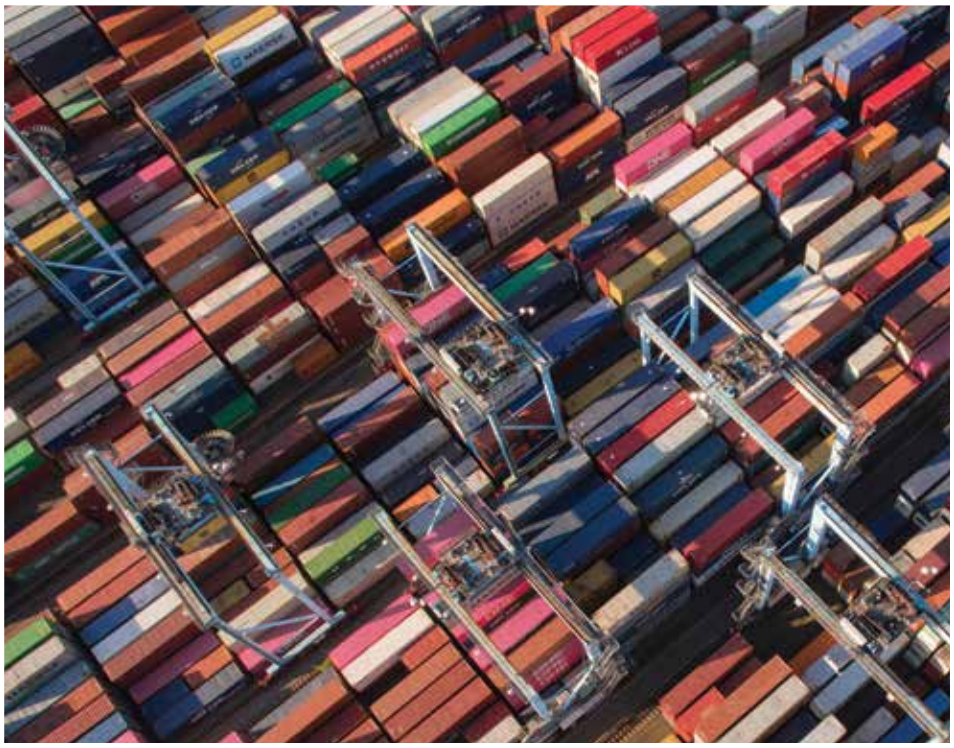
KEY STRATEGIES

to Position Virginia for Leadership in Areas of Critical National Challenge



DEVELOPED BY

VASEM

VIRGINIA ACADEMY OF
SCIENCE, ENGINEERING, AND MEDICINE

SEPTEMBER 2021

Virginia Academy of Science, Engineering, and Medicine

The Virginia Academy of Science, Engineering, and Medicine is a nonprofit organization consisting of members of the National Academies of Science, Engineering, and Medicine who reside or work in Virginia as well as other Virginians who are leaders in these fields. Through its nonpartisan network of experts, the Virginia Academy provides rigorous analytical, technical, and scientific support to inform policy on issues critical to the Commonwealth.

The Virginia Academy also promotes research, fosters interchange among individuals and organizations, and recognizes and honors Virginians who have made major contributions in science, engineering, and medicine.

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Five Strategies to Significantly Strengthen Virginia's Leadership in Areas of Critical National Challenge

Cybersecurity, climate change, pandemic disease, crumbling infrastructure, healthcare disparities, workforce development, supply chain vulnerability — these are just some of the complex and urgent challenges facing the United States and the Commonwealth in 2021 and beyond. Seen in another light, however, they represent an opportunity for the state. If we can identify differentiating strengths that will enable Virginia to help solve one or more of these issues, we can create a path to sustained economic growth in the Commonwealth.

Accordingly, the Joint Committee on Science and Technology (JCOTS) has asked the Virginia Academy of Science, Engineering, and Medicine (VASEM) to identify broad areas where Virginia has the resources, expertise, and critical infrastructure to address these challenges in uniquely powerful ways and to set aspirational goals that would help us mobilize these resources. In response, the Virginia Academy assembled an expert panel to examine trends in technology, catalog the strengths that together help differentiate Virginia from other states, and suggest how these resources might be focused on problems of national significance. Our goal is to create an agenda for further study.

In proposing these areas, the panel was cognizant of the target industry growth clusters in the five-year strategic plan (FY19–23) developed by the Virginia Economic Development Partnership. They are as follows:

- Push new boundaries as a U.S. leader in information technology
- Assemble a world-class transportation and logistics hub
- Position Virginia's manufacturing base to be future-ready
- Create business services and operations centers of excellence
- Capitalize on Virginia's unique assets to become a leader in promising disruptive technologies

This paper offers five areas for deeper study that can position the Commonwealth to leverage emerging technologies and assume leadership in critical sectors that are likely to define our future. We urge the Joint

Commission on Technology and Science to investigate these areas further and to develop roadmaps for one or more that will guide investment and policy decisions.

The time is right. On a national level, there will be significant funding available for innovative, bold action to address urgent national challenges. The appropriations contained in such federal initiatives as the Jobs Act, Build Back Better Plan, National AI Initiative Act, and the CHIPS for America Act, as well as a series of executive orders on improving the nation's infrastructure and the safety and security of its citizens, totals several hundred billion dollars. This report is the first step in a more comprehensive effort to translate these ideas into compelling initiatives worthy of bringing federal funds to Virginia. We recommend that as a next step, JCOTS ask the Virginia Academy to assemble study teams bringing together representatives from local and state agencies, private enterprise, and Virginia's universities to investigate these opportunities in greater depth, identifying technological and policy challenges, and, if practicable, laying out a roadmap to achieve them.

In selecting strategic areas, the panel looked at Virginia's natural and built resources, for instance, its central position on the Mid-Atlantic coast as well as its port and naval base. It surveyed the Commonwealth for relevant companies with differentiating products and/or expertise, flourishing public/private partnerships, outstanding programs at Virginia's academic/research institutions, and the expertise and training of its workforce. We identified areas of national importance where we have a critical mass of assets to begin making a difference. These areas with their aspirational goals are highlighted below. *(Full briefs for each of these topics are included after this introductory chapter.)*

Challenge	Aspirational Goal
Creating a reliable, affordable supply of sustainable energy	Position Virginia as a National Model for Reliable Sustainable Energy
Developing secure, trusted, resilient supply chains	Make Virginia a National Leader in Supply Chain System Security
Bringing semiconductor design, development, and fabrication onshore	Chart a Path for Virginia Leadership in Semiconductors
Improving population health and wellness	Maximize Healthcare Resources for All Citizens of the Commonwealth
Fostering smart and connected communities	Enable Virginia to Create Smarter, More Resilient Communities

Strategy 1.

Position Virginia as a National Model for Reliable Sustainable Energy

THE MOVEMENT TO A LOW-CARBON FUTURE will require the transition of virtually all forms of heating, cooling, transportation, and power to electricity generated by sustainable sources. The resulting demand will be unprecedented. Meeting this demand in a sustainable, reliable, and affordable way will be a complex undertaking, but a smooth transition is critical if industry is to grow and individuals across the Commonwealth are to thrive.

Virginia has a number of essential strategic assets that could position it to become a model for a nation navigating the transition to a new low-carbon electricity future.

The Commonwealth is in a position to demonstrate how two complementary noncarbon energy sources — offshore wind (a variable generating source) and nuclear power (a constant energy source) — can be combined with long-duration energy storage to provide sustainable, reliable energy.

Virginia has substantial assets in each area. In September 2020, Dominion Energy's Coastal Virginia Offshore Wind (CVOW) pilot project began generating power. It is the second offshore wind farm constructed in the United States. When completed in 2026, the wind farm is expected to power up to 600,000 homes and create 1,100 jobs.

Although nuclear power remains controversial, it has become increasingly clear that it must be part of the mix if the U.S. is to meet its carbon goals for 2050. Virginia already has a substantial nuclear infrastructure. Currently, the Commonwealth generates almost 30 percent of its electricity from Dominion Energy's four nuclear units, ranking eighth in the nation in its reliance on nuclear power. The nation's nuclear-powered Navy has its home in Virginia, supported by the Norfolk Naval Shipyard and Newport News Shipbuilding. Virginia is also home to half a dozen corporations that are global leaders in nuclear energy. One of these, BWX Technologies, has been selected by NuScale Power to conduct the design for manufacturability engineering work for NuScale's next-generation small modular reactor, the first to receive design approval from the U.S. Nuclear Regulatory Commission.

Virginia is also actively testing long-duration battery storage, Dominion Energy is piloting this technology in multiple areas. In 2020, it received approval from the State Corporation Commission to move forward with four battery storage pilot projects totaling 16 megawatts. They will provide key information on distinct use cases for batteries on the energy grid. Virginia Tech's Power and Energy Center is also researching ways to store electricity for later use as well as to devise methods to improve and protect the world's power grids and equipment and to design distributed and alternative power systems.

We propose further study to lay out a roadmap about how Virginia can meld these three technologies. Becoming a leader in clean energy generation will benefit the Virginia economy. Aside from the direct economic and workforce development benefits of fostering a renewable energy ecosystem, it will help attract major corporations committed to their sustainability goals.

Strategy 2.

Make Virginia a National Leader in Supply Chain System Security

A MUCH-HERALDED STRENGTH OF THE U.S. economy, its extended and extensive supply chains, was exposed by the pandemic as a vulnerability. The danger is not confined to pandemics, however. The ransomware attack on Colonial Pipeline caused panic gasoline buying this spring across the Southeast. This attack and others demonstrated that the supply chain is an irresistible target for cybercriminals. Some of the largest employers in the Commonwealth have complex supply chains that make them tempting targets of attack. To avoid economic disruption, the Commonwealth must have more resilient, diverse, and, most of all, secure supply chains.

Recognizing this crisis, President Biden signed Executive Order 14017 on February 24, 2021, to help create more resilient and secure supply chains for critical and essential goods. The executive order focuses on six key sectors: the defense industrial base; the public health and biological preparedness industrial base; the information and communications technology (ICT) industrial base; the energy sector industrial base; the transportation industrial base; and supply chains for agricultural commodities and food production.

The Commonwealth has a unique combination of assets that it can tap that would enable it to address challenges enumerated in EO 14017 and emerge as a national leader in supply chain security.

Virginia is a hub for research and education in defense logistics. Facilities include the U.S. Army Logistics University at Fort Lee, the U.S. Army Logistics Center, and the Defense Logistics Agency (DLA). In addition, it is the home of The Port of Virginia, which can process over 4 million containers annually and accommodate ultra-large container vessels. It is also a pioneer in applying advanced logistic systems to control the movement of cargo.

In addition, some of the global leaders in advanced logistics — such companies operating on the cutting edge of logistics like Amazon, Walmart, Dollar Tree, DHL Supply Chain, UPS, FedEx, Patton Logistics, Interchange, and Lineage Logistics — have substantial operations in Virginia. These companies are actively growing the Commonwealth's supply chain ecosystem. Amazon's decision, for instance, to build a new headquarters in Northern Virginia has been accompanied by a number of initiatives around the state. In May, the company announced that its massive multistory, 650,000-square-foot fulfillment center in Henrico County would feature cutting-edge robotics.

Virginia also has a research infrastructure dedicated to supply chain system security. For instance, the Coastal Virginia Center for Cyber Innovation, headquartered at Old Dominion University, focuses explicitly on maritime cybersecurity. It is one of four regional cybersecurity nodes across the state led by the Commonwealth Cyber Initiative (CCI). The University of Virginia is a founding partner of the Center for Hardware and Embedded Systems Security and Trust (CHEST), a National Science Foundation Industry-University Cooperative Research Center dedicated to addressing the research challenges that industry faces in the design, protection, and resilience of hardware from the security vulnerabilities.

Finally, Virginia is home to the state-sponsored Commonwealth Center for Advanced Logistics Systems

(CCALS). CCALS' goal is to accelerate the transition of technologies from fundamental developments through proof of concept and commercialization. CCALS' industry-led, university-implemented applied research capability also focuses on solving problems of practical importance and relevance to industry and government.

In short, Virginia has all the elements for achieving leadership in supply chain system security. Developing a mechanism that would encourage cooperation and coordination among these disparate entities certainly warrants further study. The benefits for Virginia of achieving its potential in this area would be significant. A successful Commonwealth-wide strategy for supply chain system security leadership would enable the 4,600 existing supply chain operations in Virginia to improve their resiliency to attacks by cybercriminals, grow their operations and assist Virginia in attracting new enterprises. It will also help Virginia develop a workforce with the knowledge and skills to address secure logistics challenges as the 21st-century progresses.

Strategy 3.

Chart a Path for Virginia Leadership in Semiconductors

IN 1990, THE UNITED STATES ACCOUNTED for 40 percent of global semiconductor production. By 2019, the U.S. share had dropped to just 11 percent, putting it behind Taiwan, South Korea, Japan, and China. Although the United States remains a global leader in semiconductor research and development, chip design, and some aspects of semiconductor manufacturing, the separation of development and production jeopardizes its position as a semiconductor innovator. Furthermore, its dependence on overseas supply chains increases its vulnerability to disruption from natural disaster and cyberattacks as well as trade disputes and military conflict. Similar issues threaten our national security. Semiconductors are everywhere in the military. In modern warfare, the power to compute faster than an adversary provides critical strategic advantage.

The federal government has taken a number of steps to address these issues. In June 2021, the Senate passed the U.S. Innovation and Competition Act (USICA), which provides $52 billion for domestic semiconductor manufacturing, a 30 percent boost in funding for the National Science Foundation, and $29 billion for a new science directorate to focus on applied sciences. This funding would also be used to finance provisions of the Creating Helpful Incentives to Produce Semiconductors for America Act (CHIPS for America Act) and the American Foundries Act that were included in the National Defense Authorization Act (NDAA), passed in December 2020.

This bipartisan resolve to strengthen U.S. semiconductor leadership and build manufacturing capacity, backed by a substantial commitment of funds, will create economic opportunity for states that are bold and inventive enough to seize it. Virginia can be one of these.

Virginia has a number of distinct advantages that can place it at the forefront of efforts to secure the U.S. semiconductor supply chains and energize semiconductor research and development.

