EVs and the Smart Grid

Roger L. King
William L. Giles Distinguished Professor and
Director Center for Advanced Vehicular Systems

Southern Automotive Conference 2010
Preparing for the Electric Car

October 6-7, 2010

Grid Challenges… to name a few

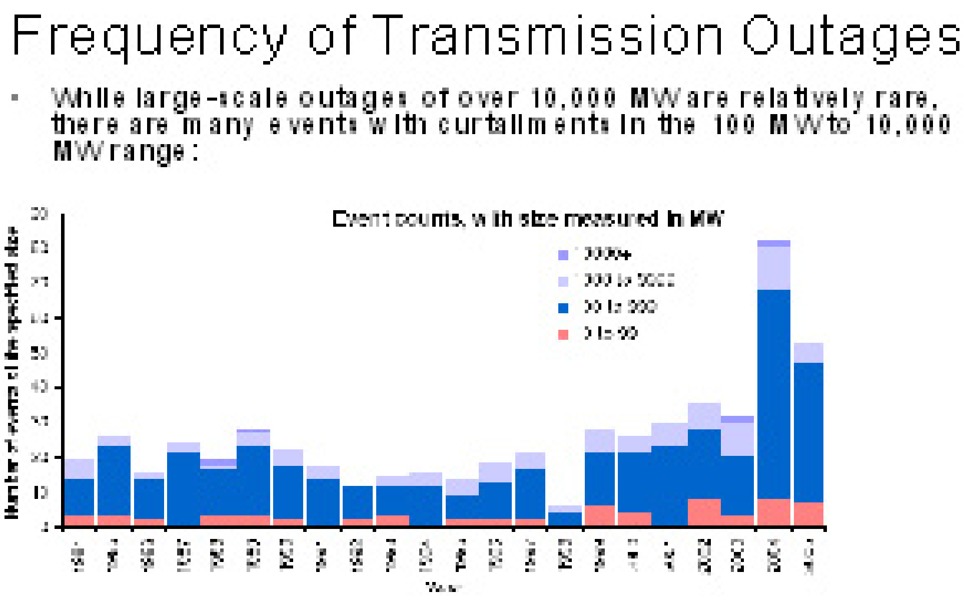
- Aging infrastructure
- Generation availability near load centers – or lack there of
- Transmission expansion to meet growing demands
- Congestion management
- Distributed resources
- Dynamic reactive compensation
- Grid ownership vs. system operation (or between Countries)
- Reliability coordination
- Supply and cost of natural resources for generation
- Need for oversight or Regulatory Audits
- Balancing between resource adequacy, reliability, economics, environmental constraints, and other public purpose objectives to optimize transmission and distribution resources to meet the needs of the end users.

Best laid plans of mice and men …

- Some of the reasons why completely reliable operation cannot be achieved on the power system:
  - Large number of possible operating contingencies.
  - Unpredictable changes due to the evolving nature of power systems that generate transient events.
  - A combination of unusual and undesired events (for example, human error combined with impact of natural or terrorist attacks on the system).
  - Reliability design philosophy that is pushing the system closer to the stability limits.

Consequences
Blackout Frequencies, 1984-2005

- Approximately 24 outages per year in the United States with curtailments in 100 to 1,000 MW range
- About 5 outages in 1000 to 10,000 MW range
- One outage every 4 years at 10,000+ MW.
- This is a global issue



Based on Hines et al; The frequency of large blackouts in the United States electrical transmission system: an empirical study, Carnegie Mellon, 2006
http://www.ece.cmu.edu/~electriconf/hines_blackout_frequencies_final.pdf

Smart Grid – What is it?

- Existing utility infrastructure + sensors and telecommunication
- From generation to transmission to distribution
- Enabling technology
  - Integration of renewables – biomass, wind, solar….
  - Handling new loads – EVs…
- Will facilitate operation of the electric grid more efficiently and reliably

Smart Grid ⬄Self-managing Technologies

A self-managing system can sense its operating environment, model its behavior in that environment, and take action to change the environment or its behavior. An autonomic **self-managing** system has the properties of self-configuration, self-healing, self-optimization and self-protection.

