S. HRG. 117–845

MADE IN AMERICA: THE FUTURE OF AUTOMOTIVE INNOVATION AND SEMICONDUCTOR CHIPS

FIELD HEARING

BEFORE THE

SUBCOMMITTEE ON SURFACE TRANSPORTATION, MARITIME, FREIGHT, AND PORTS

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDRED SEVENTEENTH CONGRESS

SECOND SESSION

MARCH 28, 2022

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

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MADE IN AMERICA:
THE FUTURE OF AUTOMOTIVE INNOVATION AND SEMICONDUCTOR CHIPS

MONDAY, MARCH 28, 2022

U.S. SENATE,
SUBCOMMITTEE ON SURFACE TRANSPORTATION,
MARITIME, FREIGHT, AND PORTS,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Detroit, MI.

The Subcommittee met, pursuant to notice, at 10 a.m., in the Fleetwood Conference Rooms, Detroit Regional Chamber, 1 Woodward Ave #1900, Detroit, Michigan, Hon. Gary Peters, Chairman of the Subcommittee, presiding.

Present: Senator Peters [presiding].

OPENING STATEMENT OF HON. GARY PETERS, U.S. SENATOR FROM MICHIGAN

Senator PETERS. Welcome. It is a great—memorable first day for everyone to be back. So thanks again to everybody for being here. Well, this committee will now come to order. And I think I want to begin by just explaining why we are here in Detroit. Last week, the Senate Commerce Committee had a hearing in Washington, D.C. about semiconductors and the role that they play in manufacturing and throughout our economy.

But today we are bringing the Committee to Michigan because it is here where—this is not an abstract concept by any means. This is where our auto manufacturing, the chip shortage, and related challenges are all taking place each and every day. And this is where I think we will be, continue to lead into the future as well, from the Greater Detroit area and the State of Michigan.

Our communities and families are steeped in these issues, and it is important to have this conversation among the people and the places that are actually experiencing them. Michigan established the American auto industry, transforming mobility in society, and quite frankly, built the American middle class that will continue leading for many years in the future.

When Henry Ford introduced the first Model T on the assembly line in 1908, it did not contain a single semiconductor chip. It is a pretty amazing feat that he was able to do that without a semiconductor. Indeed, several more decades went by and that continued to be the case. But by the 1970s, some cars started to contain a handful of chips.

The role of chips in automobiles has ballooned since then, and today's modern cars have roughly 1,000 semiconductor chips or more, spanning very cost functions and technologies, and a little—I even have a few chips right here of how tiny—imagine, this little, tiny wafer about the size of my thumbnail, the power that it has and the influence that it has, and then multiply that by a thousand throughout an automobile.

And given these developments, it is no surprise that the global chip shortage following COVID–19 pandemic has devastated—impact—has had a devastating impact on the auto industry. This chip shortage has resulted in temporary layoffs, causing hardships for workers in an already challenging time. It also cut into one of the main drivers of our national economy, which is auto production.

As President Biden has said, when he was visiting both Ford and General Motors here in Michigan, "the future of the auto industry is electric," and I would make a small addition to that Statement that the future of the auto industry is electric, as well as connected, and autonomous. In terms of electrification, novel semiconductor technologies promise to reduce charging times, extend range, and enhance performance for electric vehicles, among others.

And not only will electric vehicles help save our planet by combating climate change, they will also reduce our dependance on foreign energy sources and protect Americans from unpredictable gas prices.

When it comes to connected and autonomous vehicles, semiconductor chips will power the artificial intelligence and other capabilities necessary to make self-driving cars a reality. This aspiration can't become a reality soon enough, because as we were talking about earlier, lives are literally at stake for this technology.

Tragically, recent data shows that for the first time, for the first 9 months of 2021, an estimated 31,720 people died in car crashes. That represents a 12 percent increase over 2022. This is completely unacceptable.

Achieving a future with zero fatalities on our roads will be a challenge and require many many approaches, and there is unfortunately no silver bullet to accomplish that. But autonomous vehicles hold great promise to play a major role in reducing injuries and deaths by eliminating human error and impaired driving, which are commonly involved in the vast majority of our crashes.

These trends, electrification and autonomy, mean that in the coming years, chips will play an even greater role in the most essential functions of automobiles, both driving and powering the vehicle. So how do we prepare for this future and how do we prevent a repeat of problems like we have with the current chip shortage?

Well, we need to shore up our supply chains by making things that we need right here in America. Pretty straightforward. The pandemic has certainly delivered a very painful message in that regard. Our supply chains are efficient, but they are not resilient. So when something goes wrong, problems pile up very quickly, depriving Americans of the things that they rely on, which—and which also contributes to rising inflation.

And much of this is due to the fact that we are too reliant on overseas production. Through my role leading the Committee on Homeland Security and Government Affairs, in 2019, I released a

report on prescription drugs. Among other issues, we found that America was over reliant on foreign manufacturers for prescription drug materials and that we were poorly prepared in the event of a future pandemic.

That was in 2019. Shortly thereafter, we knew the pandemic did indeed hit us, and as we know, the Nation experienced challenges with PPE and other supply chain issues that limited our ability to have a quick COVID–19 response. And fortunately, companies such as General Motors, Ford, and Stellantis, as well as our auto suppliers, stepped up as they always step up, but they stepped up during the pandemic by repurposing their facilities to produce essential items like respirators and masks.

But in the long term, we need a national strategy to protect our economy. Whether it has to do with chips for the auto industry or other essential goods and materials, we need to start securing critical supply chains, and this is something we are already doing when it comes to national defense. As a former naval officer in the U.S. Navy Reserve and now a member of the Senate Armed Services committee, I have fought to ensure that critical assets are made here in the United States.

For example, Marinette Marine, which is right along the Michigan, Wisconsin border, is building Navy combat ships today, with about half of the workers coming from Michigan, employing hundreds of them. We would—I will say emphatically, we will never rely on the Chinese government to build our U.S. Navy warships. Never. That will never, ever happen. We will build them here in America with American workers to ensure in times of need our military is prepared.

We must apply that same approach here with semiconductor chips, especially how they are central to everything from automobiles to lifesaving medical devices. And that is why it is imperative for the Congress to fully fund the CHIPS Act. In particular, we need to pass legislation that I led with Senator Stabenow that would provide $2 billion to incentivize domestic manufacture of so-called mature chips that are in short supply and that manufacturers of all kinds rely on, especially in the auto industry.

This $2 billion is in addition to a $50 billion investment to ensure that the United States becomes the leader in the manufacture of advanced chips and other——

[Technical problems.]

Senator PETERS. Is it on now? Good. Here is the bottom line, we must remain focused on making our supply chains resilient by manufacturing critical goods in America. And that includes semiconductor chips, but other supplies that are essential to millions of American jobs like the auto industry.

So I look forward to hearing today's testimony about how we can buildup American auto manufacturing and our economy by leveraging American made chips and critical supply chains. And with that, it is now my pleasure to introduce our esteemed witnesses to provide their opening comments. Our first witness today is Mr. Steve Dawes, who is the UAW Region 1D Director.

Mr. Dawes was elected to his current role in February 2020. And over the years, he has held many leadership roles at the UAW. He has dedicated his time and energy to helping his fellow auto-

workers in creating opportunities for the next generation, and the Subcommittee is certainly very grateful for your service, Mr. Dawes, and your participation today. You are recognized for your opening comments.

STATEMENT OF STEVE DAWES, DIRECTOR, UAW REGION 1D

Mr. DAWES. Thank you. My name is Steve Dawes. Thank you for this opportunity. I am a UAW Region 1D Director. Region 1D serves a membership of 73 of the 83 counties in Michigan. I would like to start by thanking you, Senator Peters, for this opportunity to have this open discussion on semiconductor chips and the impact that it is having on our worksites. Mr. Senator, on behalf of myself and the Region 1D membership, thank you for your continued fight for our country and Michigan's working men and women.

So to fully understand the chip issue as it relates to the automotive sector, one must really understand the function of the modern automobile. My references will primarily be related to General Motors heavy duty truck assembly in Flint, Michigan, but also runs parallel to almost all other vehicles.

Today's truck functions and accessories are mostly fully run with electronics. Electronics control your brakes, steering, your fuel management, your radio, your lights, your cameras, your heated seats, your heated steering wheel, your speedometer, your dashboard, those are just a few. Many of these functions were historically operated with cables, shafts, mechanical methods.

Now, each of these functions are controlled by a dedicated module. Each of these modules contain chips. These modules may contain one chip for the more basic function or many chips for the higher functioning module. So Senator has provided some pictures for you in your pamphlet right there. So the first picture you will see is actually a module of your XM radio and your radio in a vehicle.

As you can see, from one, is the top view. Number two is a side view. And you can see the numerous electronic connectors that are hooked on to these things. Three is the bottom view. Again, another set of three connectors that come in and this is just for your XM radio to receive and communicate back to the computer. The second set of pictures are what we refer to as a BCM, which is the brake control module.

In both pictures, you can see where there are seven different areas of connection and outputs in these modules, and many modules, again, retain the chips. The brake control module is one of the more important modules in a vehicle. The interface between the brake panel and the master cylinder, senses the amount of pressure from your foot to the brakes, it talks to the rest of the braking system, including anti-light brake function along with the wheel sensors, et cetera. It is a very complex piece of the vehicle.

There are many more modules which contains chips. Some of the more important ones are actually the brake control monitor, the engine control module that controls all of the functions of the engine, the transmission control module that controls the shifting of your transmission. The engine performance is controlled by the engine control module, which also controls the governmental admis-

sions standards that we meet that could not be met with the old mechanical way.

So these are very critical, these modules and the chips that are contained in the modules. The chip and module numbers range differently from a mid-range truck. There is approximately 650 different electronic—electrical components in a vehicle. Sensor, switches, etcetera, approximately 30 of them are modules. Most of all the 651 components contain at least one chip. The 30 modules have a much more complicated architecture, as you can see in the picture, Senator.

Each containing multi-semiconductor chips, some containing 100 plus chips. 650 is an average component number but varies with the different building depending on your options, whatever. This dependency on semiconductor chips is actually, from talking to the engineers, is expected to double in the next 3 years. So very important on what our dependency are of these things.

The shorter of these chips causes the company to make hard decisions determining where the limited supplies they receive go. Do they sell it to a car assembly or a truck and SUV assembly? And what options can be eliminated or installed at a later date? Adding options later leads to extra costs, and the lack of product availability leads to customer dissatisfactions. One of the last pictures I will show you is my wife just purchased the brand new Tahoe vehicle.

As you can see as a high level, as I have highlighted, there is a credit, not equipped with heated steering wheel, includes later retrofit. Credit, not equipped with front and rear park assist, includes a later retrofit. So these are something that will have to be taken back to the dealership where somebody will have to spend hours and putting these modules into the vehicle, load them up to a computer, talking to the vehicle's computer, and so now the computer recognizes these.

Where this button is on your steering wheel for your heated steering wheel is a blank spot. So that whole mechanism would have to be changed, which in turn costs money, and takes away from a company's profit, which in turn shares with their, in our case our employees, which then turns around to be money out into our community and taxpayers. At Flint Truck Assembly, we build about a thousand trucks a day.

Every single one that is being built as we sit here today, along with the ones that will be built next week, next month, and beyond, there is someone waiting on that truck. Although we are able to produce the trucks, many which have already been built, they are waiting on the chips and modules to arrive and installed, and then delivered to the dealership. Chip shortage has continued to affect customer demands, the inability to produce certain vehicles—I will give an example, the Equinox.

When General Motors decided to take the chips from the Equinox to move them to the truck and SUV assembly, it leads to idle plants and workers not earning expendable income, income that gets back into our economy. All this is proof that we need to build these chips right here in the United States of America, where we control the quality and are not held hostage by a foreign companies or delivery issues when somebody makes a wrong turn in a canal.

We need a build here with proud Americans. That after the birth of the automakers, UAW in 1937—and Senator, you referenced how we were able to convert our factories to make ventilators and masks and PPEs and that type of stuff. Right after 1937, the birth of UAW, we also turned our factories and facilities into mass production of military planes, tanks, weapons, and other essential military products that had never been done in American history's before, mass producing of these military supplies.

We were supplying those who were defending our freedom in World War II, a country where today the hard working men and women take a box of bolt in a raw sheet metal and build the highest quality vehicles around the globe.

A country is willing and ready to produce the next generation of vehicles, but they want to do it here. They want to do it right here where we live and play. Right here, the place we love, the good old U.S. Mr. Senator, we stand ready, able, and with unlimited time tested talent. Let's build chips here, as well as the current technology for future technology. Let's do it here. Let's do it in our house.

Thank you again, Senator Peters, for the most honorable opportunity to be here with you. And the rest of the panel, and you folks, thank you very much.

[The prepared statement of Mr. Dawes follows:]

PREPARED STATEMENT OF STEVE DAWES, DIRECTOR,
UAW REGION 1D-SEMI CONDUCTOR CHIPS

My name is Steve Dawes. I am the UAW Region 1D Director. Region 1D serves the membership of 73 of the 83 counties in Michigan. I'd like to start by thanking Senator Peters for the opportunity to have this open discussion on semi-conductor chips and the impact they are having on our worksites.

Mr. Senator, on behalf of myself and the Region 1D membership, thank you for your continued fight for our country and Michigan working men and women.

To fully understand the chip issue as it relates to the automotive sector, one must understand the function of the modern automobile.

My references will primarily be related to General Motors Heavy Duty Truck Assembly Operations in Flint Michigan but will also run parallel to other vehicles.

Today's truck functions and accessories are almost fully run with electronics. Electronics control your brakes, steering, fuel management, radio, lights, cameras, heated seats, heated steering wheel, speedometer, dashboard-and those are just a few. Many of these functions were historically operated with cables, shafts, or mechanical methods. Now each of these functions are controlled by a dedicated module. Each of these modules contain chips.

These modules may contain one chip for the more basic function or many chips for the higher functioning module.

The shortage of these chips forces the company to make hard decisions determining where to send the limited supply they receive. Do they send them to car assembly or truck, SUV assembly? And what options can be eliminated or installed at a later date? Adding options later leads to extra costs and lack of product availability leads to customer dissatisfaction.

At Flint Truck Assembly, we build approximately 1000 trucks per day. For every single one that is being build, as we sit here, along with the ones that will be built next week, next month, and beyond, there is someone waiting on those vehicles. Although we are able to produce their trucks, many trucks are waiting on the chips/modules to arrive and be installed.

The chip shortage has and continues to affect customer demands. The inability to produce certain vehicles, such as the Equinox, leads to idled plants and workers not earning expendable income. Income that goes directly into our economy.

All this is proof that we need to build these chips right here in the United States of America where we control the quality and are not held hostage by overseas companies or delivery issues because a ship makes a wrong turn in a canal.

Build where proud Americans, after the birth of United Auto Workers in 1937, soon turned their factories into facilities mass producing military planes, tanks, weapons, and other essential military product, supplying those who were defending our freedom in World War II. A country where today, the hard-working men and women take a box of bolts and raw sheet metal and built the highest quality vehicles around the globe. A country that is willing and ready to produce the next generation of vehicles, but they want to do it here. Right here where we live and play. Right here, the place we love. The good ole' USA.

Mr. Senator, we stand ready, able, and with unlimited, time-tested talent.

Let's build chips here, as well as, all the current technology and future technology. Let's do it here. Let's do it in our house!

Thank you again, Senator Peters, for this most honorable opportunity.

Senator PETERS. Well, thank you, Mr. Dawes. The photographs that you referenced in your opening statement, they will be without objection entered into the record as well.

[The information referred to follows:]

GET CONNECTED

ELECTRIC VEHICLE QUARTERLY REPORT

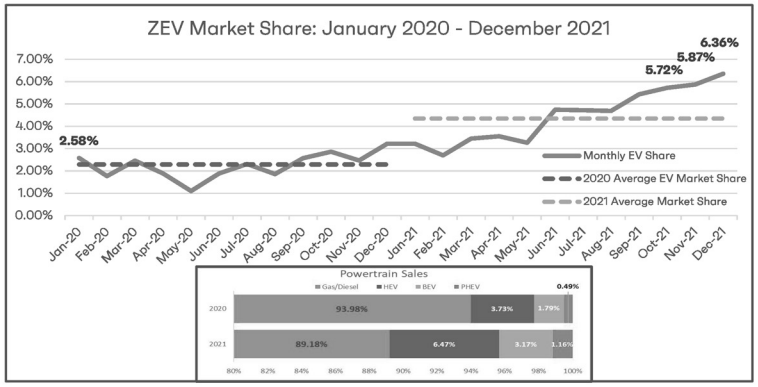
ALLIANCE FOR AUTOMOTIVE INNOVATION

FOURTH QUARTER, 2021

Contents

Electric Vehicle Sales Overview (2021)

More than 187,490 electric vehicles (EVs, including battery, plug-in hybrid, and fuel cell electric vehicles; BEV, PHEV, and FCEV, respectively) were sold in the fourth quarter in the United States. While the total volume of all sales for the quarter decreased 9 percent from the third quarter, the volume of EV sales increased 11 percent. Year-over-year (YoY), the fourth quarter had 76,000 more EV unit sales than the same period in 2020 (+69 percent, YoY). For the months of October–December, EVs represented 6 percent of overall light-duty vehicle sales, the highest for any quarter to date and a 1.1 percentage point (pp) increase over the third quarter[1]. For the full year, EV sales averaged 4.4 percent.[2] For comparison, internal combustion engine (ICE) vehicle sales decreased by 1.3 pp during the fourth quarter compared to the third quarter and nearly 6 percent compared against the same quarter a year ago[3]. For the full year, ICE sales decreased 4.8 percent from 2020.



[1] *See*, the "Get Connected: Electric Vehicle Report" for the third quarter.
[2] For the full year 2020, EVs comprised just two percent, or roughly 320,000 of the nation's 14.5 million new light-duty vehicle sales.
[3] Hybrid vehicles comprised the remainder of the gains in vehicle share.

ELECTRIC VEHICLE ADOPTION BY SEGMENT

While passenger cars once dominated the EV market, new models are being introduced, especially in the crossover utility vehicle (CUV) segment. As a result, other segments are starting to make gains, and today, light truck – CUVs, SUVs, minivans, and pickups – sales comprise nearly 58 percent of the EV market.

Monthly sales of BEV and PHEV CUVs have grown from less than 16 percent of EVs at the start of 2020 to an average of 49 percent in the fourth quarter of 2021 (averaging 51 percent of EV sales for the full year).

Plug-in hybrid SUVs entered the market in 2019 and account for a relatively small share of all EV sales (4.4%).

The very first commercially available battery electric pickup trucks arrived in September 2021 – with more models and deliveries expected soon.

