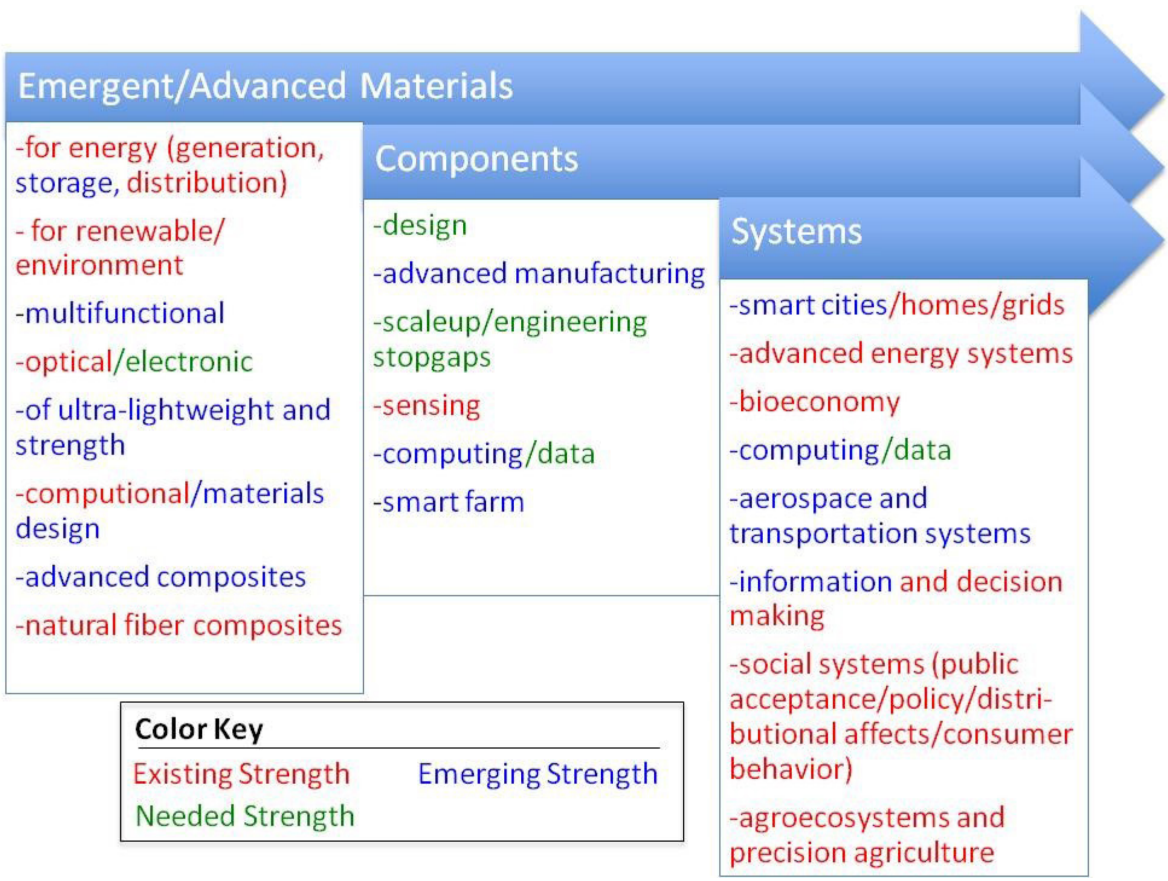
Improving Quality of Life Through Smart Systems

Defining the Challenge

Advancing societies depend upon technological innovations that improve the quality of life by driving economic growth, optimizing the use of dwindling resources, enabling self-sufficiency, and providing security for future generations. Resulting from major advances in multifunctional and smart materials and the consequential disruptive new technologies in communications and devices, and fueled by unprecedented computing power and data mining capabilities, smart systems are a transformational vehicle for enhancing well-being. Smart systems are comprised of a variety of components—an interwoven network of sensors, communications devices, automated device controls, and computational elements for pattern recognition, prediction, and decision-making. Thus advances in both materials development and computational sciences are essential to smart system innovation and will enable us to live, work, and play



more comfortably and efficiently in our environments. These advances are accompanied by the "Internet of Things"—the network of sensors, devices, electronics, software, and connectivity—that will generate massive amounts of data, requiring new approaches in data science and analytics to convert data into actionable information. The chart on the previous page shows the fundamental materials, components, and resultant systems that must be improved to be successful in this area. The flow of the chart goes from basic building blocks for advanced and emergent materials on the left side, to components in the center, and systems on the right.