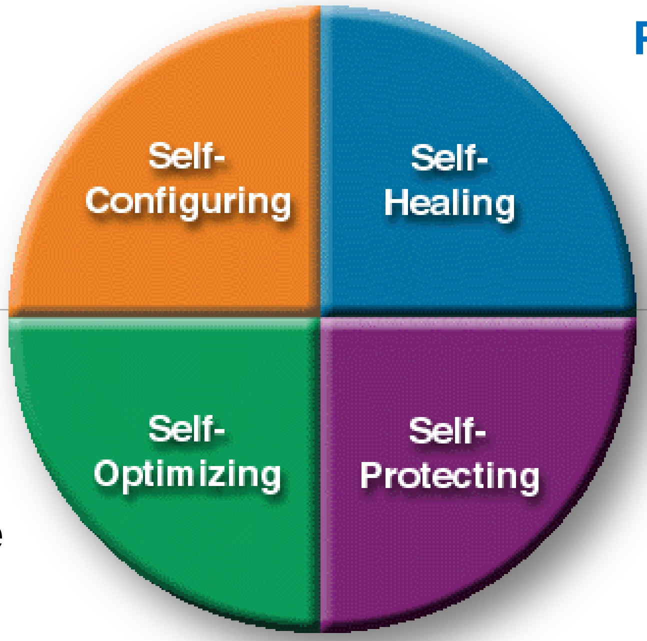
Self-managing systems deliver:

Increased Responsiveness

Adapt to dynamically changing environments

Robustness and Resiliency

Discover, diagnose, and act to prevent disruptions



Operational Efficiency

Tune resources and balance inputs to maximize use of resources

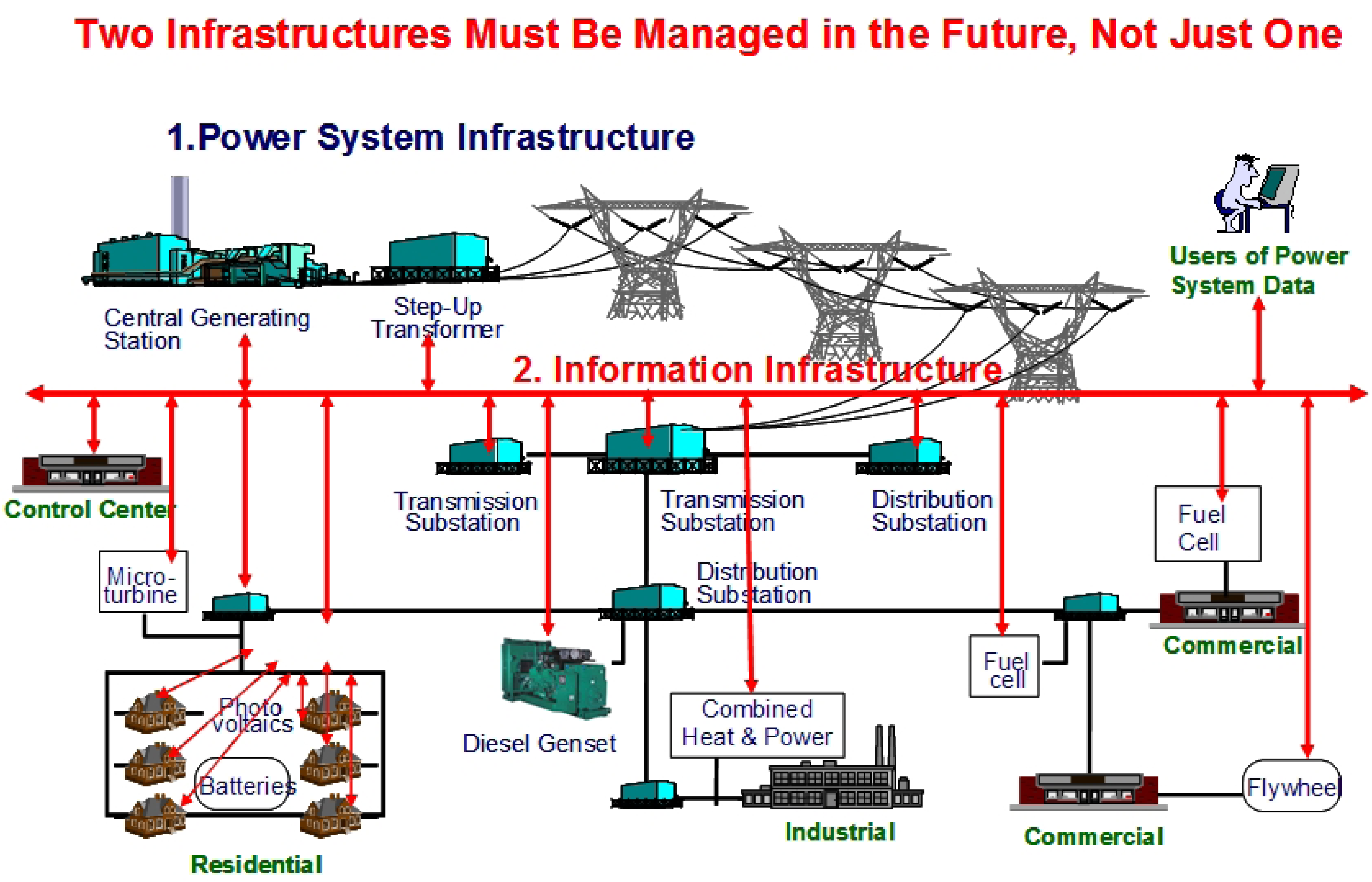
Secure Information and Resources

Anticipate, detect, identify, and protect against attacks

Source: IBM Autonomic Computing white paper

CAVS

Need to have seamless interaction between generation, transmission, load, and information