EV MODEL AVAILABILITY

78 Vehicle Models Sold in Q4 2021:

32 Battery Electric Vehicles
- 17 Cars
- 14 CUVs
- 1 Pickup
- 1 Van

43 Plug-in Hybrid Vehicles
- 20 Cars
- 17 CUVs
- 4 SUVs
- 1 Van

3 Fuel Cell Electric Vehicles
- 2 Cars
- 1 CUV

See more information about ***EV CHOICE HERE***

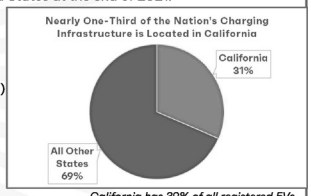
U.S. PUBLIC CHARGING INFRASTRUCTURE

While the U.S. Department of Energy notes that roughly 80 percent of all electric vehicle charging occurs at home, reliable and convenient access to workplace and public charging and refueling stations support customers that adopt EVs. Workplace and public charging infrastructure not only eases perceived "range anxiety" concerns but also increases consumer awareness of the technology. The bipartisan Infrastructure Investment and Jobs Act that was signed into law in November 2021, includes $5 billion in funding for states to establish a nationwide EV charging network and $2.5 billion in competitive grants to deploy publicly available EV charging, hydrogen fueling, propane fueling, and natural gas fueling stations through 2026. Here is a snapshot of publicly available EV charging and refueling infrastructure available across the United States at the end of 2021:

Level 2: 39,678 Locations, 88,416 EVSE Ports (+14% since 1/1/21)
DC Fast: 5,689 Locations, 21,742 EVSE Ports (+24% since 1/1/21)
Hydrogen Refueling: 48 Stations (47 of 48 are in California)
U.S. Total: *44,500 Locations, 110,158 EVSE Ports* (+16% since 1/1/21)

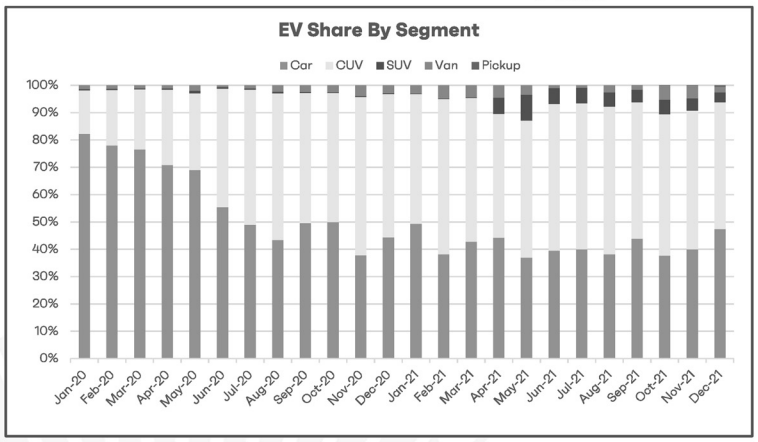
See more about state-by-state charging infrastructure on page 7

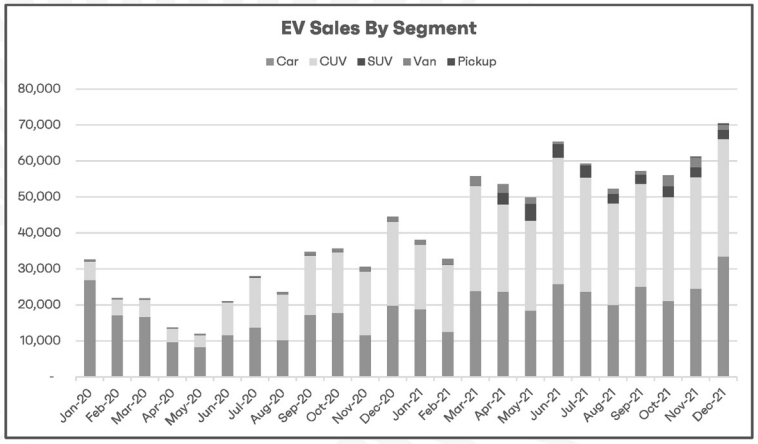
See Recommended Attributes for EV Charging Stations



California has 39% of all registered EVs

Charging information from U.S. Department of Energy Alternative Fuels Data Center, as captured on 1/1/2021 and 12/31/2021





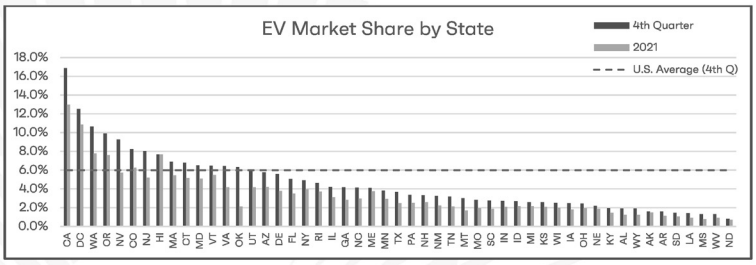
Source: Figures compiled by Alliance for Automotive Innovation with new registrations for retail and fleet data provided by IHS Markit covering January 1, 2020 – December 31, 2021.

ELECTRIC VEHICLE ADOPTION BY STATE

For the Fourth Quarter:

California continues to lead the nation in EV adoption, with BEVs, PHEVs and FCEVs making up nearly 17 percent of new light-duty vehicle registrations in the fourth quarter of 2021. There are currently 16 additional states[4] and the District of Columbia with new vehicle EV registrations above 5 percent, 5 more states than in the third quarter (new states include Arizona, Delaware, Florida, Oklahoma, and Virginia). Nationally, EV new vehicle registrations in October 2021 – December 2021 were 6 percent, a 1.07 pp increase from the third quarter of 2021.

The market share of new EV vehicles registered increased in all states, year-over-year, in the fourth quarter of 2021. Twenty-five states witnessed increased market share of EVs by 2 pp or more. Making the largest increases were California (7.6 pp), Oklahoma (6.1 pp), the District of Columbia (5.4 pp), Nevada (5.1 pp), and Washington (4.3 pp). The national average for EV sales in the fourth quarter increased by 3.1 pp YoY (from 2.9 percent to 6.0 percent EV sales).



For the Full Year:

For 2021, EV sales represented 4.4 percent of the market – a 2.1 pp increase over 2020. Nearly 13 percent of sales in California were EV, which made the largest gains of just over 5 pp YoY, but close behind with the next largest increase in market share was the District of Columbia, which improved its YoY standing by 4.9 pp. Following D.C., the states with the largest market share gains were Nevada (2.9 pp), Oregon (2.8 pp), and Connecticut (2.8). Fourteen states in total increased their year-over-year EV market share by 2 pp or more.

Some states continue to have strong EV sales, like California (13 percent), D.C. (10.9 percent), Washington (7.7 percent), Hawaii (7.7 percent), Oregon (7.6 percent) and Colorado (6.2 percent). However, 17 states had new EV registrations of less than 2 percent. All states had an EV market share of new vehicle sales above 0.5 percent.

SEE ADDITIONAL HISTORIC DATA ON EV SALES HERE

[4] States with more than a 5 percent market share of EVs: California, Washington, Oregon, Nevada, Colorado, New Jersey, Hawaii, Massachusetts, Connecticut, Maryland, Vermont, Virginia, Oklahoma, Utah, Arizona, Delaware, Florida and the District of Columbia.

GET CONNECTED
ELECTRIC VEHICLE QUARTERLY REPORT

ALLIANCE FOR AUTOMOTIVE INNOVATION

Fourth Quarter 2021, New Light-Duty Vehicle Registrations By Powertrain					Change In Market Share (2021 Q4 vs 2020 Q4), New Light-Duty Vehicle Registrations Powertrain			
State	Advanced Powertrain Market Share				Advanced Powertrain Market Share (Percentage Point Change)			
	PHEV	BEV	FCEV	ZEV	PHEV	BEV	FCEV	ZEV
AK	0.52%	1.05%	0.00%	**1.57%**	0.23	0.21	0.00	**0.43**
AL	0.69%	1.21%	0.00%	**1.90%**	0.54	0.66	0.00	**1.20**
AR	0.48%	1.08%	0.00%	**1.56%**	0.30	0.72	0.00	**1.02**
AZ	1.08%	4.66%	0.00%	**5.74%**	0.63	1.48	0.00	**2.11**
CA*	3.03%	13.66%	0.17%	**16.86%**	0.69	6.84	0.10	**7.63**
CO*	2.17%	6.04%	0.00%	**8.21%**	1.15	1.92	0.00	**3.07**
CT*	2.18%	4.61%	0.00%	**6.79%**	1.36	2.28	0.00	**3.64**
DC	4.21%	8.30%	0.00%	**12.51%**	1.58	3.77	0.00	**5.35**
DE	1.55%	4.01%	0.00%	**5.56%**	0.88	2.56	0.00	**3.44**
FL	0.70%	4.35%	0.00%	**5.06%**	0.39	2.45	0.00	**2.84**
GA	0.88%	3.27%	0.00%	**4.16%**	0.59	2.01	0.00	**2.59**
HI	1.54%	6.10%	0.01%	**7.65%**	0.22	0.40	0.01	**0.63**
IA	0.79%	1.67%	0.00%	**2.46%**	0.52	1.07	0.00	**1.59**
ID	0.94%	1.73%	0.00%	**2.67%**	0.59	0.51	0.00	**1.10**
IL	1.05%	3.13%	0.00%	**4.18%**	0.62	1.52	0.00	**2.15**
IN	0.95%	1.77%	0.00%	**2.73%**	0.62	0.85	0.00	**1.47**
KS	1.01%	1.54%	0.00%	**2.55%**	0.76	0.55	0.00	**1.32**
KY	0.54%	1.38%	0.00%	**1.91%**	0.33	0.60	0.00	**0.93**
LA	0.62%	0.79%	0.00%	**1.41%**	0.51	0.46	0.00	**0.97**
MA*	2.32%	4.57%	0.00%	**6.90%**	1.21	2.09	0.00	**3.30**
MD*	2.02%	4.45%	0.00%	**6.48%**	1.11	2.27	0.00	**3.38**
ME*	2.26%	1.84%	0.00%	**4.10%**	1.20	0.71	0.00	**1.92**
MI	0.99%	1.59%	0.00%	**2.58%**	0.77	0.84	0.00	**1.60**
MN*	1.01%	2.78%	0.00%	**3.79%**	0.52	1.05	0.00	**1.56**
MO	1.14%	1.67%	0.00%	**2.81%**	0.91	0.93	0.00	**1.84**
MS	0.57%	0.71%	0.00%	**1.29%**	0.47	0.39	0.00	**0.86**
MT	0.76%	2.22%	0.00%	**2.99%**	0.51	1.49	0.00	**2.01**
NC	0.98%	3.13%	0.00%	**4.11%**	0.62	1.85	0.00	**2.46**
ND	0.36%	0.44%	0.00%	**0.80%**	0.18	0.31	0.00	**0.49**
NE	0.90%	1.27%	0.00%	**2.17%**	0.58	0.53	0.00	**1.11**
NH	1.32%	1.98%	0.00%	**3.31%**	0.79	0.93	0.00	**1.72**
NJ*	1.49%	6.53%	0.00%	**8.01%**	0.98	2.84	0.00	**3.82**
NM	0.77%	2.48%	0.00%	**3.25%**	0.36	1.56	0.00	**1.93**
NV*	1.29%	7.95%	0.00%	**9.25%**	0.72	4.42	0.00	**5.14**
NY*	1.74%	3.15%	0.00%	**4.90%**	0.94	1.33	0.00	**2.27**
OH	0.72%	1.70%	0.00%	**2.41%**	0.48	0.76	0.00	**1.23**
OK	4.89%	1.43%	0.00%	**6.32%**	4.83	1.30	0.00	**6.13**
OR*	3.36%	6.53%	0.00%	**9.89%**	1.87	1.93	0.00	**3.80**
PA	0.96%	2.37%	0.00%	**3.33%**	0.50	0.99	0.00	**1.48**
RI*	1.96%	2.65%	0.00%	**4.61%**	1.33	1.36	0.00	**2.69**
SC	0.75%	2.00%	0.00%	**2.75%**	0.48	1.22	0.00	**1.70**
SD	0.67%	0.77%	0.00%	**1.44%**	0.48	0.46	0.00	**0.94**
TN	0.76%	2.41%	0.00%	**3.17%**	0.54	1.22	0.00	**1.76**
TX	0.68%	2.98%	0.00%	**3.66%**	0.47	1.74	0.00	**2.21**
UT	1.15%	4.79%	0.00%	**5.94%**	0.65	2.40	0.00	**3.04**
VA	1.26%	5.16%	0.00%	**6.42%**	0.64	3.03	0.00	**3.67**
VT*	2.80%	3.66%	0.00%	**6.47%**	1.53	1.61	0.00	**3.14**
WA*	1.55%	9.08%	0.00%	**10.63%**	0.55	3.76	0.00	**4.31**
WI	0.82%	1.68%	0.00%	**2.50%**	0.49	0.91	0.00	**1.40**
WV	0.51%	0.77%	0.00%	**1.28%**	0.17	0.41	0.00	**0.58**
WY	0.98%	0.90%	0.00%	**1.89%**	0.75	0.28	0.00	**1.03**
U.S.	**1.43%**	**4.55%**	**0.02%**	**6.00%**	**0.78**	**2.34**	**0.01**	**3.13**

*Denotes states that have adopted California's ZEV program.

Source: Figures compiled by Alliance for Automotive Innovation with new registrations for retail and fleet data provided by IHS Markit covering October 1, 2020 – December 31, 2020, and October 1, 2021 – December 31, 2021.

GET CONNECTED
ELECTRIC VEHICLE QUARTERLY REPORT

ALLIANCE FOR AUTOMOTIVE INNOVATION

	Full Year 2021, New Light-Duty Vehicle Registrations By Powertrain				Change In Market Share (2021 vs 2020), New Light-Duty Vehicle Registrations Powertrain			
State	Advanced Powertrain Market Share				Advanced Powertrain Market Share (Percentage Point Change)			
	PHEV	BEV	FCEV	ZEV	PHEV	BEV	FCEV	ZEV
AK	0.45%	1.03%	0.00%	**1.49%**	0.33	0.44	0.00	**0.77**
AL	0.41%	0.82%	0.00%	**1.23%**	0.31	0.40	0.00	**0.70**
AR	0.37%	0.74%	0.00%	**1.11%**	0.28	0.46	0.00	**0.74**
AZ	0.82%	3.39%	0.00%	**4.20%**	0.49	1.49	0.00	**1.98**
CA*	3.09%	9.68%	0.19%	**12.96%**	1.29	3.61	0.13	**5.02**
CO*	1.67%	4.57%	0.00%	**6.24%**	0.92	1.55	0.00	**2.47**
CT*	1.96%	3.19%	0.00%	**5.15%**	1.30	1.49	0.00	**2.79**
DC	3.91%	6.94%	0.00%	**10.84%**	1.78	3.12	0.00	**4.89**
DE	1.08%	2.68%	0.00%	**3.75%**	0.60	1.34	0.00	**1.93**
FL	0.59%	2.90%	0.00%	**3.48%**	0.39	1.35	0.00	**1.72**
GA	0.60%	2.20%	0.00%	**2.80%**	0.40	1.13	0.00	**1.52**
HI	1.44%	6.22%	0.01%	**7.66%**	0.60	1.96	0.00	**2.56**
IA	0.66%	1.12%	0.00%	**1.78%**	0.50	0.66	0.00	**1.16**
ID	0.72%	1.43%	0.00%	**2.15%**	0.47	0.62	0.00	**1.09**
IL	0.84%	2.26%	0.00%	**3.10%**	0.57	0.91	0.00	**1.49**
IN	0.69%	1.40%	0.00%	**2.09%**	0.50	0.65	0.00	**1.14**
KS	0.67%	1.40%	0.00%	**2.07%**	0.45	0.56	0.00	**1.01**
KY	0.44%	1.00%	0.00%	**1.44%**	0.30	0.46	0.00	**0.76**
LA	0.33%	0.57%	0.00%	**0.89%**	0.27	0.30	0.00	**0.56**
MA*	2.13%	3.32%	0.00%	**5.45%**	1.23	1.26	0.00	**2.49**
MD*	1.65%	3.41%	0.00%	**5.06%**	1.01	1.42	0.00	**2.43**
ME*	2.11%	1.63%	0.00%	**3.74%**	1.22	0.79	0.00	**2.01**
MI	0.82%	1.31%	0.00%	**2.13%**	0.69	0.69	0.00	**1.38**
MN*	0.80%	2.13%	0.00%	**2.93%**	0.46	0.92	0.00	**1.38**
MO	0.64%	1.30%	0.00%	**1.94%**	0.44	0.62	0.00	**1.07**
MS	0.30%	0.47%	0.00%	**0.76%**	0.24	0.24	0.00	**0.47**
MT	0.56%	1.14%	0.00%	**1.69%**	0.36	0.57	0.00	**0.93**
NC	0.77%	2.18%	0.00%	**2.95%**	0.54	1.08	0.00	**1.61**
ND	0.29%	0.38%	0.00%	**0.68%**	0.20	0.25	0.00	**0.45**
NE	0.76%	1.09%	0.00%	**1.85%**	0.58	0.50	0.00	**1.08**
NH	1.10%	1.47%	0.00%	**2.57%**	0.72	0.63	0.00	**1.34**
NJ*	1.23%	3.96%	0.00%	**5.19%**	0.76	1.55	0.00	**2.31**
NM	0.66%	1.56%	0.00%	**2.22%**	0.38	0.83	0.00	**1.20**
NV*	1.02%	4.68%	0.00%	**5.70%**	0.65	2.21	0.00	**2.86**
NY*	1.59%	2.34%	0.00%	**3.93%**	0.84	1.00	0.00	**1.83**
OH	0.57%	1.34%	0.00%	**1.91%**	0.42	0.53	0.00	**0.95**
OK	1.20%	0.89%	0.00%	**2.10%**	1.17	0.76	0.00	**1.93**
OR*	2.62%	4.96%	0.00%	**7.58%**	1.44	1.39	0.00	**2.83**
PA	0.79%	1.69%	0.00%	**2.48%**	0.46	0.66	0.00	**1.12**
RI*	1.62%	2.07%	0.00%	**3.69%**	0.86	0.95	0.00	**1.81**
SC	0.57%	1.32%	0.00%	**1.87%**	0.41	0.71	0.00	**1.11**
SD	0.46%	0.58%	0.00%	**1.04%**	0.32	0.35	0.00	**0.67**
TN	0.51%	1.59%	0.00%	**2.10%**	0.37	0.76	0.00	**1.13**
TX	0.49%	1.99%	0.00%	**2.48%**	0.34	1.05	0.00	**1.39**
UT	0.90%	3.25%	0.00%	**4.16%**	0.52	1.33	0.00	**1.85**
VA	1.05%	3.12%	0.00%	**4.16%**	0.65	1.55	0.00	**2.20**
VT*	2.50%	2.99%	0.00%	**5.48%**	1.40	1.27	0.00	**2.67**
WA*	1.36%	6.41%	0.00%	**7.76%**	0.62	2.09	0.00	**2.71**
WI	0.60%	1.36%	0.00%	**1.96%**	0.39	0.67	0.00	**1.06**
WV	0.38%	0.54%	0.00%	**0.92%**	0.23	0.27	0.00	**0.50**
WY	0.58%	0.63%	0.00%	**1.21%**	0.47	0.21	0.00	**0.68**
U.S.	**1.16%**	**3.17%**	**0.02%**	**4.35%**	**0.68**	**1.38**	**0.02**	**2.06**

*Denotes states that have adopted California's ZEV program.
Source: Figures compiled by Alliance for Automotive Innovation with new registrations for retail and fleet data provided by IHS Markit covering January 1, 2020 – December 31, 2020 and January 1, 2021 – December 31, 2021.