The first is expertise in memory and storage, which are expected to be the fastest growing segments in the semiconductor industry over the next decade. Micron Technology's Virginia location has the only fabrication facility in the United States producing semiconductor memory storage (DRAM). Micron has embarked on a plan to invest $3 billion by 2030 to expand its Manassas operation, adding another 111,000 square feet of clean space to the facility.

Virginia also has a number of well-established organizations that support innovation in semiconductors. Foremost among them is the public-private Virginia Microelectronics Consortium (VMEC). VMEC's mission is to advance microelectronic research and development, broaden the talent pipeline, and support economic growth within the Commonwealth. Another critical organization is the Commonwealth Cyber Initiative (CCI), which can provide leadership in hardware security and workforce development. CCI was funded with a multimillion-dollar investment from the Commonwealth to support world-class research at the intersection of data, autonomy, and security; promote technology commercialization and entrepreneurship; and prepare future generations of innovators and research leaders.

Virginia's universities also conduct world-class research in emerging fields relevant to semiconductor innovation. These disciplines include high-performance, low-power/energy harvesting semiconductors, high-speed semiconductors, thin films and material systems, ferroelectric microelectronics, novel memory technologies, semiconductor optoelectronic devices, and novel sensors and sensor systems.

Finally, Virginia's location provides an important differentiating advantage. Because of its proximity to Washington, it has a high concentration of defense contractors who can provide insight into critical Department of Defense microelectronic needs.

By mapping U.S. needs to Commonwealth assets, the committee determined a number of measures that should be investigated that would enable Virginia to mobilize these resources and expand its advantage.

These measures include establishing a National Center for Hardware Security, with a comprehensive focus from silicon to systems, a National Center for Critical Technologies to assure the trusted supply of critical semiconductors and integrated circuits, and a Secure Flexible Fabrication Facility, based on the Sematech model pioneered in the late 1980s. Sematech incentivized innovation in semiconductors and attracted almost $1 billion in research funding.

Taken together, these initiatives could represent a meaningful response to U.S. needs. They would also benefit the Virginia economy. According to the Semiconductor Industry Association (SIA), the total impact of the semiconductor industry on the U.S. economy amounted to $246.4 billion in 2020. It is time that Virginia took a greater share of these revenues. In addition, such initiatives might help pave the way for Virginia to secure a second major commercial fabrication facility in addition to Micron's. They are certainly worthy of future study.

Strategy 4.

Maximize Healthcare Resources for All Citizens of the Commonwealth

VIRGINIA HAS ONE OF THE PREEMINENT healthcare systems in the nation, but the pandemic highlighted a number of deficiencies that undermine the Commonwealth's efforts to provide the best possible care to all Virginians and in particular to address longstanding healthcare disparities. These deficiencies, however, are not confined to Virginia but are general across the entire United States. If Virginia can find ways to maximize the delivery of healthcare to its citizens in a fair and equitable way, these initiatives could emerge as a pattern for other states to follow.

The first deficiency is access — vulnerable populations in rural and urban areas across the state have limited access to health care. This is especially a problem for Virginia's growing elderly population and for people of color. The second issue is an inability to maximize the potential of available healthcare data, undermining the state's ability to provide personalized medicine on one end of the spectrum and manage population health on the other. The third is an inability to identify and respond to emerging healthcare crises.

In addressing these three deficiencies, the Commonwealth has a number of resources that it can build on. Access is one area in which Virginia already is a national leader, thanks in large part to the University of Virginia's Center for Telehealth. The center has supported more than 100,000 patient encounters and connects doctors and nurses with patients at more than 150 facilities across Virginia and around the world. In addition, a number of institutions in Virginia have developed smartphone applications that help patients better manage their conditions and keep them in close contact with their providers. An example of this is PositiveLinks, a smartphone application for patients with HIV/AIDS as well as Hepatitis C and opioid addiction. It is now a statewide model and has been adopted by other states and countries.

Virginia also has a series of major healthcare data repositories The Virginia Department on Health (VDH) collects data on a variety of issues including maternal and child health, cancer incidence, opioid addiction, and infectious diseases including COVID-19. It has also established the Health Opportunity Index (HOI) and created a series of HOI dashboards for every health district, county, and city in the Commonwealth. Virginia Health Information (VHI) administers Virginia's All Payer Claims Database (APCD), which includes more than a billion claims filed by an estimated 5 million Virginians covered by commercial, Medicaid, and Medicare insurance. VHI also oversees the Health Information Exchange for the Commonwealth, a secure, internet-based data exchange for medical information and is now working to expand Virginia's Advance Healthcare Directives Registry, Public Health Reporting and the Emergency Department Care Coordination Program.

The Virginia Department of Health has a wide range of monitoring programs that can form the basis of a comprehensive system to identify emerging healthcare challenges. In addition, Virginia's research universities have a number of initiatives for environmental monitoring and rapid testing of populations. There is also a large body of research underway in Virginia to detect CBRNe (chemical, biological, radiological, nuclear, and environment) threats. The sensors, models, and

predictive analytics developed for these systems could be repurposed as a healthcare early warning system.

There are a number of steps that the Commonwealth could take to better coordinate and strengthen these resources. The first is to create a group to coordinate closely with the VDH and provide technological innovation in support of its recently issued State Telehealth Plan, a comprehensive initiative designed to create an integrated approach to the introduction and use of telehealth services in the Commonwealth of Virginia. Such a group might also help create a Virginia Health Equity Dashboard, modeled after Massachusetts Race and Hispanic Ethnicity Health Equity Dashboard, which provides health outcome data from across the state and that helps guide intervention strategies.

In addition, Virginia could create a consortium of public and private entities, that would partner with VHI to develop more robust datasets and create innovative ways of applying artificial intelligence to this data to foster advances in personalized medicine and population health. An important element in this consortium would be representation from the Commonwealth's historically black colleges and universities (HBCUs) as well as Virginia's vulnerable communities to address issues of bias in technology.

This consortium would also focus on environmental and biological sensing. We have found no organization in the United States that that deploys a comprehensive network of environmental and biological sensors to improve population health.

A final area that deserves additional study is the creation at one of Virginia's universities of a School of Public Health. While there are public health programs at UVA and George Mason University, Virginia is one of the few states of its size that lacks a full School of Public Health, which would serve as a focal point for research on population health while building an expert workforce capable of acting on these findings.

Given the potential benefits of these initiatives, a study team including representatives from VDH, VHI, private entities, Virginia's HBCUs and Research 1 universities would provide a useful service by investigating this opportunity in greater depth, identifying areas in which technological innovation would have the greatest impact on the health of all Virginians, and laying out a roadmap to address these issues.

Strategy 5.

Enable Virginia to Create Smarter, More Resilient Communities

The challenges facing Virginia localities are unprecedented in their complexity, scale, and cost. Among other issues, cities and counties across the Commonwealth must address the lingering aftereffects of the COVID 19 pandemic, persistent inequities in housing and healthcare, and a looming climate crisis that will likely cause progressive dislocation and strain municipal budgets.

Smart technology can enable communities to use resources more efficiently, improve quality of life for residents, and better anticipate future needs. Smart communities are those that use data to improve the services they deliver or provide new services that were

previously unavailable. They are built on modern digital infrastructure that includes Internet of Things (IoT) sensors and actuators, high-speed networks such as 5G, advanced data handling and analytics at the edge and in the cloud, and intuitive, user-facing applications, all relying on strong cybersecurity to maintain the integrity of the data and systems. In smart communities, these technologies converge as a service infrastructure.

The Commonwealth has a number of advantages that position it well for enhancing its smart infrastructure. Its growing smart community ecosystem of public-private partnerships leverages the strengths and relationships among universities, entrepreneurs, localities and supporting agencies to ensure that leading edge research leads to practical implementations, and entrepreneurial efforts can find markets for innovative products, all while supporting the growth and evolution of critical government services and resilience.

For instance, in May 2021, Stafford County and the Center for Innovative Technology (CIT) launched the Virginia Smart Community Testbed, enabling users to explore and validate a wide range of emerging technologies from IoT to artificial intelligence to data security in a controlled setting and then directly field successful technologies in Smart Stafford.

In addition to the Virginia Smart Community Testbed and the initiatives cited above, CIT's Smart Community Strategic Initiative portfolio includes a testbed at Capital One Arena in Washington, DC with more in development (Winchester, Roanoke, Norfolk/ Virginia Beach).

There are other efforts underway that could help position the Commonwealth as a smart community leader. Under the Virginia Innovation Partnership Authority (VIPA), the Commonwealth is actively working with several federal entities to be designated one of the new technology hubs contemplated in the United States Innovation and Competition Act. Such a role would both support national security interests around technologies such as AI and 5G as well as bring potentially billions of dollars in new federal funding to the Commonwealth.

In addition, virtually all of Virginia's research universities have programs that focus on the technological building blocks of smart communities as well as their applications. To name just a few, George Mason University, in conjunction with CIT, conducts research into smart building technologies that can help first responders save lives and improve public safety. Virginia Tech offers a smart and sustainable cities major, one of the first of its kind in the United States. The University of Virginia has research programs on data-driven stormwater management and mobile ad hoc networks for connected transportation services.

In addition, a number of existing entrepreneurial accelerators (Smart City Works, RIoT, MACH37) and institutions of higher education (including the CCI as well as Germanna Community College and Shenandoah University) are part of the new CIT-led Entrepreneurial Ecosystem, which is actively delivering workforce and entrepreneurial development in such smart community technologies as autonomous systems, IoT sensors, edge computing, and low-latency applications.

Specialized military and government programs and facilities have also expressed interest in smart community technologies. These entities bring specialized strengths to the Commonwealth's effort and are engaging in collaborations with the local government programs.

Developing a mechanism that would enable Virginia to scale and better coordinate these activities, delivering meaningful smart community services while laying the foundation for further innovation is worthy of further study. One approach might be to launch a statewide Network of Smart Community Living Laboratories. Each laboratory would bring together local entities, universities, and private companies with the goal of researching, developing, testing, and commercializing smart

community applications. Initial Living Laboratories might be organized around stormwater sensing, IoT devices, transportation, drone-sensing and service delivery, and other technologies.

A successful Commonwealth-wide strategy for smart communities builds on extensive Commonwealth strengths, leverages a number of different existing funding streams, increases community resilience and operations, supports national defense and related goals, and helps build the workforce of the future. Continued support for these initiatives will ensure Virginia maintains and grows its leadership position in this area as it seeks to become both the leading supplier and leading consumer of these technologies.

Emerging and Enabling Technologies

Preeminence in each of the five areas will require expertise in a wide range of domains, but a small set of emerging technologies will be critical to them all. As a further recommendation of this expert panel, we stress the importance for the Commonwealth of continuing to support and advance the research, development, education, and training in each of them. They include:

AI — Artificial intelligence (AI) refers to the ability of a machine to perceive, evaluate, and act more quickly and accurately than human beings. In the form of such technologies as machine vision and neural networks, AI is transforming virtually every element of modern life.

5G — 5G's enhanced, mobile broadband, low latency, intelligent power consumption, high-device density, and network slicing make it foundational for smart cities, telemedicine, and intelligent manufacturing.

IoT — Internet of things (IoT) brings together information from a series of connected devices that allows for the creation of analytics of systems. These platforms, devices and datasets have the potential to provide insights, efficiencies, and new business opportunities that are applicable to healthcare as they are to logistics.

Pervasive Cloud and Edge Computing — Cloud technologies enable organizations to build applications that scale in real time with low latency, responding to demand that may change instantaneously by orders of magnitude. The pervasive cloud offers a consumption-based platform, allowing developers to quickly and cost effectively deploy applications.

The Next Step

We urge the Joint Commission on Technology and Science to initiate further study into these five focus areas to better assess the Commonwealth's value proposition, the competitive landscape, and the inventory of available resources and talent. As part of this effort, study committees should produce detailed roadmaps that describes both near-term and long-term steps Virginia can take to capitalize on its strengths to play a unique role in addressing our national challenges.

Strategic Brief 1

Position Virginia as a National Model for Reliable Sustainable Energy

Background/Opportunity/Need

The shift to a low-carbon future will require the transition of virtually all forms of heating, cooling, transportation, and power to electricity generated by sustainable sources. The resulting demand will be unprecedented. Meeting this demand in a sustainable, reliable, and affordable way will be a complex undertaking, but a smooth transition is critical if industry is to grow and individuals across the Commonwealth are to thrive. Variable energy renewables and inverter-based generation like solar alone do not provide the reliability and resiliency needed to provide consistent power. While initiatives that promote more efficient use of energy are an essential part of this transition, the movement to a low-carbon future also requires the large-scale integration of clean generation, the adoption of new technologies, and the deployment of advanced monitoring, control, and demand-side management capabilities.

There are many possibilities for combining clean generation technologies to achieve reliability and resilience. According to a recent report, *The Future of Electric Power in the United States* (2021), published by the National Academies of Sciences, Engineering, and Medicine, possible clean generation sources include utility-scale wind and solar, carbon capture with sequestration or use, and carbon-neutral fuels (for

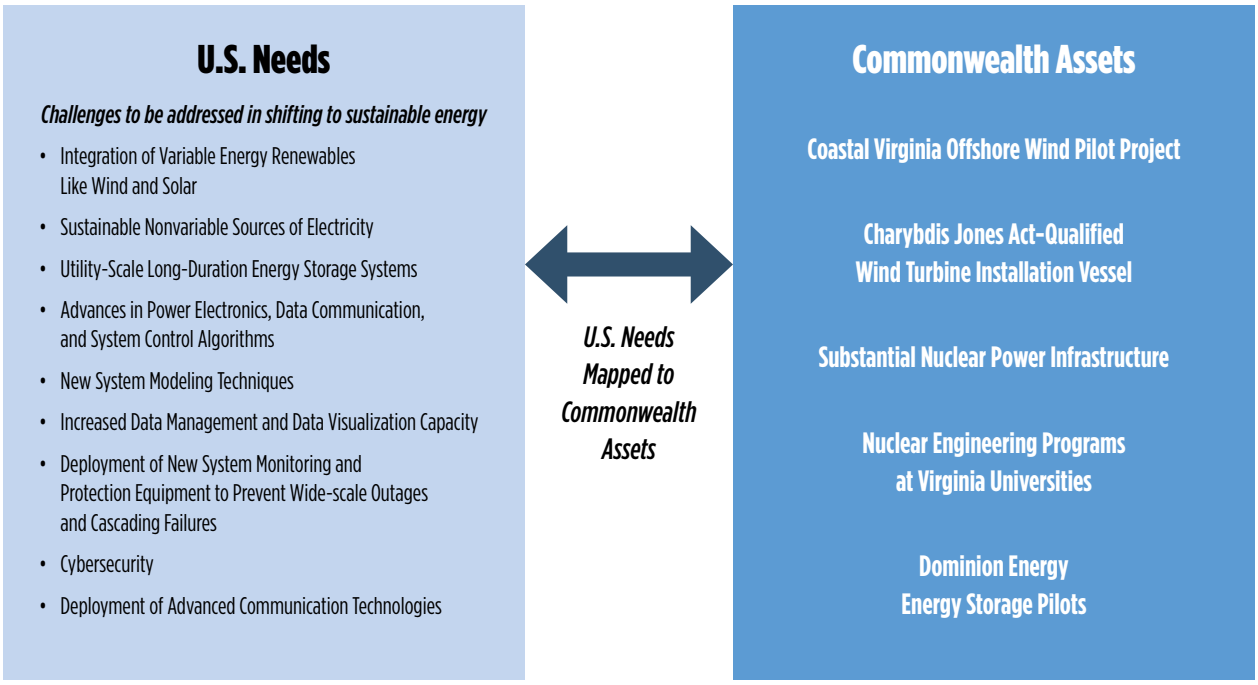


Figure 1 Virginia possesses a number of resources that can help it become a national model for reliable sustainable energy.

instance the conversion of water to hydrogen using hydrolysis).