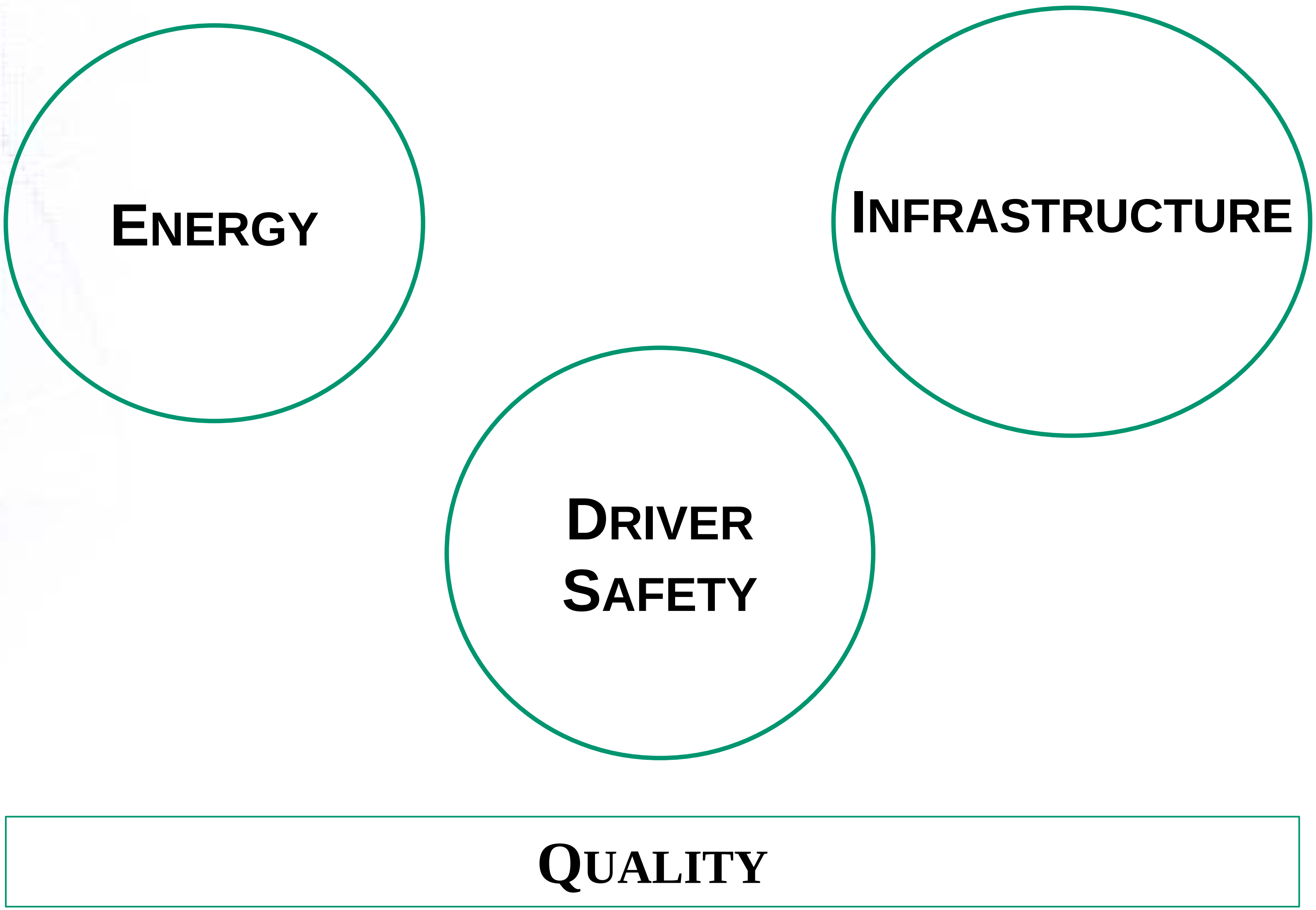
Evolution of Mississippi State Motorsports

- **SAE Formula Car**
  - Car designed and judged for safety, durability, testing, business case, …
- **Challenge X**
  - A 4 year competition that challenged students to re-engineer a 2005 GM Equinox to minimize energy consumption and emissions while maintaining or exceeding stock vehicle performance.
  - First Place overall in Years 3 & 4: National Champions!
- **EcoCAR**
  - Current competition where students are re-engineering a 2009 Saturn Vue by minimizing energy consumption and reducing greenhouse gas emissions while maintaining its utility, safety, and performance.
  - The MSU team has chosen their architecture as a plug-in, extended range hybrid that runs on B20 biodiesel!
  - First Place overall in Years 2: National Champions!
- **EcoCAR – 2**
  - **?????**

