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Overview of the Roadmap Scope and Outline

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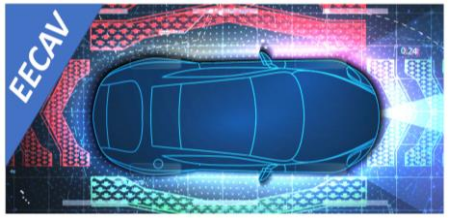
Sandia National Laboratories

Workshop on Energy Efficient Computing for Automated Vehicles (EECAV)

May 11 - 12, 2021



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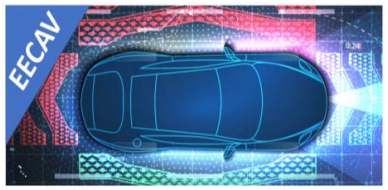


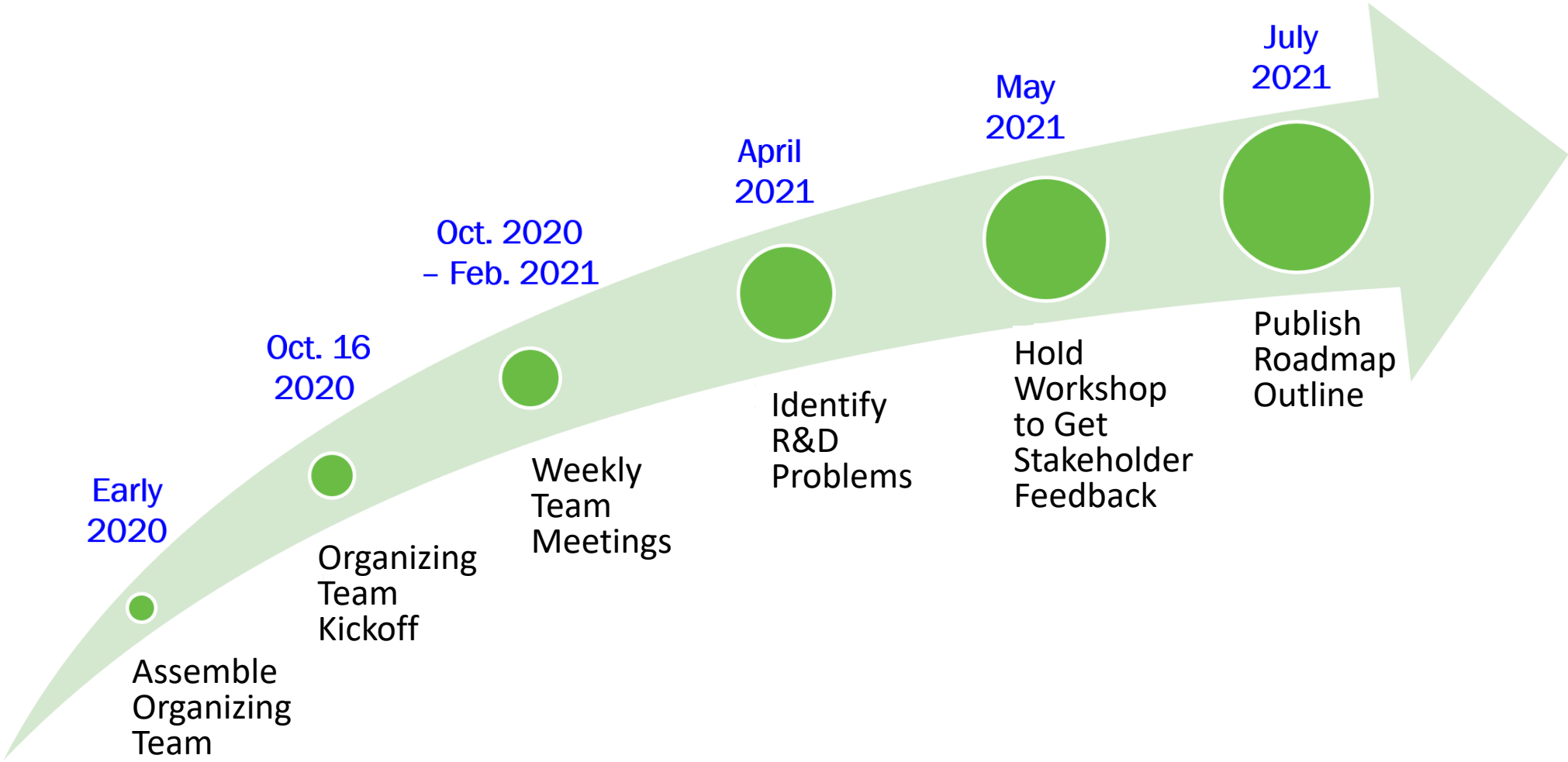
Purpose of Our Activity

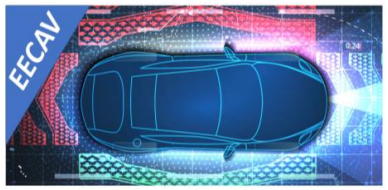
To identify R&D problems in the field of Energy Efficient Computation for automated vehicles (AV) that are suitable for public and private investment.

Approach:

- ✓ Assemble an “Organizing Team” of representatives from academia, industry and national labs to develop a “content outline” (“roadmap outline”) for a EECAV Roadmap.
- ✓ Identify the R&D challenges to computational energy efficiency that must be overcome for the realization of highly automated driving in commercial retail vehicles with lower power consumption.
- ✓ Focus on the long-term, typical of public investment and atypical of current industrial investments.
- ✓ Use the roadmap outline as an initial “seed” to a more comprehensive energy efficient computing road mapping activity in a second phase that will likely include broader partners.