REGISTRATIONS AND INFRASTRUCTURE

Public Charging Outlets And Registerd EVs (as of 12/31/2021)

	EV Level 2	EV DC Fast	H2** Fueling	Total	Percent EVs of Total VIO***	Share of Registered EVs****	EVs Per Charger	Additional Chargers Needed to Support 25% EV VIO*****	EVs Per 10K Residents
AK	72	16	-	88	0.31%	0.08%	20.24	20,569	24.15
AL	364	114	-	478	0.15%	0.35%	16.29	180,164	15.94
AR	371	66	-	437	0.14%	0.17%	8.72	99,290	12.65
AZ	1,664	420	-	2,084	0.83%	2.58%	27.13	241,010	78.85
CA*	27,847	6,666	47	34,560	2.73%	39.18%	24.89	1,090,261	217.47
CO*	2,760	584	-	3,344	0.94%	2.29%	15.07	187,582	88.47
CT*	889	310	-	1,199	0.73%	0.99%	18.21	105,608	61.13
DC	606	39	-	645	1.77%	0.28%	9.43	11,637	86.60
DE	200	90	-	290	0.56%	0.23%	17.44	32,114	52.29
FL	4,544	1,220	-	5,764	0.70%	5.79%	22.05	646,159	59.68
GA	2,845	575	-	3,420	0.49%	2.09%	13.40	329,427	43.57
HI	658	78	1	737	1.56%	0.84%	25.03	41,488	129.87
IA	359	159	-	518	0.22%	0.32%	13.63	112,503	22.37
ID	177	79	-	256	0.31%	0.28%	24.05	69,592	35.10
IL	1,752	506	-	2,258	0.52%	2.41%	23.48	360,936	41.62
IN	572	275	-	847	0.28%	0.79%	20.41	217,486	25.83
KS	815	104	-	919	0.27%	0.35%	8.47	102,257	26.73
KY	386	103	-	489	0.18%	0.33%	14.84	146,046	16.24
LA	249	81	-	330	0.14%	0.23%	15.58	135,647	11.03
MA*	3,968	431	-	4,399	0.95%	2.36%	11.78	190,669	75.11
MD*	2,334	564	-	2,898	0.85%	1.97%	14.89	178,550	71.43
ME*	471	137	-	608	0.54%	0.33%	11.85	46,806	53.85
MI	1,232	398	-	1,630	0.38%	1.48%	19.88	301,569	32.42
MN*	953	234	-	1,187	0.44%	1.05%	19.47	186,471	41.19
MO	1,841	232	-	2,073	0.30%	0.76%	8.09	198,855	27.37
MS	210	72	-	282	0.08%	0.11%	8.67	106,375	8.19
MT	100	102	-	202	0.18%	0.12%	13.48	52,570	25.63
NC	1,808	497	-	2,305	0.42%	1.79%	17.08	336,172	37.92
ND	77	57	-	134	0.10%	0.04%	5.92	28,228	10.43
NE	258	80	-	338	0.22%	0.21%	13.84	74,358	24.24
NH	220	108	-	328	0.54%	0.33%	22.24	47,611	53.79
NJ*	1,030	553	-	1,583	0.88%	2.87%	39.79	253,690	70.71
NM	278	123	-	401	0.34%	0.31%	16.97	70,043	32.47
NV*	919	335	-	1,254	0.97%	1.09%	19.08	87,202	78.83
NY*	5,790	837	-	6,627	0.83%	4.37%	14.49	407,453	49.15
OH	1,608	354	-	1,962	0.32%	1.58%	17.71	383,563	29.73
OK	334	658	-	992	0.31%	0.62%	13.78	156,694	34.68
OR*	1,578	436	-	2,014	1.24%	2.13%	23.21	132,104	111.56
PA	1,937	494	-	2,431	0.41%	2.06%	18.65	395,541	35.39
RI*	472	37	-	509	0.55%	0.21%	9.12	29,602	43.92
SC	598	175	-	773	0.23%	0.54%	15.29	185,691	23.24
SD	88	67	-	155	0.14%	0.06%	8.98	35,206	15.78
TN	1,124	230	-	1,354	0.29%	0.87%	14.18	235,153	28.35
TX	3,995	936	-	4,931	0.45%	4.83%	21.53	842,752	36.99
UT	1,613	239	-	1,852	0.80%	1.05%	12.48	101,309	73.10
VA	1,900	732	-	2,632	0.58%	1.98%	16.49	266,762	50.95
VT*	688	74	-	762	1.16%	0.29%	8.42	19,221	102.46
WA*	2,954	715	-	3,669	1.27%	4.07%	24.33	248,277	118.48
WI	607	196	-	803	0.31%	0.75%	20.57	190,144	28.41
WV	197	77	-	274	0.13%	0.09%	7.42	55,343	11.26
WY	92	75	-	167	0.14%	0.04%	5.53	23,177	15.99
U.S.	**88,404**	**21,740**	**49**	**110,193**	**0.78%**	**100.00%**	**19.93**	**9,996,838.07**	**67.11**

*Denotes states that have adopted California's ZEV program; **Hydrogen count denotes stations;
*** VIO is vehicles in operation; **** State share of U.S. Total;
*****Calculated at 1:7 ratio at 25 percent of the existing state fleet. Ratio derived from CEC AB 2127 Report of July 14, 2021
Source: Figures compiled by Alliance for Automotive Innovation with registered vehicle data provided by IHS Markit as of December 31, 2021; Charging information from U.S. Department of Energy Alternative Fuels Data Center, as of 12/31/2021.

REGISTRATIONS

EV registrations as a share of all registered light-duty vehicles are 0.8 percent (as of December 31, 2021.) There are nearly 283 million registered light vehicles in the U.S.

In 2021, California accounted for nearly 40 percent of all registered light-duty EVs in the U.S.

States with highest portion of total EVs registered in the U.S.:

1. CA* (860,256, 39%)
2. FL (127,123, 5.8%)
3. TX (106,157, 4.8%)
4. NY* (96,055, 4.4%)
5. WA* (89,281, 4.1%)
6. NJ* (62,994, 2.9%)
7. AZ (56,548, 2.6%)
8. IL (53,024, 2.4%)
9. MA* (51,840, 2.4%)
10. CO* (50,387, 2.3%)

States with highest share of registered EVs per 10,000 residents:

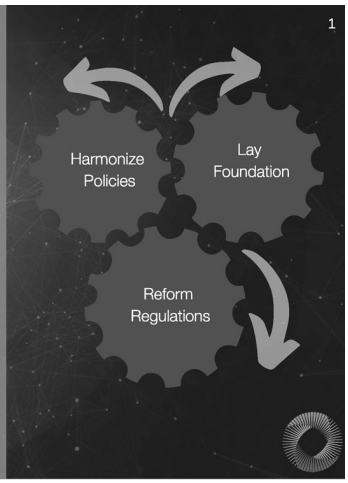
1. CA*
2. HI
3. WA*
4. OR*
5. VT*
6. CO*
7. DC
8. AZ
9. NV
10. MA*

Read more about automakers plans for an ***ELECTRIC FUTURE HERE***

We are at a pivotal time on the pathway to a cleaner, safer, and smarter transportation future. There is no doubt that Level 3-5 automated vehicles (AVs) are an important component of this future.

Focused and sustained leadership from policymakers is required to ensure this technology and the benefits it can deliver are realized. To that end, the Alliance for Automotive Innovation puts forward this FOUR-YEAR ACTION PLAN for federal policymakers to significantly advance the testing and deployment of AV technologies in the United States.

The 14 specific recommendations contained within this plan fall within the following pillars: (1) Reform Regulations to Allow for AV Deployment at Scale; (2) Harmonize Federal, State, and International Policies; and (3) Lay the Foundation to Achieve Longer-Term Objectives.



2

PILLAR 1
REFORM REGULATIONS TO ALLOW FOR AV DEPLOYMENT AT SCALE

3

RECOMMENDATION 1
CREATE A NEW VEHICLE CLASS FOR AVs

The U.S. Department of Transportation (DOT) should create a new vehicle class within the Federal Motor Vehicle Safety Standards for AVs. Since the current regulations were not written with AVs in mind, a number of existing standards assume the presence of a human driver and therefore present a barrier to the deployment of AVs without conventional driver controls. An AV class would enable the DOT to efficiently identify and categorize existing motor vehicle safety standards that should apply to AVs without impacting the applicability of those standards for conventionally driven vehicles. Although this approach would allow for AVs to be incorporated into the existing regulatory framework sooner, if a new vehicle class is not established, DOT should complete its efforts to update existing motor vehicle safety standards as expeditiously as possible.

RECOMMENDATION 2
CLARIFY APPLICABILITY OF "MAKE INOPERATIVE" PROHIBITION

Existing DOT regulations prohibit manufacturers from knowingly making inoperative any feature or system installed on or in a motor vehicle in compliance with an applicable motor vehicle safety standard. This prohibition could have unintended implications for "dual mode" vehicles that are equipped with selectable AV features that temporarily deactivate conventional driver controls while the vehicle is operating safely in "autonomous mode." To address this, DOT should confirm that the deactivation of conventional driver controls in "dual mode" vehicles, when the vehicle is in AV mode, does not fall under the "make inoperative" prohibition if the vehicle is compliant with all applicable motor vehicle safety standards while in manual driving mode.

RECOMMENDATION 3
ESTABLISH A NATIONAL AV PILOT PROGRAM

DOT should establish a robust national pilot program for AV testing and deployment. Such a program would not only provide a venue to advance DOT research objectives relating to AVs, but also provide AV developers that choose to participate with an alternative pathway to AV testing and deployment. A focused pilot program carried out under DOT's oversight could increase public exposure to the technology and provide the DOT with the data that it will need to create new safety regulations for AVs.

RECOMMENDATION 4
IMPROVE THE EXEMPTION PETITION PROCESS

Current law authorizes DOT to grant manufacturers exemptions from existing safety standards provided that vehicle safety is upheld. As the safety standards are being updated in line with RECOMMENDATION 1, DOT should simplify and streamline the existing exemption process for AVs to provide greater clarity to manufacturers. As part of this effort, DOT should issue guidance that specifies what data is required as part of the exemption application.

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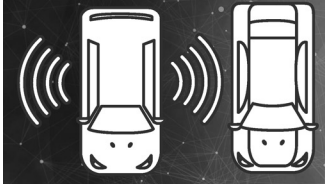

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RECOMMENDATION 5
RAISE THE CAP ON EXEMPTIONS FOR AVs

To provide for meaningful AV deployments, the U.S. Congress should enact legislation to increase the existing cap on temporary exemptions that can be granted to AVs. Under existing law, exemptions are limited to 2,500 vehicles per manufacturer annually and valid for a two-year duration. Increasing this limit will promote continued development of this technology in the United States by providing certainty to AV developers that there is a near-term path to deploy AV technologies. Raising the cap will also lead to the generation of more real-world data to support any efforts by DOT to enact new AV-specific regulations.

RECOMMENDATION 6
EMBRACE INNOVATIVE REGULATORY APPROACHES

DOT should embrace innovative regulatory approaches that are appropriately matched to the current pace of technological advancement. As part of the federal motor vehicle safety regulatory compliance and the exemption petition process, DOT should permit manufacturers to submit vehicle-specific technical design and/or build documentation. This "technical documentation" approach would accommodate unique design solutions and would empower manufacturers to use innovative safety assurance techniques, such as virtual testing with validated simulators. In addition, DOT should allow for the use of a surrogate vehicle (i.e., a vehicle that shares the same platform as the AV but has conventional driver controls) to perform certain regulatory compliance tests.

6

PILLAR 2
HARMONIZE FEDERAL, STATE, AND INTERNATIONAL POLICIES

RECOMMENDATION 7
MAINTAIN TRADITIONAL FEDERAL AND STATE ROLES

The U.S. Congress should enact legislation to clarify federal and state roles related to AVs. The federal government should maintain responsibility for the design, construction, and performance of motor vehicles, while states should continue to oversee licensing of human drivers, registration, insurance, and traffic laws.

RECOMMENDATION 8
COORDINATE STATE AV POLICIES

The current patchwork of AV laws and regulations at the state level presents challenges for manufacturers seeking to test and deploy AVs in multiple states. AV testing and deployment across state lines could be significantly improved if states coordinated with each other and sought to ensure consistency of AV laws and regulations. A federal grant program could be established to provide funding to states that agree to work together to harmonize policies that govern the testing and deployment of AVs. In addition, a unified approach to AV licensing and registration should be encouraged.

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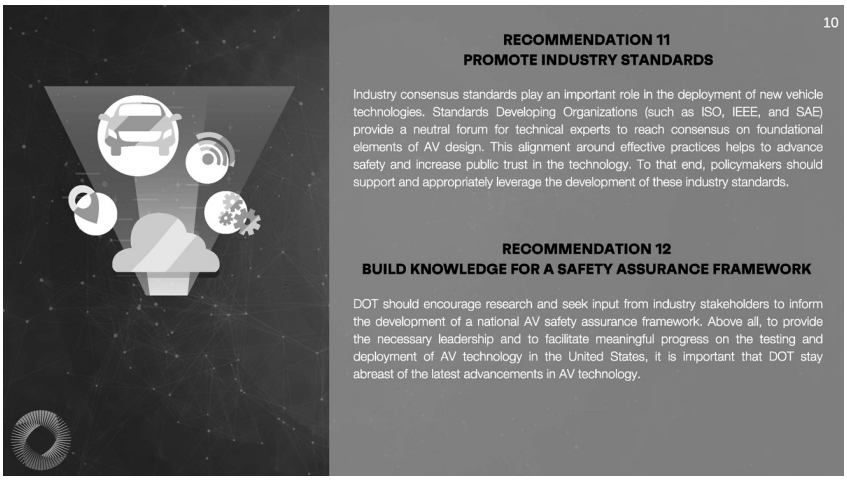
8
RECOMMENDATION 9
ALIGN STATE TRAFFIC LAWS
Variation in state traffic laws creates additional challenges for AV developers. AV developers must translate each state's traffic laws into the system's programming and capture even the slightest differences, and then continuously monitor state laws for any updates or changes. To the extent possible, states should be encouraged to harmonize traffic laws and regulations, particularly those that apply to the operation of AVs on public roads. Uniformity of state traffic laws and regulations would provide benefits not only to AV developers, but also to any road user who crosses state lines. At a minimum, a single resource of state traffic laws and real-time updates to those laws that is accessible to AV developers should be created. In addition, states should review their existing laws and identify any provisions that would prevent the deployment of AVs.
RECOMMENDATION 10
LEAD IN INTERNATIONAL FORUMS
Many AV companies, including those developing this technology in the United States, may deploy in global markets. For this reason, international alignment on AV testing and deployment regulations is helpful. DOT should actively participate in international forums, like the United Nations Economic Commission for Europe, where AV policy is being developed. DOT should also strive to implement a national AV policy framework that is reasonably aligned with international rules within the bounds of the U.S. self-certification regulatory regime.


9
PILLAR 3
LAY THE FOUNDATION TO ACHIEVE LONGER TERM GOALS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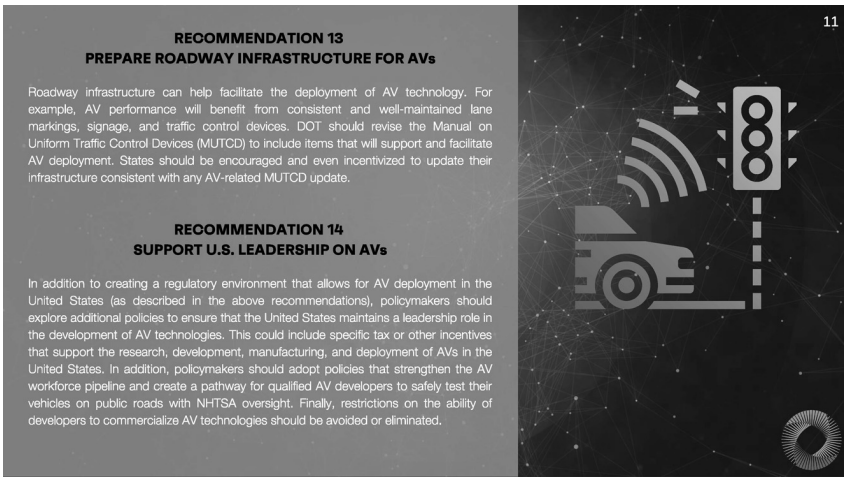
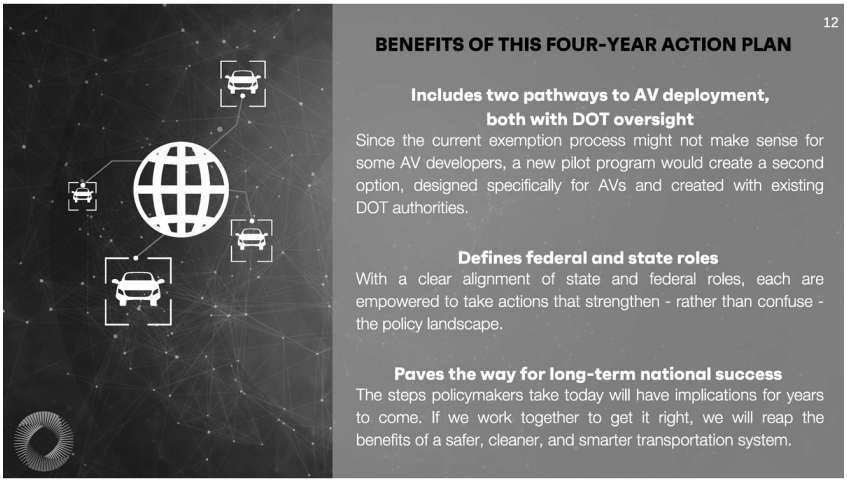
RECOMMENDATION 11
PROMOTE INDUSTRY STANDARDS
Industry consensus standards play an important role in the deployment of new vehicle technologies. Standards Developing Organizations (such as ISO, IEEE, and SAE) provide a neutral forum for technical experts to reach consensus on foundational elements of AV design. This alignment around effective practices helps to advance safety and increase public trust in the technology. To that end, policymakers should support and appropriately leverage the development of these industry standards.
RECOMMENDATION 12
BUILD KNOWLEDGE FOR A SAFETY ASSURANCE FRAMEWORK
DOT should encourage research and seek input from industry stakeholders to inform the development of a national AV safety assurance framework. Above all, to provide the necessary leadership and to facilitate meaningful progress on the testing and deployment of AV technology in the United States, it is important that DOT stay abreast of the latest advancements in AV technology.


