HPC and the Automotive Industry

Dearborn, Michigan

Paul Muzio, Chair

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HPC User Forum Steering Committee

Automotive Industry Related Presentations

- **Bridging the Automated Vehicle Gap: Consumer Trust, Technology and Liability**
  - Kristin Kolodge, J.D. Power and Associates and Tina Georgieva, Miller Canfield
- **Navigation/Localization Performance of Autonomous Vehicles**
  - Dorota Grejner-Brzezinska, Ohio State College of Engineering
- **AI for Autonomous Driving Will Revolutionize the Transportation Industry**
  - Bill Veenhuis and Norm Marks, NVIDIA
- **Use of HPC for AI Applications at Ford Motor Company**
  - Bryan Goodman
- **Computer Vision for Autonomous Vehicles**
  - Xiaoming Liu and Garrick Brazil, Michigan State University
- **Object Detection in Mobile Urban Complex Environments**
  - Ruth Cheng, US Army Corps of Engineers/Engineers Research Development Center (ERDC)

Automotive Industry Related Presentations

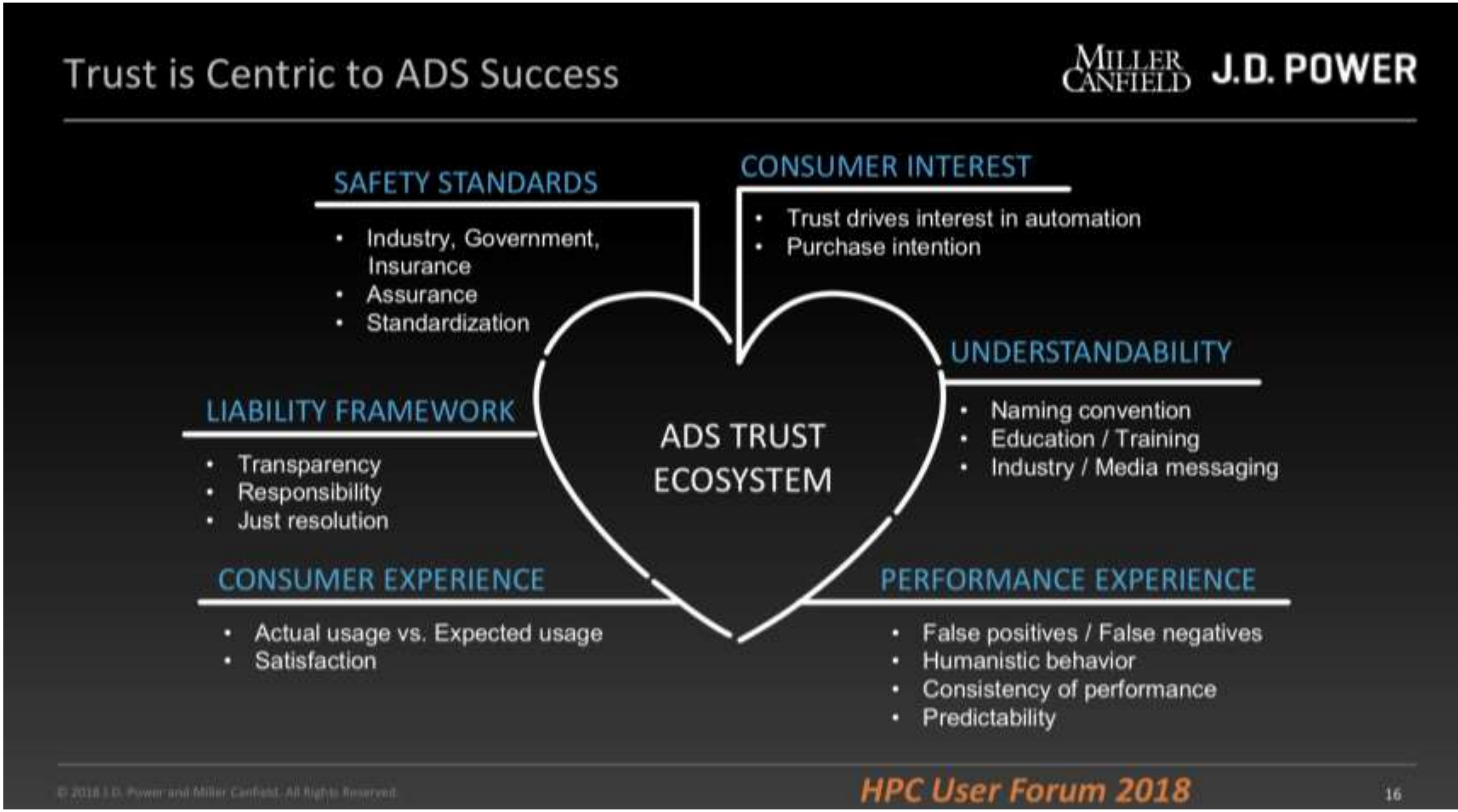
- Use of HPC to Drive Development of Advanced, More Fuel-Efficient Engines
  - Ron Grover, General Motors
- Nek5000 Engine Simulation with Exascale Scaling
  - Muhsin Ameen, Argonne National Laboratory
- The European Processor Initiative
  - Jean-Marc Denis

Bridging the Automated Vehicle Gap: Consumer Trust, Technology and Liability

- https://www.hpcuserforum.com/presentations/dearborn2018/BridgingtheAVGap_JD%20Power.pdf
- **Study focused on:**
  - **Consumer willingness to accept Automated Driving Systems (ADS)**
  - **Consumer understanding of the limitations of ADS**
    - **Skepticism**
    - **Too high expectations**
  - **Privacy issues**
  - **Legal/liability issues**
    - **Arbitration**