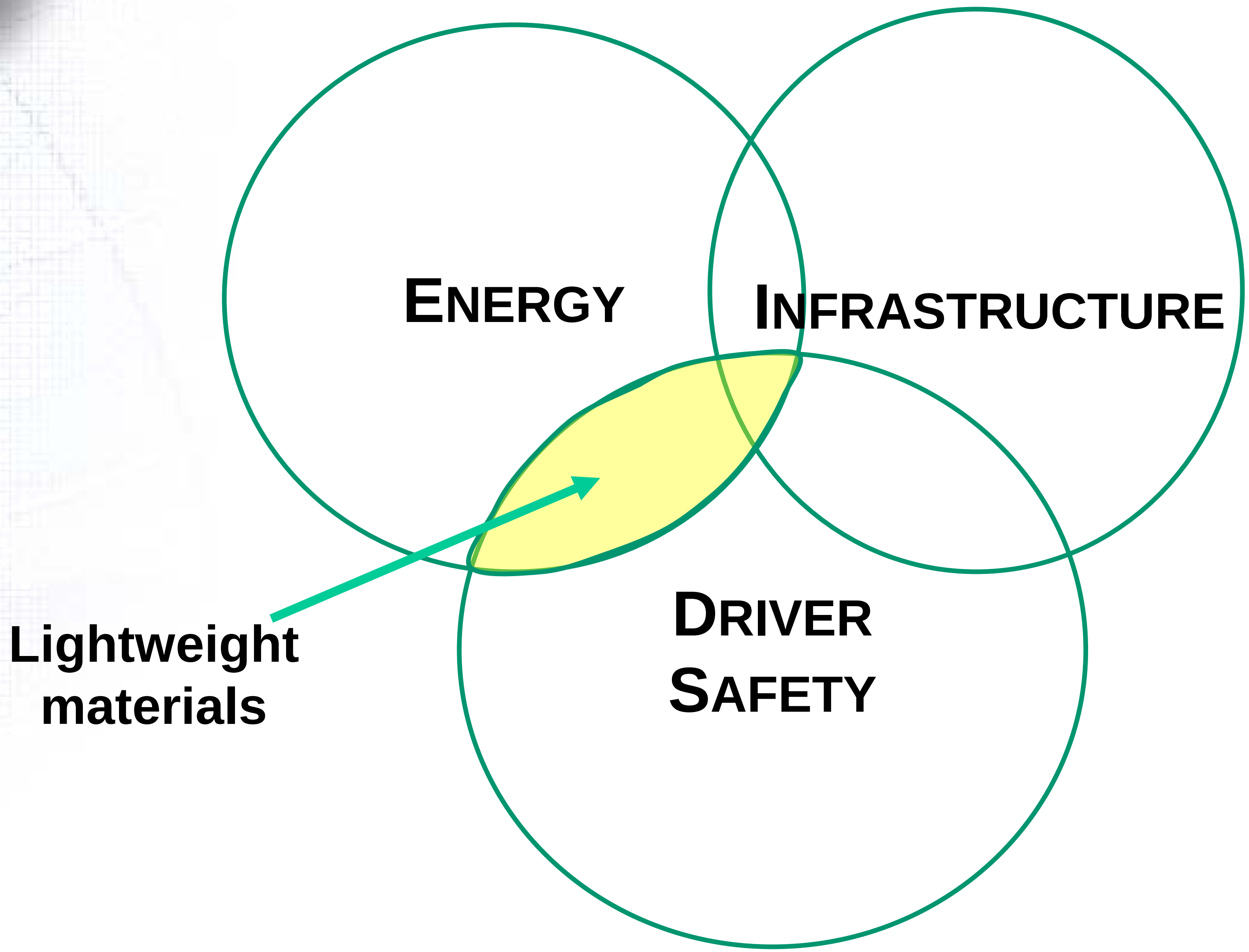
CAVS

JAMES WORTH BAGLEY COLLEGE OF ENGINEERING
MISSISSIPPI STATE UNIVERSITY

Silo View of Vehicles and Infrastructure



Systems View of Vehicles and Infrastructure

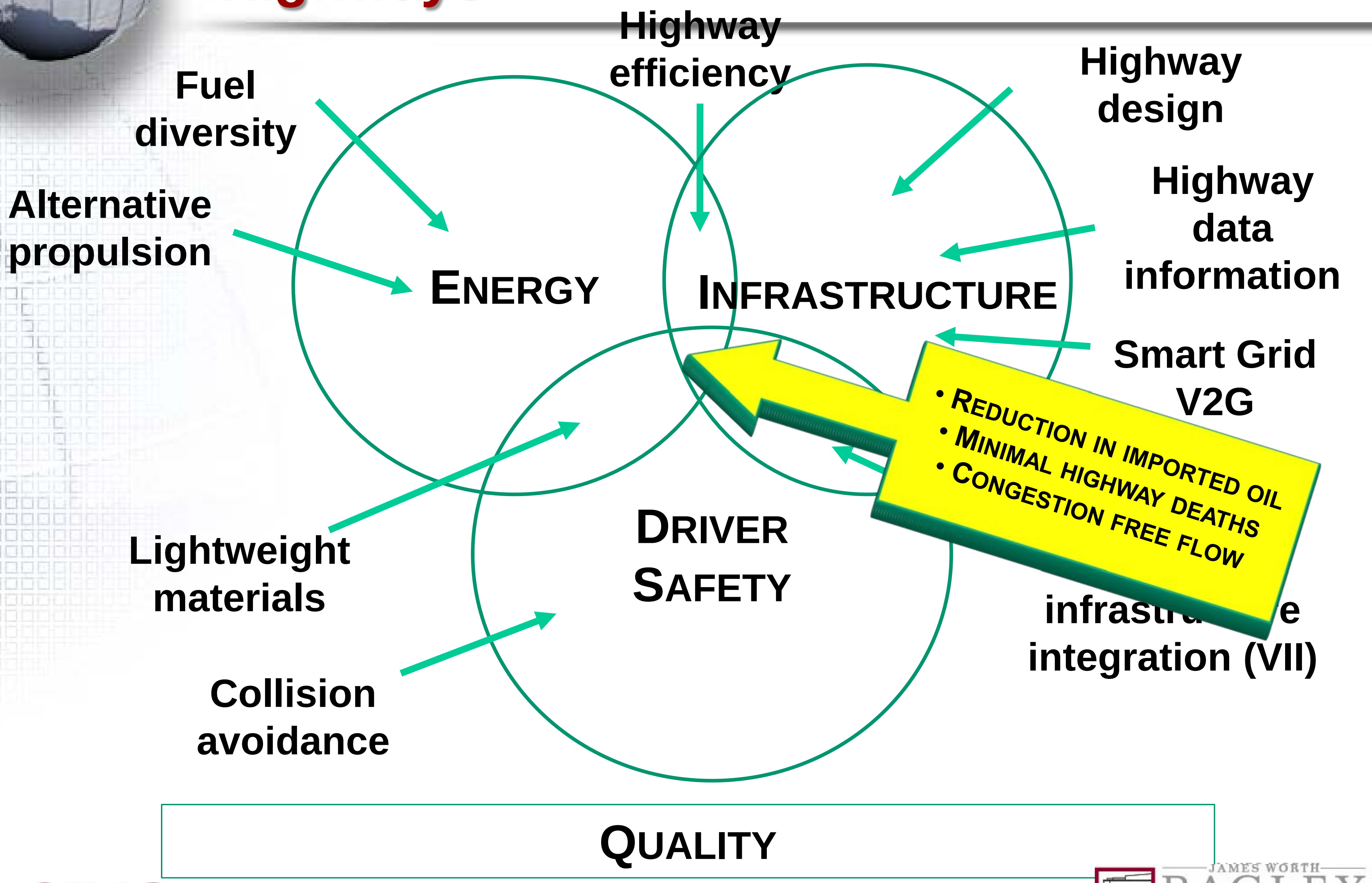


QUALITY

CAVS

JAMES WORTH BAGLEY COLLEGE OF ENGINEERING MISSISSIPPI STATE UNIVERSITY

Systems View of Vehicles and Highways



CAVS

James Worth Bagley College of Engineering
Mississippi State University

The Future is Bright

The path is starting to unfold - With the deployment of . .

- New analytical tools and computing horsepower
- Monitoring and diagnostics devices
- Modern communication infrastructure
- Availability of information across the power grid
- New generation sources and loads

Energy is difficult to stockpile today - Supply must be orchestrated to meet demand with split-second precision

Heavy lifting . . .

- Unprecedented levels of co-operation among the industry's diverse stakeholders to lead us into the 21st century
- High-end software applications that turn more data into information
- Higher bandwidth demand
- Vision to make the system predictive, self-healing and secure
- Continued investments from all stakeholders