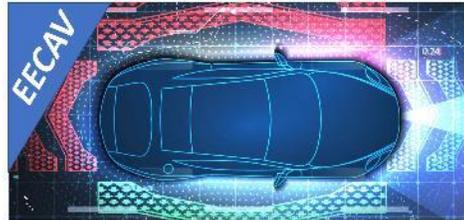


Welcome and Introduction

Zhiyong Li
Sandia National Laboratories

Workshop on Energy Efficient Computing for Automated Vehicles (EECAV)

May 11 - 12, 2021



Workshop logistics

- Please mute and turn off your video if not speaking
- Please raise your hand if you have a question or comment you'd like to make or
- Use chat liberally, we will monitor it for discussions

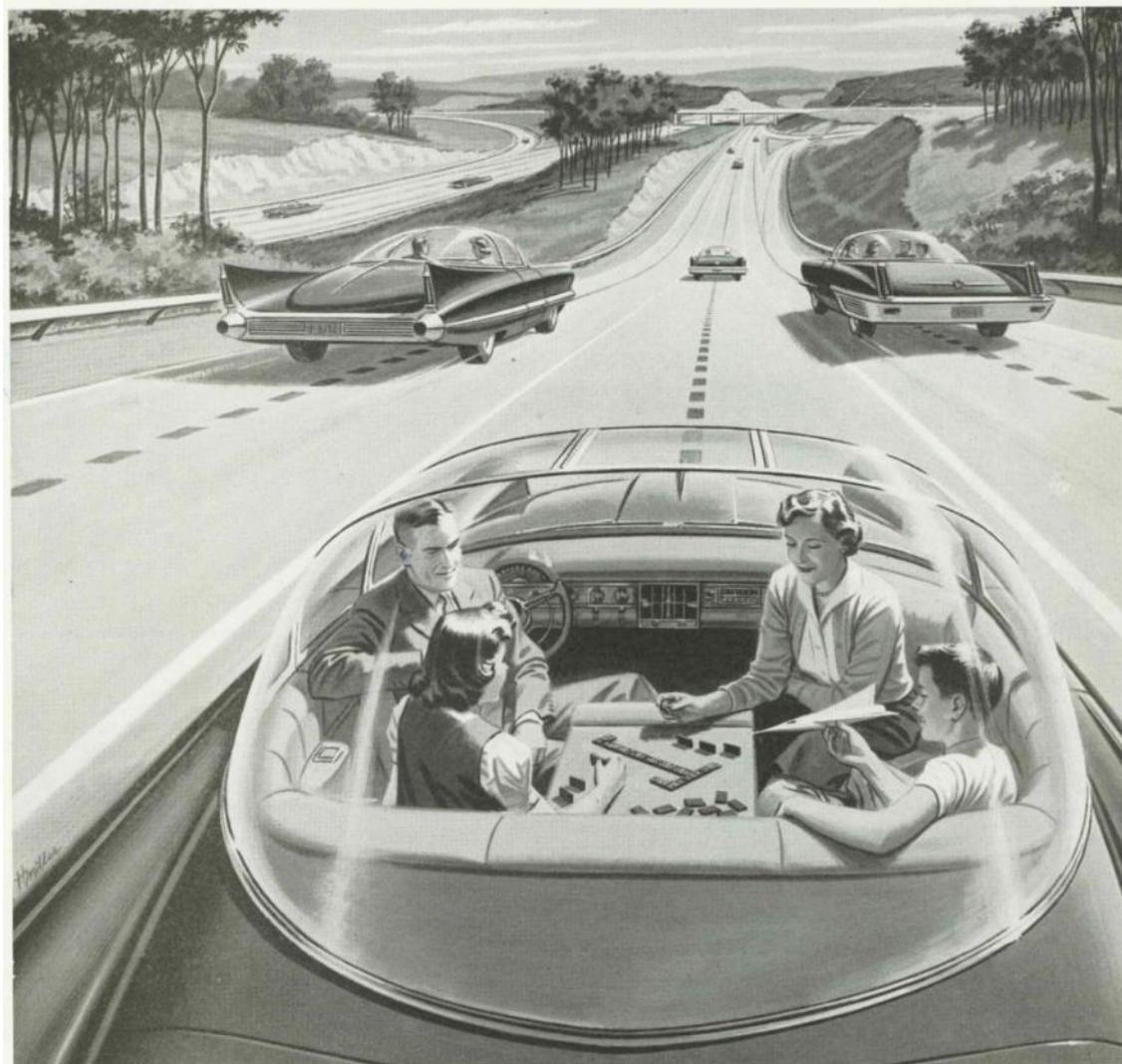


Anti-trust reminder

- Do not share any proprietary information
- Do not discuss product pricing, sales terms, territories, production, or other aspects of competition
- Do not use insider information when discussing forward-looking plans



Automated Vehicle (AV) Vision in the 1950s



ELECTRICITY MAY BE THE DRIVER. One day your car may speed along an electric super-highway, its speed and steering automatically controlled by electronic devices embedded in the road. Travel will be more enjoyable. Highways will be made safe—by electricity! No traffic jams . . . no collisions . . . no driver fatigue.

