

The U.S. must lead the way in developing technology and building infrastructure for deep-space exploration.

- A **space elevator**, or another non-rocket space launch method, is imperative for long-term, deep-space exploration. Rocket launch costs are exceedingly high. Significantly reducing the cost of putting objects into orbit with a space elevator will make possible many of the proposed large-scale space projects, such as space colonization.
- **Colonization infrastructure** can be built ahead of human arrival. From building habitats to producing rocket fuel at the destination, advances in additive manufacturing technology and robotics will enable human colonization.



- **Commercialization of space** infrastructure, such as asteroid mining and orbital propellant depots, will be built through private investment. The commercial space industry is currently flourishing with \$1.8 billion venture capital investment in commercial space startups in 2015, nearly double the amount invested during the previous 15 years combined.
- **New propulsion technologies** will make deep-space travel feasible. In-space propulsion technologies that move beyond chemical propulsion, such as plasma engines, ion drives, EM drives, solar sails, magnetic sails, nuclear fission and fusion reactors, and antimatter rockets, will enable us to travel to beyond the reaches of our solar system.

## RECOMMENDATION

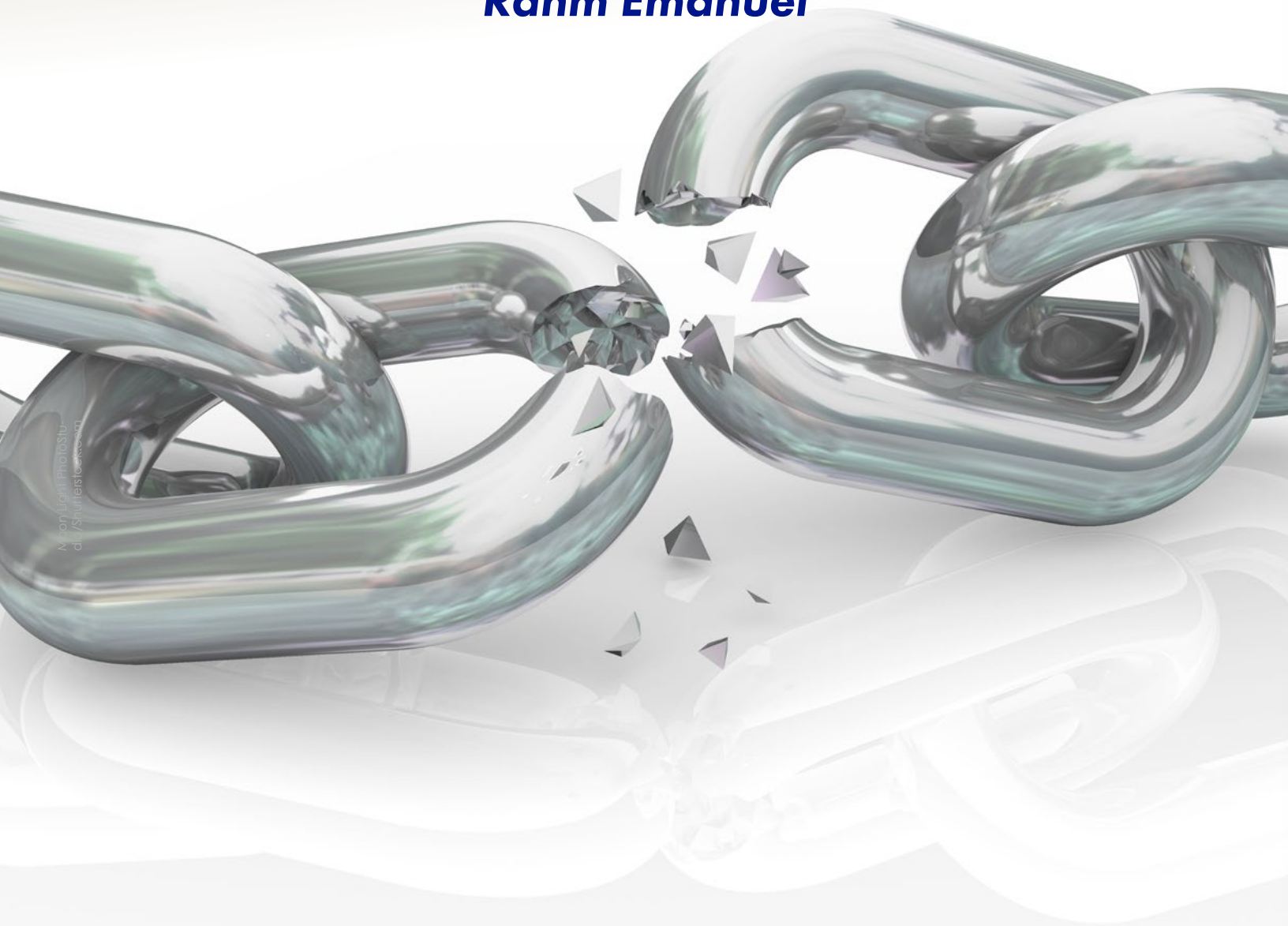
**America must renew its quest for space exploration by funding space research and incentivizing private investment.** Government should convene a public-private forum in which stakeholders can discuss the opportunities and obstacles surrounding space commercialization. Congress must fund key NASA programs to push scientific and engineering solutions to make deep-space exploration a reality. Private investment must be protected and encouraged by defining a modern legal regime for space.





**“The American  
people...want change.  
They want big ideas,  
big reform.”**

***Rahm Emanuel***



# FOSTERING AMERICAN INDUSTRY LEADERSHIP

The future of American industry should be to maintain its position as a world leader by employing a bold, strategic national industrial policy. Instead of reacting to the forces of globalization, America should harness the forces of globalization to our benefit. We should be the major pioneer of new industries, and a nation that works with global supply chains, while maintaining a robust and secure domestic ecosystem to prevent reliance on other countries. This is necessary not only for economic vitality but also for national security.



## ***Harness Globalization to Benefit the U.S.***

Globalization has allowed large and small companies in every industry to operate without allegiance to any single country. Instead of fighting that reality, we should leverage America's strengths to incentivize companies to bring their business to the U.S.

- **Respect and Protect Ideas.** A major strength of the American business environment is that companies that invest in innovation can profit from good ideas. In today's global marketplace, IP protection has become highly valuable, but current systems need updating to keep pace with the rapid rate of technological change. The damages to the U.S. economy due to IP theft have also grown to the level of hundreds of billions of dollars per year. A new IP system is needed that is based on two simple principles: 1) if taxpayer dollars funded the creation of the IP, then the public owns it, and 2) if IP was generated in the American private sector, then our country should put its full weight behind protecting that IP on the global market. The U.S. needs to show the world that it is a place where IP rights are clear and protected.
- **Change Industrial Tax Policies to Bring Companies to the United States.** U.S. tax policy currently incentivizes some companies to move their operations and profits offshore. The U.S. has one of the highest corporate tax rates (35%) in the world, and taxes U.S. companies on foreign profits, which leads them to stash foreign earnings offshore rather than bringing them back to the U.S. These policies are counterproductive and dis-incentivize businesses from operating in the U.S. or investing their earnings in the U.S. economy. Industrial tax policy should make it more attractive to bring businesses here, guided by the principles that if companies want to sell here, they should put their business here. This would include reducing the corporate tax rate to a globally competitive rate of 15% and encouraging reinvestment of foreign profits in the U.S. without penalty.
- **Protect industries that are critical to national security.** In failing to recognize the reality of global supply chains, the U.S. has also come to rely on other countries for critical resources, leaving strategic industries vulnerable to manipulation by our adversaries. We need to recognize that some industries – such as energy and semiconductors – should not be fully globalized, because they introduce fundamental vulnerabilities. A bold industrial policy must operate based on the principles that we must protect our vital industries. Providing tax reductions to industries critical to our national security would incentivize a healthy domestic ecosystem for those industries. If an industry is critical to our national security, we should be willing to take extra steps to ensure its protection.