JD Power and Miller Canfield

Bridging the Automated Vehicle Gap: Consumer Trust, Technology and Liability



JD Power and Miller Canfield

Navigation/Localization Performance of Autonomous Vehicles

- https://www.hpcuserforum.com/presentations/dearborn2018/Brzezinska_OSU.pdf
- **Smart city and smart mobility**
- **Autonomous driving in a smart city**
- **Autonomous vehicles requirements: localization, positioning and high definition maps**
- **Autonomous vehicles: testing requirements**
- **Autonomous vehicles: testing challenges**

Navigation/Localization Performance of Autonomous Vehicles

- **Smart Cities are those that have a base level of connectivity and integrated municipal services**
- **Cities built on *Smart* and *Intelligent* solutions and technology that will lead to the adoption of at least 5 of the 8 following smart parameters**
  - ✦ smart energy
  - ✦ smart building
  - ✦ smart mobility
  - ✦ smart healthcare
  - ✦ smart infrastructure
  - ✦ smart technology
  - ✦ smart governance and
  - ✦ smart education, smart citizen

Ohio State Univerity

Navigation/Localization Performance of Autonomous Vehicles

- **Smart mobility/Advanced traffic management system (ATMS)**
  - Parking management
  - ITS-enable transportation pricing system
  - *Connected vehicles/cooperative navigation*
  - *Automated/Autonomous vehicles*
  - Electric vehicles
  - Shared rides
  - Integrated multimodal transportation system
- **Goals: three zeros**
  - low or no emissions and low or no carbon footprint
  - low or no congestion = more efficient and less stressful mobility
  - no accidents and fatalities

Ohio State University

Navigation/Localization Performance of Autonomous Vehicles

- **The end of private car ownership?**
  - "Mobility as a service"
- **AVs' impact on the way we live will be transformative**
- **AVs should be thought of not as a single new product but rather as an entirely new ecosystem in the economy**
  - Sensors and other physical components for the vehicles
  - Cybersecurity
  - High-performance computing chips to power the cars' decision-making processes
  - Consumer electronics for the cars' interiors
- **Mapping and geolocation software to enable the car to navigate**

End to End Needs for Autonomous Vehicles

- https://www.hpcuserforum.com/presentations/dearborn2018/NVIDIANeedsforAtonomousVehicles.pdf
- **Exciting Time in Technology**
  - Gaming: $100 billion
  - Artificial Intelligence: $3 trillion
  - Autonomous vehicles: $10 trillion
- **Rand Corporation, study "Driving to Safety"**
  - " Autonomous vehicles need to be driven more than 11 billion miles to be 20% better than humans. With a fleet of 100 vehicles, 24 hours a day, 365 days a year, at 25 miles per hour, this would take 518 years."
  - How do we accomplish this in a reasonable time period?

End to End Needs for Autonomous Vehicles

End to End Needs for Autonomous Vehicles

- **NVIDIA best practices leads to Training, Simulation, Testing for Autonomous Driving Infrastructure (TSTADI) reference platform**
- **Understand end-to-end requirements of autonomous vehicle development**
- **AI demands data center design built on dense GPU compute-at-scale**
- **Consider the complete workflow of AI from experimentation to training to inference**
- **Weigh cost of productivity vs hardware cost alone**

Use of HPC for AI Applications at Ford Motor Company

- **Use ML/AI to improve the physics-based simulation design/engineering process**
  - **Label design data and simulation results**
  - **Train models to taker the same input and generate the correct output results without re-running the resource consuming HPC simulation**
    - **Virtual wind tunnel**
    - **Virtual crash testing**
- **Speeding up data base searches using machine translation.**
  - **Not Google translate, Ford has its "own vocabulary."**
  - **Useful for owner manuals, docs related to manufacturing, results, engineering, field feedback. Sold over 6.5M vehicles, 2M in US. ML trans service: 100k translation request/day.**
  - **"Bleu Score" – measure of translation; improving and becoming more accurate**

Use of HPC for AI Applications at Ford Motor Company

- **Computer Vision: NASCAR applications**
  - **Ideentify cars in real-time**
  - **Driving nearly 200 mph, bump each other. Assess damage in real-time.**
  - **Grill is most important area – if candy wrapper stuck on grill for long, engine will explode.**
- **Computer Vision: Production Line Application**
  - **Produce cars 1/minute – keep the production line moving.**
  - **Wheels: many different wheels for most vehicles; most are interchangeable Hard for inspectors to notice mismatches. Very easy for CV even when seeing very little of the wheel.**
  - **Painting/Dust - CV to find defects**

Computer Vision for Autonomous Vehicles

- **Detection : draw a bounding box around an object of interest**
- **Classification: Figure out what is in the box**
- **Can be multiple overlapping boxes**
- **Originally used the region convolution neural network (R-CNN) method of Girshick et. al.**
  - R-CNN uses separate steps for detection and classification
- **Switched to You Only Look Once (YOLO) algorithm of Redmon et. al.**
  - YOLO imposes a grid over each frame, each grid cell either has an object or not
  - Each grid cell predicts bounding boxes and confidence scores reflecting an estimate of accuracy.
- **YOLO achieves a higher frame rate but is less accurate when objects are small or fast moving**