The idea of self-driving vehicles dates back to 1930s to 1950s

<https://computerhistory.org/blog/where-to-a-history-of-autonomous-vehicles/>



Automated Vehicle Vision in the 2010s



The vision has refined over the years!

Electrification.

Connectivity.

Ride-share.

Benefits:

Reduced traffic congestion.

Lower transportation costs.

Improved walkability and livability.

Reduced fuel use and CO₂ emissions.

<https://computerhistory.org/blog/where-to-a-history-of-autonomous-vehicles/>



Modern AV Research

Modern AV research was initiated in the 1980s, and has continued since then...



<https://computerhistory.org/blog/where-to-a-history-of-autonomous-vehicles/>

- In 2004, DARPA made a Grand Challenge for autonomous driving in a CA desert. All teams failed, traveling barely a few miles before crashing.
- At the second try in 2005, several teams passed the challenge, including Stanley, Sandstorm, H1ghlander.



Improvements in Computation are Needed for Commercial Automated Vehicles

Improvements in computation (hardware, software) are needed to realize mass-produced automated vehicles.



Computer in Stanley car (DARPA), 2005



Photo I took at AV conference show, 2020

Improvements Needed In:

Computational capacity (“supply”) (e.g, TOPs)

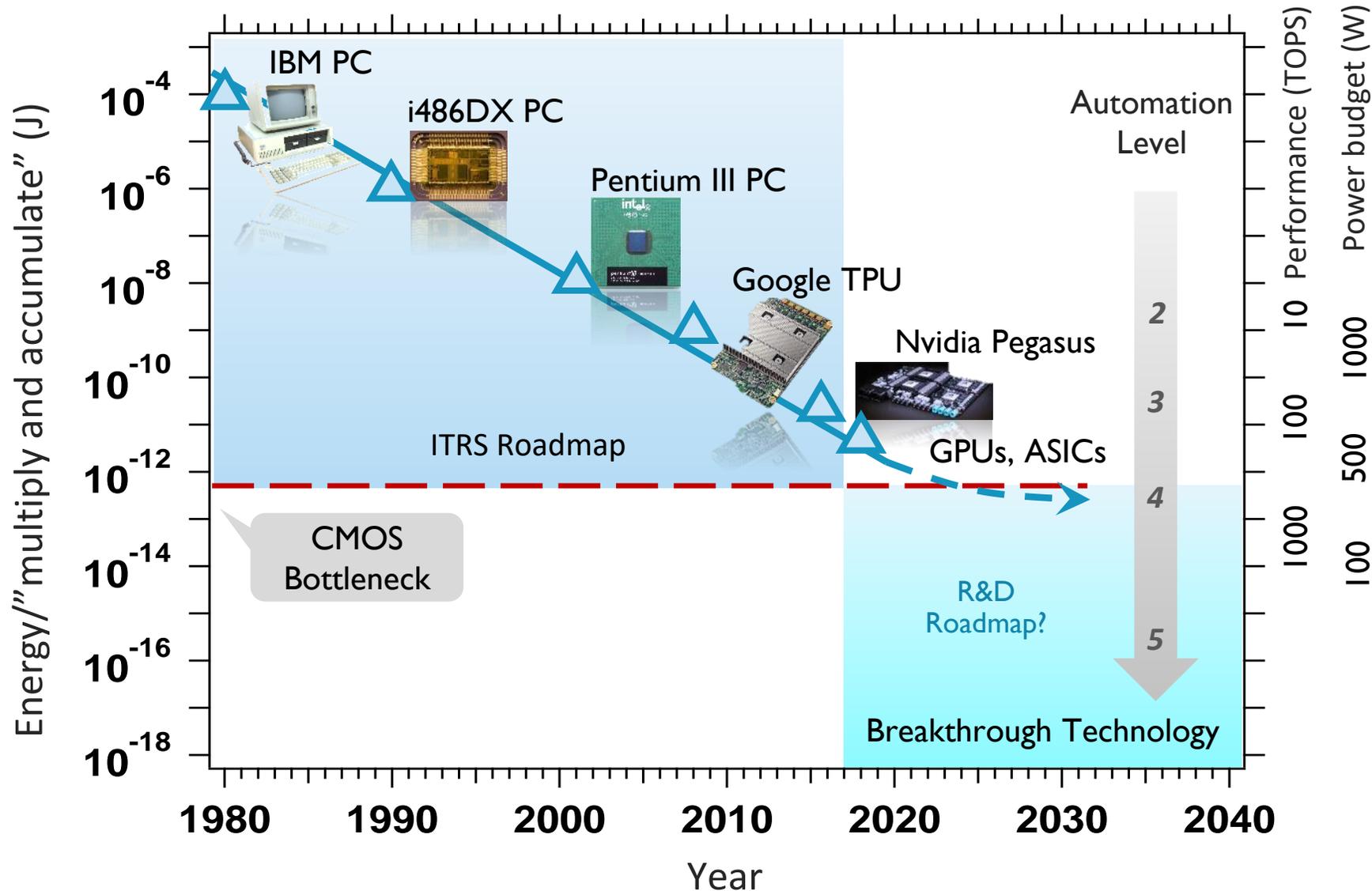
Energy efficiency with SWaP-C constraints (Size, Weight, power, and cost)