## Creating the Industries of the Future

Commercial industry changes at much faster rates than the U.S. government. New industrial policies need to look to the future of industry, not the present. Countries have the most to gain by being the heart of innovation in existing and emerging industries.

- **Invest in Research and Development (R&D) to seed the industries of the future.** The industries that will be of major global significance in the next 10 to 20 years are evident today, and the U.S. government should invest in helping them grow in this country. The scientific fields of bioengineering, neuroscience, materials science, and machine learning have rapidly advanced, producing a wealth of knowledge that will drive the development of new technologies. The U.S. should place considerable focus on funding applied R&D in these areas, to harvest the many fruits that basic research has yielded.
- **Foster innovation and transition hubs.** Centers for Industrial Innovation (CII) can accelerate the generation of new technologies and start-up companies, as well as provide workforce development. If the Federal government is an active player in such centers for innovation, it allows for continued access to new ideas that can be transformed into technologies uniquely suited for government applications. Government input and funding of such centers will insulate them from becoming captive to the largest players of the industries they support. Connecting these CII to Regional Extension Centers (a major policy program that propelled the agricultural revolution of the last century) will help U.S. companies leverage emerging technologies sooner, allowing faster increases in industrial efficiency.

## RECOMMENDATION

**The U.S. needs a unified strategic industrial policy that leverages America's strengths on the global stage. The White House should release a public document detailing an industrial policy strategy within the first 100 days.** Such a policy should make the financial environment easier for companies to bring their business to the U.S. – including lowering the corporate tax rate to 15% and not taxing international profits brought into the U.S. As well, it should consolidate copyright and patent laws into a single, simplified legal structure for IP protection. These new policies should focus on protecting American IP globally, making companies pay their fair share for goods sold in the U.S., and incentivize companies to bring their business back to this country. The U.S. should also institute policies focused on creating industries of the future by funding R&D efforts in strategic areas that will seed emerging industries, fostering the formation and growth of centers for industrial innovation, and supporting advancements in and widespread adoption of automation in all industries. With these policies, American industrial leadership will be driven by the smartest workforce in the world, strong IP protections, innovative research and development, centers that transition ideas into new technologies and markets, and economic policies that help businesses thrive.

## Supporting Industry through Intellectual Property Protection

Good ideas are a key source of potential profit for American enterprise investments in innovation. A good idea is worth far more if a company knows the idea cannot be stolen. In today's global marketplace, IP protection has become highly valuable, but current systems need updating to keep pace with the rapid rate of technological change. The explosion of the software industry has all but erased the line between copyrights and patents. The damaging effects of IP theft on the U.S. economy have also grown to the level of hundreds of billions of dollars per year. A slow and inefficient system for protecting IP rights is doubly damaging because it allows the loss of revenue from existing IP and removes incentives for innovation.

U.S. industrial policy must look to the future by simplifying the patent and copyright laws into a single IP system and greatly increasing efforts to protect American IP abroad. This new IP system should be based on two simple principles: 1) if taxpayer dollars funded the creation of the IP, then the public owns it; and 2) if IP was generated in the American private sector, then our country should put its full weight behind protecting that IP on the global market. The new system should be more engaged with the scientific communities, and adequately address the rise of industries with which the patent office has struggled, such as software, business practices, industry design, and biotechnology.

A new consolidated system should also be given the authority and resources to work closely with the Department of Commerce, the Department of Justice, and our allies to identify stolen goods, software, and trade secrets, and create significant penalties for those caught benefiting from them. The U.S. needs to show the world that it is a place where IP rights are clear and protected.



Ideas are the true drivers of progress. Innovation is powered by new and unique ideas, and economic growth is accelerated when parties are allowed ownership of financially lucrative ideas. Just as with other kinds of property, their worth to the owner plummets if that ownership is not secure. A fundamental pillar of any IP rights policy should be securing it from theft.

Unfortunately, the loss of American IP has exploded in recent years, to the point where it has been characterized as “the greatest transfer of wealth in history.” It is estimated that the annual economic impact of IP theft in the U.S. is in the hundreds of billions. Lack of adequate protection of IP rights is doubly devastating on economic growth, causing both lost revenue for the rightful owners of the IP and stalling technology development in the affected industries. The U.S. system for IP rights has not only failed to adequately protect existing IP, but is increasingly failing to function in recognizing new IP.

To adequately support U.S. industry in creating and protecting IP rights, the following actions should be taken:

- **Form an interdepartmental task force focused on IP protection.** Many departments conduct operations that can be leveraged for reversing the incentive structure for IP theft. Current efforts are aimed at defensive measures, which does not address a key root cause of IP theft: its demand. The Department of Commerce, Department of Justice, Department of State, and organizations in the intelligence community all have a role to play in finding and prosecuting IP thieves, as well as imposing severe penalties on any organizations found to be trafficking or using stolen IP.
- **Increase cooperation with allies and the World Intellectual Property Organization.** IP theft is a global problem, with 50% to 80% being conducted by China. Fighting it will require global cooperation. The U.S. has been working with allies in Europe and Asia to coordinate their various patent processes. They should expand these coordinated efforts to include IP rights protection.
- **Expand eligibility of software for patents and streamline the examination process.** The rapid pace of advancement in software capabilities and sophistication has rendered the slow patent application process useless for many digital industries. The standard method of IP protection for computer software, for example, has become copyrights, because of how easy and expedient they are to obtain. Copyright laws are, however, far weaker than those that protect patents. The current practice of limiting patent eligibility to only devices that use software is antiquated and does not adequately recognize the utility of software. The White House should direct the U.S. Patent and Trademark Office to overhaul its patent examination process for software to evaluate software algorithms and the technologies that execute them in a way that is timely and beneficial to industry.
- **Pass legislation requiring that legal costs of patent infringement cases be paid by the loser.** A major misuse of the patent system comes from unreasonably interpreting patent language using the threat of lawsuits to extort money from companies. “Patent trolls” specialize in extorting start-ups and small businesses because they likely do not have the resources to pay the legal fees necessary to defend themselves in court. Requiring the losers of patent infringement cases to pay legal costs would relieve innocent parties of this burden and eliminate the incentive that creates

patent trolls. Furthermore, such a policy would deter companies from infringing on existing patents, as it would greatly increase the penalty for such actions.

- **Create a clear, unified policy regarding IP rights resulting from federally funded R&D.** A major roadblock to public-private collaboration on R&D is the confusing and chaotic nature of IP ownership resulting from federally funded R&D. The line between funding R&D programs and purchasing newly developed technologies is not clearly defined, creating a reluctance to work with the government and sometimes accusations of overreach. These problems can be easily avoided if the government creates a clear policy based on the simple principle that any IP generated from taxpayer funding belongs to them (i.e. is public property) and IP from private R&D is privately owned. From that clear position, the government should negotiate with companies to find amenable ways to gain access to that private IP when needed. The President's Council of Advisors on Science and Technology should be tasked with working with industry leaders and the S&T community to construct and communicate this through a clear policy.
- **Increase support for the U.S. Patent and Trademark Office (USPTO).** Increase in patent applications in the past 20 years has wildly outpaced the increase in patent examiners. This has caused a sharp nosedive in the quality of USPTO operations, simultaneously causing too many bad patents to be granted and too many good patent applications to be rejected. This overburdens the process of appealing rejected applications, causing good ideas to take years to become patented, and allows the proliferation of "patent trolls" that use patents with unreasonably broad scope to intimidate and extort businesses. These problems are especially apparent in the areas of software, biotechnology, and business methods. Increasing support of the USPTO will help reverse this trend.
- **Improve training and evaluation of Patent Examiners.** The training and review process of patent examiners, the workhorse of the USPTO, routinely fails to recognize and learn from its best examiners, who usually leave the office to work for private firms. Part of this fundamental failure is that only approved patents are reviewed, when rejected applications provide as much, if not more insight into the quality of the examiner's work.
- **Create technical advisory committees for each Patent Technology Center.** The current methods the USPTO uses to keep its workforce properly educated on the scientific R&D that drives industry (and therefore the types of incoming patent applications) is unstructured and inadequate. To do its job properly, the office needs to stay informed of industrial R&D trends and focus on rapidly developing and updating best practices for evaluating applications. The Department of Commerce should direct the USPTO to create a technical advisory committee for each of its technology centers, comprised of S&T leaders in academia and industry. These committees should be tasked with helping the centers create and update guidelines for examining patent applications.