RECOMMENDATION 13
PREPARE ROADWAY INFRASTRUCTURE FOR AVs
Roadway infrastructure can help facilitate the deployment of AV technology. For example, AV performance will benefit from consistent and well-maintained lane markings, signage, and traffic control devices. DOT should revise the Manual on Uniform Traffic Control Devices (MUTCD) to include items that will support and facilitate AV deployment. States should be encouraged and even incentivized to update their infrastructure consistent with any AV-related MUTCD update.
RECOMMENDATION 14
SUPPORT U.S. LEADERSHIP ON AVs
In addition to creating a regulatory environment that allows for AV deployment in the United States (as described in the above recommendations), policymakers should explore additional policies to ensure that the United States maintains a leadership role in the development of AV technologies. This could include specific tax or other incentives that support the research, development, manufacturing, and deployment of AVs in the United States. In addition, policymakers should adopt policies that strengthen the AV workforce pipeline and create a pathway for qualified AV developers to safely test their vehicles on public roads with NHTSA oversight. Finally, restrictions on the ability of developers to commercialize AV technologies should be avoided or eliminated.
11



Senator PETERS. Our next witness today is Mr. Garrick Francis, Vice President of Federal Affairs at the Alliance for Automotive Innovation, also known as Auto Innovators. Mr. Francis joined the Auto Innovators in January 2021.

He leads the Federal affairs team that serves as a liaison for the automotive industry to both policymakers and the Congress as a whole. Mr. Francis brings over 30 years of experience working in the transportation sector and other industries.

Mr. Francis, welcome to the Subcommittee. You may proceed with your opening comments.

STATEMENT OF GARRICK C. FRANCIS, VICE PRESIDENT, FEDERAL AFFAIRS, ALLIANCE FOR AUTOMOTIVE INNOVATION

Mr. FRANCIS. Thank you, Senator. Chairman Peters, on behalf of the Alliance for Automotive Innovation and our members, I thank you for the opportunity to appear at this hearing today to share my perspective on how the auto industry in the U.S. is at the forefront of innovation and the importance of a robust and resilient supply chain that enhances U.S. competitiveness.

We appreciate continued engagement with your office regarding the ongoing challenges in the semiconductor supply chain to develop supportive policies that can help ease those constraints and develop further domestic production capacity, including fully funding the authorized program for the CHIPS for America Act as encompassed in legislation in both chambers, including the bipartisan United States Innovation Competitiveness Act, or USICA.

Maintaining and enhancing U.S. leadership in automotive innovation, however, is not just about the future of the auto industry. It is about the Nation's global competitiveness and economic security. Nations that lead the development and adoption of innovative technologies such as electrification, connectivity, and automation, as you referenced, will also shape supply chains, define global standards, and potentially reshape the international marketplace.

And Senator, you mentioned the transformation in the role that Michigan played in the auto industry. Today we are on the verge

of another transformation in the automotive industry in the United States that will fundamentally alter personal mobility. Through substantial long term investments in electrification, as well as advanced safety technologies, including automation, the industry is redefining motor vehicle transportation.

Likewise, Government policies, investments, and programs must be modernized and transformed to reflect changes in the global marketplace and gaps in its supply chain. Globally, the automotive industry annual invest more than $125 billion in research and development, $20 billion more than the software and Internet technology industry.

Roughly $24 billion of this annual investment occurs in the U.S., which supports alone 108,000 jobs, and harnesses the innovation and ingenuity of major automakers and their work force.

Despite the industry's resiliency over the past 2 years, there is no question that lingering uncertainties associated with the COVID–19 public health emergency, along with recent global conflicts and other disruptions, will continue to stress supply chains and influence consumer trends, further straining the capital resources necessary to invest in future technology development.

At a time when demand for semiconductors will continue to increase across all sectors, the auto industry represents one of the fastest and most substantial growth sectors for the semiconductor industry. As mentioned, semiconductors are used in a wide and growing variety of automotive electronic components that perform vital functions, vehicle control, safety, emissions, driver information, and others.

The transformations underway across the auto industry are driving increased demand and the number and variety of semiconductors necessary for automotive production. Expanding and securing critical supply chains while developing new ones is a key factor in whether the U.S. will remain a leader in automotive innovation.

Currently, the auto industry is facing substantial production losses stemming from capacity challenges across the semiconductor supply chain. Semiconductors, of course, are just one example of the type of investments needed to support U.S. leadership and job growth. But the challenges and opportunities before us are bigger than any one component part, policy, branch level of Government, or industry sector.

For the U.S. to remain a leader in the development and adoption of transformational automotive technologies, we need a comprehensive national vision and strategy rooted in economic, social, environmental, and cultural realities. That comprehensive strategy must address several pertinent and pressing questions, what supply chains are available and will they need to change? What are the challenges to developing the U.S. supply base for specific new technologies?

Senator, how are we preparing or repositioning the U.S. work force, including auto workers, suppliers, and related workers for these new technologies? What are the impediments to consumer adoption and affordability of advanced vehicle technologies, including electrification and automation? How do we address the challenges and barriers unique to certain communities, such as rural

and disadvantaged, and ensure advanced vehicle technologies are accessible and beneficial for all Americans?

What other industries, stakeholders, or sectors will be necessary to realize the potential of these important transformations? These are but a few challenging questions at the core of maintaining U.S. competitiveness and enhancing U.S. leadership in automotive innovation. Strategies must account for these realities, otherwise they could inadvertently harm the Nation's work force, limit consumer options, and jeopardize our Nation's future and global competitiveness.

Our goal, Senator, in working with you is to avoid such outcomes by continuing to work collaboratively with policymakers and other stakeholders to maintain the U.S. global leadership in automotive innovation.

So today, on behalf of the auto innovators and our member companies, I look forward to working with you, other Members of Congress, and the Administration to develop and implement policies such as those being discussed today, to realize the promise of cleaner, safer, smarter transportation future, while ensuring the U.S. leads automotive innovation for generations to come.

So again, I appreciate being here today.

[The prepared statement of Mr. Francis follows:]

PREPARED STATEMENT OF GARRICK C. FRANCIS, VICE PRESIDENT, FEDERAL AFFAIRS, ALLIANCE FOR AUTOMOTIVE INNOVATION

Chairman Peters, Ranking Member Fischer and distinguished members of the Committee: on behalf of the Alliance for Automotive Innovation (Auto Innovators) and our members, I thank you for the opportunity to appear at this hearing today to share my perspective on how the auto industry in the U.S. is at the forefront of innovation and the importance of a robust and resilient supply chains that enhance U.S. competitiveness in the future of mobility, as evidenced by the current challenges associated with semiconductors.

We appreciate continued engagement with your offices regarding the ongoing challenges in the semiconductor supply chain and supportive policies that can help to ease those constraints and develop future domestic production capacity, including fully funding the authorized programs from the *CHIPS for America Act* as accomplished in legislation in both chambers, including the bipartisan *United States Innovation Competitiveness Act* (USICA).

Maintaining and enhancing U.S. leadership in automotive innovation, however, is not just about the future of the auto industry—it is about the Nation's global competitiveness and economic security. *The nations that lead the development and adoption of innovative vehicle technologies, such as electrification, connectivity, and automation, will also shape supply chains, define global standards and, potentially, reshape the international marketplace.*

The Alliance for Automotive Innovation was formed in 2020 to serve as the singular, authoritative, and respected voice of the automotive industry in the United States. Our 17 manufacturer members produce nearly 98 percent of the cars and light trucks sold in the U.S., and our 21 supplier and value chain members are responsible for integral parts and technologies in these vehicles. In total, our industry employs roughly 10 million Americans, in addition to those who are employed in the technology and mobility sectors directly.[1] We account for nearly six percent of our country's gross domestic product and represent our country's largest manufacturing sector.[2]

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[1] Auto Alliance multi-industry contribution analysis: the economic impact of automotive manufacturing, selling, repairing, renting, and additional maintenance modeled using IMPLAN economic analysis data software, 2017 data year.

[2] *Id;* Bureau of Economic Analysis, Gross Output by Industry, *https://apps.bea.gov/iTable/iTable.cfm?ReqID=51&step=1,* Last accessed June 1, 2020; Bureau of Labor Statistics, Employ-

Continued

Today, we are on the verge of a transformation in the automotive industry in the United States that will fundamentally alter personal mobility. Through substantial, long-term investments in electrification,[3] as well as advanced safety technologies, including automation, the industry is redefining motor vehicle transportation. Likewise, government policies, investments and programs must be modernized and transformed to reflect changes in the global marketplace and gaps in the global supply chain.

Globally, the automotive industry annually invests more than $125 billion in R&D, $20 billion more than the software and Internet technology industry.[4] Roughly $24 billion of this annual investment occurs in the U.S., which supports 108,000 jobs and harnesses the innovation and ingenuity of major automakers and their workforce.[5] As part of this commitment to bring new cutting-edge vehicle technologies to the U.S. market, the auto industry relies on high-quality patents and the fair and reasonable licensing of standardized technologies.

While the U.S. is well positioned to continue its long-standing leadership in automotive innovation, we cannot be complacent. Across the globe, nations are backing bold commitments with government investments and supporting policies. China has already established EV battery supply chain and manufacturing dominance. Likewise, Europe is responding by developing its own supply chains. Japan has made a bold commitment to support fuel cell technology advancements.

China is moving aggressively to lead in safety technology advancements—including AVs. As evidenced by experience in other sectors—such as information and communications technologies—as well as the current EV battery supply chain, falling behind global competitors presents long-term risks to U.S. competitiveness and economic security.

The industry's commitment to a cleaner, safer, and smarter future for personal mobility. remains on display as the nation—and the world—grapple with numerous 'once in a generation' challenges at the same time. Through a worldwide pandemic and amid turmoil that is currently disrupting global supply chains, Auto Innovators' members continue innovating, building on decades of experience in precision manufacturing, supply networks, logistics, and purchasing to sustain and boost manufacturing, production and distribution in the U.S.

Senators in both parties clearly understand the reality facing the automotive industry. Despite the industry's resiliency over the past two years, there is no question that lingering uncertainties associated with the COVID–19 public health emergency, along with recent global conflicts and other disruptions will continue to influence consumer trends and stress supply chains, like what our industry is currently experiencing with semiconductors, further straining the capital resources necessary to invest in future technology development.

At a time when demand for semiconductors has and will continue to increase across all sectors, the auto industry represents one of the fastest and most substantial growth sectors for the semiconductor industry. Semiconductors are used in a wide and growing variety of automotive electronic components that perform vehicle control, safety, emissions, driver information, and other critical functions. In addition, there are many innovations underway in the automotive space that will define the future of safety and mobility—including electrification, automation, and connectivity—that are highly dependent on semiconductors. The transformations underway across the auto industry are driving increased demand in the number and variety of semiconductors necessary for automotive production.

The chips that are generally used in vehicles are not the same chips that are used in consumer electronics devices. As with many defense and industrial control users, auto manufacturing relies on a wide range of chips, including a substantial number of mainstream—also known as mature, legacy, or lagging-edge—nodes. Further, the chips used in many automotive applications must be more robust and reliable than leading edge chips that are used in consumer electronics devices because they must withstand challenging internal and external environments for the useful life of the vehicle. These dynamics are reflected in the below chart from the USITC.

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ment and Output by Industry, *https://www.bls.gov/emp/tables/industry-employment-and-output.htm,* Accessed June 1, 2020

[3] For the purposes of this document, the term electrification includes all zero emission or electric vehicles ("ZEVs" or "EVs"), including plug-in and plug-in hybrid EVs as well as fuel cell technologies.

[4] Strategy&, "The Global Innovation 1000 Study," Data Download 11/2/2020 *https://www.strategyand.pwc.com/gx/en/insights/innovation1000.html?utm_campaign=sbpwc&utm_medium=site&utm_source=articletext*

Figure 1. Different Requirements of Consumer and Automotive Semiconductor End Use Markets

Semiconductor Feature	Consumer Electronics	Automobile Electronics
Process Technology	28 → 7 nanometers	180 → 7 nanometers
Temperature Range	32 – 100 Degrees Fahrenheit	-40 – 300 Degrees Fahrenheit
Operating Lifetime	3 – 5 Years	15 Years
Tolerated Failure Rate	<1,000 parts per million	Zero parts per billion
Long Term Supply Needed?	No	Yes, up to 30 years' worth

Expanding and securing existing supply chains, while developing new ones, is a key factor in whether the U.S. will remain a leader in automotive innovation. Currently, the auto industry is facing substantial production losses stemming from capacity challenges across the semiconductor supply chain. This shortage of semiconductors is an outgrowth of a confluence of factors: an unexpected and unprecedented eight-week shutdown of vehicle production across all of North America (and similar closures across the globe); a rapid increase in demand for consumer products as the global population adjusted life in response to the COVID–19 public health emergency; disruptions to semiconductor manufacturing and packaging around the world due to public health restrictions, natural disasters and a major plant fire; a resurgence in demand for personal transportation; and changes in consumer discretionary spending, among other factors. As a result of these supply chain constraints, numerous automakers have been forced to halt production and cancel shifts in the United States, with serious consequences for their workers and the communities in which they operate.

Unfortunately, production forecasts in North America continue to be adjusted downward. In February 2021, industry was predicting that production would fall by 1 percent due to the chip shortage. By May, production forecasts had fallen by 5 percent. As 2021 drew to a close, forecasts had fallen by 21 percent for the year.[6] According to industry analysts, motor vehicle production losses in North America exceeded 3 million vehicles in 2021 due to these disruptions.[7] The data also suggests that North American production is being disproportionately impacted relative to other global markets. For example, North America, which historically produces around 17 million vehicles annually, lost more than 3 million units in 2021. In contrast, China, which historically produces more than 24 million vehicles, announced production losses of 1.9 million vehicles.[8] While there is no industry consensus on how long the shortage will continue to impact production, and where, analysts estimate supply challenges are likely to persist into 2023.

These production shortfalls come at a time when sales inventory of vehicles in the U.S. is at an all-time low. In fact, in September 2021, light vehicle inventory fell below 1 million units for the first time in decades. This is a 64 percent drop in inventory from the prior year. Since then, vehicle stocks have started to make small, incremental gains, but remain 60 percent lower than a year ago and 74 percent lower than the same period in 2019. Likewise, days' supply is currently at 24, compared to 78 in February 2019.

Automakers and value chain partners are working diligently to navigate these current supply chain challenges. For example, OEMs are employing a range of strategies to manage available supplies, including shifting chip supply to meet consumer demand, reducing content in production vehicles, partially manufacturing vehicles and parking them for later completion, and other measures to manage the near-term supply constraints. At the same time, semiconductor production capacity is at all-time high, with more units shipped—across all sectors—in Q3 2021 than any quarter in history.[9] In addition, there is increased collaboration and engagement between OEMs and suppliers as companies seek to improve long-term planning within the semiconductor supply chain.

Even as automakers and suppliers work to navigate the current landscape, there is an undeniable need to expand semiconductor manufacturing capacity and regional

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[5] National Science Foundation, Info Brief, *"Businesses Reported an 11.8 percent Increase to Nearly a Half Trillion Dollars for U.S. R&D Performance During 2019,"* 11/18/21

[6] IHS Market, e-mails, "IHS Markit Monthly Automotive Update—February 2021," 2/16/2021 and "IHS Markit Monthly Automotive Update—December 2021, 12/10/21

[7] Automotive News, *The latest numbers of the microchip shortage: Have factory cuts peaked?,* December 20, 2021, available at *https://www.autonews.com/manufacturing/latest-numbers-automotive-microchip-shortage-15* (Data supplied by Autoforecast Solutions, Inc.)

[8] IHS Market, e-mails, "IHS Markit Monthly Automotive Update—February 2021," 2/16/2021 and "IHS Markit Monthly Automotive Update—December 2021, 12/10/21

diversity to support a robust and resilient semiconductor supply chain that meets the growing demands of the auto industry, as well as other sectors of the economy. This requires a significant investment in, and sustained commitment to, building additional domestic semiconductor capacity—from mature to leading-edge—that meets the future needs of the auto industry in the United States. For this reason, Auto Innovators strongly supports full and robust funding for the programs authorized under the *CHIPS for America Act* as well as enactment of a semiconductor manufacturing investment tax incentive such as the one proposed in the *FABS Act.*

Semiconductors, of course, are just one example of the type of investments needed to support U.S. leadership and job growth. But the challenges and opportunities before us are bigger than any one component part, policy, branch or level of government, or industry sector. For the U.S. to remain a leader in the development and adoption of transformational automotive technologies, we need a comprehensive national vision and strategy rooted in economic, social, environmental, and cultural realities. That comprehensive strategy must address several pertinent and pressing questions:

- What supply chains are available, and will they need to change? What are the challenges to developing the U.S. supply base for specific new technologies?
- How are we preparing or repositioning the U.S. workforce, including auto workers, suppliers and related workers for these new technologies?
- What are the impediments to consumer adoption and affordability of advanced vehicle technologies, including electrification and automation?
- How do we address the challenges and barriers unique to certain communities, such as rural and disadvantaged, and ensure advanced vehicle technologies are accessible and beneficial to all Americans?
- What other industries, sectors or stakeholders will be necessary to realize the potential of these important transformations?

These are but a few of the challenging questions at the core of maintaining U.S. competitiveness and enhancing U.S leadership in automotive innovation. Strategies must account for these realities, otherwise they could, inadvertently, harm the Nation's workforce, limit consumer options, and jeopardize our Nation's economic future and global competitiveness. Our goal is to avoid such outcomes by continuing to work collaboratively with policymakers and other stakeholders to maintain the U.S.'s global leadership in automotive innovation.

Auto Innovators believes that realizing this future requires a sustained holistic approach with a broad range of complementary supply-and demand-side legislative and regulatory policies. To that end, we have developed a series of proposals that match dynamic public policy with significant private investment and engagement. The foundational piece to all of these proposals is our Innovation Agenda which recognizes the key realities and factors necessary for the U.S. to remain the leader in automotive innovation. We have subsequently released more specific policy recommendations, to highlight critical technologies and the importance of a predictable policy environment to preserve and enhance U.S. leadership in a number of automotive policy areas as outlined below.

Accelerating Acceptance of Electric Vehicles:

Electric vehicles are one of the best examples of why a comprehensive vision and strategy is crucial to building successful markets for the next generation of vehicle technologies. From 2017 through 2030, Automakers and their battery partners will invest $91.8 billion in the U.S. to electrify their products. On a global scale, automakers are planning to invest $515 billion globally over the next decade to bring exciting new EV models to market, including battery, plug-in hybrid, and fuel cell electric vehicles.

Auto Innovators' *Get Connected Electric Vehicle Quarterly Report* shows steady growth in the EV sector. Through the fourth quarter of 2021, EV sales comprised 78 different models and represented over 4 percent of the light-duty market—up from 2 percent of the light-duty market in 2020. By mid-decade, IHS Markit predicts that there will be 130 EV models available in the U.S.

Even with this steady growth in EV market share, meeting the goals of automakers and policymakers alike, and achieving requirements in the EPA's final greenhouse gas emissions rule for model years 2023–2026, will require a significant increase in EV sales. However, with the right complementary policies in place, and a sustained national investment in those policies, the auto industry is poised to accept the challenge outlined by President Biden of driving new EV sales to between 40 and 50 percent of the market by 2030. To meet this goal, a comprehensive approach that includes investments and supportive government policies is needed with

a focus on three key areas: consumer affordability and awareness; charging and hydrogen fueling infrastructure; and innovation, manufacturing, and supply chain.