Reliability (Stability against temperature, humidity, radiation)

Safety, security



Improvements in Computational “Supply”



-- Reductions in the vehicle computational “demands” will help, but it looks like significant improvements in computational “supply” will still be needed.



How to Guide R&D in EECAV? A Roadmap is Needed

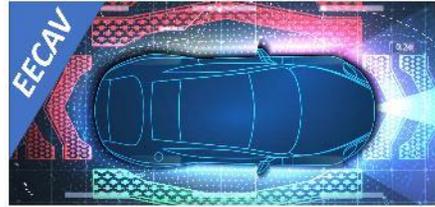
DOE sponsored a workshop in 2019 to collect the initial inputs on advanced computing need for CAV

A poster for a workshop titled "WORKSHOP ON ADVANCED COMPUTING FOR CONNECTED & AUTOMATED VEHICLES". The top half features a 3D rendering of a city street with cars and infrastructure. Below the image, the text reads: "Date: May 7, 2019". The bottom section contains the following text: "The U.S. Department of Energy's (DOE) Vehicle Technologies Office (VTO) invites you to a Workshop on Advanced Computing for Connected & Automated Vehicles (CAVs) at Lawrence Berkeley National Laboratory in Berkeley, California. This one-day summit will explore advanced microelectronics and computing approaches that can help meet future energy, cost, and computational requirements for CAVs. The workshop will bring together experts from the microelectronics industry, autonomous vehicle innovators, national laboratories, and academia in a precompetitive forum to discuss critical questions, including: • What system sensing and computing architectures will fully automated vehicles require, and how much energy will those technologies consume? • Which advanced computing approaches could reduce the energy requirements for fully automated vehicles while meeting their computational requirements?" A large number "7" is displayed in a box, indicating the date. At the bottom, it says "RSVP TODAY TO JOIN THE DISCUSSION" with the URL "http://www.cvent.com/d/16q0h3". Logos for the U.S. Department of Energy and Lawrence Berkeley National Laboratory are at the bottom.

The cover of a Sandia Report titled "Workshop on Advanced Computing for Connected and Automated Vehicles". The top section is teal with the text "SANDIA REPORT SAND2019-14177 Printed November 2019" and the Sandia National Laboratories logo. The middle section is white with the title "Workshop on Advanced Computing for Connected and Automated Vehicles" and the author "C. Mailhot". The bottom section is white with a blue geometric pattern and the text "Prepared by Sandia National Laboratories Albuquerque, New Mexico 87185 and Livermore, California 94550".