Long-duration electricity storage must also play a key role in the low carbon energy future. It is an enabling technology for achieving the reliability and resiliency necessary for an economy dependent on electricity. Long-duration electricity storage can provide the balance that enables large-scale deployment of variable energy renewable resources and inverter-based generation. It also increases the system's ability to cope with disruptive events.

To achieve significant penetration levels for renewables and distributed energy resources (DER), it will be necessary to deploy many utility-scale energy storage systems at strategic locations throughout the power system. The wide-scale adoption of renewable and DER will also require working with many technical areas that are cross-cutting and can be leveraged across multiple sectors. These include:

- Advancements in power electronics, data communication, and system control algorithms
- New system modeling techniques
- Increased data management and data visualization capability
- Deployment of new system monitoring and protection equipment to prevent wide-scale outages and cascading failures
- Cybersecurity
- Deployment of advanced communication technologies across the Commonwealth of 5G and broadband
- Development of new electric utility blackstart capability to support this new dispersed generation to expedite recovery from extreme events.
- Leveraging the existing natural gas infrastructure to support hydrogen in the future.

Existing Commonwealth Strengths/Relationships/Resources

The Commonwealth currently has strengths in several areas that are critical to achieving low-carbon goals. These are highlighted in Figure 1 at left.

Wind Power

Virginia is well positioned to become a significant producer of offshore wind. In September 2020, the Coastal Virginia Offshore Wind (CVOW) pilot project began generating power. It is the second offshore wind farm constructed in the United States and the nation's first offshore wind project owned by an electric utility company, Dominion Energy. When completed in 2026, the wind farm is expected to power up to 600,000 homes and create 1,100 jobs.

Enabling and deploying the electric transmission infrastructure, essential for accessing large scale offshore wind generation, has already led to development of sophisticated modeling techniques, unique transmission ancillary support equipment installations, and other specialized equipment, by this Virginia-based organization.

Virginia also has a number of other strengths and ongoing developments that may accelerate Virginia's leadership in wind power. The maritime construction and engineering skills resident in Virginia's ports will provide innovation as Virginia expands its offshore facilities.

One barrier to offshore wind is Jones Act compliance, which specifies that only U.S.-built-and-operated ships can move goods between U.S. ports. In practice, this means that the U.S. must build its own fleet of turbine installation vessels, rather than rely on European vessels. In response, Dominion Energy is leading a consortium building *Charybdis,* America's first Jones Act-qualified offshore wind turbine installation vessel. The vessel is designed to handle current turbine technologies as well as next-generation turbine sizes of 12 megawatts or larger. It will also be capable of installing foundations for turbines. This $500 million project is expected to be completed in 2023 and will use Hampton Roads as its port of call.

The *Charybdis* will help cement Virginia's position as the East Coast center for offshore wind innovation and workforce development. In addition to deploying *Charybdis* to support the construction of CVOW, Dominion Energy recently signed an agreement to charter the vessel to Ørsted and Eversource to assist them install two major offshore wind farms in the Northeast.

Virginia is also at the forefront in developing the wind turbines of the future. UVA's SUMR 50-megawatt wind turbine project, supported by a Department of Energy ARPA-E grant, features extreme-scale, 200-meter blades, generating 10 times more energy than current wind turbines.

In September 2020, the Coastal Virginia Offshore Wind (CVOW) pilot project began generating power. When completed in 2026, the wind farm is expected to power up to 600,000 homes and create 1,100 jobs.

Small modular reactors and microreactors are seen as the future of nuclear power. Various companies are commercializing 300-megawatt SMRs, which can be assembled in the factory and transported to the final location, cutting assembly time, cost, and risk.

Nuclear Power

Virginia already has a substantial nuclear infrastructure. Currently, Virginia generates almost 30 percent of its electricity from Dominion Energy's four nuclear units in the state, ranking eighth in the nation according to the U.S. Energy Information Administration. The nation's nuclear-powered Navy has its home in Virginia, supported by the Norfolk Naval Shipyard and Newport News Shipbuilding. In addition, two major federal facilities located in Virginia, the Norfolk Naval Shipyard and NASA Langley, are active in research and development of nuclear technology, and NASA Langley, along with NASA Wallops Space Facility, is exploring the integration of nuclear energy into space missions.

Virginia is also home to headquarters, facilities, and operations of half a dozen corporations that are global leaders in nuclear energy. In addition to Newport News Shipbuilding, they include MPR Associates (Alexandria), Framatome Inc. (Lynchburg), BWX Technologies, Inc. (Lynchburg), NovaTech (Lynchburg), Virginia Uranium (Chatham), and Bechtel (Reston).

Small modular reactors and microreactors are seen as the future of nuclear power. Various companies are commercializing 300-megawatt SMRs, which can be assembled in the factory and transported to the final location, cutting assembly time, cost, and risk. Microreactors are even smaller, rated at 0.2–10 megawatts, and can be transported as fully operational units by semi-tractor trailer to provide power at the grid edge, in remote locations not easily served by the grid, or in emergency situations. In Virginia, BWX Technologies has been selected by NuScale Power to conduct the design for manufacturability engineering work for NuScale's SMR nuclear power module, the first to receive design approval from the U.S. Nuclear Regulatory Commission.

Nuclear education continues to be a key initiative in many universities across the Commonwealth. Virginia Tech, Virginia Commonwealth University (VCU), the University of Virginia (UVA) and Old Dominion University have degree programs and research relationships and are training the next generation of expertise and leadership needed to support the nuclear energy sector.

Energy Storage

Dominion Energy is piloting this technology in multiple areas. In 2020, it received approval from the State Corporation Commission to move forward with four battery storage pilot projects totaling 16 megawatts. They will provide key information on distinct use cases for batteries on the energy grid. For instance, it has installed two battery systems totaling 12 megawatts at the Scott Solar facility in Powhatan County They will provide valuable information on the proficiency of battery technology to store energy generated from solar panels during periods of high production and release energy

during periods when load is high or solar generation is low. It would also reveal how well a battery can optimize power production of the solar facility.

Virginia Tech's Power and Energy Center is also researching ways to store electricity for later use as well as to devise methods to improve and protect the world's power grids and equipment and to design distributed and alternative power systems.

Compelling Initiative/Solution that Addresses Opportunity and Builds on Strengths

The Commonwealth of Virginia has a unique opportunity to become a leader and model for the nation for a new low-carbon electricity future by reliably integrating offshore wind, nuclear power, and long-duration electricity storage. Although nuclear power remains controversial, the argument for combining these three elements has become increasingly compelling as the U.S. strives to meet its goal of net zero emissions economy-wide by no later than 2050.

There are a number of reasons why combining offshore wind and nuclear makes good sense. The combination of firm-generation and variable-generation no-carbon sources are necessary for reliable energy production. Furthermore, the U.S. will need to maintain its foundation of nuclear generation if it hopes to meet its climate goals. According to the U.S. Energy Information Agency (February 2021), fossil fuels currently account for 60.3 percent of U.S. utility-scale energy generation. Renewables account for 19.8 percent, of which the largest component is wind at 8.4 percent. The 94 operating reactors in the United States are responsible for 19.7 percent of U.S. energy production. Increasing nuclear capacity, even modestly, will help the United States reach its goals — and reducing capacity will make those goals more difficult to reach.

Other nations have realized this. The United Kingdom, for instance, has announced plans to rapidly expand offshore wind capacity by 2030 while investing in traditional nuclear powerplant and SMR development to meet net-zero carbon emissions goals by 2050. A new nuclear power station, expected to produce 7 percent of the country's needs, is expected to open in 2026. United Kingdom regulators are even exploring combining offshore wind and nuclear into a single unit. In 2021, NuScales's SMR has been chosen for a unique wind-nuclear hybrid project in Wales that would produce green hydrogen as well as power.

There are a number of reasons why combining offshore wind and nuclear makes good sense. The combination of firm-generation and variable-generation no-carbon sources are necessary for reliable energy production.

Given that Virginia already relies on nuclear generation for a third of its power and it is one of the nation's leaders in offshore wind, Virginia has an opportunity to be a pioneer in building an integrated system for energy generation, backed by electrical storage, that would be a national model. Given the potential benefits to the Commonwealth enumerated below, a study team bringing together representatives from state and federal government agencies, Dominion Energy, the Commonwealth's leading offshore

wind and nuclear companies, and Virginia's universities would provide a useful service by investigating this opportunity in greater depth, identifying technological and policy challenges, and, if practicable, laying out a roadmap to build a system that would serve as an example for other states.

Potential Benefits to Commonwealth and the Nation

The shift to sustainable clean energy is driven by the need to mitigate the effects of climate change. To the extent that Virginia becomes a model for sustainable, reliable energy, it can help forestall the disruption that rising seas and extreme weather will have on its economy and the lives of its citizens. The switch to nonpolluting forms of energy will also improve the health of Virginians. Although some natural gas generation will be required over the next 20 years after major events such as hurricanes and to support the system when there is not sufficient zero carbon resources or for blackstart, these plants will increasingly move to hydrogen for their fuel source.

Becoming a leader in clean energy generation will benefit the Virginia economy in a number of ways. More than 300 of the largest companies in the world have joined RE100, declaring their intent to use 100 percent renewable energy and often announcing ambitious schedules to reach these goals. They include such industry leaders as General Motors, Wells Fargo, and HP. States that offer a reliable source of noncarbon energy sources will attract and retain industries that require access to highly reliable clean energy, not just for operational purposes, but to meet their environmental, social, and governance (ESG) commitments. By setting its sights on becoming a national model for sustainable energy, Virginia will be in an excellent position to attract these companies

In itself, this initiative would also directly benefit Virginia's economy. It would foster a renewable energy ecosystem including companies serving its offshore wind, nuclear, and storage industries including those that provide installation and maintenance support for turbines. It will provide a stimulus for groundbreaking discoveries necessary for affordable, reliable generation and distribution of sustainable energy in such areas as offshore wind foundation design, offshore wind installation techniques, and flexible AC transmission, storage, and synchronous generation placement. And, by creating a demand for power and nuclear engineers, strengthen these programs at our universities and encourage the development of a well-educated workforce able to address one of the signature challenges of the 21st century.

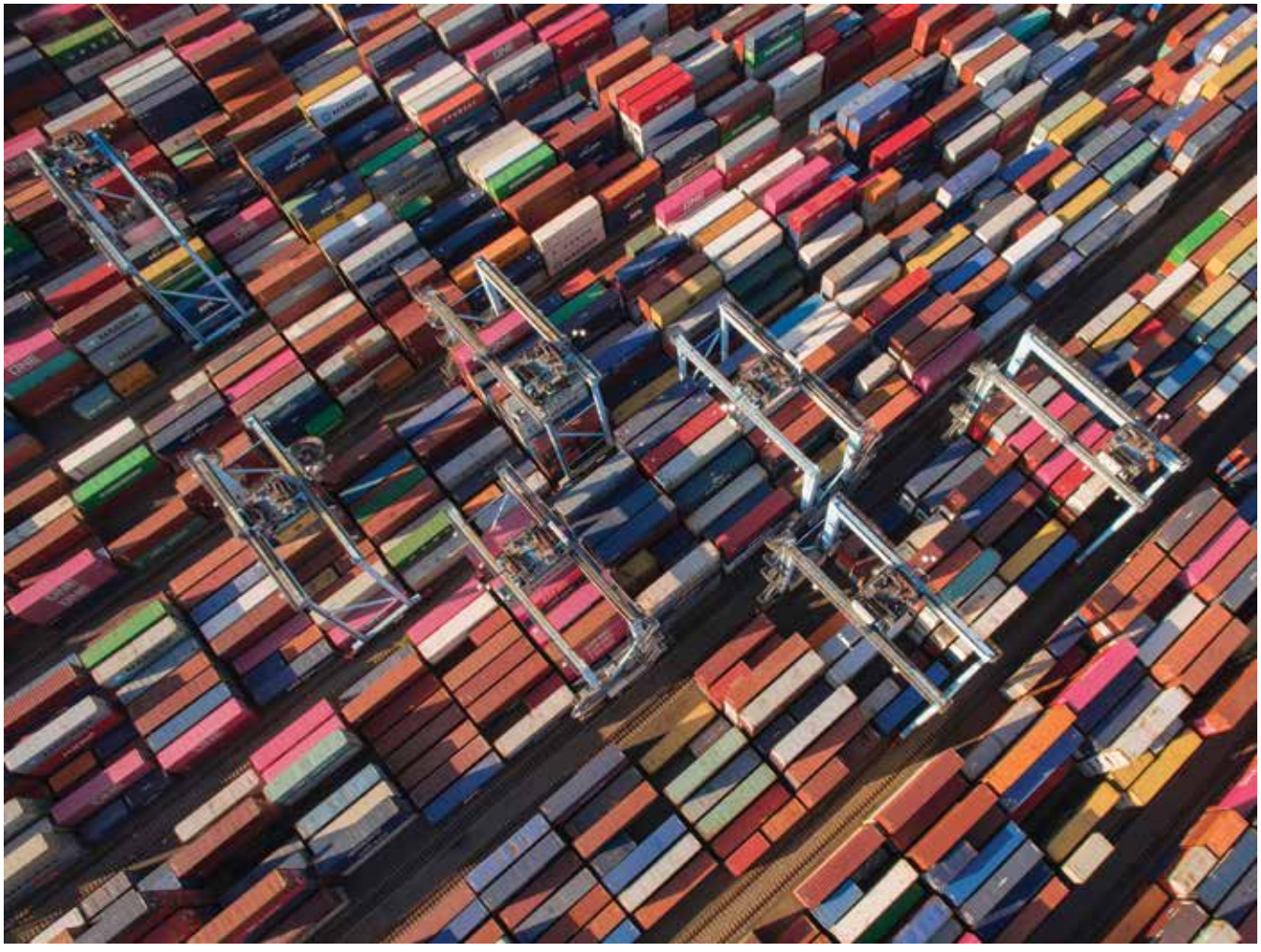
Strategic Brief 2

Make Virginia a National Leader in Supply Chain System Security

Background/Opportunity/Need

A much-heralded strength of the U.S. economy, its extended and extensive supply chains, was exposed by the pandemic as a vulnerability. During the pandemic, the United States found itself dependent, for example, for essential goods like PPE on China and other nations with divergent interests. After the pandemic, our just-in-time supply chain is proving unequal to the demands of a reviving economy, hampering the recovery and fueling inflation.