Auto Innovators and our member companies commend the bipartisan efforts that went into enacting the Infrastructure Investment and Jobs Act (IIJA). Notably, the $7.5 billion included in the law for electric vehicle charging and hydrogen fueling infrastructure is an important first step in jumpstarting public investment in a nationwide charging and hydrogen fueling network. Currently, there are 44,500 publicly available EV charging locations and 110,158 charging ports nationwide—representing a 16 percent increase since January 1, 2021. While the $7.5 billion is a crucial investment in expanding availability of public charging stations, substantially more will need to be invested—by both utilities and the public and private sectors. The bipartisan IIJA law also included supportive provisions for supply chains for clean energy technologies, including those related to battery manufacturing and recycling. These funding streams will certainly provide key components in supporting innovation and developing the necessary supply chains to support the expansion of EVs in the U.S.

Auto Innovators remains committed to continuing to work with Congress, the Administration, and policymakers at all levels of government to craft the additional complementary policies necessary to make EVs more affordable for all consumers, further the development of charging and hydrogen fueling infrastructure, and continue to boost investment in the domestic EV supply chain to enhance U.S. leadership in developing the technologies to achieve a cleaner transportation future.

In fact, as today's hearing examines American manufacturing and supply chains, the supply side represents one of the best opportunities to develop long-term and sustainable U.S. leadership in automotive innovation. Vital aspects of the EV supply chain require the manufacturing of batteries and battery components (critical minerals extraction, processing, battery cell production, end of life recycling) and fuel cell stacks. In 2019, Chinese chemical companies accounted for roughly 80 percent of the world's total output of advanced battery raw materials. Investments in tax incentives, grants, and loan programs for both R&D and manufacturing can help to provide the support needed to develop and bolster the U.S. supply chain and manufacturing capacity for EVs. Such programs will allow manufacturers to retool, expand, or build new facilities for the manufacture of light-, medium-, and heavy-duty plug-in and fuel cell electric vehicles, and their batteries, fuel cells, components, and related infrastructure that will be key factors in driving automotive innovation in the United States for generations to come.

The AV Policy Roadmap:

I would be remiss if I did not emphasize the potential that Automated Vehicles (AVs) have to increase the safety of our Nation's roadways by decreasing the number of motor vehicle crashes due to human error. They also hold promise to provide numerous social and economic benefits, including increased mobility for older adults and people with disabilities, reducing traffic congestion, reducing emissions, and fostering investment and economic growth.

The U.S. has an opportunity to advance global leadership in developing these revolutionary technologies and new mobility business models through a national approach that reduces uncertainty and paves the way to long-term success. That is why, in 2020, we released the *Policy Roadmap to Advance Automated Vehicle Innovation.*

The Roadmap outlines the auto industry's AV policy priorities and includes fourteen specific recommendations that can be implemented by Federal policymakers over the next four years to facilitate the testing and deployment of AVs at scale. These recommendations are focused on reforming regulations, harmonizing policies, and laying the foundation to achieve longer-term objectives—including expanding the number of exemptions that DOT can provide on a case case-by by-case basis—with safety oversight and full enforcement powers—which can then provide the data necessary to support future Federal Motor Vehicle Safety Standards for AVs.

Innovating for a Safer Future:

If the U.S. is to remain a global leader in automotive safety innovation, our policies and programs must keep pace. Uncertainty with respect to safety priorities from both a regulatory and consumer education perspective can be an impediment to investment in advanced safety technologies. The New Car Assessment Program (NCAP) is an important tool used by NHTSA to educate consumers on vehicle safety through easily understood ratings. NCAP modernization is long overdue. Unfortunately, the program has not been updated since 2011 and has failed to keep pace with innovations in crash avoidance technologies.

An effective and consistently maintained NHTSA NCAP, guided by mid-and long-term roadmaps, will leverage market forces to accelerate the development and deployment of advanced safety technologies.

That is why last year Auto Innovators released the *Plan to Advance Safety at the Speed of Innovation.* This document outlines our vision for a 21st Century NCAP, including five recommendations to ensure that NCAP achieves its main objectives of providing meaningful information for consumers, accelerating the deployment of safety technologies, and supporting future regulatory activity.

In addition to longer-term recommendations, our plan also encourages an immediate "Kick Start" that would incorporate five crash avoidance technologies into the NCAP program. These include:

- Forward Collision Warning/Automatic Emergency Braking (FCW/AEB)
- Pedestrian Automatic Emergency Braking (PAEB)
- Lane Departure Warning (LDW)
- Lane Departure Warning with intervention/Lane Keep Assist (LDW/LKA)
- Automatic High Beam Headlamps/High Beam Assist

These are all proven safety technologies that are already helping to avoid costly crashes, while saving lives, on our Nation's roadways today. The key to building greater consumer acceptance and adoption of these foundational advanced driver assistance systems (ADAS), and future safety technologies such as AVs, is consumer education that creates awareness about the life-saving potential of these innovations.

The value of an NCAP that has developed a process for continuously evaluating emerging safety technologies and folding them into a Long-Range Roadmap for vehicle manufacturers cannot be overstated. It permits automakers to develop long-term safety strategies that are aligned with the identified NCAP safety priorities and expected updates. As a result, when updated ratings are implemented, manufacturers have had enough time to have products in place that provide the enhanced safety performance. This is a "win-win-win" scenario for government, vehicle manufacturers, and especially consumers.

Conclusion:

The auto industry has long been an economic engine for the Nation that millions of workers depend on for their livelihoods. The industry is poised to remain the bedrock of U.S. innovation and manufacturing for decades to come. Realizing this potential, however, requires collaboration, cooperation, and creativity among all stakeholders.

It is imperative that we work collaboratively to develop a robust, national approach to automotive innovation that encourages and incentivizes research and development, testing and deployment, investment in a resilient supply chain, and bolstering U.S.-based manufacturing of advanced technologies, while also mitigating unintended consequences of narrow policy objectives. Likewise, a failure to embrace and encourage adoption of advanced vehicle technologies in the U.S. risks ceding technology leadership and supply chain dominance to global competitors. The nations that lead the development and adoption of innovative vehicle technologies, such as electrification, connectivity, and automation, will also shape supply chains, define global standards, and potentially, reinforce U.S. auto manufacturing and leadership in the international marketplace. This is not just about the future of the auto industry in the U.S.—it is about the Nation's global competitiveness and economic security.

On behalf of Auto Innovators and our member companies, I look forward to working with both Congress and the Administration to develop and implement policies such as those discussed to realize the promise of cleaner, safer smarter transportation future while ensuring the U.S. leads automotive innovation for generations to come.

Senator PETERS. Well, thank you. Thank you, Mr. Francis, for your opening comments. Our next witness today is Mr. Jay Rathert. Mr. Rathert has been with KLA for 26 years. And among other roles, he is the Co-Creator and Owner of companywide automotive strategy for KLA.

Before joining KLA, he was a Top Gun trained and decorated F–14 fighter pilot, go Navy. Welcome, Mr. Rathert. Thank you for your service to our country. You may proceed with your comments.

STATEMENT OF ROBERT J. RATHERT, SR. (JAY), SENIOR DIRECTOR, STRATEGIC PARTNERSHIPS, KLA

Mr. RATHERT. Thank you, Senator Peters. On behalf of KLA, it is an honor to be here to address the hearing with the other committee members, and online, and those who were testifying. Really all of us carry a technology miracle with us practically everywhere we go without giving it another thought.

More than 7 billion smartphones are in use today, and each is loaded with a few dozen of the most advanced chips ever designed. Inside those chips are incomprehensibly small transistors that allow it to do its many functions, and the continuous march of chip technology known as Moore's Law, has shrunk these transistors to the point that 150 million of them will fit into the period at the end of a sentence.

The chip that is the brains of your smartphone is about the size of a postage stamp, and it has 12 billion of these transistors in it by itself. KLA is a quality focused company and our role, simply put, is to help chip manufacturers everywhere ensure that individual transistors that power chips function as designed or manufactured and reliably do so day after day. The technology that KLA brings has enabled the advance of the entire semiconductor industry for more than 45 years.

We are the third largest semiconductor equipment company in the U.S., and our equipment is in every chip fab worldwide. These same chips are now incorporated into many products, including automobiles, enabling innovations like driver assistance features, electrification and the autonomy that we are addressing today, that appeal to today's drivers. But many are surprised to learn that premium cars may contain not just a few dozen chips, but the premium cars are now up to as many as 10,000 individual chips.

And when I started this just a few years ago, we used to say only 3,000, so it has tripled in just a few years at the premium level. A growing percentage of these advanced chips are central to the operation of the vehicle, serving in either mission critical or safety critical roles. When a chip fails in your phone after a few years, it is a frustrating inconvenience.

But when a chip fails in a car crash, it can be catastrophic, not only bad for business or brand reputation, it can put lives at stake. So KLA believes in the growth and the importance of chips in automobiles, and it is a secular significant shift, and that our quality role will be crucial to its success.

In recognition of this trend, KLA has built a second headquarters campus here in Michigan to be close to the heartbeat of America's automotive industry and to collaborate with the community of local car manufacturers, suppliers, and academics that are bringing innovation to this market.

As part of the Good Jobs for Michigan Program, our move here was conceived in partnership with the Michigan Economic Development Corporation and approved by the Michigan Strategic Fund, and we are proud of our plan to bring 600 new high tech jobs here to the region.

The forces that power the semiconductor industry success are access to a talented and creative work force, a fair and hospitable business environment, and an ongoing commitment to an invest-

ment in R&D. And as the transistors shrink further to 3 nm and below, the technical challenges continue to grow harder for everyone across the industry. Innovation and collaboration across the supply chain are crucial.

While the U.S. currently maintains leadership in many sectors that support semiconductors, sadly America's share of global chip manufacturing has fallen to just 12 percent, down from 37 percent in 1990. Nearly three quarters of chips are now built in Asia, including all of the most advanced ones found in your phone and in your car, as well as an increasing share that power the internet, cellular networks, cloud computing, and A.I.

Many of these chips are designed here at home, but all they are built overseas by two major contract manufacturers known as foundries. Each of these are susceptible to unplanned disruption, either from natural disasters or geopolitical events, creating a significant strategic liability for America and our economy and our jobs here at home.

In the past, America had multiple domestic chip manufacturers vying for technology leadership. Most fell behind on the necessary investment to remain technically competitive and therefore profitable, and this caused them to change their strategies away from the cutting edge, leaving only one viable U.S. supplier position to potentially serve this market and compete here at home against the entrenched foundry leaders overseas.

The importance in R&D investment to stay relevant and competitive in this rapidly evolving business cannot be overstated. Furthermore, the capital to build even one 5 nm chip can exceed $15 billion. Tax policy and incentives are often the key factors in determining where and when these factories are built.

KLA's business is worldwide, but we support efforts to increase competition in the chip industry and to re-shore advanced manufacturing and foundry production in America. Investments like the CHIPS Act enable America to advance our competitive differentiation and reinforce the strength of domestic semiconductor businesses ecosystem.

Therefore, we support the $52 billion in public funding of the CHIPS Act to supplement the $70 billion in private capital the industry already invest in R&D each year and $150 billion in CapeX the broader industry will spend. But long term change requires a long term view.

As such, we also support concepts like the FABS Act to provide ongoing tax credits for R&D investments that will encourage the growth of our domestic manufacturing base and create a positive economic ripple across the economy.

We also support programs that focus on STEM education to develop the best and brightest workers here at home, as well as those that allow us to attract and retain the best in global talent.

At KLA, our motto is keep looking ahead, reflecting our focus on enabling the advance of semiconductor technology, and we are grateful to those in the U.S. Congress, like you, Senator Peters, and the State of Michigan who share this view and who support this strategic industry. Thank you.

[The prepared statement of Mr. Rathert follows:]

PREPARED STATEMENT OF ROBERT J. RATHERT, SR. (JAY), SENIOR DIRECTOR, STRATEGIC PARTNERSHIPS, KLA

On behalf of KLA, it is an honor to be here to address this hearing.

Nearly all of us carry a technological miracle with us practically everywhere we go without giving it another thought. More than 7 Billion smartphones are in use today. Each is loaded with a few dozen of the most advanced chips ever designed. Inside those chips are incomprehensibly small transistors that allow it to perform its many functions. The continuous march of chip technology, known as Moore's Law, has shrunk these transistors to the point that 150M of them will fit in the period at the end of a sentence. The chip that is the brains of a smartphone (the application processor) is the size of postage stamp and contains nearly 12B transistors itself. KLA's role, simply put, is to help chip manufacturers ensure that each transistor that powers these chips functions as designed when manufactured—and reliably does so, day after day. The technology KLA brings has enabled the advance of the entire semiconductor industry for more than 45 years. We're the third largest semiconductor equipment company in the U.S. and our equipment is in every chip fab, worldwide.

Chips are now incorporated into many products, including automobiles, enabling innovations like driver assistance features, electrification and autonomy that appeal to today's drivers. Many are surprised to learn that premium cars may contain, not a few dozen chips, but more than 10,000. A growing percentage of these are advanced chips that are central to the operation of the vehicle, serving in either mission critical or safety critical roles. When a chip fails in a phone after a few years, it's a frustrating inconvenience. But when a chip fails in a car, it can be catastrophic: not only bad for business or brand reputation, it can put lives at stake.

KLA believes the growth in importance of chips in automobiles is a significant secular shift, and that our quality role will be crucial to its success. In recognition of this trend, KLA has built a second headquarters campus here in Michigan to be close to the heartbeat of America's automotive industry and to collaborate with the community of local car manufacturers, suppliers and academics that are bringing innovation to this market. As part of the Good Jobs for Michigan program, our move here was conceived in partnership with the Michigan Economic Development Corporation (MEDC) and approved by the Michigan Strategic Fund. We're proud of our plan to bring 600+ high-tech jobs to the region.

The forces that power the semiconductor industry's success are access to a talented and creative workforce, a fair and hospitable business environment and an ongoing commitment to an investment in R&D. As transistors shrink further to 3nm and below, the technical challenges continue grow harder for everyone across the industry. Innovation and collaboration are critical.

While the U.S. currently maintains leadership in many sectors that support semiconductors, sadly, America's share of global chip manufacturing has fallen to just 12 percent, down from 37 percent in 1990. Nearly three quarters of chips are now built in Asia, including all of the most advanced ones found in your phone and car—as well as an increasing share that power internet, cellular networks, cloud computing and AI. Many of these chips are designed here at home, but all are built overseas by two major contract manufacturers, known as foundries. Each of these are susceptible to unplanned disruption, either from natural disasters or geopolitical events, creating a significant strategic liability for America.

In the past, America had multiple domestic chip manufacturers vying for technology leadership. Most fell behind on the necessary investment to remain technically competitive and therefore profitable. This caused them to change their strategies away from the cutting edge, leaving only one US-based supplier positioned to potentially serve this market and compete here at home against the entrenched foundry leaders overseas. The importance in R&D investment to stay relevant and competitive in this rapidly evolving business cannot be overstated. Furthermore, the capital required to build even one 5nm chip fab can exceed $15B. Tax policy and incentives are often key factors in determining where and when these factories are built.

KLA's business is worldwide, but we support efforts to increase competition in the chip industry and to re-shore advanced manufacturing and foundry production in America. Investments, like the CHIPs act, enable America to advance our competitive differentiation and reinforce the strength of the domestic semiconductor business ecosystem. Therefore, we support the $52B public funding of the CHIPS act to supplement the $150B in private capital the industry is already investing this year. But long-term change requires a long-term view. As such we also support concepts like the FABs act to provide ongoing tax credits for R&D investments that will encourage the growth of our domestic manufacturing base and create a positive eco-

nomic ripple across the economy. Similar programs created the astonishing economic engine that is the Taiwan Science Park. We also support programs that focus on STEM education to develop the best and brightest workers here at home, as well as those that allow us to attract and retain the best in global talent.

At KLA, our motto is "Keep Looking Ahead" reflecting our focus on enabling the advance of semiconductor technology. We're grateful to those in the U.S. Congress and in the state of Michigan who share this view and who support this strategic industry.

Thank you.

SUPPLEMENTARY WRITTEN TESTIMONY

Understanding the chip manufacturing landscape:

- Companies that design and manufacture their own chips are known as Integrated Device Manufacturers, or IDMs. Intel is an example of an US-based IDM.
- Foundries are contract manufacturers. They build chips designed by others. They are selling their manufacturing expertise and factory capacity. The leading foundries that can produce the most advanced chips include TSMC, based in Taiwan, and Samsung, based in Korea. GlobalFoundries and several others also serve this market, but can no longer compete for the most advanced designs. While the bulk of foundry production is overseas, Samsung and GlobalFoundries have existing foundry fabs in the U.S. and TSMC has broken ground for a new fab in Arizona. Intel has announced their intent to re-enter the foundry business in the US.
- Fabless companies, such as Qualcomm, Apple or Nvidia, only design chips. They are 100 percent reliant on foundries to manufacture for them.
- Some U.S. IDMs with older factories (such as NXP or Texas Instruments), also use foundries for two different reasons.
  1. When demand temporarily exceeds their internal capacity, they can send overflow to be manufactured by the foundry without building an expensive, new factory. When demand returns to normal, they can turn off foundry orders without idling an internal factory and laying off workers.
  2. They also use foundries to produce branded chips whose advanced designs exceed their in-house capability to manufacture. They are 100 percent reliant on foundries to build these chips.
- Foundries now produce a large percentage of chips worldwide and all of the most advanced designs. If overseas foundry manufacturing capacity were disrupted due to natural disasters or geopolitical events, the economic and strategic impact to the U.S. economy and all of its many chip-reliant sectors would be devastating, dwarfing the current shortages.

Understanding the chip reliability problem

- Semiconductors require very precise manufacturing. The transistors and the connecting circuitry in today's advanced chips measure just a few tens of nanometers (millionths of a millimeter) in size. Minute manufacturing deviations of even a few nanometers can prevent the chip from functioning properly and must be carefully controlled. These processing flaws are known as defects.
- Semiconductor chips have a long manufacturing cycle, lasting 3 months or more. The most advanced chips may require 800 or more individual processing steps. Specialized processing equipment from leading U.S. companies like Applied Materials and Lam Research as well as ASML (Netherlands) and others perform these many steps. Nanoscale manufacturing defects in the chip are possible at any step due to misprocessing, unpredicted tool failures or a variety of random or systematic causes.
- Complex, automated inspection systems from KLA and others monitor each key process step to ensure the quality of the chips, finding defects and alerting manufacturers to the source of any problem.
- Completed chips are electrically tested on automated test equipment before entering the supply chain so that non-functioning or poorly functioning chips can be identified and removed.
- Some chips may contain small, partial defects that don't yet impact the chip. These can't be detected by the tester, and therefore "escape" into the supply

chain. Known as latent defects, they fail only after being in the operating environment.

- These types of defects are a great concern to the automotive industry, especially for autonomous driving and other safety-related applications. Latent defects impact vehicle reliability and brand reputation. Failures can create a liability issue and put customers at risk. The dramatic increase in chip content per car increases the likelihood of these premature failures. The pressure to put the newest chip technologies into cars further exacerbates the issue.
- Collaboration across the supply chain: including vehicle manufacturers, Tier 1 suppliers of electronics, chip manufacturers, process tool and tester suppliers and quality-focused companies like KLA are the best opportunity to identify and remove chips that may contain latent defects and bring undesirable risk to this important emerging capability.