Reforming the patent system to make it easier for innovative ideas to be legally recognized and guaranteed protection in a global marketplace will not only reverse the loss of billions in revenue to industries, but it will be a major factor in influencing entire industries to bring their business to the U.S.

## Bringing Back Industry with Tax Policy

Companies today have the freedom to locate their business practically anywhere in the world, meaning they are free to choose the countries with tax policies that work best for them. In recent decades, the U.S. has refused to update its industrial tax policies to encourage business and as a result has seen many corporations relocate to countries with friendlier business environments. If the U.S. truly wants to encourage bringing business back, it needs to change its industrial tax policies that incentivize that reestablishment. The U.S. can incentivize the reestablishment of domestic industry by changing industrial tax policies in the following areas:

- **Lower the federal corporate tax rate from 35% to 15%.** Since 2003, the worldwide average corporate tax rate has dropped from 30% to under 23%. The corporate tax rates of the most competitive countries are below that, at around 12% to 15%. If the U.S. hopes to compete with the rest of the world to be the home of industry, having a competitive corporate tax rate should be its first priority.
- **Eliminate taxes on foreign profits being brought back to the U.S.** The U.S. hampers corporations currently located in the U.S. by taxing them on foreign profits brought back to the U.S. Foreign profits have already been taxed by the country in which they originate, and the U.S. is the only major economy that taxes this revenue a second time. The result of such a backwards policy is that U.S. corporations keep those funds overseas, instead of investing them in the U.S. economy. Eliminating this tax policy will allow U.S. companies to bring these funds home and inject them into the economy here.
- **Tax foreign goods sold here as if they were made here.** Products made in the U.S. use the infrastructure, workforce, and financial protections provided by the Federal government, which are paid for through tax dollars. Taxing foreign goods sold here as if they were made here would motivate corporations to move their manufacturing to the U.S. That way they would be able to utilize the infrastructure, bankruptcy protections, and skilled workforce that their taxes provide.



## Protecting Critical National Security Industries

The global economy is increasingly intertwined and supply chains for even the simplest products can stretch across the world. Some industries, however, are so vital to U.S. national security that they should be protected at any cost.

The inherent vulnerabilities of a global supply chain can be catastrophic to U.S. national security. Other parts of the world have recognized the important fact that companies are not beholden to individual nations and have used this perspective to their advantage in recent decades, pulling many U.S. companies overseas. In failing to recognize the reality of global supply chains, the U.S. has come to rely on other countries for critical resources, leaving strategic industries vulnerable to manipulation by our adversaries. The effect of globalization on some industries - including energy, semiconductors, healthcare, and the defense industrial base - is to introduce fundamental vulnerabilities into critical national security systems. Examples include malicious code inserted onto hardware that goes into defense systems, theft of millions of medical records and "ransomware" attacks, and theft of designs for weapons systems.



Our adversaries are increasingly using nontraditional “Gray Zone” methods, including manipulating and disrupting industries with the intent to disrupt our economy, and are actively investing in their own domestic industries as a form of economic warfare. These nontraditional methods are inherently more difficult to respond to through methods traditionally under the purview of the Department of Defense. Without the ability to use responsive measures, defensive measures must be taken. These industries must be protected from malicious manipulation.

In counteracting the industrial policies of other nations that are detrimental to U.S. economic vitality, the Department of the Treasury should work with the Departments of Defense and Homeland Security to identify industries critical to U.S. national security and provide positive incentives for companies in those industries to locate themselves in the U.S. These actions should include:

- **Use tax policy to retain critical industries to generate jobs and revitalize the economy.** This could include adjusting corporate tax policies to encourage critical industries to be headquartered in the U.S. Although this could mean that certain industries would not pay any corporate tax, the net economic and national security benefits to the U.S. would be far greater. Encouraging major companies like Intel to retain their corporate headquarters in the U.S. would entail that all the supporting industries that make up their supply chains would be retained as well. The net result will be significant increases in jobs and economic growth.
- **Foster a healthy domestic ecosystem for industries critical to our national security.** In many critical industries, the only available suppliers are offshore. This results in a critical dependency and potential single point of failure in the supply chain that could lead to catastrophic national security effects, particularly in a time of war. Analyzing the full supply chain of critical industries, identifying gaps in the domestic ecosystem for those industries, and developing strategic policies for closing those gaps will ensure that critical industries are secure against attempts at economic warfare by other countries.
- **Provide support to critical industries to combat IP theft and cyberattacks.** Industries that are critical to national security, such as the defense industrial base, are under constant cyber attack as adversaries try to steal IP and critical design information. Cyber Command and other organizations within the Department of Defense can work with members of these critical industries to develop better technologies and practices to defend against cybercrime.
- **Use tax breaks or other incentives to encourage critical industries to retain talent.** These could include providing competitive employment benefits (vacation, healthcare, maternity/paternity leave, salary, education benefits); establishing public-private partnerships with companies and universities to provide a pipeline of talented students; and fostering professional and continuing education incentives to keep the workforce at the cutting edge.

It is important that the Administration recognize specific industries as possessing critical national security importance and develop national strategies to protect them. If an industry is critical to our national security, we should be willing to take extra steps to ensure its security.

## **Research and Development: Seeding the Industries of the Future**

Commercial industry changes at much faster rates than the U.S. government. New industrial policies need to look to the future of industry, not the present. Countries have the most to gain by being the heart of innovation in existing and emerging industries. We need to build towards the industries of the future.

The research and development (R&D) of today seeds the technological advances of tomorrow. Industries are created out of new science and technology. The pioneering applied research at the DOD in the 1970s created the basic structure that became the internet today, which has spawned multiple industries and transformed all others. More recently, the government has invested \$181B in biotechnology research over the last decade. The fruits of these investments are now being seen in the explosion of the commercial biotech industry. As Vannevar Bush wrote in his report to President Roosevelt, "without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world."

The robust S&T research infrastructure in the U.S. continually generates ideas and discoveries that have the potential to be transitioned into technologies that can transform industries or create entire new ones. The scientific fields of bioengineering, neuroscience, materials science, and

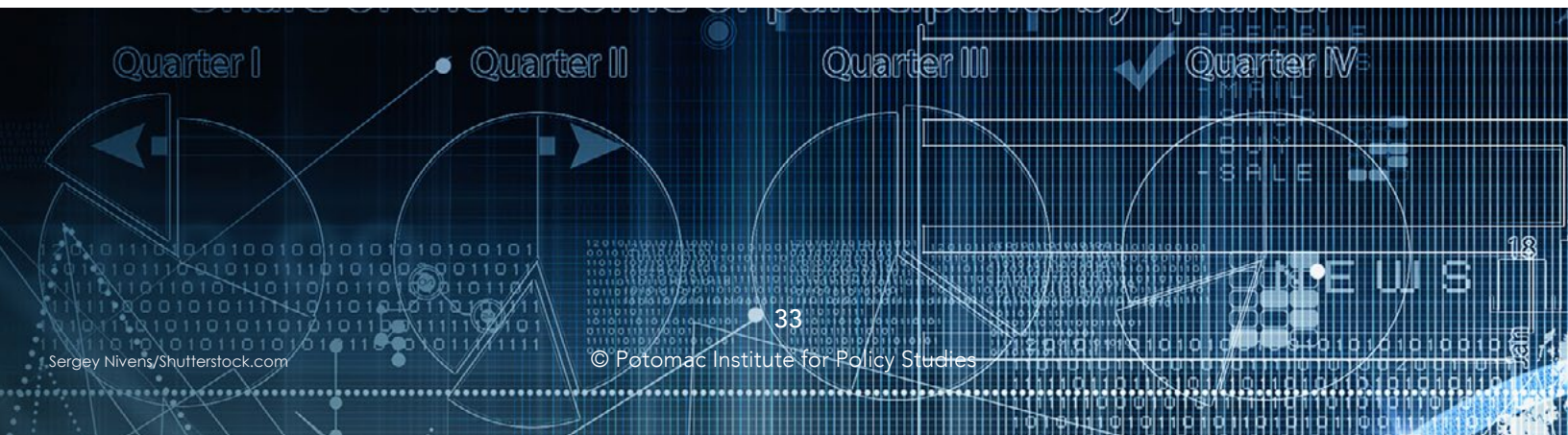




machine learning have advanced by leaps and bounds, producing a wealth of knowledge that will drive the development of new technologies. The U.S. should place a major focus on funding applied research and development in these areas, to harvest the many fruits that basic research has yielded. In order to accomplish this, the U.S. should:

- **Continue to invest in research and development.** The U.S. needs to maintain its investment in R&D. Doing this will continue to encourage innovative ideas and spawn new technologies. Decades of data show that new industries emerge from new technologies, so investment in R&D is the first step to economic development.
- **Create a Department of Science.** The U.S. spends approximately \$153B annually in R&D across many disciplines. It would be prudent to coordinate Federal S&T research funding, facilitate data sharing across programs and disciplines, and connect basic science advances to applied R&D centers/programs. A Department of Science could identify and focus on major areas of S&T that will truly revolutionize the future. Such a department can also promote a national strategy for the most important areas of S&T, the ones anticipated to impact not just the U.S. but the world in ways that will forever change humanity.
- **Focus defense spending on applied research.** Defense S&T funding should be focused on applied research to help bridge the valley of death in creating new applications of technology. New industries will develop when we turn research ideas into technological proofs of concept. Defense rather than non-defense spending is particularly important, given its history and infrastructure for supporting technology development and targeting advanced technologies that will transfer to domestic industries.
- **Create bold R&D initiatives.** R&D initiatives in bioengineering, neurotechnology, and automation will ensure that the industries of tomorrow are centered in the U.S. These three areas have been a major investment of U.S. science and technology spending over the last decade. New industries will emerge by focusing research spending and coordinating research initiatives in these areas.

New industries have been the backbone of American economics for the last two centuries. It is critical that we continue to invest in science and technology to develop new products and expand the U.S. economy.



## Centers for Industrial Innovation

For the last century, America has been the most innovative country in the world, and our economy has prospered as a result. The best way maintain this economic strength is to continue to innovate – not looking to the technologies and industries of the past. U.S. industrial policy should look to the future of industry, and drive innovation in new and emerging technologies, by fostering Centers for Industrial Innovation throughout the country.

The robust S&T research infrastructure in the U.S. continually generates a wealth of new ideas and discoveries that have the potential to be transitioned into technologies capable of transforming industries and creating entirely new ones. The major hurdle impeding technology development and transition is the gap between investment in basic research and product development for the commercial market, commonly known as the *valley of death*. Innovation Centers can bridge this valley of death by providing more opportunities for innovators to test and prototype their ideas and connect them with early investors (both for private industries and government agencies).

Building a network of Centers for Industrial Innovation throughout the country can jumpstart innovation and foster the generation of new ideas, technologies, and companies. Public-private research consortia have proven effective in transforming other countries of the world into major industrial powerhouses by enabling – not directing – industry. Centers of this kind were critical in transforming U.S. agriculture over the course of the last century.


Strategically located centers focused on industrial innovation, technology transfer, and information can benefit not only the industries they serve, but also revitalize the local regions they inhabit. The semiconductor industry, for example, directly employs over 250,000 workers in the U.S. and indirectly, over a million. It reinvests more revenue into R&D (consistently around 20%) than any other industry. The key to staying ahead in semiconductors is to out-innovate the competition. Providing resources to help domestic semiconductors reduce their R&D expenditures would greatly help them stay competitive on the global stage. Furthermore, if the U.S. government is an active member in such a consortium, it can leverage that relationship to ensure it has access to the technologies developed therein.

The National Network for Manufacturing Innovation (now known as Manufacturing USA) provides a good starting framework, but is fatally flawed. In its current state, the institutes that make up Manufacturing USA are doomed to fail. Centers for innovation abroad, such as the Fraunhofer Society, IMEC, and the EMBL are successful in large part because governments provide a small but significant amount of support and technical guidance, which allows the centers to retain some independence from the industries they serve and to continue to focus on R&D directions that are two or three generations ahead of the state-of-the-art.



To achieve greater economic growth, the U.S. should leverage one of its greatest strengths: innovation. Specific actions include:

- **Foster innovation and transition hubs.** Centers for Industrial Innovation (CII) can accelerate the generation of new technologies and start-up companies, as well as provide workforce development.
- **Ensure government derives direct benefits from the Centers.** If the Federal government is an active player in Centers for Industrial Innovation, it can maintain access to new ideas that can be transformed into technologies uniquely suited for government applications. Government input and funding of such centers will also insulate them from becoming captive to the largest players of the industries they support.
- **Leverage and improve the existing National Network for Manufacturing Innovation (NNMI) centers.** The Administration should direct the National Institute of Standards and Technology (NIST) to amend the charter of the NNMI to make them more sustainable over the long term – for example, by eliminating the seven year sustainability requirement.
- **Ensure Innovation Centers benefit local economies.** The Centers for Industrial Innovation should contain local level outreach efforts modeled on the system of agricultural Regional Extension Centers that propelled the agricultural revolution of the last century. For example, incentivize innovation institutes to locate themselves in or near cities with populations under 1 million and less than 5% estimated population growth since 2010.
- **Commission an independent study to examine the industries most likely to benefit from and sustain centers for innovation.** NIST should then take steps to ensure that centers in the NNMI exist to serve those industries.



**“Voters go into the ballot box with big ideas in their mind: leadership, change, experience, hope.”**

***Kellyanne Conway***

# REVOLUTIONIZING MEDICINE

American medicine provides some of the world's most innovative treatment, but variability of care across the healthcare system is high, the costs are becoming unbearable, and the overall system has not kept up with rapid technological change. The next Administration has made reforming the healthcare system a priority. The best way truly revolutionize the practice of medicine is to look to the future and leverage the power of data, scientific, and technological advances.

The future of medicine in America works for the patients, not for the status quo. It harnesses technological advancement, open data, and personal data to bring innovation to the forefront, to lower costs, prevent disease, and improve treatment. To reach this future, we need policy solutions and funding plans that are as pioneering, flexible, and as rapid as the science and technology that will bring us new cures.

Incremental revisions to current policy and funding programs cannot get us to this future; visionary policy and programs that are designed from the foundation up will. Piling more layers on the ailing and crippled healthcare policy foundation of the past works against us and keeps our systems locked into a dysfunctional and obsolete framework. Structuring regulation and targeting investment together towards a data-driven, risk sharing, and patient-centered future for medicine are key to enabling a brighter future.

An effective revolution in medicine should:

- **Harness the potential of big data and internet-of-things devices.** The future of medicine will take advantage of real-time sensing and data collection capabilities. Diagnostics will transcend reliance on comparisons to average expected values and be determined by the precision of individual health baselines. Individualized treatment and diagnosis will often happen outside of the clinic during daily life. Data from every patient and every treatment will be integral to the continuous evaluation and re-evaluation of medical practice.
- **Shine a light onto healthcare economics.** The current system obscures economic data in order to continue charging America more for providing poorer care; transparency is key to building the healthcare system of the future. Price discovery coupled with real-time analytics will reduce costs and abuse, reveal inequities so that they can be addressed, and enable competition and the development of new mechanisms for cost sharing, liability, and insurance.
- **Train the healthcare workforce of the future.** Artificial-intelligence-based medical education systems, modular certification infrastructure, and simulation-based practicums will allow us to develop the types of skilled providers that we need where and when we need them. Future licensing and certification requirements will be based upon the knowledge and skills that practitioners need for the practice of medicine in a real-time, data-driven world.