The danger is not confined to pandemics, however. The ransomware attack on Colonial Pipeline caused panic gasoline buying this spring across the Southeast. A month later, JBS USA Holdings, which is responsible for one-fifth of the nation's supply of meat, paid $11 million to hackers who had encrypted its data. These attacks and



others demonstrated that the supply chain is an irresistible target for cybercriminals. Some of the largest employers in the Commonwealth have complex supply chains that make them tempting targets of attack. They include such companies as Huntington Ingles-Newport, Nestle USA, Sodexo, Bechtel, and Dupont. To avoid economic disruption, the Commonwealth must have more resilient, diverse, and, most of all, secure supply chains.

Recognizing this crisis, President Biden signed Executive Order 14017 on February 24, 2021, to help create more resilient and secure supply chains for critical and essential goods. The executive order launches a comprehensive review of U.S. supply chains and directs federal departments and agencies to identify ways to secure U.S. supply chains against a wide range of risks and vulnerabilities including cyberattacks.

The executive order focuses on six key sectors: the defense industrial base; the public health and biological preparedness industrial base; the information and communications technology (ICT) industrial base; the energy sector industrial base; the transportation industrial base; and supply chains for agricultural commodities and food production.

In implementing the order, the administration sees opportunities to grow the American economy, increase wages, benefit small businesses and historically disadvantaged communities, strengthen pandemic and bio preparedness, support the fight against global climate change, and maintain America's technological leadership in key sectors.

Existing Commonwealth Strengths/Relationships/Resources

Supply chain vulnerability is a threat to Virginia's economy, but it is also an opportunity for growth. The Commonwealth has a unique combination of assets that it can tap that would enable it to emerge as a national leader in supply chain security. These are highlighted in Figure 1.

Defense Logistics and Port and Transportation Facilities

Virginia is a hub for research and education in defense logistics. Facilities include the U.S. Army Logistics University at Fort Lee, the U.S. Army Logistics Center, and the Defense Logistics Agency (DLA) (including its Aviation Command, Energy Command, and Strategic Materials Command).

In addition, it is the home of The Port of Virginia, the only East Coast port with Congressional authorization for 55-foot channels. The port can process over 4 million containers annually and accommodate ultra-large container vessels. It is also a pioneer in applying advanced logistic systems to control the movement of cargo. For instance, turn times at the port are 35 minutes, significantly below the industry standard of 60 minutes. In addition, Virginia boasts 3,000-mile railroad network anchored by Class I railroads CSX and Norfolk Southern, and the second-densest road network in the Southeast.

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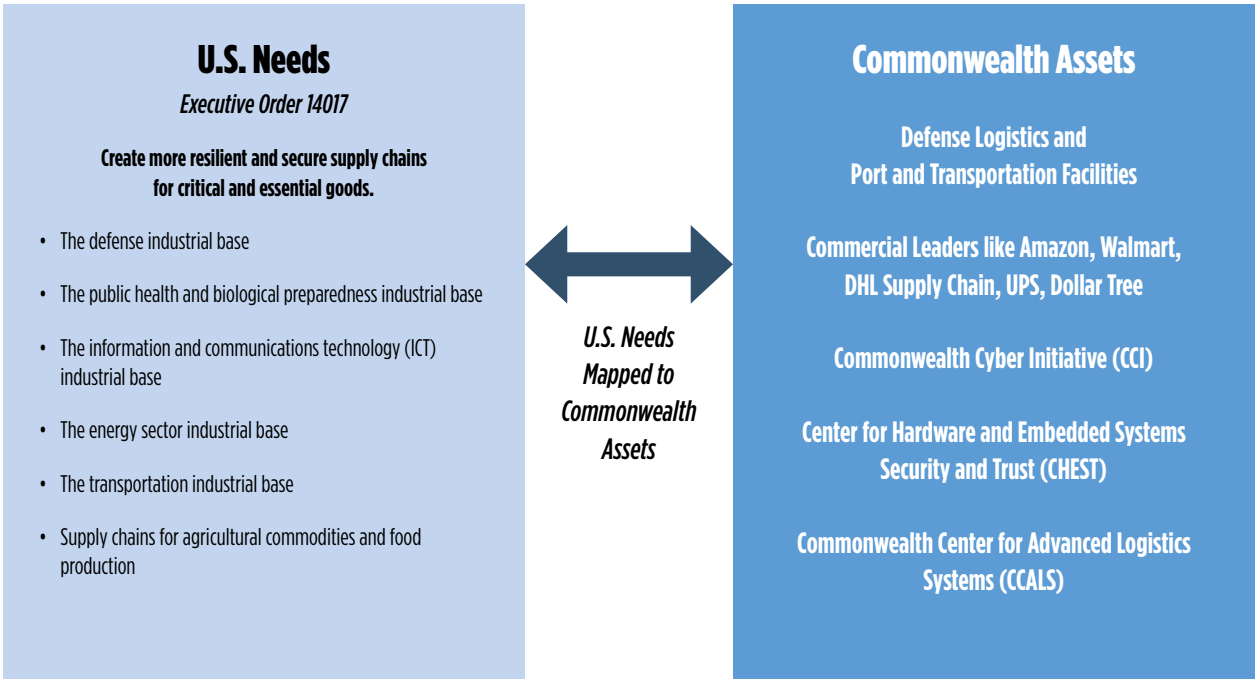


Strategic Brief 5

Figure 1 The Commonwealth possesses a number of assets that are already engaged in ensuring supply chain security and that support the thrusts of Executive Order 14017.

Commercial Logistics Leaders

In addition, some of the global leaders in advanced logistics—such companies operating on the cutting edge of logistics like Amazon, Walmart, Dollar Tree, DHL Supply Chain, UPS, FedEx, Patton Logistics, Interchange, and Lineage Logistics — have substantial operations in Virginia. They have been attracted by Virginia's combination of strategic location, world-class infrastructure, highly ranked business climate, and leading universities.

These companies are actively growing the Commonwealth's supply chain ecosystem. Amazon's decision, for instance, to build a new headquarters in Northern Virginia has been accompanied by a number of initiatives around the state. In May, the company announced that its massive multistory, 650,000-square-foot fulfillment center in Henrico County would feature cutting-edge robotics. In commenting on the plan, Gov. Ralph Northam cited the development as reinforcing "the state's standing as both a technology hub and a leader in supply chain management." Later this year, Amazon plans to launch a robotics fulfillment center in Suffolk and a processing center in Chesapeake.

In addition to providing testbeds for innovation, these advanced logistics companies play an important role in the state's economy. The Henrico center will add more than 1,000 new jobs to Amazon's existing workforce of 27,000 full- and part-time employees in the state. A new 500,000-square-foot high-bay facility being developed by DHL Supply Chain in Stafford County will add almost 600 more. More than 250 supply chain management projects have been announced since 2010, representing almost 20,000 jobs and over $1.5 billion in pledged capital investment.

Research Infrastructure

Virginia also has a research infrastructure dedicated to supply chain system security. A number of its major universities are at the forefront of research in making supply chains more robust and secure. For instance, the Coastal Virginia Center for Cyber Innovation, headquartered at Old Dominion University, focuses

explicitly on maritime cybersecurity. It is one of four regional cybersecurity nodes across the state led by the Commonwealth Cyber Initiative (CCI), based at the Virginia Tech Research Center in Arlington. CCI is a state-funded network of 21 Virginia universities and 320 faculty members. It was funded with a multimillion-dollar investment from the Commonwealth to supports world-class research at the intersection of data, autonomy, and security, promote technology commercialization and entrepreneurship; and prepare future generations of innovators and research leaders.

The University of Virginia is a founding partner of the Center for Hardware and Embedded Systems Security and Trust (CHEST), a National Science Foundation Industry-University Cooperative Research Center. Other universities conduct research in areas critical to secure supply chains. In addition to systems security, these fields include data science, internet-of-things, artificial intelligence, and machine learning.

Finally, Virginia is home to the state-sponsored Commonwealth Center for Advanced Logistics Systems (CCALS). CCALS is an applied research center that bridges the gap between fundamental research that is typically performed at universities and product development that is routinely performed by companies. CCALS' goal is to accelerate the transition of technologies from fundamental developments through proof of concept and then commercialization. CCALS' industry-led, university-implemented applied research capability also focuses on solving problems of practical importance and relevance to industry and government.

Compelling Initiative/Solution that Addresses Opportunity and Builds on Strengths

The Commonwealth has substantial technological cybersecurity expertise, a number of programs at our universities that focus explicitly on the security of our supply chain systems, a series of companies whose business model is founded on cutting-edge logistics, and an enviable array of testbeds that it can use to explore new methods of preventing and containing cyberattack. Taken together, these attributes position Virginia to provide leadership in critical areas of concern and in many of the key domains specified in Executive Order 14017.

For instance, one area of pressing concern is electronic hardware and embedded systems. Vulnerabilities to embedded devices — which can include embedded circuits, sensors, software, and microprocessors — can be introduced during design, manufacturing, testing, transport or any stage of the system lifecycle. By working with industry and government partners, researchers can develop methods to identify and address the priorities for security, assurance and trust across integrated systems. Specific research topics might include anti-reverse engineering and anti-tampering as well as secure communication protocols, vulnerability analysis, and infrastructure safety and resilience. As a founding partner of CHEST, UVA positions Virginia to play a leading role in this area. In addition, CCALS has a major initiative on ensuring the trust and security of embedded hardware and components in cyberphysical, Internet of Things (IoT), and logistics systems.

CCI has also set the stage for a variety of initiatives that can take advantage of existing testbeds, reinforce supply chain security within Virginia, and position Virginia as a national leader. Recent CCI projects support experimental learning modules for a planned Cybersecurity Monitoring Command and Control Center

at The Port of Virginia. By encouraging collaboration on this project across Virginia's cybersecurity ecosystem, Virginia could assist the port to make this command-and-control center a national model.

Virginia is also positioned to play a leading role in helping the Defense Logistics Agency secure its supply chain operations. Protecting the military's supply chain from malicious attack is a major national priority, but it is also a difficult challenge. DLA's global supply chain extends to 46 states and 28 countries and encompasses a myriad of complex and interconnected systems, processes, facilities, infrastructure, suppliers, transportation nodes, end-users, and employees. Each supply chain component is susceptible to adversarial exploitation and disruption from threats that range from stealing the identity of legitimate suppliers to injecting malware and introducing counterfeit parts. The DLA is charged with leveraging emerging technologies that contribute to a trusted, safe, and cybersecure supply chain. Virginia has the technical expertise to help DLA identify its supply chain vulnerabilities, monitor and detect intrusion, and prevent and/or contain damage.

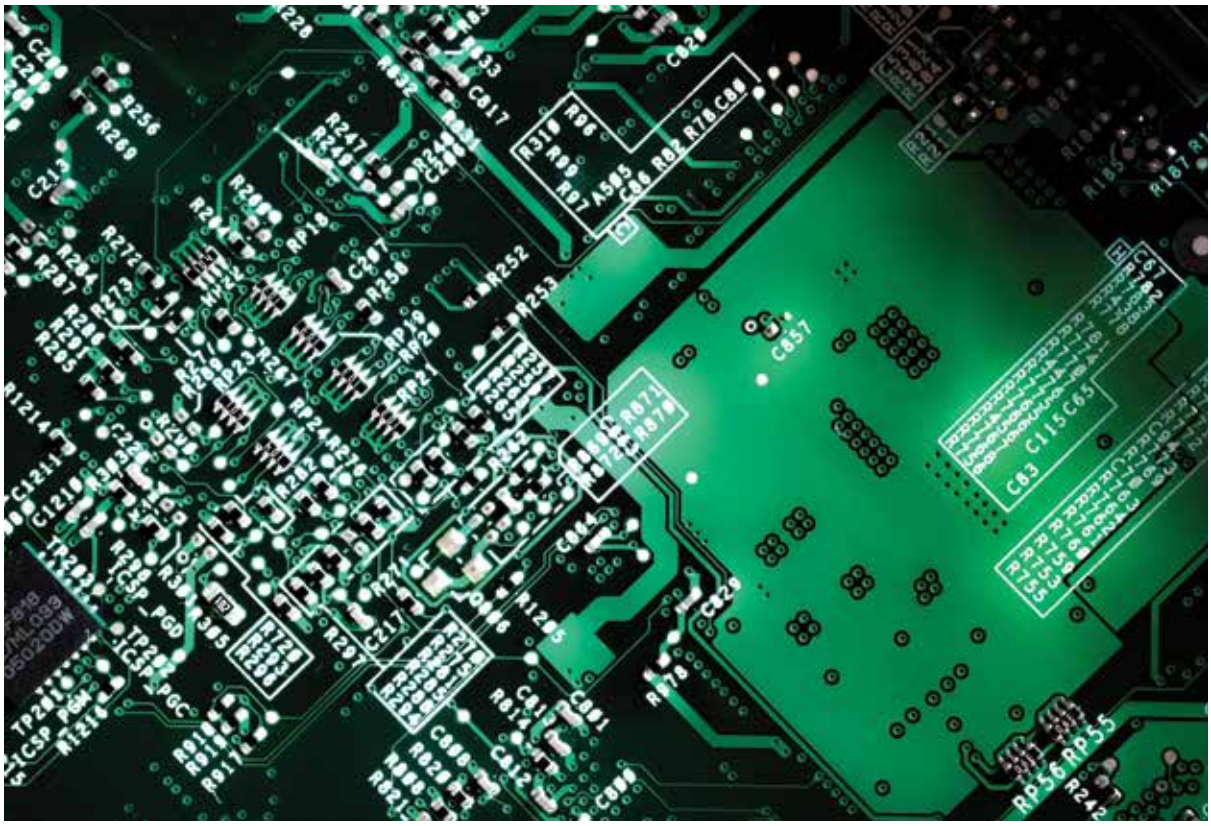
In short, the Commonwealth has already embarked on a number of secure logistics initiatives and is well positioned to do more. The challenge is to bring these efforts together and identify specific areas in which Virginia can demonstrate national leadership. This will require further study. There are, however, a number of promising areas for investigation, based on the extensive strengths and resources already resident in the Commonwealth.