Chips in conventional cars and EVs

- Today's vehicles contain virtually every type of device and design technology to power the driver assistance features, connectivity, navigation, electrification and autonomy capabilities.
- Cars contains dozens of chip-based sensors like CMOS imagers, short and long range radars and ultrasonic ranging systems. Each of these chips feeds data to high power computing systems to make sense of the car's environment and compare it in real time to software models to help it decide on safe actions. These computer chips will be in contact with other chips that actuate lighting, signaling, braking and other safety features. Other chips power the dash and infotainment in the cockpit. Still other chips keep your car in communication with GPS, Bluetooth and emerging connectivity with traffic infrastructure and other vehicles, while others monitor the safe operation of the engine. Chips are critical to performance, innovation and safety in the car.
- While chip content is rapidly growing in all vehicles, it is significantly higher in EV vehicles.
- While most chips are built on silicon wafers, specialized chips made to handle the high power associated with EV electric motors and charging are creating new opportunities for emerging materials like silicon carbide or gallium nitride that can handle the higher voltages in a smaller chip, along with many other advantageous attributes.
- These new semiconductor types are less mature than silicon-based devices, causing more defects and an increased focus on the type of quality improvement that KLA makes possible.

US competitive interests

- America is rightly concerned about U.S. technology and/or IP being used against our national interests for defense or intelligence use-cases, among others.
- Manufacturing the most advanced chips requires a few very specific technologies from U.S. and allied sources. Limiting these few critical systems alone is sufficient to hobble any advanced chip development.
- The "Big 3" U.S. chip equipment providers (Applied Materials, Lam and KLA) have emerging competitors for the more mature manufacturing technologies made in overseas (China) chip fabs that serve consumer markets. These simpler technologies aren't practically applicable to the national defense interests. Blanket prohibitions, export licensing, etc. on all systems and parts hinder the ability of American companies to serve these non-strategic markets and have the unintended consequence of making overseas competitors stronger. U.S. semiconductor manufacturers can collaboratively work with the U.S. government to better meet the desired policy goals while simultaneously sustaining American competitive business advantages
- In healthy, competitive semiconductor markets, prices for chips at newly released process technologies start very high when demand for them is hot and supply is still somewhat constrained. As the technology (a.k.a. node or design rule) matures, prices fall toward their marginal cost as capacity comes on line, competitors emerge and process economies of scale take hold. Fab personnel and resources then begin to be reallocated to the next technology shrink, powering Moore's Law, as suppliers race to bring the next new, more powerful and economical chips to market and catch the next wave of higher prices. Laggards who fail to bring their technology to market on time, miss the period of high profits, hurting their profitability and ability to invest in new fab capacity and technology. Historically, this initiates a downward spiral of that is difficult to

recover from. Remaining competitive requires successful technology development based on both sufficient investment and effective execution.

Chip shortage

- The ongoing chip shortage is the confluence of several short term and long term causes. Long-term, chip demand continues to climb against a historically conservatively growing supply base. Short term, unplanned fab interruptions and misallocation due to COVID and changing inventory models has led to increasing lead times and downstream interruptions for chip customers.
- Existing fabs and foundries are wringing out all inefficiencies and running at very high manufacturing capacity. New capacity comes online very slowly—measured in years—as new fab decisions are made, planned, built, qualified and products ramped to volume. Equipment lead times exceed 1 year alone. Capacity adds started today won't be felt for a significant period of time.
- KLA's role in improving quality and yield (percentage of working chips vs chips produced) helps chip fabs maximize their productivity, assuring that highest possible percentage of chips that start the manufacturing line are available to serve customers when they finish three months later.

Senator PETERS. Thank you, Mr. Rathert. Our last witness today is Mr. Glenn Stevens, Executive Director of MICHauto and Vice President of Automotive and Mobility Initiatives at the Detroit Regional Chamber. Mr. Steven's hall leads MICHauto, the voice and convening body for Michigan to address key industry issues for talent, advocacy, and awareness.

Mr. Stevens has more than 25 years of experience across the automotive steel—equipment industries. He is a proud Michigander, a graduate of Michigan State University—go green. And welcome, Mr. Stevens. You may proceed with your opening remarks.

STATEMENT OF GLENN STEVENS, EXECUTIVE DIRECTOR, MICHAUTO

Mr. STEVENS. Thank you. Well, I have never followed a Top Gun before, so I will do my best. Thank you for your service. Welcome to the Detroit Regional Chamber. It is a pleasure and honor to have you, Senator Peters, members of the Subcommittee, and fellow industry peers.

We are lucky enough to have Ford, Stellantis, Denso, Foley, Dunamis Energy, the MEDC, and Automation Alley. I hope I didn't forget you but thank you for being part of our community here. As you know, we have submitted written testimony, but I would also like to add that, to pick up on Mr. Dawes comment, this weekend, driving around Metro Detroit, two things stood out to me.

One is the number of parked vehicles that are sitting waiting for chips or completion of semiconductor components, and they are everywhere, new vehicles, vehicles that are important to these customers. And the second thing, as many of you know, when you pass an auto dealership, it looks quite different than we are used to it.

There are virtually no vehicles on those lots, and it is very difficult to buy a new vehicle. With those things in mind, please allow me to express the following frame of things. The United States, and particularly Michigan, remains at the forefront of auto mobility, innovation, and production. The Great Lakes region is number one in automotive manufacturing jobs. The Great Lakes states' investment in R&D outpaces the rest of the nation, and Michigan represents 18 percent of all U.S. vehicle production.

However, as both the COVID pandemic, the weeklong closure of the Ambassador Bridge in early February, Russia's recent invasion of Ukraine, another earthquake unfortunately in Japan, there are clear episodes of instability that transcend national borders and also have painful impacts on the global supply chain in Michigan's signature industry.

As this committee knows, the current shortage of semiconductors has hampered the auto industry's ability to build and sell vehicles. The vehicle industry now considers them unrecoverable, and in Michigan alone, we are approaching 300,000 vehicles last year, 2.3 million in the United States, compared to 1 million in China. There is no silver bullet to this issue.

In fact, I am sure Mr. Ford would have something to say about the supply chain efficiency and resiliency if he were here with us today. But currently, a disproportionate number of these chips are manufactured away from our shores, in other countries, and stall U.S. production, and it illustrates the problematic nature of relying on these foreign suppliers.

Therefore, our elected labor and industry leaders must prioritize building a more resilient domestic supply chain. Intel's announcement in Ohio is a perfect great step. Arizona's announcements with regards to it, hopefully in Michigan, we will have plants like that here in the future.

We urge the lawmakers and the community to further extend and commit the approval of the CHIPS Act, but also the FABS Act, the Investing in Domestic Semiconductor Manufacturing Act, and the Securing Semiconductor Supply Chain Act. All of these are complementary and bipartisan pieces of legislation that demonstrate from what my colleagues from industry and labor have shown, that building this technology in the United States isn't just good for business and the American worker, it is sound public policy.

Investing more in domestic chips means expanding not just the number of manufacturing jobs, but also high tech jobs. These facilities are often called labs to fab, and their amount—there are a tremendous amount of high tech workers, skilled trade workers, and production workers available in these facilities for our American workers.

We see this as both something that represents good, high paying jobs, but will also require sophisticated talent strategy here in Michigan and the rest of the country to support that. This is something that we in MICHauto and the Detroit Regional Chamber are very committed to.

Speaking of AVs, we also would like to ensure that the Senate also would revive the AV START Act, first introduced by yourself, Senator Peters, and Thune. We believe this legislation is highly needed, and we hope that we will anticipate that again in the future and look forward to supporting it.

Finally, in order to ensure that the leaders in this technology and other mobility innovation remain here, we also need high skilled and high tech talent workers from other places, around the country but other countries. So we would also encourage lawmakers to sharpen this competitive edge by taking up the bipar-

tisan immigration legislation currently in the House of Representatives.

The Fairness for High Skilled Immigrants Act would remove arbitrary per country caps on the number of high skilled foreign workers that could come to the United States. In closing, Michigan, the birthplace of the automotive industry, remains globally competitive as a leader in the automobile sector.

The industry employs over 1.1 million people, directly and indirectly in our state, and contributes over $300 billion of the economy to our State every year. Continues to draw significant foreign and domestic investment. We welcome KLA to our community, and they have been a great citizen and we would like to see more of that type of company here in Michigan.

We hope that here in our state, our Administration and policymakers will prioritize the domestic sourcing of these production and also the high skilled talent factor in research, design, engineering centers across our state and country. Policymakers would therefore be wise not to let the past success of the American auto industry lull us into a false sense that we will continue this and enjoy its success in the future.

We need our leaders, from Capitol Hill to the C-suite to the Union Hall, to come together, champion, and enact the type of future oriented legislation I talked about today—we all have talked about today.

These bipartisan pieces of legislation are our chance to secure America and Michigan's position as a dominant leader in automotive and mobility manufacturing and innovation for the future. We shouldn't pass this opportunity up. Thank you, Senator Peters and to my peers. Really appreciate the opportunity today.

[The prepared statement of Mr. Stevens follows:]

PREPARED STATEMENT OF GLENN STEVENS, EXECUTIVE DIRECTOR, MICHAUTO

The United States and particularly Michigan remains at the forefront of automobility innovation and production worldwide. The Great Lakes State leads the Nation in the number of automotive manufacturing jobs, investment in automotive R&D far outpaces the rest of the nation, and Michigan auto manufacturing output represents eighteen percent of all U.S. vehicle production. However, as both the COVID–19 pandemic, the weeklong closure of the Ambassador Bridge in early February, and Russia's recent invasion of Ukraine has made clear, episodes of instability that transcend national borders also have painful impacts on the global supply chain and Michigan's signature industry. As this committee knows, the current shortage of semiconductors has hampered the auto industry's ability to build and sell vehicles here in America and around the world. In fact, according to AutoFocus Solutions, Michigan Automakers produced 280,000 fewer vehicles, known as "unrecoverable vehicles," in 2021 due to the semiconductor shortage. Furthermore, North America in general produced 2.3 million unrecoverable vehicles compared to China at one million.

There is no shortcut or silver bullet to solve this issue, chips are among the most important components in the assembly of vehicles and will only become more important as autonomous and electric vehicles become more ubiquitous throughout the market. Currently, a disproportionate amount of chip manufacturing is done far from our shores, in countries like Taiwan and South Korea and the shortage of chips now stalling U.S. auto production, illustrates the problematic nature of relying on these foreign suppliers. Therefore, our elected, labor, and industry leaders must prioritize building a more resilient domestic supply chain.

Intel's announcement earlier this year that it would invest $20 billion in the construction of two chip factories in Ohio is a promising signal that policymakers and the private sector are recognizing the importance of this issue. Lawmakers in Washington can turbo charge these efforts by passing the CHIPS Act which would invest

$52 billion to expand domestic research, design, and production of chips. There are several other important pieces of legislation I would like to highlight as well. The FABS Act creates a tax credit for semiconductor manufacturing and design that will further incentivize domestic production. The Investing in Domestic Semiconductor Manufacturing Act will ensure that the CHIPS Act, once enacted, will include U.S. suppliers that produce the materials and manufacturing equipment that enable semiconductor manufacturing. This will further incentivize the production of materials and equipment in the United States while also reducing the risk of foreign supply chain bottlenecks. The Securing Semiconductors Supply Chain Act will direct the Commerce Department's SelectUSA program to solicit feedback from states about how they are working to attract foreign direct investment related to semiconductor supply chains, and then to develop a strategy to build on states' efforts and augment them with Federal support. All these complimentary and bipartisan pieces of legislation demonstrate what my colleagues from industry and labor also know, that building this technology in the United States isn't just good for business and the American worker, it's sound public policy.

Investing more in domestic production of chips means expanding not just the number of manufacturing jobs but also high-tech jobs associated with the automotive industry and strengthening our ability to keep such jobs in the United States. This is both an opportunity and a challenge as these represent thousands of good, high paying jobs but will require a sophisticated talent strategy that requires both the public and private sectors to implement. Congress could take a huge step toward implementing such a strategy by agreeing upon a finalized competitiveness package, that reconciles the House's Creating Opportunities for Manufacturing, Pre-Eminence in Technology and Economic Strength (COMPETES) Act and the Senate's U.S. Innovation and Competition Act (USICA). In addition to including much of the legislation I previously mentioned that will directly support U.S. manufacturing, both the House and Senate legislation include significant new funding for our Nation's science agencies and R&D that will drive innovation in all kinds of important areas, from AI and machine learning to Critical Minerals Mining Research. This legislation would also establish a regional technology hub program that could greatly benefit a region like ours as it grapples with the automobility industry's rapid transition around both EVs and AVs.

Speaking of AVs, to ensure that we're not just building the vehicles of today but also innovating for those of tomorrow, policymakers should act now. To this end, we encourage the adoption of Federal legislation that will create a safer and robust autonomous vehicle testing and research environment. Therefore, the Senate should revive the AV START Act. First introduced to the Senate in 2017 by Senators Peters and Thune, this legislation would create a Highly Automated Systems Safety Center of Excellence to review, assess and validate the safety of self-driving vehicles; expand testing exemptions to ensure vehicle manufacturers and manufacturers of automated driving systems are eligible; and give the National Highway Traffic Safety Administration the authority to expand exemptions for automated vehicles. This is the type of proactive policymaking that can future proof the Nation for what may otherwise be a tumultuous period for both the industry and drivers as more and more autonomous driving technology is adopted.

Finally, in order to ensure that we are the leaders in this technology and other mobility innovation, we need more high-skilled and high-tech workers to come to the United States. Lawmakers from both parties are aware, in the global economic competition with China and other economic powers, there is perhaps nothing more important than the battle over talent attraction and retention. Despite the much-heralded rise of China over the last several decades, there is still no better place to innovate and do business than the United States. Our universities and research institution are the best in the world. Our business climate and rule of law ensure that new businesses can grow faster and without the fear of public or private interference or corruption that they might encounter elsewhere. Lawmakers can sharpen this competitive edge by taking up the bipartisan immigration legislation currently in the House of Representatives. The Fairness for High-Skilled Immigrants Act would remove arbitrary per-country caps on the number of high-skilled foreign workers that can come to the United States each year. The current system caps the percentage of green cards that any one country can receive at seven percent, a threshold that is quickly met by large populous countries with many high skilled workers eager to come to our country. Removing these caps will ensure that a first-come-first-serve and merit-based system can be implemented that will positively benefit America's need for high skilled talent in places like Southeast Michigan and around the country.

In closing, Michigan, the birthplace of the automobile, remains globally competitive as a leader in the automobility sector. The industry employs over 1.1 million

people in the State, contributes $304 billion every year to the State economy, and continues to draw significant foreign talent and investment to Michigan. However, this status will be challenged as the industry continues to undergo historic transformations in the coming years. Policymakers would therefore be wise not to let the past success of the American auto industry lull us into a false sense that we will continue to enjoy such success in the future. We need all our leaders, from Capitol Hill to the C-Suite to the Union Hall, to come together, champion, and enact the type of future oriented legislation I have talked about today. These bipartisan pieces of legislation are our chance to secure America and Michigan's position as a dominant leader in automobility manufacturing and innovation. We shouldn't pass it up.

Senator PETERS. Well, thank you, Mr. Stevens and each of our witnesses. Thank you for your opening remarks. Mr. Dawes, certainly, the public has seen an awful lot of media attention to the chip shortage and the impact that it has had on the auto industry, but your folks have experienced it firsthand as a result of layoffs and changes to try to adapt to the shortages.

That is why Senator Stabenow and I secured $2 billion in the Senate-passed Competitiveness Bill to manufacture the so-called mature legacy chips here in Michigan that are used by automobiles. This is in addition to the $50 billion that is in the package to include research and development, as well as manufacturing for advanced semiconductors.

But my question for you, sir, is can you describe the human impact of the chip shortage and tell the Committee how it affected not only autoworkers, but also communities in Michigan and across the country?

Mr. DAWES. Well, it is a devastating effect because, you know, as we have all lived through this pandemic, you know, we are social people. We like to be out in public, we like to go to ballgames, and we like to go to work. We like to go to work and probably build the vehicles that we build in this State, in this country to the point where they are the best built and reliable vehicles in the globe.

And when that gets restricted and you are told, hey, we are shutting your facility down for weeks and weeks and weeks only due to a lack of parts, that is very devastating for a person that wants to come to work and make a living and provide for his family and pay their fair share of taxes.

So it has had a huge effect. And especially when you can relate it to something that is in our grasp, something that we could be doing, something that we could be building right here in the United States, and more importantly, in my opinion, Michigan. Two of the main components that you need to build semiconductor chips are electricity and water.

Now, ironically, as I sit here and say that looking out over this—one of them we have plenty of. Nobody else has what we have. And so there is no better argument and no better place to build than right here in Michigan.

Senator PETERS. Yes, absolutely. You talked about, in our grasp and acting, and I think all of the witnesses have mentioned legislation before Congress to address this issue. So my question to you again, Mr. Dawes, is if we don't pass this legislation, what signal is that sending to autoworkers and working people across the country if we don't pass this legislation?

Mr. DAWES. Well, I think the signal is that, you know, as Americans, as working men and women of this great country, is we go

to work every day and we do our fair share, and we expect a fair day's pay. And we are willing, we are able. We have time tested talent as history has shown, so we can do it. We are willing to do it. We stand ready.

And the roadblock, if it is our legislative process that puts a roadblock into the men and women that want to come to work and make it a fair days' wage so they can go and pay their fair share of taxes to keep this country going, that is absolutely devastating, that something like that could hinder and put a roadblock in.

Senator PETERS. Yes. Thank you. Thank you. Mr. Rathert, in November, Michigan was proud to welcome KLA to Ann Arbor, where the company opened its second headquarters, especially considering how clear it has become that the semiconductor industry is absolutely essential to our auto industry, and really the entire modern economy for that point.

In Michigan, we make things, and while we are known for making cars, our engineers and our workers have the skills and talent to develop a wide range of cutting edge technology like KLA's semiconductor manufacturing tools. Of course, Michigan has so much to offer that it makes it, I think, a top destination for innovators like KLA, and you have demonstrated that with your selection to locate here.

But my question for you is, sir, is can you discuss KLA's selection process that culminated with choosing Ann Arbor for your second headquarters? And can you pinpoint some of the reasons why Michigan is where KLA wants to be?

Mr. RATHERT. Yes, sir. Yes, Senator. So KLA started out as a Silicon Valley company, but we are now a Michigan company. Our new headquarters opened here in Ann Arbor, as the Senator mentioned it, last fall, and we already have 400 new hires at that site. And I checked our website before the meeting today, and we have 200 recs opened now.

So if you love hi tech, come be one of us. We have invested $195 million so far, and our new campus is adjacent to the University of Michigan. We looked at hundreds of sites before we picked Michigan, but we were drawn by engineering—by the strong engineering talent here.

And I heard your comments before, Michigan builds things. Absolutely. That is why we are here. Our partnership with the University of Michigan Engineering School helped be a feeder for the kind of talent we need to build these complex systems. We like your international access with your airport here. Easy to get to Asia and Europe where our customers are.

We had a great partnership with the Michigan Economic Development Corporation. And most importantly, as we went searching, Michiganders had a can do and how can we help attitude. And we didn't encounter that everywhere. So you made us feel welcome. Happy to be here.