WSU's Role in the Solution

Washington State University is well-positioned to take on this challenge, building on our research strengths in smart systems, materials science, computational sciences, design disciplines, and social sciences. The power engineering program at WSU, in collaboration with local and national industry, Battelle, and the U.S. Department of Energy, developed the region's first Smart Grid community in Pullman, demonstrating how smart grid technology can promote the safety, security, reliability, and efficiency of energy delivery. As distributed and intermittent energy sources are incorporated into the grid, the smart grid work is critical for maintaining reliability and is dependent upon foundational research in state-of-the-art materials for energy production and storage. As applied to industrial complexes or entire cities and regions, in collaboration with the design disciplines and social sciences, smart environments will allow individuals to be more productive and self-sufficient, buildings to be more energy efficient, communities to be more connected, and infrastructure to be more sustainable and secure. An example of this is how WSU researchers are designing smart environments technologies that provide automated health monitoring and assistance for older adults and those with disabilities, allowing them to "age in place." WSU faculty researchers develop novel machine learning methods, reliable sensor networks, and innovative new materials that drive sustainable infrastructure development and monitoring of these systems. As the quantity and complexity of "Internet of Things" data grows exponentially, gleaning actionable information requires collaborative, multifaceted, and innovative involvement from the fields of design, materials, computer science, math, statistics, operation and management, economics, sociology, psychology, and public policy. WSU faculty working in data science and data analytics, along with their allied collaborators, will assist makers of public policy in comprehension of these highly complex issues.

Key Research Themes

- Smart and sustainable systems
  - Next generation smart and sustainable buildings
  - Transforming the U.S. power grid
  - Enhancing performance and well-being in cities via digital technologies
  - The Internet of Things
- Foundational and emergent materials
  - Multifunctional, multiphysics, and smart materials
  - Sensors and wide bandgap semiconductors
  - Bio-based materials and green manufacturing
  - Computational materials science
- Computing, data, and information
  - Data-driven decision making
  - Systems analytics
  - Computational design
- Economic, social, and policy dimensions of technology

- Public policy
- Communications
- Economic models and impacts
- Ethics

Descriptive Sentences of Each Key Research Theme

1. **Smart and sustainable systems.** "Smart" systems are complex networks based on a variety of components. As these systems become more sophisticated, going beyond machine-to-machine communications, smart environments and smart systems hold the possibility of automation in practically all fields. Advanced applications of smart systems are evolving all around us including smart homes, smart cars, smart manufacturing facilities, smart farms and food production systems, smart power grids, and smart cities.

2. **Foundational and emergent materials.** Materials that optimize resource management, are environmentally friendly, and provide enhanced performance provide the foundation of advanced infrastructures that will improve the quality of life. These may include emergent materials, whose essential physical properties may be more than the sum of their components, and which provide a basis for new materials design strategies that leverage basic physics and chemistry in tandem with computational design.

3. **Computing, data, and information.** The "Internet of Things," as well as advances in high performance computing, are generating copious amounts of data, whether from sensor networks or computing calculations. Computational effort is required in designing materials and systems, as well as in operating smart environments. Computers, through strategic data analytics, must be able to recognize actions and respond accordingly.

4. **Economic, social, and policy dimensions of technology.** Public acceptance of new technologies like smart systems is imperative, as is the ability to incorporate such systems into our lives in a way that is economically viable. As we begin to adopt smart systems, there are strong components of design, human behavior, society, and public policy that must be addressed concomitant with technological advances.