The Commonwealth has already embarked on a number of secure logistics initiatives and is well positioned to do more. The challenge is to bring these efforts together and identify specific areas in which Virginia can demonstrate national leadership.

Potential Benefits to Commonwealth and Nation

Virginia's leadership in supply chain cybersecurity could play a major role in strengthening the nation's economy as well as in supporting our national defense. It would also provide a number of benefits for the Commonwealth. Supply chain operations are extraordinarily important to Virginia's economy. For instance, in fiscal year 2018, The Port of Virginia contributed $39.3 billion (7.5 percent) to Virginia's gross state product, and $23.0 billion (7.0 percent) to total employment compensation as well as generating almost 400,000 billion (9.5 percent) of Virginia's full- and part-time jobs. The Virginia Economic Development Partnership reports there are almost 300,000 people working the supply chain industry and core supply chain occupations in Virginia.

A successful Commonwealth-wide strategy for supply chain cybersecurity leadership would enable the 4,600 existing supply chain operations in Virginia improve their resiliency to attacks by cybercriminals, grow their operations and assist Virginia in attracting new enterprises. It will also help Virginia develop a workforce with the knowledge and skills to address secure logistics challenges as the 21st-century progresses.



Strategic Brief 3

Charting a Path for Virginia Leadership in Semiconductors

Background/Opportunity/Need

In 1990, the United States accounted for 40 percent of global semiconductor production. By 2019, the U.S. share had dropped to just 11 percent, putting it behind Taiwan, South Korea, Japan, and China. There are a number of reasons for this decrease. The first is the adoption by many U.S. firms of a "fabless" business model, in which semiconductor manufacturing is outsourced to companies abroad. Another is the aggressive effort by peer and near-peer nations like China to bolster their semiconductor capacity.

Although the United States remains a global leader in semiconductor research and development, chip design, and some aspects of semiconductor manufacturing, the separation of development and production jeopardizes its position as a semiconductor innovator. Furthermore, its dependence on overseas supply chains increases its vulnerability to disruption from natural disaster and cyberattacks as well as trade disputes and military conflict.

The global chip shortage that emerged in the wake of the COVID 19 pandemic only highlighted this weakness. The most publicized consequence was the disruption to the U.S. auto industry, but the shortage touched virtually

every sector of the economy. With demand spiking after the pandemic, overstressed semiconductor supply chain and limited U.S. capacity has slowed the recovery.

Similar issues threaten our national security. Semiconductors are everywhere in the military, used for weapons systems, communications, command and control, and radar and targeting — as well as in defense disruptive technologies like hypersonics, AI, and 5G. In modern warfare, the power to compute faster than an adversary provides critical strategic advantage.

To mitigate supply chain risks and ensure that semiconductors used in sensitive military systems do not have malware embedded in them, the Department of Defense (DOD) established the Trusted Foundry Program. The two companies operating under this program, however, only produce a small percentage of the nearly 2 billion semiconductors DOD acquires each year, and there is concern that the trusted military foundries are falling technologically behind commercial fabrication facilities in East Asia.

The Federal Response

The Biden administration has taken a number of steps to address these issues. In February, President Biden signed Executive Order 14017, directing the federal government to conduct a 100-day review of supply chains in four areas including semiconductors. At the end of this period, the government launched a task force to develop plans to address supply chain deficiencies.

In June 2021, the Senate passed the U.S. Innovation and Competition Act (USICA), which provides $52 billion for domestic semiconductor manufacturing, a 30 percent boost in funding for the National Science Foundation, and $29 billion for a new science directorate to focus on applied sciences. Significantly for Southwest Virginia, the USICA contains $10 billion to reshape cities and regions across the US into technology hubs, focusing on channeling research and development to create cutting-edge industries and creating new, well-paying tech jobs outside of the coasts.

This funding would also be used to finance provisions of the Creating Helpful Incentives to Produce Semiconductors for America Act (CHIPS for America Act) and the American Foundries Act that were included in the National Defense Authorization Act (NDAA), passed in December 2020. The NDAA authorizes the Department of Commerce to provide eligible companies or consortia with subsidies of up to $3 billion each — or more in exceptional circumstances — for building or updating domestic facilities and equipment related to "semiconductor fabrication, assembly, testing, advanced packaging, or research and development." In addition, the Department of Commerce is directed to award grants to certain states to assist in financing the construction, expansion, or modernization of microelectronics fabrication, assembly, test, advanced packaging, or advanced research and development facilities.

There are also efforts underway to bolster military chip design and production. As part of a CHIPS for America Act provision included in NDAA, the Department of Defense was directed to incentivize the formation of private research consortia and authorized to establish a national network for microelectronics R&D to "enable the cost-effective exploration of new materials, devices, and architectures, and prototyping in domestic facilities to safeguard domestic intellectual property." The Under Secretary of Defense for Research & Engineering, has specifically identified trusted microelectronics and, microelectronics manufacturing as a critical strategic priority for national security.

Additionally, the NDAA calls for the DOD and the Director of National Intelligence to jointly enter into arrangements with private sector entities to provide incentives for the creation, expansion, or modernization of microelectronics manufacturing or advanced research

and development facilities capable of producing secure and specialized microelectronics for use by DOD, the intelligence community, critical infrastructure sectors of the U.S. economy, and other national security applications.

This bipartisan resolve to strengthen U.S. semiconductor leadership and build manufacturing capacity, backed by a substantial commitment of funds, will create economic opportunity for states that are bold and inventive enough to seize it. Virginia can be one of these.

Existing Commonwealth Strengths/Relationships/Resources

Virginia has a number of strengths that can contribute to U.S. efforts to secure its semiconductor supply chains and energize its semiconductor research and development. It is clear, however, that significantly expanding mass semiconductor manufacturing in Virginia is not a route immediately available to it. Six semiconductor companies currently manufacture 300 mm silicon wafers at 20 fabs in the United States. These fabs are located in eight states, with the largest number in Texas (five), Oregon (four), and New York (three). Virginia has one, the Micron Technology memory/DRAM fabrication facility in Manassas. Virginia currently lacks the industrial base — the network of suppliers and the knowledgeable workforce — needed to support another major facility. Nor has Virginia historically been able to offer the kind of substantial incentive that states like New York have provided to induce companies to build new fabrication facilities in the Commonwealth.

That being said, Virginia does have a number of distinct advantages that can help it contribute to securing the U.S. semiconductor supply chains and promoting advances in semiconductors in ways that other states lack. The first is expertise in memory and storage, which are expected to be the fastest growing segments in the semiconductor industry over the next decade. Micron Technology's Virginia location has the only fabrication facility in the United States producing semiconductor memory storage (DRAM), and Micron is shipping memory chips built using the world's most advanced DRAM process technology from its factories in Taiwan. The company is expected to introduce this technology at its U.S. operations. Accordingly, Micron has embarked on a plan to invest $3 billion by 2030 to expand its Manassas operation, adding another 111,000 square feet of clean space to the facility.

Virginia also has a number of well-established organizations that support innovation in semiconductors. Foremost among them is the Virginia Microelectronics Consortium (VMEC). This consortium is comprised of major Virginia universities, members of the Virginia Community College System, Micron Technology, BAE Systems, Virginia Diodes, Virginia Economic Development Partnership (VEDP), and the Army Night Vision Labs in Fort Belvoir. VMEC's mission is to advance microelectronic research and development, broaden the talent pipeline, and support economic growth within the Commonwealth. VMEC supports the Virginia Nano-Networked Infrastructure, a collaborative effort to share university semiconductor assets across the Commonwealth.

Another critical organization is the Commonwealth Cyber Initiative (CCI), which can provide leadership in hardware security and workforce development. CCI was funded with a multimillion-dollar investment from the Commonwealth to support world-class research at the intersection of data, autonomy, and security; promote technology commercialization and entrepreneurship; and prepare future generations of innovators and research leaders.

Virginia's universities also conduct world-class research in emerging fields relevant to semiconductor

innovation. These disciplines include high-performance, low-power/power harvesting semiconductors, high-speed semiconductors, thin films and material systems, ferroelectric microelectronics, novel memory technologies, semiconductor optoelectronic devices, and novel sensors and sensor systems. They have also led or participated in major National Science Foundation Engineering Research Centers in such fields as power electronics, advanced materials, self-powered sensing, computation, and communication, and other fields, demonstrating their ability to assemble expertise from the top universities and government laboratories across the nation.

Finally, Virginia's location provides an important differentiating advantage. Because of its proximity to Washington and the location of the Pentagon in Virginia, it has a high concentration of defense contractors who can provide insight into critical Department of Defense microelectronic needs. These include Lockheed-Martin, Northrop Grumman, General Dynamics, Bechtel Group, and SAIC. One of these companies, BAE Systems, operated a specialty microelectronics fabrication facility in Manassas until 2014. Researchers at Virginia's universities and corporations have extensive relationships with Department of Defense organizations, such as the Night Vision and Electronic Sensors Directorate, that promote the development of advanced microelectronics.

Compelling Initiative/Solution that Addresses Opportunity and Builds on Strengths

To restore U.S. Semiconductor leadership, a diverse and wide-ranging set of needs must be addressed. Some of these needs are highlighted in Figure 1.

The Virginia Academy team mapped these needs to existing Commonwealth assets and determined there are several specialized areas where Virginia may have a significant impact.

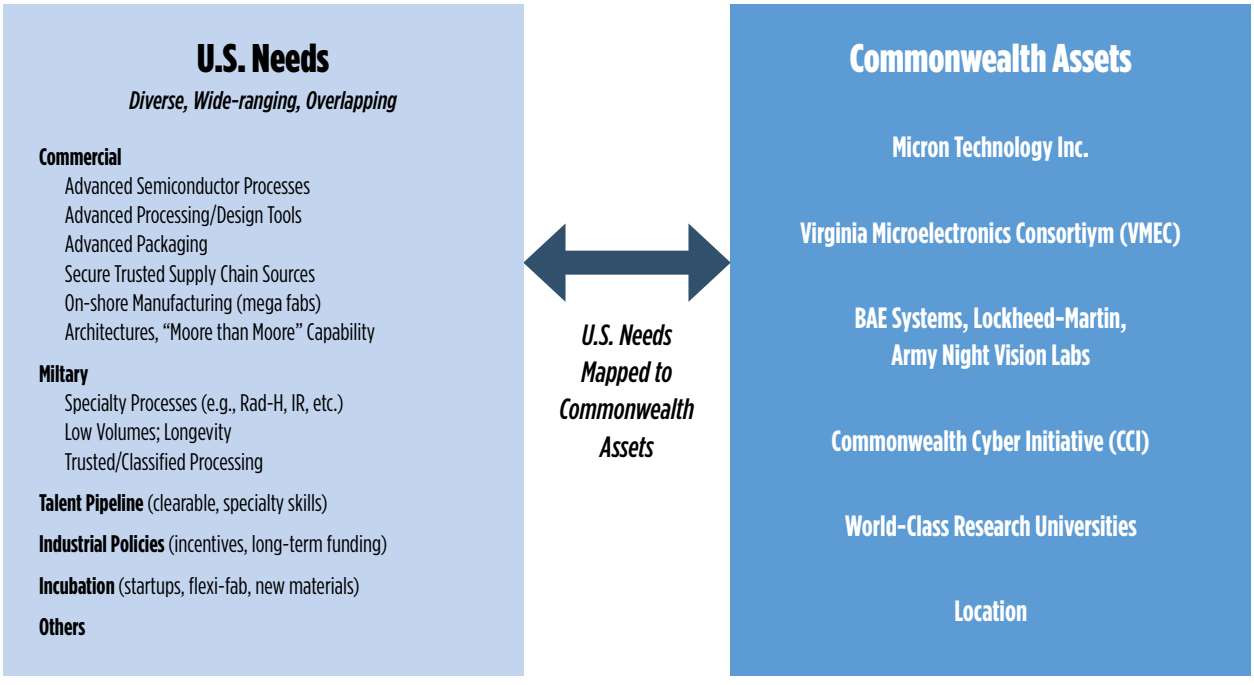


Figure 1 Restoring US Semiconductor leadership requires investment in a host of commercial and military disciplines, supply chain, talent pipeline, industrial policies, and incubation of new ideas.