- ✓ Perform honest technical assessment without bias or favoritism to a particular technology, ensuring a technically sound input for an eventual long-term EECAV roadmap that can guide R&D investment.

Schedule That We Have Been Following





First Step: Literature Review

Has Anybody Done Something Like This Before? Answer: No

We searched the technical literature for articles relating to computational energy and AV: Several dozen articles were found.

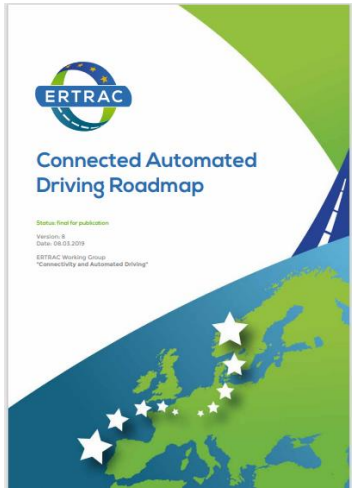
Result:

None of these articles, or reviews, discuss the supply* part of our problem. They all assume the computational capability will be there. A few articles discuss the demand* side of our problem, namely the sensor/camera data that must be processed computationally. There is no discussion of computational energy efficiency. **Thus, we are not re-inventing the wheel.**

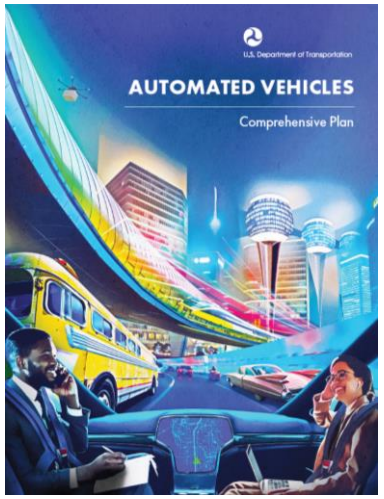
**Computational Supply: The capability of the chip to perform algorithms and functions (TOPs) for self-driving.*
Computational Demand: The demand on computation from AV features, AV functionalities, operating design domains, etc.

The literature review will be an appendix to our Roadmap Outline, which will be published.