- **Re-envision the biomedical research system.** The future of research will be built upon a foundation of artificial intelligence and real-time sensors. It will be relieved of barriers to data access. Better physical models of human health will be realized, ushering a new a new era of personalized medicines and treatments that target causes instead of symptoms of disease. Research will be a national pursuit with every patient participating as a partner. Enabled by a system that connects everyone and everything, clinical trials will be long-term, large cohort, and diverse. Discoveries will come from our homes and our high schools as well as our universities and industry.

## RECOMMENDATION

America needs a healthcare plan for the future, designed to shape a system that will support innovations in healthcare delivery, treatment, science, and technology for 2050 and beyond. The new Administration has an opportunity to reimagine healthcare as we know it and make America the world leader in healthcare innovation and opportunity. A revolutionized American healthcare system can be the greatest system that the world has ever seen!



## ***Harness the Potential of Big Data and Internet-of-Things Devices***

Medical practice and treatment development still relies on methods and regulations developed for a world with limited information technology capability. Healthcare needs to step out of the box and into the world outside of the confines of traditional systems. In the medical system of the future every patient should be a data point in the continual evaluation and reevaluation of healthcare practices and products. Treatment decisions will include just-in-time interventions and big data-driven diagnoses, and will integrate information about life-style factors to ensure that all Americans get the best treatment, when they need it. To harness the potential of big data and internet-of-things devices, the Administration should make the following actions a priority:

- **Initiate and fund a national task force to develop health data sharing pilot programs.** This force should include representatives of all of the relevant agencies and be charged to collaborate with the healthcare industry to develop pilots for large-scale health data sharing that implement significant data security measures, respect patient privacy concerns, and are aimed at eventual national level implementation. A national data sharing system will enable real-time system-wide data aggregation and assessment, and allow us to identify better treatments faster and to reduce the use of inefficacious or counter-indicated treatments, and implement preventative practices to keep Americans healthy and out of hospitals.
- **Charge the health-related agencies and offices to develop a clear vision and roadmap for the clinical trials system of the future.** This system must harness big data and the internet-of things to significantly increase the speed of the approval processes. It must also balance the risks and rewards of new products in an era of globalization and intense market pressure. Relying only on short trials and small cohorts no longer makes sense in a world where conditional approval and re-approval for new drugs, therapies, surgeries, and medical devices can be implemented based upon long-term full patient population data analysis.
- **Task and fund the health agencies to reimagine practitioner education and advising systems for the data age.** The health agencies should be funding research into innovations in medical practitioner training, educational systems, and workforce development. They should also be supporting pilot programs that study implementation of artificial intelligence-based systems in the decision making process. Medical practitioners and systems need to be prepared to take advantage of the data surge that is accompanying the future of medicine.
- **Charge the Office of the National Coordinator for Health Information Technology (ONC-HIT) to lead the health agencies in developing a national plan to address the infrastructure and regulation needs of health information management systems.** The health management systems of the future must allow patients and practitioners to collaborate together using real-time data to optimize health

outcomes. Health information management systems need to receive inputs from diverse devices and sources, protect incoming and outgoing data streams, and have the capacity to compute and advise practitioners and patients in real-time.

Systemic integration of real-time data collection systems and artificial intelligence allows precision therapies, right-time interventions for high-risk populations, and effective preventative care to be seamlessly integrated into the lifestyles of Americans. We can get better drugs to market faster, eliminate ineffective procedures faster, help people heal faster, and make diagnoses faster; all with the help of data systems that work for us rather than against us. Implementing a national coordinated strategy to enable and support widespread health data-sharing will have far-reaching impact on the future.





## Shine a Light onto Healthcare Economics

The U.S. currently has a complex, convoluted, and wasteful system of billing, insuring, and paying for medical care. The system relies on lack of transparency and our limited oversight capability to maintain the status quo and continue to have costs rise while many elements of care can and should become cheaper. To ensure the future of healthcare is not hindered by the economic convolutions of the current system, the Administration should make the following actions a priority:

- **Advance legislation to mandate price discovery for transparency, and equity.** Transparency in pricing will foster competition at all levels in the healthcare industry and it will allow identification of discriminatory and unreasonable pricing. When data is coupled with analytics and artificial intelligence, real-time assessments of the financial health and equity of the system are possible.
- **Advance legislation to codify health data ownership.** Healthcare data is valuable to the patient, the practitioner, and many outside parties. We believe that health data belongs first to the patient, above all others. As the value of health data increases, and the potential of artificial intelligence to manage general care increases, patients may even be able to offset their general care expenses by sharing their data with industries and health systems. New legislation is needed to clarify the rights of the individual, the government, academic researchers, providers, and private industries to own, share, and purchase access to the health data of individual Americans.
- **Appoint a bipartisan committee to assess current healthcare regulations, liability, and responsibility structures for outdated and counter-productive elements and identify solutions.** Limitations imposed by past regulations can significantly increase the cost of care. Liability concerns also increase costs, and the role of patient responsibility in reducing the cost of care must also be addressed. This committee should develop regulatory revisions and innovations that harness data and technological solutions to reduce costs.
- **Direct and fund the health agencies to support pilots for alternative payment models and data-driven evaluation of systems already being piloted.** The current system relies primarily on a complex fee-for-service model that does not reward expertise or efficiencies. Pilots of alternative systems are already being implemented at some of the nation's top health centers. These types of trials should be highly supported and strictly evaluated to identify the elements of medical payment systems that optimize treatment outcomes and reduce costs.

The Federal government must understand who and what it is subsidizing in order to make data-driven decisions. We need to develop detailed economic models that make sense for a data-driven future healthcare system to ensure financial health of all the stakeholders. Revolutionizing the economics of medicine requires the same type of big data analytics that major

industries are putting into place to optimize their workflows, product lines, and supply chains. A focus on transparency and on data-driven evaluation of the current and alternative systems allows us to identify where cost savings can be implemented successfully, where fraud and abuse of the system can and/or does occur, and where inequities exist.



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## Train the Healthcare Workforce of the Future

The healthcare system of the future will require new methods, practices, and management structures in order to improve our ability to provide the right care at the right time. Technology will bring such vastly new capabilities to the medical system that traditional roles of practitioners will be transformed. The health care workers of the future will have significantly different duties, and therefore training will need to change. Artificial-intelligence based medical training systems, modular certification infrastructure, advanced simulation training, and virtual reality practicums will advance our ability to provide this training. Future licensing and certification requirements will be based upon the knowledge and skills that practitioners need for the practice of medicine in a real-time data-driven world. To advance the future of the healthcare workforce the Administration should make the following actions a priority:

- **Create a Federal program to fund research, evaluation, and innovation of health care practitioner education programs and methods.** Practitioner certification requirements are determined by the individual colleges, boards, and associations. This system incentivizes protectionist behavior and hinders educational innovation. Without research on current and alternative methods, there is little incentive for the education and certification systems to innovate and develop economical educational resources that are appropriate for the data-driven future of medical care.
- **Initiate a formal review of America's healthcare practitioner training and certification programs.** It should not cost so much to train a doctor and we should not have the oversupply of some specialists and the dearth of generalists and mental health care providers that we do. Supporting, expanding, and contracting medical training programs is neither data-driven nor conformant to any national strategy. We need to assess the local, regional, and national needs for specialists, generalists, and other care providers and we need to take advantage of data and technology to train them at a lower cost.
- **Fund evaluation of traditional career trajectories and hierarchies in medical systems and development of pilots to test alternative models.** Alternative systems, like modular certifications and virtual reality-enabled medical training may allow providers to develop new capacities at their own pace and without the high costs and limitations of formal educational stages. Clinical tasking might be better defined based upon assessed capabilities rather than on traditional job titles. Alternative systems for career advancement and system organization that harness technology may be economical, local, and may even provide better education. Evaluation and pilots are the only way to find out.
- **Develop a technology and data-driven strategy to address the inequities in accessibility of healthcare.** There is enormous variability in the accessibility of both general and specialty care across the regions of America. Technological solutions like telemedicine programs and artificial intelligence-based systems are desperately needed in places where care options are limited. New strategies to develop care solutions in areas that lack sufficient medical practitioners are necessary to ensure that the right care can be available wherever it is needed.