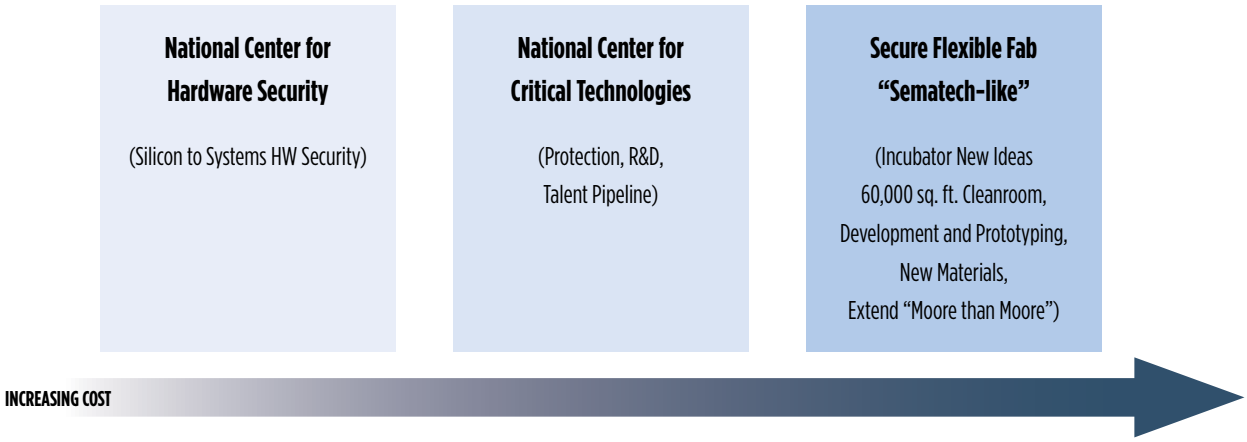


Figure 2 The Commonwealth is well suited to provide solutions in hardware security, critical technology protection/advancement, and incubation of new ideas.

Among the areas that warrant further investigation is hardware cybersecurity. At the end of 2020, the CCI provided $4 million for research projects in such areas as secure materials for 5G applications, secure sensors for health applications, and small satellite security. One potential idea is to leverage federal funds to create a **National Center for Hardware Security**, which would focus on all aspects of hardware security from manufacture of integrated chips to cards/boards, and systems. All elements such as design, fabrication/build, test, packaging, and supply chain management would fall under its purview. Because there will always be some degree of dependence on foreign sources, one objective of this center might be to create techniques to safeguard existing supply chains.

Another area in which Virginia can make a contribution to national needs is trusted supply of and research on specialty semiconductor processes and integrated circuits (ICs) that are critical to our defense systems. Examples of such technologies are radiation-hardened, infrared, and high-speed electronic warfare technologies. These unique technologies are normally produced in captive defense fabrication facilities, but these facilities have fallen behind the technology curve and lack the talent to sustain and modernize them. Defense contractors located in/near the Commonwealth are very aware of these problems and can team with Virginia's universities to protect, advance, and generate a clearable and knowledgeable talent pipeline to sustain technologies critical for national defense and to conduct research that will take them to the next level. A **National Center for Critical Technologies**, we believe, would help mobilize resources in the Commonwealth and around the country to further these efforts.

A final area that we believe is worthy of further investigation is the creation of a private/public **Secure, Flexible Fabrication Facility** that would draw on the resources of the Commonwealth, the federal government, Micron Technologies and other local defense companies, and Virginia's research universities. This would be structured along the lines of the National Semiconductor Technology Center called for in the proposed CHIPS legislation. Such an organization would be modeled after Sematech, a research consortium in Austin, Texas. From fiscal year 1988 to fiscal year 1996, Congress provided a total of approximately $870 million to Sematech through the Defense Advanced Research Projects Agency (DARPA). A 1992 evaluation by the General Accounting Office, now the Government Accountability Office, found that Sematech had shown that a government-industry R&D consortium can help improve a U.S. industry's technological position by developing advanced manufacturing technology.

Unlike traditional trusted foundries that do not permit new materials and experimentation, the secure flexible fabrication facility would offer a flexible capability that will allow for new materials, prototyping, innovation, and incubation of new ideas for technology readiness level 4 (TRL-4). This facility, much like a national war college" would also be charged with educating, training and developing a new and diverse, clearable workforce pipeline dedicated to the Department of Defense and general microelectronic needs.

The Commonwealth's universities could support these efforts by introducing new degree programs in trusted manufacturing and cyber hardware/software security. The curricula of these programs would span semiconductor development, systems-level design, and advanced manufacturing. There are currently many novel advanced technology developments such as energy harvesting, autonomous processing and low-power electronics that could be pursued in this facility. VMEC, working in conjunction with CCI, could serve as a catalyst for the development of these degree programs. At the same time, the electrical and computer engineering departments in the Commonwealth's engineering school, prompted by the creation of National Institute of Standards and Technology (NIST) and NIST-generated employment opportunities — could renew their emphasis on microelectronics. These changes could be supported through existing VMEC seed grants and scholar programs.

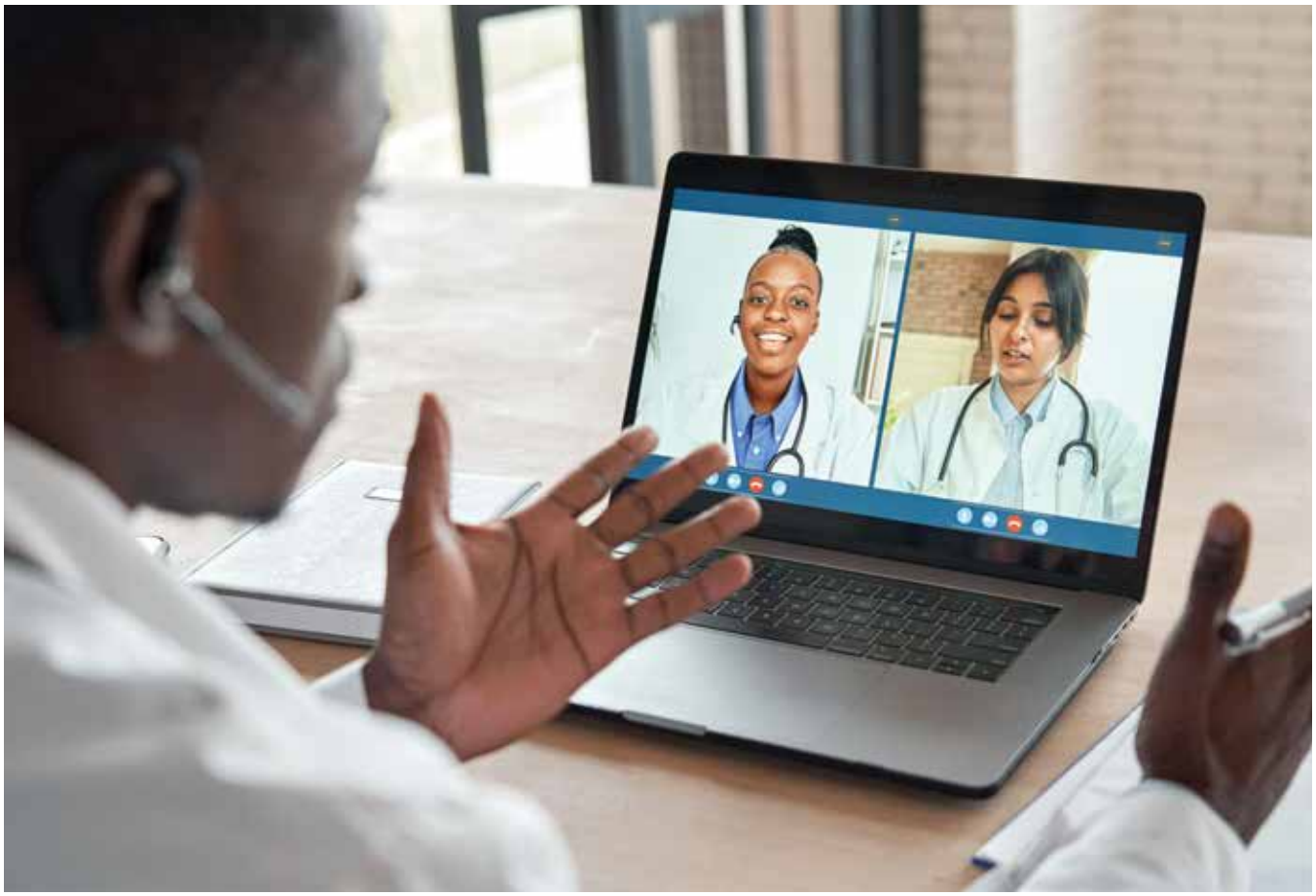
These initiatives, which capitalize on distinctive Virginia's strengths, would represent a fresh start for Virginia in semiconductors. Given the potential benefits, a study team bringing together Micron, Virginia's important defense contractors, and representatives from major electrical and computer engineering programs would provide a useful service by investigating this opportunity in greater depth, exploring challenges to achieve U.S. semiconductor leadership, laying out a roadmap to address these issues, and identifying sources of federal, DOD, and private funding.

Potential Benefits to Commonwealth and the Nation

In a recent commentary in Fortune, Keith Jackson, chair of the Semiconductor Industry Association (SIA), declared that "it's time for the U.S. government to be bold and meet the aggressive commitments other nations are making to gain semiconductor leadership. Taking ambitious action now will make our country's supply chains more resilient and ensure the world's most advanced chips are researched, designed, and manufactured in the U.S. for decades to come."

Taken together, these initiatives could represent a meaningful response to this call to action. They would also benefit the Virginia economy. According to the SIA, the total impact of the semiconductor industry on the U.S. economy amounted to $246.4 billion in 2020. The semiconductor industry's jobs multiplier is 6.7, meaning for each U.S. worker directly employed by the semiconductor industry, an additional 5.7 jobs are supported in the wider U.S. economy. In addition, semiconductor jobs are well paying. According to the Congressional Research Service, the semiconductor manufacturing workforce earned an average of $166,400 in 2019, more than twice the average for all U.S. manufacturing workers ($69,928). It is time that Virginia took a greater share of these advantages.

In addition, these initiatives will only augment the advantages that according to Micron President and CEO Sanjay Mehrotrah, have made its Manassas fabrication facility such a success for Micron. These are Virginia's talent pool, which consists of the second highest concentration of tech workers of any state in the nation, and the support of its strong university system. An added benefit: If Virginia is success in securing funding for any of the initiatives we propose investigating, it will increase its likelihood of securing a second major commercial fabrication facility.



Strategic Brief 4

Maximizing Healthcare Resources for All Citizens of the Commonwealth

Background/Opportunities/Need

Virginia has one of the preeminent healthcare systems in the nation, but the pandemic highlighted a number of deficiencies that undermine the Commonwealth's efforts to provide the best possible care to all Virginians and in particular to address longstanding healthcare disparities. These weaknesses undercut the state's ability to respond to infectious diseases like COVID-19 and HIV/AIDS, care for Virginians with such chronic issues as diabetes, cancer, and opioid addiction, and act preemptively to minimize or avoid medical emergencies. These deficiencies, however, are not confined to Virginia but are general across the entire United States. If Virginia can find ways to maximize the delivery of healthcare to its citizens in a fair and equitable way, these initiatives could emerge as a pattern for other states to follow.

There are a host of issues that prevent states from providing high-quality care to its citizens. Some of the most complex — such as HIPAA privacy restrictions —

The state would benefit from the development of HIPAA-compliant methods to combine health records with other sources of data, creating a more nuanced understanding of patient populations.

can best be addressed by policymaker, and the public health community has long recognized that addressing the social determinants of health — such as housing, neighborhood environment, and social support and capital — have the most potential for reducing healthcare gaps. Nonetheless, technological innovation in medical care can have a significant effect in reducing healthcare disparities.

Access

The first is access. Vulnerable populations in rural and urban areas across the state (in Northern Virginia and Richmond as well as in Southwest, Southside, and on the Eastern Shore) have limited access to health care. This is especially a problem for Virginia's growing elderly population and for people of color.

The Centers for Disease Control Social Vulnerability Index (SVI) pinpoints those communities that are especially at risk during public health emergencies, caused, for instance, by a natural disaster or infectious disease outbreak. It combines such factors as socioeconomic status, household composition, minority status, housing type, and transportation. There are a number of communities across the state that rank poorly on the SVI. Parts of Tazewell County, Frederick County, and Richmond, for instance, all have SVIs of 0.9 or higher, which puts them among the most vulnerable nationwide.

These areas coincide with those who are medically underserved according to the U.S. Health Resources and Services Administration (HRSA). HRSA designates an area or population as medically underserved if it has too few primary care providers, high infant mortality, high poverty, or a large elderly population. There is a higher proportion of medically underserved areas in Virginia than in states like Illinois or Indiana.

Maximizing Healthcare Data

The second issue that undermines the Commonwealth's ability to provide high-quality healthcare to all its citizen is an inability to maximize the potential of available healthcare data. Balkanized record-keeping by health districts, medical centers, and insurance companies impedes Virginia's ability to deliver best possible healthcare and to make productive use of such tools as artificial intelligence and machine learning, undermining the state's ability to provide personalized medicine on one end of the spectrum and manage population health on the other. The state would benefit from the development of HIPAA-compliant methods to combine health records with other sources of data, creating a more nuanced understanding of patient populations.

Such systems have already led to better outcomes. Having full electronic data on every patient improved diabetic care, chronic heart disease care, and stroke and heart damage prevention at Kaiser Permanente — and it created major reductions in the complications of care for chronic care patients in every category of care in all of those settings. In addition, having continuous use of comparative data on care-site performance by race and

by ethnicity, as well as by the other measures of patient status, helped reduce cancer deaths, prevented both strokes and adverse heart effects, reduced chronic care complications, and allowed for focus of care efforts by care site and by patient in ways that continue to improve today in those care settings.

