Intelligent Infrastructure for Human-Centered Communities

Background: The world is witnessing a dramatic transformation due to the confluence of disruptive trends, which include: (*i*) rapid urbanization and explosive growth in population that is shifting locus of economic, social, and technological activity toward emerging countries and communities — these communities are undergoing industrial, social, and economic revolution, (*ii*) accelerating technological change leading to transformative advances in information technology, health care, manufacturing, and transportation — leading to instant communication and boundless data; here, data is a new natural resource, mobile is the new office space, personalized and precision products and medicine are the new ways to satisfy the consumer, (*iii*) the world is smaller and more connected in so far as information, mobility, and trade is concerned — complex co-evolving socio-technical networks are enabling more efficient flow of capital, goods, people, and information. Infrastructure networks that support our communities co-evolve with the communities that use and modify them.

This Destination Area aims to design, develop, and understand social, technical, economic, cultural, political, and information paradigms to support sustained and adaptive human societies. This area seeks to find a balance between advancing the technology with economic and policy structures that are equitable, fair, and lead to overall well-being of the society. By nature, the Destination Area is multi-disciplinary — new paradigms in experiential learning and training that will produce graduates who are the world leaders. Technology, infrastructure design and development, policy, data science, and economics will be woven with traditional disciplinary curriculum to create “VT-shaped” students who will contribute to society and employers immediately. Themes include smart, healthy, and sustainable cities and communities; transportation systems; human safety, health, and wellness; integrated energy systems; network science and engineering; public policy; and cyber-physical systems.

Current Virginia Tech Differentiators:

- The complete supply chain for the Architecture, Engineering, Construction (AEC) Industry, including substantive intelligent design/build expertise. Leaders of virtual design, intelligent means and methods, smart buildings, and University/Industry partnering.
- Pioneering intelligent autonomous systems that operate in land, sea, and air domains. Focus has been on safety systems, self-driving cars, and mobility
- International leadership in integrated energy systems, including power electronics, power systems analysis and energy management and policy; focus on integrated energy systems leading to energy efficiency, zero-net energy usage, renewable energy sources, and decreased fossil-based energy solutions
- Cyber-physical systems that leverage the Internet of Things revolution and advances in pervasive computing leading to adaptive and resilient systems; improving infrastructure systems by using wireless sensors and actuators to enable robust, resilient monitoring, and management
- Modeling, simulation, analytics, and decision-support environments that leverage modern high performance computing and big data to advance the state of the art in public policy, economics, network science, and smart cities.
- Strong emphasis on rural communities, infrastructure, ecology, and end-to-end agriculture, using autonomous systems, cyber-physical systems, and novel informatics.

Experience and Assets: Virginia Tech comprises a large number of disciplinary-specific and interdisciplinary assets to develop intelligent infrastructure and human-centered communities. The Virginia Tech Transportation Institute has superior knowhow in vehicle-to-vehicle or vehicle-to-infrastructure systems. The Virginia Connected Corridors and the Virginia Automated Corridors initiatives represent partnerships between the transportation institute, the Virginia Department of Transportation, and the Virginia Department of Motor Vehicles, among others. These initiatives allow connected- and automated-vehicle developers to develop technologies along two test-track environments — the Virginia Smart Road in Blacksburg, Virginia, and the Virginia International Raceway in Alton, Virginia — as well as on operational roadways in Northern Virginia. In addition, the Virginia Center for Autonomous Systems, which is an interdisciplinary initiative of the Institute for Critical Technology and Applied Science and the College of Engineering, conducts research that spans every application domain — sea, land, air, and space. The Center for Power Electronics provides state-of-the-art solutions to problems in electrical power delivery and distribution. The center has more than 90 industrial affiliates and has graduated over 150 doctoral students. The Biocomplexity Institute of Virginia Tech is at the forefront of developing scalable cyber-infrastructures and decision support systems that aid in the design, analysis, and engineering of complex inter-dependent physical, social, and informational infrastructures. Wireless@Virginia Tech partners with the Center for Advanced Engineering and Research and the Mid-Atlantic Broadband Cooperative to identify medical applications and address the challenges of the increasingly cluttered wireless spectrum. The Discovery Analytics Center leads advanced analytical and visualization tools for urban science, health sciences, and critical infrastructure protection. The Global Forum on Urban and Regional Resilience leads effort to unite policymakers, urban planners, and architects to study important questions related to resiliency and sustainability issues as they pertain to regional and national development. The Myers-Lawson School of Construction uniquely integrates construction education and research as a joint venture between the College of Engineering, and College of Architecture and Urban Studies. The Metropolitan Institute focuses on issues related to urban growth. In addition, the university's Center for Design Research has led the development of futuristic new structures known as lumenHAUS and futureHAUS. Other assets include the Urban Living Laboratory in the National Capital Region, the Center for Energy Harvesting Materials and Systems, the Center for High Performance Environments, the Smart Infrastructure Laboratory, and the Hume Center for National Security and Technology.

Examples of Targeted Hot Spots:

- **Cyber-physical systems**: Opportunity to lead the development of sustainable materials with sensors and instruments providing on-demand data about performance and efficiency for systems that are smart and self-healing.
- **Virtual Design and Smart Construction:** Based on modern production principles, and the emergence of virtual, digital, tools, and semi-autonomous systems, the planning, design, materials, construction of buildings and structures is rapidly changing, and this provides a leadership opportunity for Architecture/Engineering/Construction and interdisciplinary cross proficiency and integration.
- **Pervasive decision support systems**: Based on advances in HPC, data sciences, modeling and simulation to develop novel decision support and policy informatics environments.

- **Autonomous Systems**: Lead the development of self-driving, interconnected transportation systems with a focus on human safety and wellness. Issues of policy and ethics are interspersed in the development of such systems.
- **Integrated energy systems**: Distributed Smart Energy, focused on developing on-demand energy through a combination of highly efficient and environmentally friendly conventional and renewable energy sources.
- Enhance the university's investment in the other Destination Areas by coupling experts in security, public policy, data and decision sciences, and integrated health to work on emerging problems in sustainable and ecologically sensitive urban growth, smart and connected infrastructures, and policy making in the digital world.

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