We continue to want to grow here. And furthermore, in my experience, where chip companies land, things tend to cluster up. I think about Austin and Chandler, Arizona, Portland, San Jose. So I think when the secret gets out, there will be more like minded high tech companies who will join us here.

Senator PETERS. First of all, thank you for that answer. I am going to ask a few of you some questions here related to autonomous vehicles which represent the future for the auto industry. And certainly while the exact timing and the details are going to be influenced by both, technological factors as well as economic factors, one way or another, cars will ultimately be autonomous.

And there are already autonomous vehicles on our roads in various parts of our country. And I think that, quite frankly, is really good news, especially in light of the tremendous safety benefits that these automobiles are going to deliver. And I cited some figures in my opening comment that really scream out for change when you are talking about the lives of tens of thousands of Americans who die on our highways every year.

So Mr. Rathert, getting back to you, could you share some more details with this subcommittee on how semiconductor chips will play a role in making autonomous vehicles a reality?

Mr. RATHERT. Yes, Senator. So many of the chips that are in your vehicles today have been in the supply chain for a long time, and the quality has been well tested, well-proven. Qualified chips might be in the supply chain as long as 15 years. So there is lots of opportunity to assure that chips in critical roles will be reliable.

I think the concern as we push into these advanced capabilities like autonomous driving, we are going to bring some technology and some very advanced chips, maybe from the consumer space that haven't had that long time to mature. And we are going to ask and perform functions that will be mission critical and safety critical. We are going to put our families in those cars.

We are going to want those chips to perform reliably. Now this is KLA's core mission, and that is why we are so interested in working closely with the automotive sector, but the OEMs, with the Tier 1s, help them to understand the nuances of chip quality, how to make sure that all those new devices, which there may be thousands interacting with each other, and we can do so flawlessly, we want to make sure that that goes well. Protects the lives that it is intended to.

Senator PETERS. Alright. Thank you. Mr. Francis, my question for you also follows along with autonomous vehicles here. In my mind, we are going to have autonomous vehicles, as we mentioned. The only question is, will the United States and its allies actually lead the way in developing this technology, or are we going to cede this advantage to other nations like China?

So my question to you, sir, is can you comment on the importance of maintaining our competitive advantage when it comes to autonomous vehicles, as well as related essential technologies like artificial intelligence?

Mr. FRANCIS. Certainly. Thank you for that question, Senator. You know, the American auto companies and auto companies that produce here have invested billions of dollars in research and development in autonomous vehicles. One of the things that Mr. Rathert mentioned is, is that, you know, these are going to take time to mature. But good public policy will also make sure that we do it safely and we do it smartly.

We need our companies to have the opportunity to test and deploy so that these things can be tested in real conditions. And so,

you know, as we look to the future, our competitiveness, foreign nations are already invested in this technology. And so we in the United States need to make sure that our public policy is keeping pace with that global investment.

At the auto innovators, we have developed an AV roadmap that lays out a clear 4 year plan for policymakers to preserve and enhance U.S. leadership in autonomous vehicles and autonomous technology development for life saving technologies. We need to look at it that way. Autonomous vehicles offer a great opportunity for people around the country, whether it is in rural areas or disadvantaged areas, that have mobility challenges.

And as I mentioned before, in the auto industry, a number of things that are going to happen in the auto industry and that happen here in Michigan find their way into other things, defense industry benefits, education industry benefits, medical industry benefits.

So our supply chains that are so vital and so important to Michigan and to autonomous vehicles are connected across the spectrum of U.S. manufacturing. So your leadership in talking about how to move that conversation forward in terms of AV, and your bipartisan work to try and find a way to encourage public policies that do just that, will continue to be very critical.

Senator PETERS. Alright. Thank you. So, Mr. Dawes, when we are talking about these changes, my question for you, sir, is what are you seeing in terms of deployment of these technologies play out actually in the factories, on the shop floor? And specifically, how has making cars changed over the years as you have watched it with respect to chips? And where do you see things heading when it comes to workers?

Mr. DAWES. Well, as I said earlier, the difference in the modern vehicle—what the vehicle was when I grew up is totally different. You open the hood of a vehicle today versus just a few years ago, you look in there and you would see the steering shaft come out, going down to the steering box, and all that is, is a clump of wires coming out that does—that performs all of that.

So that is a big part of how manufacturing has changed today. And quite frankly, those of us, me included years ago that were reluctant to that change maybe or afraid of that change, now enjoy that change. I love my heated steering wheel—I love my heated seats in Michigan, and everyone in here has got something either on their hip or their pocket or laying on the table.

As Mr. Rathert said, is that who to believe years ago what their cell phone would do. I remember I had a bag phone and look at what one does today. So there is a huge shift in how we manufacture and what the functions of the vehicles and how they are performed, more so than the functions. So, that is a big change.

What we see, one of the other major changes is when you remove the internal combustion engine along with the transmission as we know it today and then drive shaft into the rear axle that is a significant change that will be taken over with electrical components. But approximately today, 80 percent of the vehicle remains unchanged. You still have all your interior, your steering wheels, your brake pedals, your seat, your heating, your air conditioning out-

side, you still got your sheet metal, you still got your tires, and what have you, and then the frame structure.

You know, all of that, whether it is, you know, propelled with an internal combustion engine or electric motor, you still have all the safety features, crash specifications, and what have you. All of them safety features that still need to maintain. So about 80 percent of the vehicle remains unchanged.

So those are some of the things that, you know, are naturally on our radar. And I got to tell you, I am a GM guy. I don't have any Ford or Stellantis in my region. I have all General Motors.

But I can tell you with working with our General Motors counterparts in the design and the engineering and at the management level, along with our membership and our leadership in our factories, we launch vehicles like have never been launched with the quality and time-frame that have never been done in the history of this country.

And I give that accolades to the management and the union and working together, and we look forward to these future changes. They are part of our lives. We do them every day. And as I said earlier, we stand willing and ready.

Senator PETERS. Right. I am going to want to return in a moment to electrification, labor issues, and the talent development, et cetera. But before I do that, I want to return to the current chip shortage for a moment. And my question is going to be for you, Mr. Stevens. You know, when it comes to chip shortage, as I mentioned, the public is aware of the impact that it has on the auto production, but they aren't necessarily aware of the very long supply chain that gets to that auto production. It is very complex. Numerous players.

So when auto production is disrupted, it doesn't just affect the major automakers, which people are familiar with. It involves numerous suppliers' businesses, many of which are small businesses that are involved in every step of auto production and countless workers all along that chain. And that is why I believe it is so important that we fund the CHIPS Act and the $2 billion investment in legacy chips, as I have already mentioned.

Not only will manufacturing chips in America create numerous good paying jobs in the semiconductor industry, but it is going to protect and grow jobs all through the manufacturing sector. And so my question for you, sir, is can you describe the ripple effects that the chip shortage has caused throughout the auto supply chain?

And if you could comment on what funding the CHIPS Act will mean to workers and businesses all up and down that chain and why we need to take action on it.

Mr. STEVENS. Certainly. We will focus on Michigan, which we do well. So the auto industry is in virtually every community in Michigan, virtually every single community, and we will see it very clearly in an assembly plant, but you don't see it so much as you go down into the lower tier companies.

And those lower tier companies, which might employ 10 people, 60 people, all the way up to 6,000 people, they are what contributes to local communities, local economies, and there is an indirect multiplier effect in each one of those communities. So when there is disruption, for example, the 2-weeks down of a General Motors

plant, you can imagine what that does to the local community on a daily basis.

And when that stacks up, like it has stacked up over the last couple of years with the supply of the microchips and the problems, it has had an exponential factor on our communities. So the localization and the investment in our own country of stabilizing and making that supply chain more resilient so those peaks and valleys of production are not seen, these plants require stability, but so do the communities to operate.

So we are hopeful as we see these investments in the United States, it will—we will start to see even more growth in those economies and certainly not the dramatic impact that these economies feel in these local communities, as well as the large cities.

Senator PETERS. Alright. Thank you. The—Mr. Rathert, question for you, and this turns us back to the electrification of the fleet, which we have been talking about and how innovative semiconductor technologies are going to help reduce charging times as well as increase battery range, which is critical for this transition to occur.

Not only will it benefit the environment by reducing emissions, which is a huge benefit, but it will also end our need to rely on gas to power our vehicles and remove a really a major transportation cost, as well as we see potential National Security issues for around the world. So my question to you, sir, is can you talk about how semiconductors are going to help enhance EVs and make a fully electric future truly possible?

Mr. RATHERT. Yes, Senator. So EVs are different from your standard combustion engine automobile, and the fact that chip content is nearly three times what you would find in your standard automobile. And a lot of those chips are coming from a technology that has been used—it is called silicon carbide.

It has actually been used in a lot of cases before, but now we are bringing it into our automobiles and it is handling this battery management, fast charging, lots of the capabilities that make EVs possible, and we have really never stress tested it the way silicon has been tested for the last 70 years. So there is a lot of maturing going on in that part of the economy right now.

I was in North Carolina this last week working with a company to try and improve the kind of necessary quality they are going to need to deliver silicon carbide. So I think there is a lot of people interested in that. It will power your vehicles into the future and bring the sorts of capabilities that we are all interested in, this additional safety, this reduction of greenhouse gas, and so the productivity gains we hope to get so.

Senator PETERS. Very good. Thank you. Mr. Francis, could you expand a little bit on how you believe, and your organization believes electrification is going to literally transform mobility in the future?

Mr. FRANCIS. Certainly, Senator. I mean, as we look at it, our members, our automakers, and our suppliers are investing hundreds of billions of dollars investment in moving toward electrification.

And they have done that because it is what the consumer wants. It is what the consumer sees as the future. And so as we look to

it, we see a couple of things, both supply side and demand side. And working with the Government—there are a number of necessary conditions for the success of this transformation. The technology is there, and we are continuing to build on that technology.

Our members are—have announced more than almost 150 new models of EVs in the next several years to be available to consumers at all price points. And so the market is rich, the market is developing. But I think one of the things we are looking at, as Mr. Rathert said, is that as these technologies mature, we are focused on safety, we are focused on consumer adoption, we are focused on a number of advancements.

And so the supply chain overall is extremely critical, and semiconductors are a major part of that. But it is also, as I mentioned, there are a number of other things in the U.S. supply chain in terms of a robust, resilient supply chain we need to be looking at. We need to be looking at critical minerals.

We need to be looking at those production capabilities and how we can do it in the U.S. in a smart and environmentally sensitive way. So there are a number of components to it, but our members, as I mentioned, are all in. They are dedicated to this cleaner, safer, smarter transportation future and electric vehicles including, you know, battery electric.

And a number of things all fit into that. And so it is a risk robust growing market for our folks. And I think again, it is what consumers are telling us they want.

Senator PETERS. Yes. Very good. Mr. Stevens, we, those of us in Michigan, have seen many transformations through the auto industry through many, many years, starting back before our time with Henry Ford with the, let me be clear, before our time, that brought the assembly line. And the auto industry has been always very highly adaptive, as well as our auto workers who have been an integral part of all of that.

And so now we are discussing some other transformative changes from electrification to automation. So if you could talk a little bit about what trends in the auto industry we are talking about in the future, what that actually means for Michigan, and more importantly, how can the State of Michigan actually harness them to create absolute new generation of opportunity here in our state?

Mr. STEVENS. Yes, that is a great question. And to pick up on Mr. Dawes earlier when he said that 80 percent of the vehicle remains the same. It does, but the nature of those components dramatically changes. So you have the vehicle becoming a telecommunications provider, ultimately. So there is a technology stack with the vehicle that is occurring. And when you look at the other significant changes, we know it is the propulsion system.

But it is not just the propulsion system that is changing because we have traditionally focused on the industry, when you look at design, engineering, and manufacturing. Now, there is two things in front of it and before it, that is the grid and the infrastructure that supports electrification and recyclability.

Recyclability has always been important to the industry, but now it becomes critical, particularly because of the critical minerals. We need to bring them back to the front of the process. So the economic opportunity when you look at all four of these major areas

with regards to telecommunications and software and electrification, it is a tremendous opportunity for Michigan.

We are working very closely with the Governor's Administration and the Legislature right now. I can very honestly and safely say that we were pleased with the progress that is being made. There is an incredible focus right now on all four of those areas, and specifically the focus is on talent. Because there is going to be requirements for talent in this transition that we don't currently have or are not generating enough of.

So the economic opportunity for the industry as it transforms is one thing, and the talent opportunity, and building a more diverse and inclusive workforce along the way is something that is everybody—everybody is committed to. I think we are going in the right direction.

The MEDC has got a new strategy, a new leadership, and it has got a new organization. We are very pleased by what we see. So we are on the right path right now.

Senator PETERS. Well, thank you, Mr. Stevens. Mr. Dawes, as was discussed, the issue of talent and the ability to make things is going to be critical for the future of Michigan. And in your written testimony, you mentioned that Michigan is the ideal location to grow domestic manufacturing because our workers are ready and, "have unlimited time tested talent to offer."

And in the coming years, it won't be just auto manufacturing, it is going to be all sorts of advanced manufacturing, which will represent the future. Certainly, the semiconductor industry is a prime example of that future, and the need for folks who understand how to make things.

If Congress passes the CHIPS Act, our country is going to start building lots of chip manufacturing plants, and there certainly is a concern out there as to whether or not we are going to have workers to fulfill those roles in these new manufacturing plants.

So my question to you, sir, is can you talk about the kind of training and skills that Michiganders develop by working in the auto industry now or in other manufacturing settings, and how this demonstrates that we have the workforce that is ready to fill the needs for the semiconductor manufacturing industry as well?

Mr. DAWES. Yes, absolutely. I can proudly sit here and tell you that I spent a lot of years working in the factory and representing workers, and I can tell you through our joint programs with the Big Three, and which actually filters down into our independent parts suppliers and our technical office professionals, is we take safety at the highest level.

And that gets—everybody gets trained along with the different areas of assembly, repair, installation of equipment, and a skilled trade department, whether they are trained to bend pipe, to pull wire, or to work on model cons or programing, so much of our assembly equipment or our paint departments or whatever.

So internally, we focus a lot on training and bringing people up to the next level so that when the new process comes in, they are trained and that they understand the process. And as that process moves forward, we continue to send them vehicles out the door at the highest quality.

One prime example is in Flint, Michigan, we lobbied for a lot of the years with General Motors and General Motors invested in a brand new paint shop for a Flint truck assembly, which went from lacquer base and that type of paints to water based paint.

And the sophistication and the pure technology that is in this place now is just—it will blow your mind from what are you used to seeing and what you would see today. And all of our folks were trained and spot ready when that equipment hit the floor, got bolted down, and started running trucks.

Senator PETERS. Right, right. Mr. Rathert, I would certainly like your commentary on this issue as well about some of the potential workforce synergies between folks who are involved in auto production and semiconductor production.

Mr. RATHERT. Yes, Senator. Semiconductor design and process engineering are engineering intensive. But when you walk inside a chip fab, the only thing that feels a little different is people are wearing these clean room suits, maybe you have seen pictures of this before, but ultimately it is really manufacturing, right at a very small scale, if you will. But there is still people moving materials, people controlling quality, smart trained workers bring these chips to life.

I think the skills that Michiganders have based on manufacturing automobiles and your rich manufacturing history in other areas are just the types of skills that can be transformed and to fit into the chip world where we are building the chips themselves, building the equipment that does it, building the factories that make the chips. Michiganders are well equipped with your long history of building things to be successful.

Senator PETERS. Great, thank you. Mr. Stevens, as we have discussed, the growth of the auto industry and the impact on the country and the fact that it created the American middle class, there has certainly been incredible opportunities that have resulted from the industry. But all too often some communities are left behind, especially communities of color.

And as we look to the years ahead and think about shaping opportunities for autoworkers, as well as in the semiconductor industry, which are good paying jobs in manufacturing, I would like your thoughts on what you are seeing in Michigan on this front, to have a very diversified work force, and how we can step up this important priority?

Mr. STEVENS. Well, I think, first of all, it is extremely important, and there is a focus on this, that we raise the educational attainment of all of our people in this State, and that means something post high school. It could be a welding certificate, it could be coding, it could be an advanced degree, but we need to raise that educational attainment level in Michigan.

That is something the Detroit Regional Chamber is very committed to. In addition to that, the K–12 base level education is important. But beyond that, all of our citizens, whether they work in the industry 4.0 in the factory or they work on the connected vehicle, electric vehicle, they will need more digital skills.

Every job classifications, digital skills score a rating, according to the Brookings Institute, continues to go up. So this is really essential for us as we prepare people. But I also think that, and we are

seeing this right now, and I think Natalie's company with Dunamis Energy is a perfect example.

Electrification, because of all of those different parts of the industry, provides an opportunity for more people to be participating in the economy of that electrification. And I think her company is a perfect example where they are going to build chargers here in Detroit.

So we see these opportunities, but it is going to be incumbent upon us to prepare our youth with K through 12, to get the educational attainment, and to get the right alignment of skills for the industry demand, whether it be in the labs to fabs, a semiconductor plant, or a charging network plant, or a traditional automotive plant.

Senator PETERS. Thank you. Mr. Francis, I would like you to add your perspective from automakers on making the industry more diverse and more inclusive. What is your assessment of where we are, what more we need to do going forward?

Mr. FRANCIS. Certainly, Senator. I think—I would say that as we look toward the future and we look at what the technology development can really do—Mr. Dawes held up an XM radio module, Mr. Rathert held up his phone, Mr. Stevens talked about telecommunications, you talked about connectivity. And what I think this transformation can do is, it really is about connecting people. And while automation is not new, the speed of automation has certainly increased.

And so it is incumbent upon us, and our members have taken to heart really looking at how communities are impacted, whether it is rural communities or disadvantaged communities or communities of color, both in terms of the workforce that they can attract in these times and in terms of the consumers that they can service in these times. So I think it is not just on one side, but it is on all of those sides.

And I think that it is important that we continue to look at workforce training. It is important we continue to look at informing our young people about the path that they can take. You know, what are the opportunities that they might not have seen before? And so these are new things and these kinds of new jobs in the U.S. economy. We have seen with this whole new burst of technology that we have already seen new jobs and new skills.

And for whatever skill level you might have. But I do think, as Mr. Stevens said, it is important that we begin to train our young people at an early age about the digital future, about the technology future, and retraining.

You know, we have, you know, in this country, we have people working longer than ever and we have people who are capable, you know, well into their mature years, as we talked about mature nodes, that, you know, we do retraining that allows them to participate as well across the spectrum.

Senator PETERS. Right. Thank you. Thank you. Mr. Rathert, as you know, the Senate and the House have now both passed separate bills to fund chips, and I am hopeful we will get an agreement soon and we will be able to come together on a fairly large package and send it off to the President to be signed into law.

So certainly, I believe it is essential so that the Federal Government can start implementing these incentives and boost domestic manufacturing, which will help everything we are talking about here today. But I believe we can't act soon enough. Statistics show that America share of global semiconductor manufacturing has dropped from 37 percent to just 12 percent today, and that puts our economy, and as we have discussed, our National Security at risk.

And as Congress works to finalize this funding, this important question, I have also introduced a bipartisan bill called the Investing in Domestic Semiconductor Manufacturing Act. My bill would ensure that CHIPS Act incentivizes—gives incentives to boost domestic semiconductor manufacturing to include U.S. suppliers that produce the materials and the manufacturing equipment that enables semiconductor manufacturing.