The decisions about what qualifications are needed for specific care tasks, how those qualifications can be obtained, how many practitioners are trained in specific duties and specialties, and where services can and/or should be obtained need to be addressed strategically. Transparency in data about our healthcare system's capabilities and limitations will permit the development of analytical and predictive models that can be used to optimize America's ability to provide sufficient, high-quality, affordable care.



## Re-envision the Biomedical Research System

Biomedical research is one of America's greatest enterprises but there is still much room for improvement. Today's system is built upon a 1950s foundation that is inadequate to the needs of today's clinical practice, and has grown haphazardly according to the priorities of the moment rather than a holistic strategy. The future of biomedical research will be built upon a foundation of artificial intelligence, real-time sensors, and data-driven national priorities.

The current research system has become a field of ivory towers without windows to let in the light or sufficient stairs to take the next generation of scientists up to the top of their fields. The future of biomedical research is an age of citizen science where experimentation is a national pursuit and every patient a partner; where discoveries will come from our homes, our schools, and our laboratories.

With data sharing and accessibility, the future of biomedical research will allow for infinite collaboration potential, will have room for millions of inexpensive experiments based upon data models, and will base attributions upon diverse types of contributions including data and analysis. To make this future a reality the Administration should prioritize the following actions:

- **Direct our funding agencies to distribute resources according to national need.** Data-driven assessment of research funding priorities, programs, workforce development, and career trajectories across the federal system is necessary to prioritize programs that take medicine toward a future of precision models and treatments for health and disease and to ensure investment in the researchers of the future.
- **Mandate data sharing and transparency for all federally funded research.** The current attribution and funding system dis-incentivizes data sharing and transparency, despite the obvious benefits to the pace and output of the field as a whole. Additionally, data sharing and transparency will ensure a sound foundation of knowledge for initiating new research directions by allowing availability of all results (even negative results) and by affording easier detection of reproducibility problems and fraud. Measures should be taken that strongly encourage real-time data sharing and collaboration in order to reduce the barriers that prevent good science from being widely accessible.
- **Revise outdated legislation and regulations concerning human data.** Health data privacy and security are essential elements of the medical system of the future but researchers, providers, and facilities still need to use that same data to better understand biological systems, innovate in medical practice and assess their facilities. Technological methods to protect data ownership and anonymity exist but regulations and data ownership rights limit the capability to share data or access protected data for experimentation and assessment. The Common Rule, the Genetic Information Nondiscrimination Act (GINA), and other regulations impacting health data privacy and protecting Americans from discrimination need to be updated for biomedical researchers to be able to maximize their ability to use the data that the system already creates.

- **Assess the roles of government, academia, and industry in funding research and pilot new models for hastening the bench-to-bedside transition.** The roles of the different stakeholders in funding the national biomedical research enterprise remain nebulous. The lack of strategic divisions leaves major funding support gaps within the transition of research discoveries from the bench to the bedside. New funding systems and approaches are needed in partnership with industry and academia to ensure that the basic government funded research is able to reach fruition and benefit patients.

Deep understanding of our research funding and research production infrastructure is required to identify gaps and over-investment and to predict our future needs. This understanding can only come from data about our current system. Such data will allow us to build the models needed to describe and predict the efficacy and strength of our biomedical research system and to coordinate our research goals more highly with the needs of patients. It will allow industry to better develop their investment portfolios, and government to selectively invest in areas where industry will not due to profit insufficiencies, rather than investing across the board. It will allow academia to better regulate its training programs and to build the science practitioners that are needed for industry, government, and academic needs.

## RECOMMENDATIONS

In 2000, the U.S. healthcare system ranked 37th out of 191 countries in World Health Organization assessment of overall healthcare, and little evidence suggests that figure would improve if this analysis was conducted today. Multiple studies over a significant period, have ranked the system poorly on efficiency, equity, and outcomes, including the *2014 Commonwealth Report Fund* report which places it in last place in an assessment of 11 developed countries. A significant overhaul is necessary to bring the healthcare system to the level of leadership on the world stage that the U.S. should aspire to and owes its citizens. This revolution in medicine in America requires coordinated modernization efforts on the economic, technological, educational, and managerial fronts.

The key to developing a new system is to fully understand the needs and limitations of our current system. This cannot be done without data transparency. Full and continuous research accessibility of machine readable data from ALL aspects of our medical system will allow the most accurate descriptive and predictive models to be produced as frameworks for developing, piloting, and implementing a healthcare system that works and benefits all Americans.

Regulatory changes and pilot programs are required to make this vision of real-time-data-driven healthcare a reality. In the legislative arena, a replacement for the Affordable Care Act could be a good place to start by including language that makes sharing your health data within the system and with academic researchers a requirement for government subsidized health care. In the future, to get, you must also give.

The next step is to revisit the policies impacting healthcare that are sprinkled throughout the legislative framework of the U.S. code and appropriations, agency regulations, agency guidelines, and state laws. A fully coordinated approach to revising these policies is needed to optimize the potential for healthcare data accessibility and usability. This approach should rely on scientific principles to evaluate the effectiveness of these policies in order to determine what works and what does not.

Pilot programs are needed to determine how health data should be used and secured and how privacy should be protected and respected as healthcare moves forward towards the technologically advanced and data-driven future. The healthcare system of the future must use all of the tools at our disposal to optimize prevention, early detection, and wellness while also maintaining economic viability. New models and strategies for delivery, treatment, management, organization, education, and research need to be supported, piloted and evaluated so that the healthcare system of the future is intentionally and effectively designed to support the needs of all Americans.

With concerted effort towards using the data we have better, using technology to seamlessly collect the data types that we aren't collecting yet, and working across agencies and branches to pioneer new programs and practices, we can reach a spectacular future for healthcare and make America's healthcare system the world's best healthcare system.



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**"Government is really successful when it's willing to make big, bold objectives, like, 'We're going to get to the moon.' But without leaders with big ideas, we get stuck."**

**Bill Maris**





# CLIMATE ENGINEERING: A NEW OPPORTUNITY

Within the next 10 years, American ingenuity can give us the power to engineer the environment on a global scale in order to overcome the challenges associated with climate change. It will be advancements in bio- and geo-engineering technologies that make this possible, and these technologies represent new industries and opportunities for American corporations and entrepreneurs. The next Administration should foster the development of a new industry in climate engineering so American innovation can help us engineer our way out of the climate problem.

Scientific trends clearly show that the climate is changing more rapidly than in times past, even if people disagree why and whether humans are the cause. The nature of this latest shift in the global climate is likely to lead to great harm and suffering around the world if a strategy is not developed to develop and use tools for engineering our world on a grander scale. Today's discussions and debates focus on trying to correct these trends by rolling back carbon output, ignoring the negative economic consequences of that approach. A truly successful solution will focus, not on carbon output, but on technologies that can recapture and repurpose this carbon, while also affecting the other factors that control climate.



**The answer is not to try and reverse these changes, but rather to use science to engineer our way out of the climate challenge.**

This is the same logic we've used in the past to fix some of our problems with farming. During the 1930s in the Great Plains, farmers took advantage of new mechanized farming equipment to convert more than 5 million acres of previous unfarmed land into farmable land. The goal was to increase yield and turn higher profits. The deep plowing strategies ended up transforming the Great Plains by displacing the native, deep-rooted grasses that protected the lands from times of drought. When the droughts came in the 1930s, the topsoil literally blew away with the winds creating the "dust bowl" this time is often referred to. It was a great lesson that our technologies can fundamentally change local environments, and this can be for better or worse depending on our knowledge about how those environments exist. A similar thing occurred during the 1800s and early 1900s as the U.S. overproduced cotton and tobacco on much of the farmable land in the south. The effect was to decimate the soil and render it nearly useless. The answers to these problems were later provided by agricultural science, which engineered natural processes such as crop rotation and fertilization to replenish the soil. This not only increased production far beyond what was previously possible, but did so in a more sustainable way (i.e., no more dust bowls!). This use of agricultural science and engineering also led the U.S. agricultural industry to remain a world leader in food production and transform our way of life. We can do the same to address the climate change problem today; we can use science and engineering to fix our problem and generate new economic growth.