High-level AV "Timelines" From Different Countries



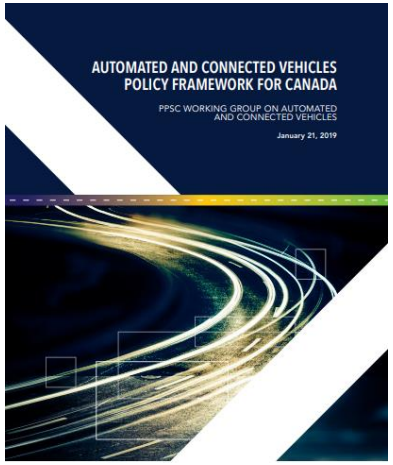
EU (2019)
Full AV beyond 2030



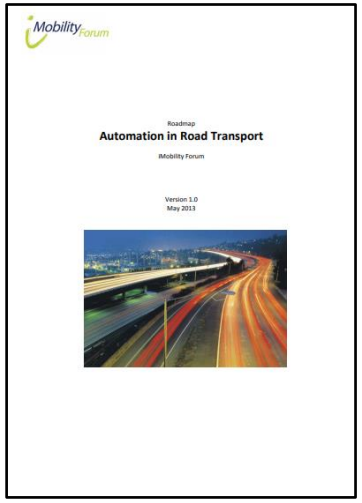
United States
(2021)
Full AV "unknown"

Austria
(2016)
Full AV ~ 2030

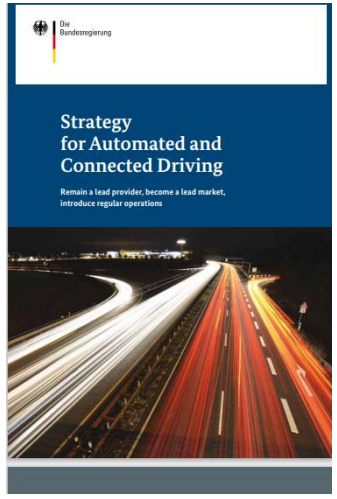
UK
(2019)
Full AV ~ 2030



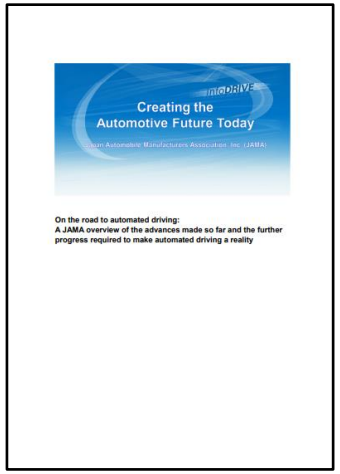
Canada
(2019)
Full AV "uncertain"