By growing the domestic footprint of U.S. companies that produce essential materials and equipment, we can create more opportunity for manufacturers here in Michigan as well as across the country, certainly at the same time strengthening all of those supply chains. So I am glad that the House has taken up my language, and it is in the bill. Now, we are hopeful to get it in the complete package going forward.

So my question for you, sir, is can you discuss how incentivizing the domestic construction of facilities to produce materials and semiconductor manufacturing equipment is a key part of the solution to shore up the supply chains, in addition to building the facilities where the semiconductors are actually manufactured?

Mr. RATHERT. Yes, Senator. And again, we are grateful at KLA for your leadership as well as that of your colleagues in the House and in this bicameral and bipartisan approach to the CHIPS Act and the surroundings supporting legislation. Semiconductors are constantly evolving. There is new materials, new methods, new packaging, it moves at a very rapid pace. One thing is constant though, that it gets harder with each node.

Each change brings new challenges, new obstacles, what we like to call defects, and that is KLA's business. We are there to help. We can't rest. We can't make a misstep, which is why we personally invest heavily in R&D. But we can always raise the bar higher. America's equipment manufacturers, KLA, and our peer companies do have foreign competitors.

We want to ensure that this equipment business stays here in America, that we are able to serve our domestic and overseas suppliers that are important for alleviating this chip shortage, and we believe the CHIPS Act is an important part of that.

Senator PETERS. Great. Thank you. Mr. Stevens, companies in Michigan are certainly positioned to fill some of the void of suppliers and equipment manufacturers and materials. Companies in Michigan like KLA are a prime example, who have recently located here. Thank you again for doing that. It is wonderful to hear. We also have Hemlock Semiconductor up in Saginaw, so I think this is—shows us that we have some great opportunities to increase this type of business in our State.

So my question for you is, could you talk a little bit about how the CHIPS Act, and my specific proposal, could support economic development efforts here in Michigan through both the semicon-

ductor industry as well as the auto industry really working together?

Mr. STEVENS. Yes. Well, it is really important that we focus on what is needed for a company to make a decision to either grow the business that is already here or to come here. And of course, there is a myriad of factors around that. The business climate is important, and there are a lot of things that go with the business climate. The incentive climate is important. There is a lot of things that go with that too.

Your specific legislation with regards to full funding from the Act and also the supplemental $2 billion to work with Select USA is extremely critical to let and enable economic development. And then, really the critical factor is talent. So when Michigan looks at what it has and what it needs to do, these Acts all help in their own way, but all complementary together, as I referenced in my testimony, they work together to provide an opportunity for Michigan.

So it puts us in the game because of our know-how from an engineering design manufacturing standpoint, but also because we innovate here. You know, there are more telecommunications patents that come out of this region than anywhere in the country, including Silicon Valley. So there is a lot of innovation that goes on here, too. But, you know, we complement what you put forward, and we hope it all becomes a reality because it will help Michigan.

Senator PETERS. Alright, thank you. Mr. Francis, I mentioned in my opening remarks how injuries and deaths on our roads have been unfortunately rising. And considering that human error is usually the major factor in those crashes, if we can remove the human driver, autonomous vehicles certainly hold an incredible promise of 1 day to significantly reduce these injuries and deaths, but it is certainly going to take some time before we get to full autonomy.

But in the meantime, there are a number of other technologies that are being rolled out that get us on that path, things from lane departure warnings to automatic emergency braking, all of these new technologies are going to save lives. But they all require sophisticated software, all require semiconductor chips, once again.

So my question for you, sir, is how will securing our supply chains for semiconductor chips facilitate the development of life saving technologies that fall short of automation, but also called advanced driver assistance systems as we wait for the fully autonomous future?

Mr. FRANCIS. Yes, thank you, Senator. Safety is at the heart of what our suppliers and automotive makers are doing every day. You know, it is really job one. And so we have always been investing in technologies that would improve safety. And so making sure that we are able to have the supply chain that produces the things necessary on a consistent basis is really important. I mean, as Mr. Dawes mentioned, you know, there are choices having to be made about things that are going into vehicles.

And those are somewhat, you know, comfort things. But the safety critical systems are the things that we continue to focus on, and we have not been compromised in any way in those things. And so I think our members continue to look at these safety critical tech-

nologies and these advancements of being able to provide these at all levels for our consumers to make sure that they are in place.

And so making sure that we have a robust, resilient, reliable domestic supply chain that will provide the semiconductor chips and the things we need to be able to continue these advancements is extremely important. And in the legislation that you put forward and that your bipartisan support that you have led is really important, a signal from the Government, a signal from your colleague that says, you know, we are putting safety at the forefront.

Safety technologies are extremely important. So we want to continue to work with you to make sure that we are able to continue to lead the Nation and lead the world in implementing new safety technologies.

Senator PETERS. Well, I appreciate that. Thank you. Thank you, Mr. Francis, for those comments. Mr. Stevens, as we are talking about autonomous and AVs, I think the question—there isn't the question of if we are going to get there, it is coming. It is just a matter of what time, timeframe. But the outstanding question that we have to resolve and one that I am very passionate about is whether or not the United States will maintain its leadership in the development of autonomous vehicles or are we going to cede this ground somewhere else?

And we can't do that. It has to be here in the United States. But in order for the United States to dominate the future, we have to have laws and regulations that actually facilitate the safe development of these autonomous vehicles. As you are well aware, our current regulatory frameworks are simply outdated. They are not designed to deal with self-driving cars. They always assume there is a human as a driver, and that is a good assumption right now. That is totally accurate.

But things will change in the years ahead. And certainly, I am going to continue to work on legislation to modify those regulations. But my question to you, Mr. Stevens, could you expand on the economic impact that autonomous vehicles will have on Michigan? And quite frankly, what will happen if we lose our leadership in autonomous vehicles?

Mr. STEVENS. Certainly. While we are always proud to say that Michigan is an epicenter, a global epicenter for mobility, but we are also not so naive to think that everybody doesn't want to be that global epicenter, too. And so that has been why we have been focused since really 2015 as a state to bring together the parties. Policy has been at the forefront of it. Michigan has, under Governor Snyder and now under Governor Whitmer, maintained its focus on making sure we have the most progressive, safety first policy for autonomous vehicle development.

Now, a lot of the attention and focus on the autonomous vehicles actually dimmed a little bit from the beginning of the pandemic, and there is no question about that. Many companies didn't put the R&D in the last couple of years, but the companies that are core to this industry, Cruise Automation, Waymo, Argo, Aurora, and the Chinese, and also some of the Europeans, have not stopped the focus on this.

Number one, because it can save lives. We know that this technology can really, really benefit deaths from the roads from that

standpoint. But the economic opportunity and monetization when you look at the development of advanced driver assistance systems is huge. So that is why we are so focused on here in Michigan.

But like all the other things we have talked about today, it is incumbent and critical for America to make sure that we protect the intellectual capital, make sure it is developed here and stays here, and that we control not just it from a National Security standpoint, but an economic opportunity standpoint also.

Senator PETERS. Great. Thank you. Mr. Francis, I know you think a lot about this as well. What do we need to do to make sure it stays in the United States?

Mr. FRANCIS. Well, Senator, I think that, you know, good public policy is important. You know, creating opportunities for, you know, testing and deployment, making sure that, you know, communities have what it takes to do these types of things. And at AV Roadmap, one of the things that we had suggested is, you know, updates to what we call the manual of uniform traffic control devices.

And that is, you know, providing grants for a wide range of communities for widespread testing and deployment, both rural and urban. So it is creating those types of policies that match the investment that our companies are putting into it, that allows them to begin to get these things on the road. Because as you mentioned, it has an incredible opportunity for opening up personal mobility for all different types of communities.

And so, you know, if we are going to make sure that, you know, we are leading the world and leading the nation, we need to make sure that we are manufacturing the components here, that we are creating test beds here, that we are creating opportunities for deployment here that can showcase what autonomous technology can do.

And that is going to be an incremental change. It is not going to be overnight. We know that. And so that is the thing that will allow consumers and suppliers and everyone to participate in that transition.

Senator PETERS. Alright, thank you. Certainly, we are in a very transitory time. Change is happening quickly. And my question for you, Mr. Dawes, is we want to make sure workers are fully prepared for these changes and share in the opportunities that are there.

So if you could elaborate, you have already discussed it somewhat, but if you could elaborate on how Congress specifically can support workers to ensure that they have the preparation necessary to embrace this future when it comes to technological changes, changes that we can't even probably predict today. Things are going to be different a week or a month from now. What more can Congress do to help workers?

Mr. DAWES. Well, I think some of what Congress can do is, when people get educated on a change or educated on a purpose, they understand it more. And when they understand more, they embrace it more and they realize that, hey, this is going to be part of my life. This is going to be where we are going to go.

I think the investment in American people is huge. I think that shows the leadership that shows by example that we know you can

do it. We have the faith you can do it. You have shown over time that you have done it in the history of this country, time after time, after time. This is no different, we are just going into a little different—little different program than what we are used to.

And we are counting on you, America. We are counting on you, the men and women in this proud, great country. So we are willing to show you and give you the tools for your toolbox. Let's do it.

Senator PETERS. Very good. Amen. That is all I will say to that. So I appreciate all of your testimony. One last question as we wrap up. This time has gone by very quickly. And my last question is for you, Mr. Rathert. As I have mentioned, Michigan is very proud to have welcomed your company to Ann Arbor.

And when we look at the semiconductor industry and how it makes investments, we tend to see a pattern of clusters, which is not unusual to the semiconductor industry, fairly typical of all industries.

Companies always gain synergies by being close to one another. So my question to you, sir, is, with KLA helping lead the way here in Michigan, how do you think Michigan can leverage your presence in Ann Arbor to grow the semiconductor industry footprint here in Michigan?

Mr. RATHERT. I believe when the word gets out about the skilled workers that KLA is finding here in Michigan, with the talent and the capability and the success we are going to demonstrate here, as well, frankly, as some of the cost savings, the cost benefits of being here in Michigan, I think it will take on a life of its own, frankly, Senator. But certainly welcome any kind of efforts to advance that through the Chamber of Commerce here or with our partners with the Michigan Economic folks.

We are happy to partner with them and highlight our success here. We are sure it is going to have a very successful outcome and that should just naturally bring some of our peer companies here when the word gets out.

Senator PETERS. Well, we welcome your success. Success breeds success, and so we will continue to build on that. Before I wrap up today's hearing, I would like to address some administrative issues.

First off, the hearing record will remain open for 2 weeks until April 11th of 2022. Any Senators or others who would like to submit questions for the record, should do so by April 11th. And we ask that witnesses provide responses to the Committee as quickly as possible, but no later than April 25th.

With that said, in closing, I guess the question is what have we all learned here today? At first, I would say we all know that automobiles already depend heavily on chips. In the future, this trend will only continue, and we cannot achieve an electric or an autonomous future or the safety, as well as the environmental benefits of these vehicles without a secure supply of semiconductor chips.

Second, our supply chains are or at least they were before the pandemic, efficient, but they clearly are not resilient. For too many essential goods, including chips, we rely too heavily on foreign suppliers, including suppliers who are often located in unstable parts of the world or are controlled by our adversaries.

This means our supply chains are subjected to numerous risks abroad, including from transnational shipping, which can have ab-

solutely devastating consequences. Indeed, we have seen with the pandemic with medical supplies and with automobile manufacturing, it is not an understatement to say that these risk gravely threaten our National Security as well as our economy.

So then that leads to the next question, so what is the solution? And I think we need to make things here in America and I think hopefully all of you would agree, and I want to make them in Michigan specifically, but America, then Michigan first and foremost.

And that is why I have worked to grow the domestic auto production and tackle issues related to the chip shortage by fighting for funding to make chips in the United States, in addition to onshoring semiconductor supply chains through legislation I authored, which has now passed through the House.

The bottom line is we have the greatest workers in the world, the greatest drive for innovation, and certainly, I think, the greatest potential of any nation on the Earth. We need electric and autonomous vehicles to save our planet, as well as to save lives on the road, and we need to make them here in the United States of America.

If we need pharmaceuticals, medical devices, and vaccines to stay healthy, we should be making those in America as well. And if we need chips to stay competitive in the global economy, we need to make them in America. The entrepreneurial spirit and the work ethic of our State and nation literally built the American middle class and helped make America the superpower in the 20th century.

And in the 21st century, we have everything we need to succeed here at home. And that is why I will continue to fight for the future. I want to certainly thank our participants who I know share that vision too, to fight for the future, and to continue to support the United States and our manufacturing abilities as the greatest nation on Earth.

So thank you for your participation here today. We will now conclude this hearing. This hearing is now adjourned.

[Whereupon, at 11:30 a.m., the hearing was adjourned.]

A P P E N D I X

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. AMY KLOBUCHAR TO ROBERT J. RATHERT, SR. (JAY)

Semiconductor Workforce. Semiconductor companies frequently compete for a specialized pool of talent. The U.S. will need 70,000 to 90,000 workers or more to be added by 2025 to meet critical workforce needs.

Question. What additional investments could Federal and state governments be making in education and training, and what current programs could be expanded or modified, to support the semiconductor workforce?

Answer. Senator Klobuchar,

Thank you for your concern regarding this important issue.

Success in the semiconductor industry requires more than just building factories. All aspects of this industry—from device design, to the advanced equipment needed to fabricate the chips, to nanoscale manufacturing in the fab—are knowledge-intensive, operating at the frontiers of science and technology.

Advanced semiconductor devices have 800 or more complex, nanoscale manufacturing steps. Each process step must be designed and performed perfectly for the chip to function. Semiconductor technology evolves rapidly and innovation based on the experiences of past successes and failures is critical for timely development of a viable, competitive capability. Applicable expertise is critical.

For America to lead again in this growing and strategic market, we will need both near-term and long-term plans to develop, attract and retain the requisite skills, innovation and experience to ensure success here at home. There are legislative implications for both education and immigration.

To add an additional 70,000 to 90,000 semiconductor workers by 2025 (<3 years) requires attracting a combination of existing skilled workers, as well as those nearing completion of their studies.

Near-term recommendations

Semiconductor companies rely heavily on workers with advanced STEM degrees in their new-hire pool. Within KLA US, 30 percent of our workers have a masters or PhD degree, more than twice that of the normal U.S. population aged 25 or greater.[1] The complexity of chip design, equipment development and nanoscale manufacturing requires cutting-edge engineering and analytical skills to understand and manage. The U.S. produces approximately 34,000 PhD graduates each year across all STEM fields of study, of which 42 percent are international students.[2]

- *Domestic advanced STEM degree students–* These candidates are in heavy demand, often seeking employment in high-profile American companies, such as Apple or Google. Targeted grants or scholarships—or novel ideas such as making student loan payments tax deductible for advanced degrees finding employment in the semiconductor field—could make the semi sector more attractive for U.S. citizens. Semiconductor engineers become high-earners, allowing the U.S. to recoup the deferred tax dollars in future years.

Mid-term recommendations

To support the successful growth of the U.S. semiconductor industry in the mid-term, the U.S. should prioritize opportunities to develop the available talent pool over the longer 3–7 year time horizon.

- *Career transition:* Congress and industry should partner through hiring incentives and educational credits or subsidies to transition interested, existing mid-career domestic workers with the appropriate fundamental engineering, technical, manufacturing or military backgrounds into semiconductors. Fellowships,

[1] U.S. Census Bureau

[2] *U.S. Universities Fall Further Behind China In Production Of STEM PhDs,* Forbes, Aug 7, 2021

apprenticeships and other training programs that invest in developing the skills needed for long-term success are important enablers of this path of workforce development

- *U.S. undergraduates seeking advanced STEM degrees:*
  - In conjunction with industry, the Federal government should assist in boosting awareness of the critical and growing role that semiconductors play in our lives and economy, generating interest in potential careers in this strategic industry.
  - Universities could guarantee admission to graduate engineering programs for their undergraduate engineers with a minimum target GPA to continue their momentum and reduce barriers to progress for the best candidates.
  - Incentives that encourage undergraduate workshare/co-op programs and internships could bring semiconductor companies and interested young talent together, leading to company-funded graduate-education opportunities for the best long-term prospects
  - Congress could put temporary, targeted incentives (*i.e.,* student aid, grants, zero-interest loans, loan forgiveness or tax benefits) into the hands of undergraduate students if they choose advanced STEM degrees in relevant areas, including physics, computer science, electrical engineering and materials science. This would make these fields of study more attractive to U.S. students. Commitment to work within the semiconductor field for a predefined number of years could be a requirement to realize these benefits.
- *Hi-tech skilled manufacturing:* Every semiconductor company has need of many skilled supporting workers for jobs that don't require advanced degrees. Operators and technicians in the fab and assemblers in the equipment industry are the semiconductor equivalent of workers on the factory manufacturing floor. These workers need training to be successful in the complex, "clean-room" environment and these skills could be developed in state-level community colleges and certificate programs, private trade colleges, or apprenticeships that provide on-the-job training. Those states with schools located near U.S. chip or equipment manufacturing could provide skills that create a ready pipeline of capable U.S. workers for high paying, high-tech jobs. Just as Michigan attracted a new HQ and manufacturing facility from KLA, states with an abundance of skilled manufacturing resources can find a win-win with other companies in the semiconductor industry.

Longer term recommendations

America must develop the core of our future talent pool at home over the next 7–10 year time horizon and beyond.

In conjunction with industry and academia, the U.S. should expand our investment in a National Semiconductor R&D Center to compete with Europe's IMEC as a premier open source development center for technology and talent. (*i.e.,* Albany Nanotech or equivalent). America's existing leadership in innovation and R&D could be leveraged into advantage for domestic manufacturing that creates jobs and opportunity here at home.

The U.S. should also invest in leading engineering universities to expand their STEM graduate programs and laboratory facilities for advanced semiconductor studies to increase our domestic capacity to produce PhDs with the necessary skills. Taiwan recently committed $338 million to increase their capacity of semiconductor PhDs.[4]

Through educational policy at the secondary school level, the U.S. should direct science or physics curricula to include exposure to fundamentals of transistors, chips, circuit design and programming within programs that appeal to youth, such as robotics. The U.S. should create additional advocacy and awareness for STEM through afterschool science programs, mentorship, and interschool science-related competitions. Where feasible, creating specialized science and technology affinity-schools within school districts is alternative way to attract and develop nascent talent in an immersive, science-centric environment. Improving U.S. student performance in science and math is a prerequisite for success in creating a larger pool of advanced degree students. KLA encourages a broader discussion with Congress, education experts and industry leaders to create a plan for national-level success.

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[4] *Asian universities step up semiconductor programmes,* University World News, Yojana Sharma, Oct. 22, 2021

Summary

Just as the instruments alone don't make the orchestra, neither is simply funding new chip factories sufficient to restore America's semiconductor leadership.

Along with a fair and hospitable business environment and ongoing R&D investment, having the right talent is a critical component if America is to be successful in reversing the trend of semiconductor technology innovation and manufacturing capacity moving overseas.

To protect America's economic and strategic interests, we must attract, retain and develop our own pool of engineers and skilled workers in this increasingly competitive international market if we're to successfully staff America's future semiconductor fabs.

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