Developing a Healthcare Early Warning System

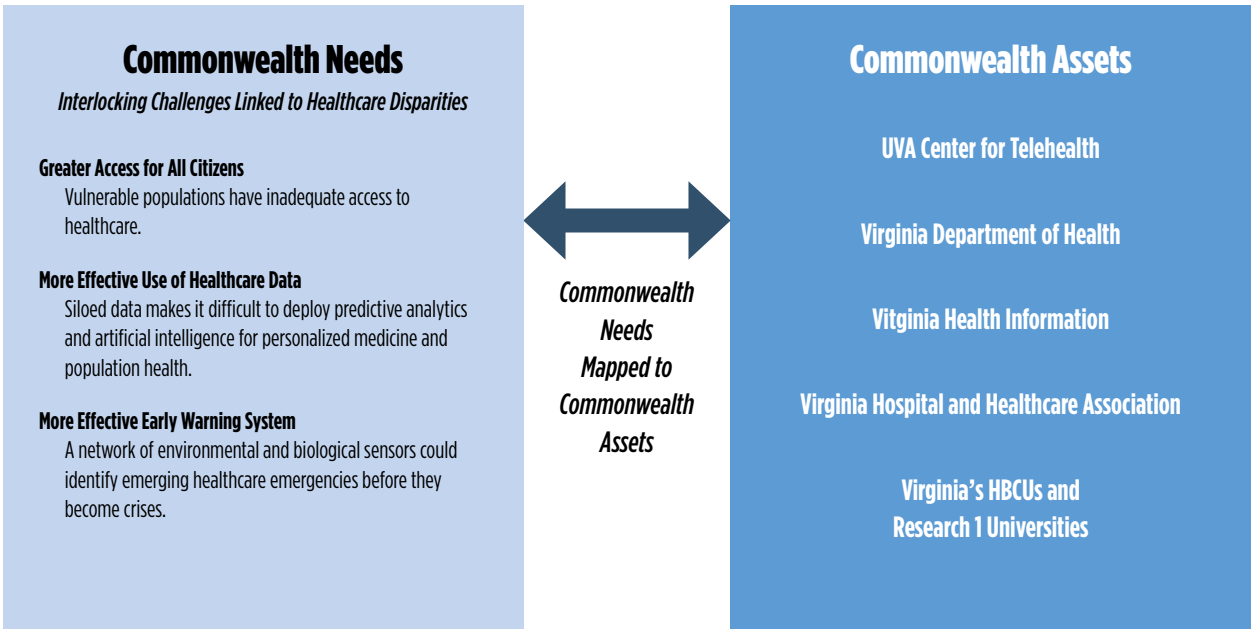
The third technological issue that Virginia faces was spotlighted by the pandemic, which demonstrated how unequal existing resources are to the challenge of tracking emerging major healthcare emergencies. Among other issues, we lack a system of environmental and biological sensors and models that could enable healthcare officials to monitor critical factors that could lead to healthcare emergencies as well as predictive tools that can help us deploy resources wisely and stay ahead of these crises. These early warning detection networks might include air and water quality measurements, meteorological data, wastewater analysis, clinical case findings, and syndromic surveillance. To address these issues, the National Science Foundation recently issued a solicitation for development grants for its Predictive Intelligence for Pandemic Prevention initiative. Among its goals, advancing state-of-the-art forecasting, real-time monitoring, mitigation, and prevention of the spread of pathogens.

If Virginia makes progress addressing these three critical challenges, the Commonwealth could emerge as a center of healthcare innovation, recognized both nationally and internationally, not only for developing advanced technologies but also for utilizing them strategically to improve the health of Virginia's citizens.

Existing Commonwealth Strengths/Relationships/Resources

In addressing these three deficiencies, the Commonwealth has a number of resources that it can build on. These are highlighted in Figure 1 below.

Figure 1 Virginia possesses a number of resources that can help it develop technology that can help reduce healthcare disparities



Virginia's research universities have a number of initiatives for environmental monitoring and rapid testing of populations. These capabilities have been highlighted in the course of the COVID-19 pandemic.

Access

Access is one area in which Virginia already is a national leader, thanks in large part to the University of Virginia's Center for Telehealth, which was founded in 1995. Since that time, the center's interventions have saved Virginians more than 21 million miles of travel and its preventive care has reduced hospital readmissions by more than 40 percent regardless of payer. It has supported more than 100,000 patient encounters and connects doctors and nurses with patients at more than 150 facilities across Virginia and around the world.

Currently, the center offers telehealth services in more than 60 different clinical specialties, in neurology, cardiology, obstetrics and gynecology, oncology, and psychiatry to name just a few. It provides care to patients with stroke, diabetes, cancer, dementia and many more conditions, care that is equivalent to and, in some respects, superior to what they could receive from face-to-face encounters. In the aftermath of the pandemic, utilization of these telehealth services has skyrocketed.

The center works closely with counterparts at other medical centers in Virginia, including Virginia Commonwealth University and Carilion Clinic, to expand access and to advocate for more extensive, high-quality broadband service across the Commonwealth. The center is also a regional leader. It secured funding from HRSA to create the Mid-Atlantic Telehealth Resource Center (MATRC), which now energizes collaboration through eight states and the District of Columbia. Center staff have also assumed leadership roles in such organizations as the Virginia Telehealth Network and the American Telehealth Association. For instance, Karen Rheuban, MD, founding director of the center, is a past president of the American Telemedicine Association.

In addition to telehealth, a number of institutions in Virginia have developed smartphone applications that help patients better manage their conditions and keep them in close contact with their providers. An example of this is PositiveLinks, a smartphone application for patients with HIV/AIDS as well as Hepatitis C and opioid addiction. It is now a statewide model and has been adopted by other states and countries.

Maximizing Healthcare Data

There are a number of healthcare data repositories in Virginia. The Virginia Department on Health (VDH) collects data on a variety of issues including maternal and child health, cancer incidence, opioid addiction, and infectious diseases including COVID-19. It has created an easily accessible portal to disseminate the data it has accumulated. Each data portal page provides interactive data at the most granular level available. VDH has also created a Health Opportunity Index, a series of dashboards for all the health districts, counties, and cities in the Commonwealth. It is designed to help communities understand the many factors determining health, so they can work to improve the health outcomes for all their residents.

Another source of health information for Virginia is Virginia Health Information (VHI), founded in 1993. The VHI board has representatives of private companies as well

as physicians from Virginia's medical centers. Since 2013, VHI has administered Virginia's All Payer Claims Database, which has benefited from $1.3 million of support from the VDH and Virginia's Department of Medical Assistance Services. It includes more than a billion claims filed by an estimated 5 million Virginians covered by commercial, Medicaid, and Medicare insurance.

The VHI is in the process of becoming the first state to fully implement the common data layout (CDL) for its All-Payer Claims Database (APCD). Developed jointly by states and health plans around the country, the CDL is intended to serve as a national standard for APCD collection that minimizes administrative burden on health plans and maximizes data quality. VHI also oversees the Health Information Exchange for the Commonwealth, a secure, internet-based data exchange for medical information and is now working to expand Virginia's Advance Healthcare Directives Registry, Public Health Reporting and the Emergency Department Care Coordination Program.

Finally, a number of Virginia's research universities have programs designed to advance the state-of-the art in healthcare data management and analytics and to build Virginia's workforce in this area. This includes the Division of Social and Decision Analytics at UVA's School of Data Science, Virginia Tech's concentration in Health Information Technology, part of its Master of Information Technology program, and Eastern Virginia Medical School's Master of Healthcare Analytics program.

Developing a Healthcare Early Warning System

The Virginia Department of Health has a wide range of monitoring programs that can help it identify emerging healthcare challenges. This includes its environmental monitoring program, which focuses on radiation threats from nuclear facilities, water-quality monitoring conducted by its Division of Shellfish Safety, and the public health assessments conducted by the Office of Environmental Health Services. It has also deployed a syndromic surveillance system. Its Office of Epidemiology collects and analyzes health data from participating emergency departments and urgent care centers to identify emerging trends of public health concern.

In addition, the Virginia Hospital and Healthcare Association's (VHHA's) research department draws upon multiple data sources, including its own statewide databases. It aims to supplement hospitals and health systems with analytics for population health management and clinical decision support. This includes monitoring such factors as air and water quality and combines this information with healthcare data to spotlight patient care trends.

Virginia's research universities also have a number of initiatives for environmental monitoring and rapid testing of populations. These capabilities have been highlighted in the course of the COVID-19 pandemic. For instance, in the early days of the pandemic, researchers at UVA quickly scaled their capacity to administer clinical PCR testing from 60 tests to 1,500 tests daily, giving the state better insight into the spread of the disease at a time when shortages of testing supplies and equipment were causing critical delays. UVA researchers also fielded a system to monitor wastewater from dormitories, which enabled the university to pinpoint and quarantine COVID clusters.

There is a large body of research underway in Virginia to detect CBRNe (chemical, biological, radiological, nuclear, and environment) threats, most but not all of which is being conducted for the military and the Department of Homeland Security. For instance, the Biocomplexity Institute at Virginia Tech has a contract from the Defense Threat Reduction Agency to build a Comprehensive National Incident Management System. The sensors, models, and predictive analytics developed for these systems could be repurposed as a healthcare early warning system.

Compelling Initiative/Solution that Addresses Opportunity and Builds on Strengths

Virginia has critical resources in three areas in which technological innovation can accelerate its efforts to provide high-quality healthcare to all its citizens. There are a number of steps that the Commonwealth could take to better coordinate and strengthen these resources.

Access

In February 2021, the Virginia Department of Health (VDH) issued its State Telehealth Plan, a comprehensive initiative designed to create an integrated approach to the introduction and use of telehealth services in the Commonwealth of Virginia. In the course of 17 virtual meetings held during summer and early fall 2020, the experts assembled by VHD developed a set of core strategies for using remote patient monitoring services and store-and-forward technologies, including the treatment of patients with chronic illness; the inclusion of telehealth services in hospitals, schools, and state agencies; and the collection of data regarding the use of telehealth services.

Accountability for implementing these strategies rests largely with state agencies. We propose the creation of counterpart group, composed of private enterprise, nonprofits, and Virginian's research institutions that would work with these agencies on elements of the plan's strategic initiatives that have a technological component. For instance, the plan calls for the promotion of care and safety for patients with chronic illness and/or disabilities. The counterpart group could work with state agencies to identify desired telehealth interventions, identify technologies required to implement them, and secure additional resources to develop and deploy them. Such a group might also help create a Virginia Health Equity Dashboard, modeled after Massachusetts Race and Hispanic Ethnicity Health Equity Dashboard, which provides health outcome data from across the state and that helps guide intervention strategies.

Dual Focus: Maximizing Healthcare Data/ Developing a Healthcare Early Warning System

Virginia Health Information is pioneering innovative ways to disseminate health care data to organizations in Virginia to help them improve care and save lives. We propose creating a consortium of public and private entities, that would partner with VHI to develop more robust datasets and create innovative ways of applying artificial intelligence to this data to foster advances in personalized medicine and population health. It would include representatives from UVA's School of Data Science, Virginia Tech's program on Health Information Technology program, and Eastern Virginia Medical School's Master of Healthcare Analytics program.
An important element in this consortium would be representation from the Commonwealth's historically black colleges and universities (HBCUs) as well as Virginia's vulnerable communities to address issues of bias in technology.

A second focus on this consortium would be environmental and biological sensing. We have found no organization in the United States that that deploys a comprehensive network of environmental and biological sensors to improve population health. As a result, the field is clear for Virginia to emerge as a national leader, designing critical sensing networks that would identify healthcare emergencies, integrating data from existing ground and satellite sources, and developing sensors that could address informational gaps in these networks. These are broad multidisciplinary issues, requiring contributions across such fields as computer science, engineering, environmental sciences, and medicine.

School of Public Health

A final area that deserves additional study is the creation at one of Virginia's universities of a School of Public Health. While there are public health programs at UVA and George Mason University, Virginia is one of the few states of its size that lacks a full School of Public Health, which would serve as a focal point for research on population health while building an expert workforce capable of acting on these findings. Over time, this school could assume responsibility for administering the counterpart organizations envisioned in this brief.

Given the potential benefits of these initiatives, a study team including representatives from VDH, VHI, private entities, Virginia's HBCUs and Research 1 universities would provide a useful service by investigating this opportunity in greater depth, identifying areas in which technological innovation would have the greatest impact on the health of all Virginians, and laying out a roadmap to address these issues.

Potential Benefits to Commonwealth and the Nation

The past 150 years have witnessed unprecedented advances in health care. Diseases that once cut lives short are no more than chronic disorders, and our ability to image the human body, to repair damaged tissue, and to transplant organs is nothing short of miraculous. If anything, the pace of discovery and innovation has only accelerated. While these advances will no doubt save untold lives, the biggest impact we can have on healthcare in Virginia is to ensure that all Virginians can take full advantage of modern healthcare. Through judicious use of technology, we can help ensure that every citizen of the Commonwealth has access to the highest quality care, that the potential of healthcare data is fully realized for personalized medicine as well as population health, and that we are forewarned of emerging medical emergencies.

Diseases that once cut lives short are no more than chronic disorders, and our ability to image the human body, to repair damaged tissue, and to transplant organs is nothing short of miraculous.

It has been almost a decade since the Virginia Department of Health released its last Virginia Health Equity Report, designed to pinpoint the causes of the most glaring disparities in healthcare outcomes. It concluded that health disparities — in addition to their cost in human life and suffering — account for 10 percent of all health care costs for the Commonwealth, funds that could be spend creating opportunities to be healthy instead of treating disease — and further that they represented 1.9 percent of Virginia's GDP, whether through health care costs, lost productivity, or premature death.

The authors of this report noted that there is a 26-year difference in life expectancy across census tracts in Virginia. Harnessing technology to enhance access, better inform strategy, decision-making, and implementation, and avoid healthcare emergencies can help close this gap.