Today we are rapidly improving our ability to engineer biology to take on the properties we want, which in turn will give us new ways to engineer the environment. Pairing our advancements in bio-engineering technologies with other geo-engineering technologies gives us even more of an opportunity to take control over how the Earth changes. The opportunity exists for us to engineer a better tomorrow.

To capitalize on the next big engineering opportunity, the next Administration should:

- **Provide the right incentives to engineer a solution to the climate problem.** American innovation is what makes this country great; let's apply that American innovation to climate engineering. Putting in place policies and regulations that encourage corporations and entrepreneurs to invest in climate engineering will usher in a new era of economic prosperity.
- **Ensure responsible development of bio- and geo-engineering technologies.** The technologies that exist to manipulate the natural world are incredibly powerful. In the hands of the ignorant or the malicious, they could be used to destroy the world rather than improve it. New policies and control regimes will be needed to ensure these technologies are developed and used responsibly.
- **Study the science of the natural world and develop precision models of the climate.** Unlocking the secrets of Nature will be essential to engineering our way out of the climate problem. Better scientific models of the climate will foster innovation in new technologies to improve the environment. Additionally, better models will allow safer and more efficient uses of these technologies to improve the world.

## RECOMMENDATION

The next Administration needs to develop a comprehensive strategy that capitalizes on advancements in bio- and geo-engineering technologies in order to engineer our way out of the climate problem by helping open up new climate engineering industries for American capitalism to thrive. This will require new breakthroughs in the life and earth sciences, better models of the climate, and new control regimes to ensure these powerful tools are responsibly used and developed.

The answer to the climate challenge is to move forward, not to go back. We need to use our science and technology to develop a capability that will benefit humanity for millennia to come. Not only will this help ensure economic prosperity and the long-term survival of humanity on Earth as the planet continues to change and evolve, but it will also provide us with the tools and wisdom to do things such as terraforming planets like Mars, creating entirely new opportunities for humanity to flourish. The next Administration has an opportunity to not just rebuild America, but to rebuild Earth.

When John F. Kennedy gave his “moonshot” speech to Congress in 1961, he committed the U.S. to landing a man on the moon and returning him before the end of the decade without ever successfully launching a single rocket. The challenge seemed impossible to fulfill at the time, but with the U.S. government's commitment to making it happen, by 1969 we had engineered our way to the moon, forever changing the course of humanity. The next Administration should make the same kind of bold claim, propel humanity forward, and commit to developing the ability to engineer the climate within the next 10 years. The task might seem equally as impossible today as going to the moon was in 1961, but the reality is we have the advantage of already having many of the technologies needed to do this. All we need now is an Administration bold and brave enough to commit us to the “moonshot” of our time.



## Build a Climate Engineering Industry

Developing a national strategy for how to take control and engineer the climate will create new engineering industries that work in complementary ways to traditional industries, ushering in a new era of economic prosperity. The next Administration has a great opportunity to protect Americans from the potentially harmful effects of a changing climate, while also opening up new markets and opportunities for corporations and entrepreneurs to thrive in the U.S.

Engineering our way out of the climate problem and opening up the climate engineering market will require the U.S. to:

- **Incentivize the development of geo-engineering technologies.** The Administration, with input from private industry and academia, should research and establish the appropriate incentives and boundaries to enable the climate engineering industries we need. These incentives, which likely will include competitive industrial tax policies, improvements to how the U.S. recognizes and protects IP, and collaborative centers for industrial innovation, will encourage corporations and entrepreneurs to create new industries designed to engineer our world on a scale capable of controlling the climate. Establishing such markets and capabilities may also yield future fruits as we venture to other planets like Mars.
- **Incentivize the development of biotechnologies that can help improve the planet.** Working with biotech industry and academic leaders, the NIH – together with support from the NSF and DOD – should lead an effort that identifies the right incentives and boundaries needed use biology to engineer the environment. The discovery of CRISPR has helped rapidly advance the field of synthetic biology in only a couple of years. The biotechnology industry will be the next major industry to transform societies. Genomic manipulation technologies alone have already led to the creation of bacteria that can help fertilize soil, produce fuels and degrade waste, including radioactive waste. Establishing the appropriate incentives and boundaries will ensure continuing development of the biotech industry is transparent and safe, to prevent these new capabilities from doing major damage.
- **Incorporate climate science into infrastructure designs.** Improving our understanding of climate science will allow us to rethink the designs and nature of our national infrastructure. This could include incentives for cities and states to incorporate climate science into their infrastructure designs to help expand the climate's capacity for localized change. Using climate science to help realize ideas like environment rotation, similar to crop rotation in farming, for urban cities could drastically improve the climate while enabling continued global economic growth. Making, placing, and connecting sensors on the scale needed will provide huge demand for key U.S. industries of microelectronics, IT, and data analytics. With better science we can design our cities and nation to help build the climate we want.

## RECOMMENDATIONS

The next Administration should develop a climate engineering strategy to guide science and industrial policy and release a document detailing that strategy within the first year. The next Administration should form a working group with representatives from government (including NOAA, NASA, NIH, NSF, DoE, and DOD), industry, academia, and international partners, to provide recommendations for this strategy.

It is time to reimagine the climate and use the power of bio- and geo-engineering technologies to open up new markets for the American economy to thrive, while also ensuring we are continually protected against the potential harmful impacts associated with a changing climate. This will require a national strategy aimed at developing the necessary knowledge and tools for corporations and entrepreneurs to create climate-engineering industries that know how to safely and efficiently change the environment, while also making a profit.



## Ensure Responsible Development of Bio- and Geo-Engineering Technologies

New technologies have provided an unprecedented ability to control and manipulate life on Earth. Possessing the power to engineer our genes and our climate carries significant responsibilities; however, to each other and to the future of our planet. These technologies must be carefully managed in order to ensure their safe development, and to enable investments that could improve the lives of all human beings.

Responsible management of bio- and geo-engineering is essential for investors and industrial stakeholders aiming to help engineer ourselves out of the climate problem. A clear and consistent regulatory framework is needed for industry to operate with confidence. Entrepreneurs must be reassured that their investments will be protected, and therefore proper protection of U.S. IP should be a major focus. A modern control regime will allow bio- and geo-engineering to reach their full potential and change the world.

- **The next Administration should ensure responsible development and use of climate engineering technologies.** As a major funder of new technology development and the primary body responsible for national security, the DOD is ideally suited to work with the FDA and the DOC to establish new control regimes for managing these bio-technologies (and later geo-technologies) to ensure their use is limited and properly monitored, to prevent it from falling into the wrong hands.
- **New international control regimes must be established for managing bio- and geo-engineering technologies.** Existing policies and international frameworks for controlling these technologies are inadequate and must be revised. Rules and regulations for nature conservation, agriculture, and bioweapons were not written for an era of massive control over our genes and climate. New national and international control regimes must be created to address the novel capabilities enabled by bio- and geo-engineering technologies.
- **We must develop policies for how these technologies should be developed and used, and protect against potential risks.** Large bio- and geo-engineering projects inherently carry risks. It is critical to create data-driven policy options that articulate which risky projects are permissible and which are not, and how these risks might be managed and controlled. International guidelines must also create a consistent IP scheme and coordinate risk frameworks between the U.S. and other countries. This is particularly important for encouraging industry to invest in big engineering solutions to the climate problem.

### RECOMMENDATION

The next Administration should ensure responsible development and use of climate engineering technologies. As part of the climate engineering strategy described above, the Administration should ensure that major stakeholders participate in the development of control regimes for bio- and engineering technologies. Panels should be convened representing major stakeholders from industry and universities to help create these guidelines, and to ensure that potentially world-changing projects can succeed.