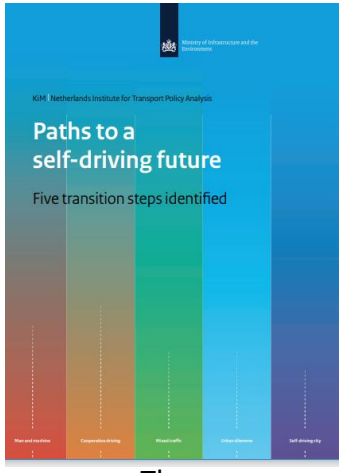
EU
(2013)
Full AV ~ 2029



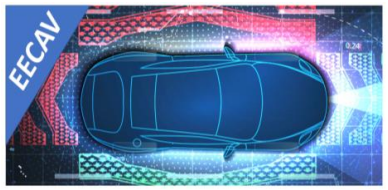
Germany
(2015)
Full AV beyond 2030



Japan
(2016)
Full AV in 2050



The Netherlands
(2016)
Full AV ~ 2065

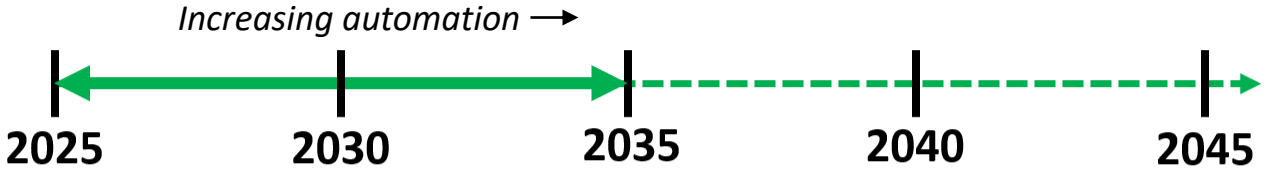


There are 3 Timelines to Track

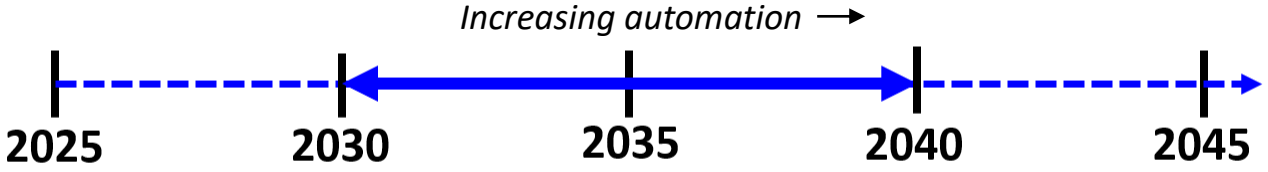
We thought about the roadmap outline in terms of 3 conceptually distinct timelines:

- The Timeline for establishing commercial-ready compute system for AV computation
- The Timeline for the R&D that enables these system
- The Timeline for OEM implementation of those system in future mass-produced AV.

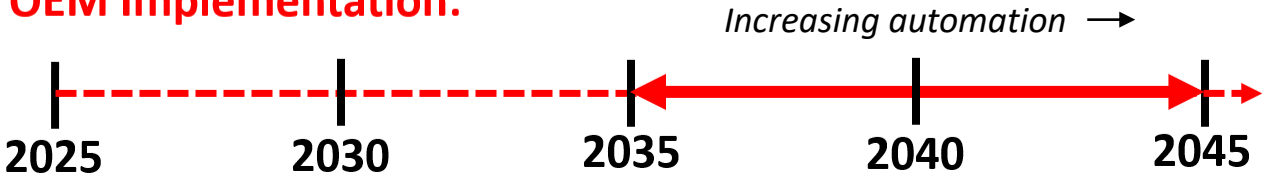
R&D:

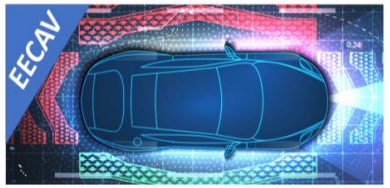


Commercial-ready Chips:

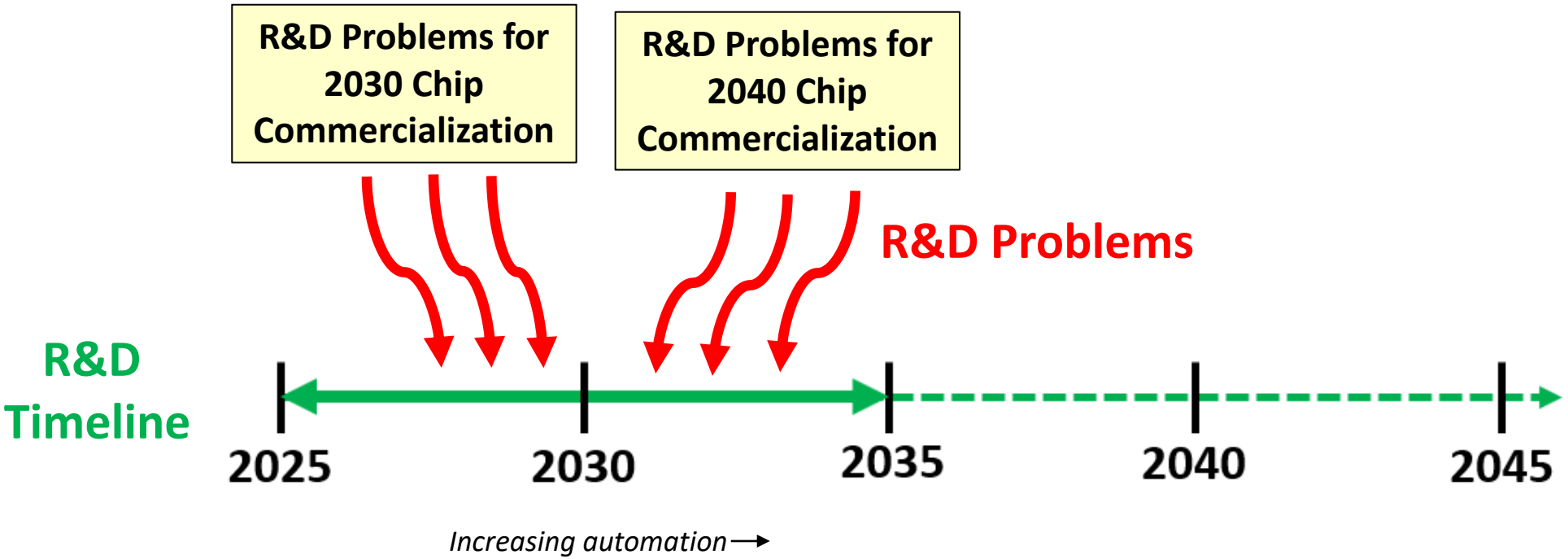


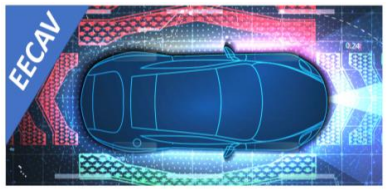
OEM Implementation:





We Identify R&D Problems and Place Them on the R&D Timeline

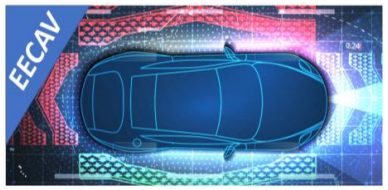




The R&D Problems are Organized into 4 Technical Areas

I. Chips: Materials, Devices and Circuits (Lead: John Paul Strachan, HPE, now Forschungzentrum Jülich)
II. Chips: Architecture, Safety and Security (Lead: Rob Aitken, ARM)
III. Algorithms and Data Management (Lead: Robert Dick, UMichigan)
IV. Sensors Data Interface (Lead: Jace Mogill, USCAR)

-- Each Team worked offline to identify R&D Gaps within their Technical Areas, particularly problems with a long-term focus. The R&D problems were then brought to the entire Organizing Team for discussion and priority ranking.



We Need Your Feedback On…..

We are needing your feedback on some basic underlying assumptions we made, difficulties we encountered, and the R&D problems we have identified.

Assumptions:

e.g., all the required computational capability resides on the vehicle.

Difficulties:

e.g., making quantitative the needed improvements in the 4 Technical Areas.

R&D Problems:

Will be described for each Technical Area I - IV.

We need your feedback on the R&D problem areas we have identified. We are not looking for technical solutions. We are working in the "problem space" to identify R&D areas that would benefit from public and private investment.

Thank You!

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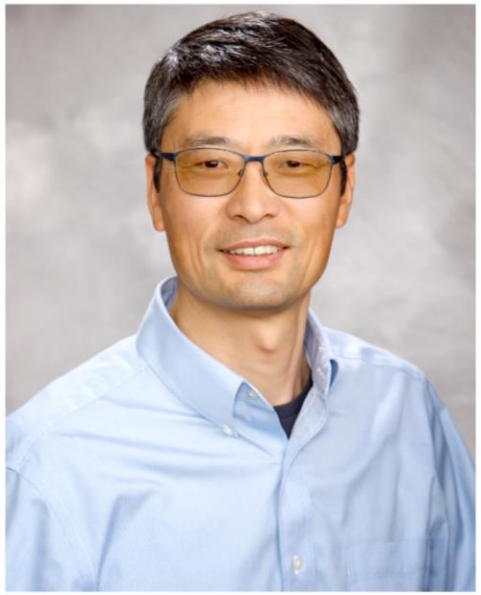

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