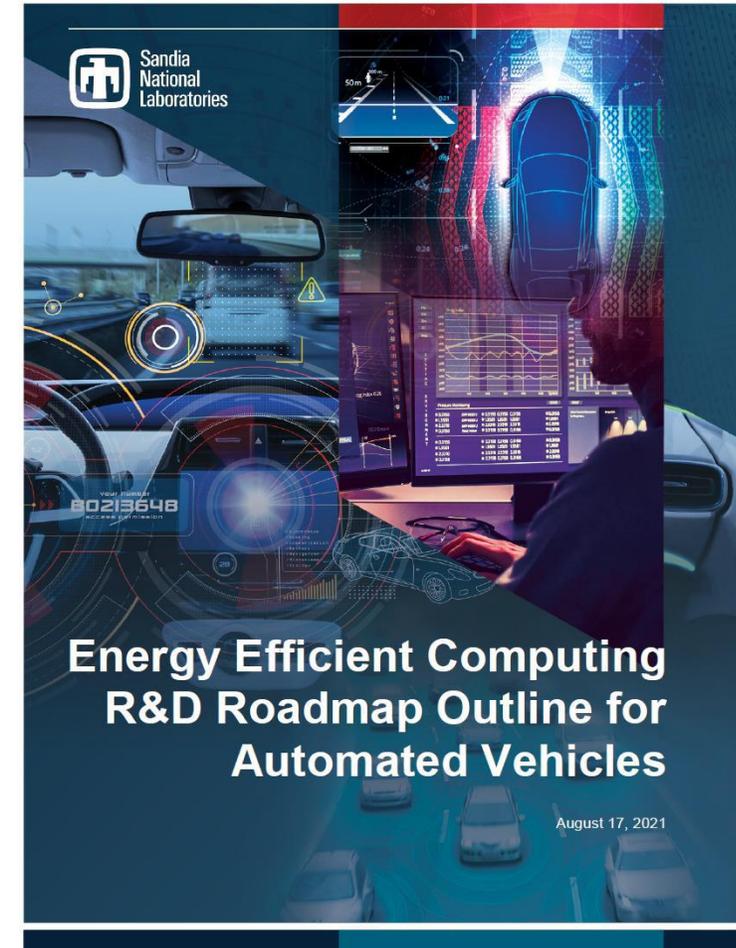
“computing performance” / watt. The DOE could develop public data sets to support algorithm and software development. Analogous to the VTO battery program, the DOE could co-create a roadmap with industry to help drive and quantify precompetitive advancements in computing performance. To overcome computing challenges for highly automated vehicles, a broader dialogue is necessary about long-term research needs and the role for DOE and its national laboratories. The

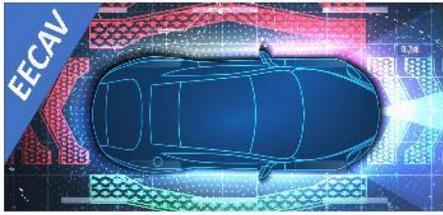
(available upon request)



Developing a Roadmap Outline

In 2020, Sandia pulled together an Organizing Team to formulate the EECAV problems and identify R&D areas that could benefit from public and private investment (i.e., the roadmap outline).





Purpose of This EECAV Workshop

Purpose: Collect feedback from all stakeholders on the scope, timeline, assumptions, and identified R&D problems that the Organizing Team has come up with thus far.

Some things to note:

- Please focus on R&D problems and technical gaps, not proposed solutions.
- No proprietary information.
- We will distribute a questionnaire at the end to collect more feedback.
- We welcome volunteers to join us to develop the full roadmap!

Agenda for May 11, 2021

TIME	EVENT	SPEAKER
8:30-8:40 am (PDT)	Welcome and Introduction	Zhiyong Li/SNL
8:40-8:50 am	Opening Remarks	Sarah Allendorf/SNL
8:50-9:00 am	Organizing Team Introduction	Organizing Team
9:00-9:40 am	Overview of the Semiconductor Projection and Automated Vehicle Development	Matt Marinella/SNL Jace Mogill/USCAR
9:40-10:00 am	Feedback on overview	All participants
10:00-10:10 am	Break	
10:10-10:40 am	Overview of the Roadmap Scope and Outline	Lennie Klebanoff/SNL
10:40-11:30 am	Feedback on Roadmap Scope and Outline	All participants
11:30-11:50 am	Feedback Summary	Carrie Burchard/SNL Lennie Klebanoff/SNL
11:50-12:00 pm	Preview of Day 2 Activity Adjourn for Day 1	Zhiyong Li/SNL

Agenda for May 12, 2021

TIME	EVENT	SPEAKER
8:00-8:05 am (PDT)	Introduction of Day 2	Lennie Klebanoff/SNL
8:05-9:05 am	Technical Area 1 - Materials, Devices and Circuits Feedback Session	John Paul Strachan/HPE Session Chair
9:05-10:05 am	Technical Area 2 - Architecture, Safety and Security Feedback Session	Rob Aitken/ARM Session Chair
10:05-10:15 am	Break	
10:15-11:15 am	Technical Area 3 - Algorithms & Data Management Feedback Session	Robert Dick/University of Michigan Session Chair
11:15-12:15 pm	Technical Area 4 - Sensor Data Interface Feedback Session	Jace Mogill/USCAR Session Chair
12:15-12:30 pm	Review Feedback Summary We'll reflect back to the group the feedback we captured. <ul style="list-style-type: none">• Did we miss anything?• Did we capture the feedback correctly?• Additional questionnaire• Next Steps	Carrie Burchard/SNL Lennie Klebanoff/SNL
12:30-12:35 pm	Closing Remarks	Sarah Allendorf/SNL