## Study the Problem to Find Opportunities

A key enabling factor for the future of climate engineering will be the use of science to develop better physical and statistical models of the natural world. By fostering new opportunities to study the global environment, more precise models of the natural world can be discovered that can help corporations and entrepreneurs develop new bio- and geo-engineering technologies in safe, effective, profitable, and predictable ways. This is a similar approach as seen in the pharmaceutical industry, where government funded research provides the fundamental knowledge needed for companies to develop new innovative approaches to fighting disease.

- **The next Administration should develop a coordinated and collaborative science initiative aimed at studying the science of climate engineering.** In order to do this, coordinated initiatives will be needed to study the science of the natural world, develop precision models of the climate, and understand the fundamental science of bio- and geo-engineering tools. This will require the U.S. to:
- **Create a global network of sensors to monitor and study all types of environments.** The more data we have on how the natural world changes, the more we can understand the factors that drive such change. NOAA, NASA, and the EPA should be tasked with working with each other and private industry to establish a global network of sensors where data can be stored and analyzed in real-time, to rapidly improve our understanding of climate science. It will be through the use of this sensory data using things such as big data analytics and artificial intelligence, that we build better physical models of the climate allowing us to understand the many complexities associated with the living and physical systems. All of this will lead to more precise climate models that make it easier and safer to use technology to engineer our way out of the climate problem with American innovation.
- **Prioritize discovery of more reliable physical models of biological and environmental systems.** This will enable the development of improved technologies that can be used to manipulate these systems in predictable ways, designed to make the world better. By providing the foundational knowledge needed to engineer our way out of the climate problem, the next Administration will have given industry the wisdom needed to spark American innovation to drive the climate engineering market, similar to the current relationship between the pharmaceutical industry and government. Additionally, this will also provide policy-makers the necessary knowledge to craft policies to ensure the safe, fair, and productive use of these tools.
- **Learn how to harness the power of biology to improve the environment.** The CRISPR revolution is rapidly accelerating fields such as synthetic biology giving us more control over the properties and capabilities of living organisms. The NSF and NIH are ideally suited to lead the charge in improving the knowledge and the tools of biological sciences will provide new opportunities and open up new

markets for us to engineer biology to improve the environment. Those government bodies should make creating funding streams for researchers a top priority to develop biological systems that work symbiotically with the environment to improve it. That will allow our scientists and engineers to more rapidly obtain the necessary knowledge needed to engineer our way out of the climate problem with biology in responsible, safe and effective ways.

## RECOMMENDATION

**The Administration should focus on engineering our way out of the climate problem.** To inspire American innovation and spur development of this future industry, we need to further develop the fundamental building blocks; data about the natural world, precision models of the climate, and deeper understanding of the bio- and geo-engineering tools involved.

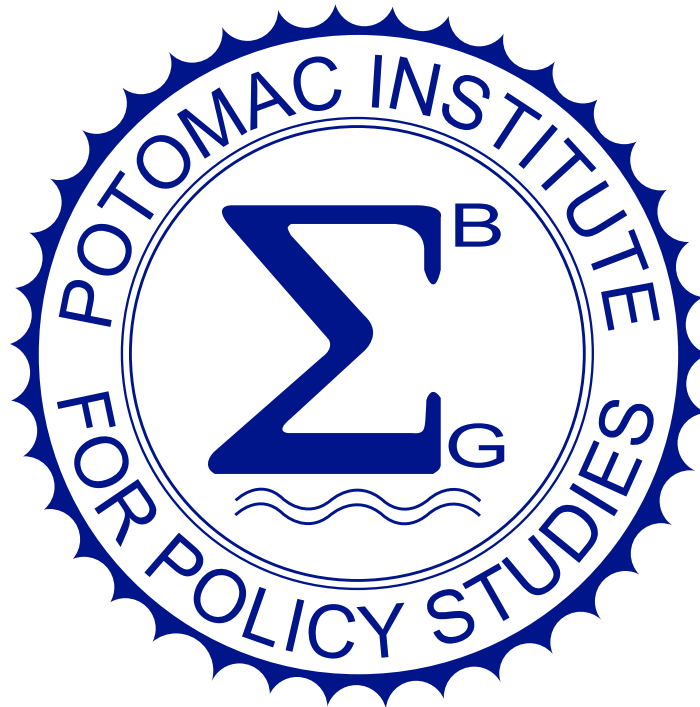






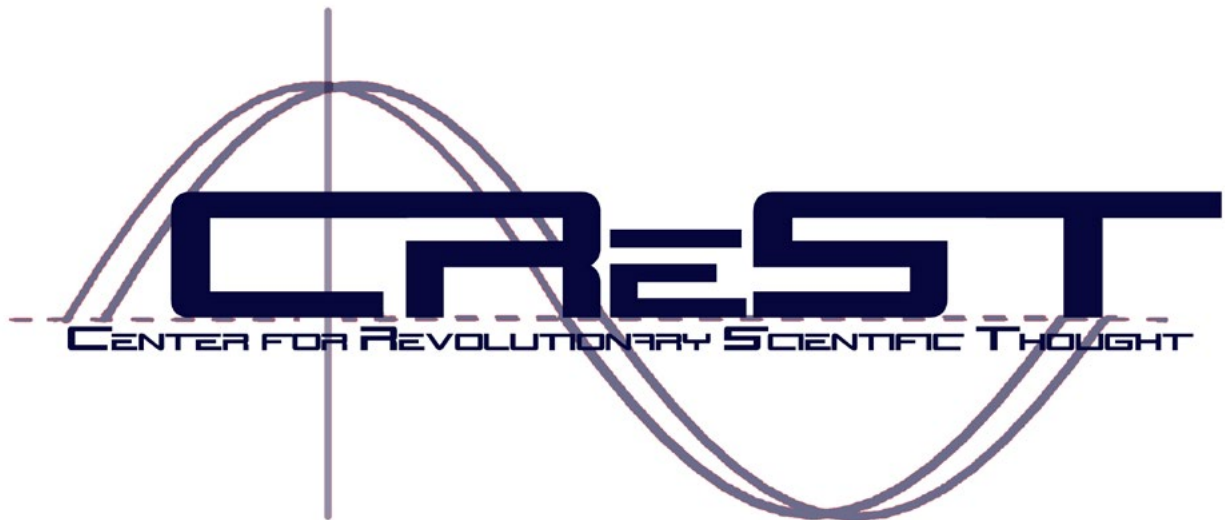
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**The Potomac Institute for Policy Studies** is an independent, 501(c)(3), not-for-profit public policy research institute. The Institute identifies and aggressively shepherds discussion on key science, technology, and national security issues facing our society. The Institute hosts academic centers to study related policy issues through research, discussions, and forums. From these discussions and forums, we develop meaningful policy options and ensure their implementation at the intersection of business and government. The Institute remains fiercely objective, owning no special allegiance to any single political party or private concern. With over nearly two decades of work on science and technology policy issues, the Potomac Institute has remained a leader in providing meaningful policy options for science and technology, national security, defense initiatives, and S&T forecasting.



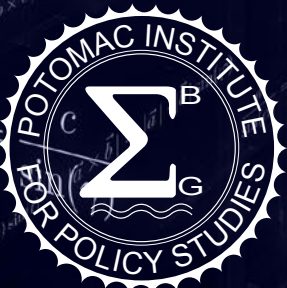
# ABOUT THE CENTER FOR REVOLUTIONARY SCIENTIFIC THOUGHT

**The Center for Revolutionary Scientific Thought (CReST)** serves as the Potomac Institute's internal research and development and futures group, using innovative techniques to anticipate the policy impacts of emerging technologies. Bringing together individuals from a variety of backgrounds to foster academic and policy discussions on science and technology futures, CReST develops new ideas about the future directions of science and technology, formulates strategies on how to achieve revolutionary gains in science and technology, provides a forum to discuss the associated political, legal and social issues, and informs the public and policymakers to solve vital societal problems.



“Ideas are like fish. If you want to catch little fish, you can stay in the shallow water. But if you want to catch the big fish, you’ve got to go deep. Down deep the fish are more powerful and more pure. They’re huge and abstract. And they’re very beautiful.”

David Lynch



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