DRIVING FAST
AND FURIOUS?
THAT'S LUDACRIS

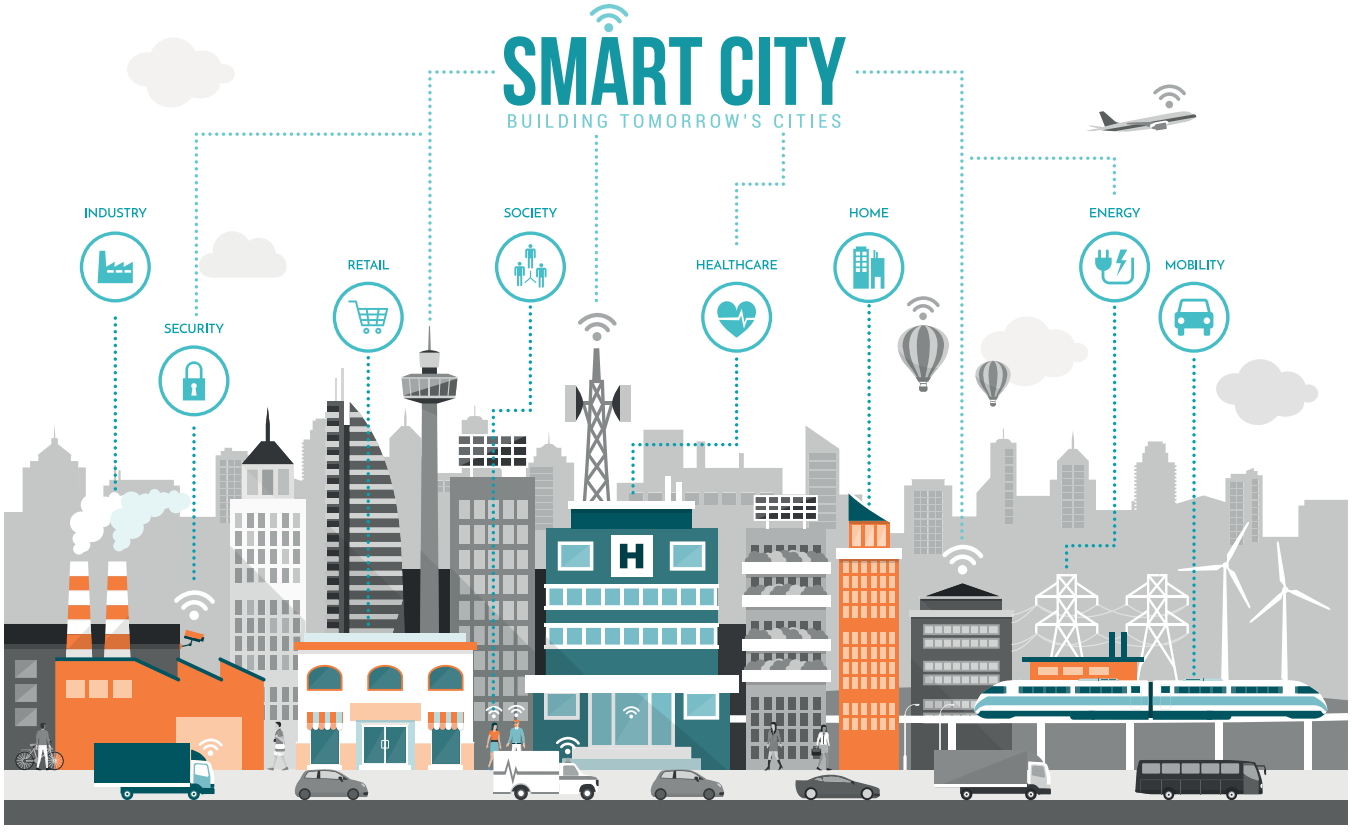
Strategic Brief 5

Enable Virginia to Create Smarter, More Resilient Communities

Background/Opportunities/Need

The challenges facing Virginia localities are unprecedented in their complexity, scale, and cost. Among other issues, cities and counties across the Commonwealth must address the lingering aftereffects of the COVID 19 pandemic, persistent inequities in housing and healthcare, and a looming climate crisis that will likely cause progressive dislocation and strain municipal budgets.

Smart technology can enable communities to use resources more efficiently, improve quality of life for residents, and better anticipate future needs. Smart communities are those that use data to improve the services they deliver or provide new services that were previously unavailable. They are built on modern digital infrastructure that includes Internet of Things (IoT) sensors and actuators, high-speed networks such as 5G, advanced data handling and analytics at the edge and in the cloud, and intuitive, user-facing applications, all relying on strong cybersecurity to maintain the integrity of the data and systems. In smart communities, these technologies converge as a service infrastructure.



Some examples of smart community technology being prototyped in Virginia include:

- Flood sensors being deployed statewide that can trigger local road closures and issue notifications to commercial traffic applications such as Waze to re-route drivers
- Autonomous vehicles providing shuttle services between the Dunn Loring Metro station and the Mosaic District in Fairfax County, heightening mobility for people without access to private vehicles and increasing social equity
- Automatic correlation of wastewater testing data with Health Department data to better pinpoint local COVID outbreaks and support more targeted responses
- Drones used by public safety personnel to respond to emergency events that issue geospatial alerts to the Virginia Flight Information Exchange for airspace coordination with other drone operators

The benefits of smart communities transcend individual jurisdictions. The workforce and economic development opportunities arising from the evolution and deployment of smart technologies are crucial to overall growth of digital industry in the Commonwealth.

While Federal and state resources play a key role in funding these efforts, the point of delivery is generally local governments, who may not have the resources or expertise to implement these critical services. For example, the inability to mount robust cyber defenses, a prerequisite for smart communities, has led to a well-publicized spate of ransomware attacks, which according to the publication *American City & Country*, cost local and state governments over $18 billion in 2020.

The Federal Response

Fortunately, the federal government has recognized the need. The proposed infrastructure bill contains many elements that could help Virginia built out its smart community infrastructure. Figure 1 indicates how these provisions support smart communities.

The United States Innovation and Competition Act of 2021 addresses many of these same technologies including artificial intelligence (AI), data science, advanced computing, advanced communication, and others.

Both the infrastructure bill and the Innovation and Competition Act provide funding opportunities that the state, local government, and the Commonwealth's research universities could tap to strengthen and extend Virginia's smart community infrastructure.

Existing Commonwealth Strengths/Relationships/Resources

The Commonwealth has a number of advantages that position it well for enhancing its smart infrastructure. The statewide smart community ecosystem already encompasses many state and local government entities including a number of participating cities and counties, nonprofits, start-ups, and larger commercial entities, as well as Federal executive agencies and the military.

This growing ecosystem of public-private partnerships leverages the strengths and relationships among universities, entrepreneurs, localities and supporting agencies to ensure that leading edge research leads to practical implementations, and entrepreneurial efforts can find markets for innovative products, all while supporting the growth and evolution of critical government services and resilience.

Some examples of local government leadership embodying community-driven innovation in developing smart communities include:

- Fredericksburg City is developing a Smart Riverwalk Park, a new public park along the Rappahannock that provides public Wi-Fi, video links to local law enforcement, public data on parking availability, and the ability to directly connect electronics for concerts in the park.
- Roanoke City is installing a new generation of flood sensors provided by the Department of Homeland Security and is leading efforts to develop a smart integrated water management program.
- Winchester is piloting the use of drones to improve government operations and services, including rooftop inspections and water-meter reading.
- Jurisdictions in the Tidewater region are hosting workshops and industry days on smart technologies for port security.
- NASA Langley Research Center is focusing on integrated data management for base operations, deploying a distributed network of IoT sensors to provide better awareness of activities on the base, including both ground and air operations.
- Fairfax County is using smart technology to improve public safety at key intersections, using AI-enabled cameras to collect and characterize near misses among bikes, pedestrians and vehicles leading to improved intersection design.
- Stafford County is actively incorporating advanced drone technology into its emergency response and law enforcement protocols.

In May 2021, Stafford County and the Center for Innovative Technology (CIT) launched the Virginia Smart Community Testbed, a facility that has gained global attention in communities of practice. The testbed has been covered, for instance, in *Forbes magazine,* and Gartner, the global research and advisory company, plans to devote a white paper to it.

The testbed's underlying vision is to make Virginia a leading state in smart community implementation. The testbed is designed as a shared knowledge platform, engaging private and public interests to develop practical and relevant solutions in four areas: public safety, data

Figure 1

Infrastructure Bill Elements	Smart Community Benefits
Prepare more of our infrastructure for the impacts of climate change, cyber-attacks, and extreme weather events	• Sensors and data for environmental monitoring • Increased cyber security • Improved emergency response
Upgrade our power infrastructure	• Allows for flexible, resilient energy allocation
Connect every American to reliable high-speed internet	• Enable more people to access smart community services
Repair and rebuild our roads and bridges with a focus on climate change mitigation, resilience, equity, and safety for all users, including cyclists and pedestrians	• More efficient use of transportation infrastructure • Improved public safety

Stafford County and the Center for Innovative Technology (CIT) launched the Virginia Smart Community Testbed, a facility that has gained global attention in communities of practice. The testbed's underlying vision is to make Virginia a leading state in smart community implementation.

security and training, economic development and tourism, and 5G technology and broadband expansion. It will enable users to explore and validate a wide range of emerging technologies from IoT to artificial intelligence to data security in a controlled setting and then directly field successful technologies in Smart Stafford. For example, the Commonwealth Cyber Initiative (CCI) research into 5G security will be implemented directly on the 5G infrastructure in the Virginia Smart Community Testbed, allowing entrepreneurs to build more secure high-bandwidth applications.

In addition to the Virginia Smart Community Testbed and the initiatives cited above, CIT's Smart Community Strategic Initiative portfolio includes a testbed at Capital One Arena in Washington, DC with more in development (Winchester, Roanoke, Norfolk/Virginia Beach).

There are other efforts underway that could help position the Commonwealth as a smart community leader. Under the Virginia Innovation Partnership Authority (VIPA), the Commonwealth is actively working with several federal entities to be designated one of the new technology hubs contemplated in the United States Innovation and Competition Act. Such a role would both support national security interests around technologies such as AI and 5G as well as bring potentially billions of dollars in new federal funding to the Commonwealth.

In addition, virtually all of Virginia's research universities have programs that focus on the technological building blocks of smart communities as well as their applications. To name just a few, George Mason University, in conjunction with CIT, conducts research into smart building technologies that can help first responders save lives and improve public safety. Virginia Tech offers a smart and sustainable cities major, one of the first of its kind in the United States. The University of Virginia has research programs on data-driven stormwater management and mobile ad hoc networks for connected transportation services.

In addition, a number of existing entrepreneurial accelerators (Smart City Works, RIoT, MACH37) and institutions of higher education (including the CCI as well as Germanna Community College and Shenandoah University) are part of the new CIT-led Entrepreneurial Ecosystem, which is actively delivering workforce and entrepreneurial development in such smart community technologies as autonomous systems, IoT sensors, edge computing, and low-latency applications.

Specialized military and government programs and facilities have also expressed interest in smart community technologies. These entities bring specialized strengths to the Commonwealth's effort and are engaging in collaborations with the local government programs. They include:

- Smart base efforts by the Marine Corps at Quantico, the Port of Virginia, and NASA Langley

- Drone and counter-drone testing opportunities at Ft. Pickett
- A MITRE UIX program in conjunction with CIT and universities like Old Dominion University to develop a data cube architecture for integrating disparate data feeds
- The Commonwealth Data Trust developed by the Chief Data Officer to provide a governance structure for data sharing and access control
- Coordination with public safety assets and capabilities via the Public Safety Innovation Center

Figure 2 shows how these various Commonwealth resources support both technology development and specific infrastructure elements of smart communities.

Compelling Initiative/Solution that Addresses Opportunity and Builds on Strengths

The Commonwealth has substantial strengths in smart community technology and has embarked on a series of initiatives to build out smart community infrastructure in a number of localities. The challenge is to scale and better coordinate these activities, delivering meaningful smart community services while laying the foundation for further innovation.

One way to achieve these goals is to develop a statewide Network of Smart Community Living Laboratories. Each laboratory would bring together local entities, universities, and private companies with the goal of researching, developing, testing, and commercializing smart community applications and developing uniform standards that could enhance their integration. For instance, a Living Laboratory focused on automated stormwater management, a pressing problem in the Tidewater region, could bring together specialists in hydroinformatics from UVA, representatives from such Tidewater localities as Norfolk and Virginia Beach, officials from the Port of Virginia and federal and military installations in the area, and private architect and engineering firms. Similar Living Laboratories might be organized around IoT devices, transportation, drone-sensing and service delivery, and other technologies.

There are number of issues that must be resolved to launch this network:

- The role and responsibilities of an overarching governing body charged with coordinating and supporting the activities of the individual living

Figure 2

Resource	Technologies						Infrastructure Elements							
	IoT	SG	Cyber Security	AI/ML	Edge Compute	Analytics	Comms	Power	Mobility	Water	Facilities	Sensors	Data	Applications
VIPA/Federal	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CIT Strategic Initiatives	●	●	●	●	●	●	●	●		●	●	●	●	●
Smart Community Testbed (Stafford)	●	●	●			●	●			●	●	●	●	●
Entrepreneurial Accelerators	●		●	●		●		●	●	●	●	●	●	●
University Programs	●	●	●	●		●	●		●		●		●	
Military/Civilian	●	●	●		●		●	●	●		●	●	●	●
Commonwealth Agencies	●	●	●				●		●				●	

laboratories, promoting the exchange of information and increasing their overall impact.

- The initial set of focus areas, technologies that reflect the Commonwealths existing strengths and target areas of most pressing need.
- The workforce development issues that must be addressed to create a thriving smart community ecosystem.

An innovative aspect of this network is the leadership provided by local communities to drive development of value-added use cases specific to their needs as well as early market adoption for technologies as they move out of research environments and into practice. "Community-driven innovation" would be the tagline of the Living Laboratories network, a recognition that technology and entrepreneurship are not in themselves sufficient unless accompanied by specific market pull and community acceptance.

With the Federal focus and new funding for community resilience and technology competitiveness, we believe the living laboratories approach may position the Commonwealth as the leading hub for development and implementation of these technologies that make up the new digital infrastructure. We believe that further study is warranted to refine the Living Laboratories approach and develop a roadmap for implementation.

Potential Benefits to Commonwealth and Nation

Virginia's leadership in smart communities will provide substantial economic development in the Commonwealth while supporting the national goals of resilience and technology competitiveness. Benefits to Virginia can be extrapolated from the following market statistics, but one thing is abundantly clear: leadership in this market space will result in substantial economic opportunities for Virginia companies and numerous job opportunities for Virginia citizens.

Take a single smart community technology: IoT. *Fortune Business Insights* notes that the global market size for smart city IoT was $110.56 billion in 2020 and is projected to grow from $134.47 billion in 2021 to $582.38 billion in 2028, a compound annual growth rate of 23.3 percent.

As *RTInsights writes* about IoT Careers 2020, "Nearly every industry in the world will have job roles for workers who understand [this] technology and can navigate the rapidly expanding technological world."

Finally in terms of national defense preparedness, the same set of technologies used for smart communities apply directly to smart bases as well. Additionally, the skills training is identical for both domains, and future defense concepts build on and can be explored and tested in the Living Laboratories initiative. These collaborations are already in progress, with obvious benefit for national needs.

A successful Commonwealth-wide strategy for smart communities builds on extensive Commonwealth strengths, leverages a number of different existing funding streams, increases community resilience and operations, supports national defense and related goals, and helps build the workforce of the future. Continued support for these initiatives will ensure Virginia maintains and grows its leadership position in this area as it seeks to become both the leading supplier and leading consumer of these technologies.

Appendix A

Members of the Committee

This report benefited from the insight and expertise of our board members:

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Appendix B

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KEY STRATEGIES

to Position Virginia for Leadership in Areas of Critical National Challenge

DEVELOPED BY

VIRGINIA ACADEMY OF SCIENCE, ENGINEERING, AND MEDICINE

SEPTEMBER 2021

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