VISION ZERO
zero deaths • zero serious injuries
MONTANA DEPARTMENT OF TRANSPORTATION

Autonomous and Connected Vehicles

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Montana Department of Transportation
October 31, 2019



Quick Overview

http://www.goldmansachs.com/our-thinking/pages/auto-2.0.html?mediaIndex=1&autoPlay=true&cid=PS_02_01_07_00_01_17_01&mkwid=fzIjUYjj

Quick Overview

- Defining Autonomous & Connected Vehicles
- Historic Perspective
- Benefits
- Issues
- Infrastructure needs and impacts

The Road to Full Automation

Fully autonomous cars and trucks that drive us instead of us driving them will become a reality. These self-driving vehicles ultimately will integrate onto U.S. roadways by progressing through six levels of driver assistance technology advancements in the coming years. This includes everything from no automation (where a fully engaged driver is required at all times), to full autonomy (where an automated vehicle operates independently, without a human driver)..

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) AUTOMATION LEVELS

Full Automation

0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

How Soon?

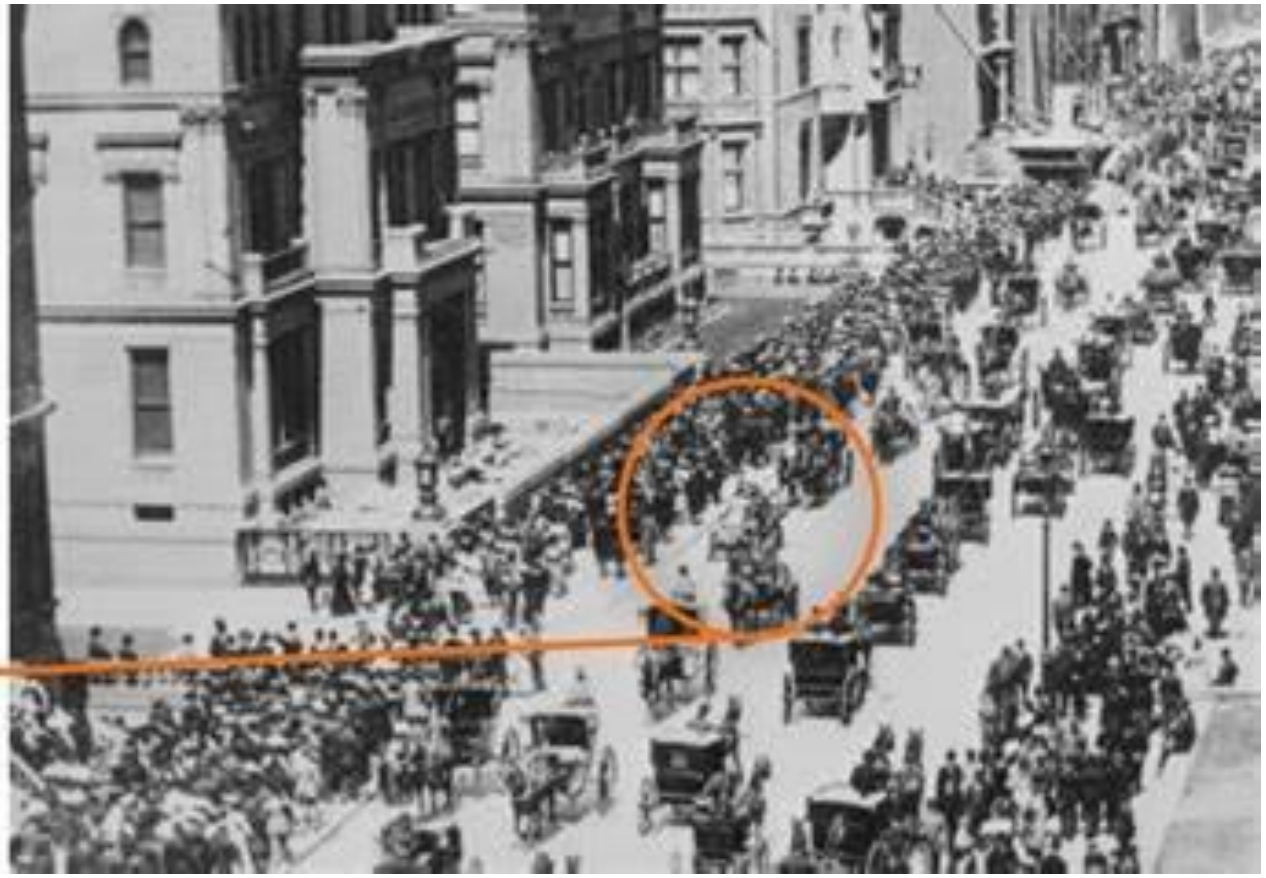
5th AVE NYC

1900

Where is

the

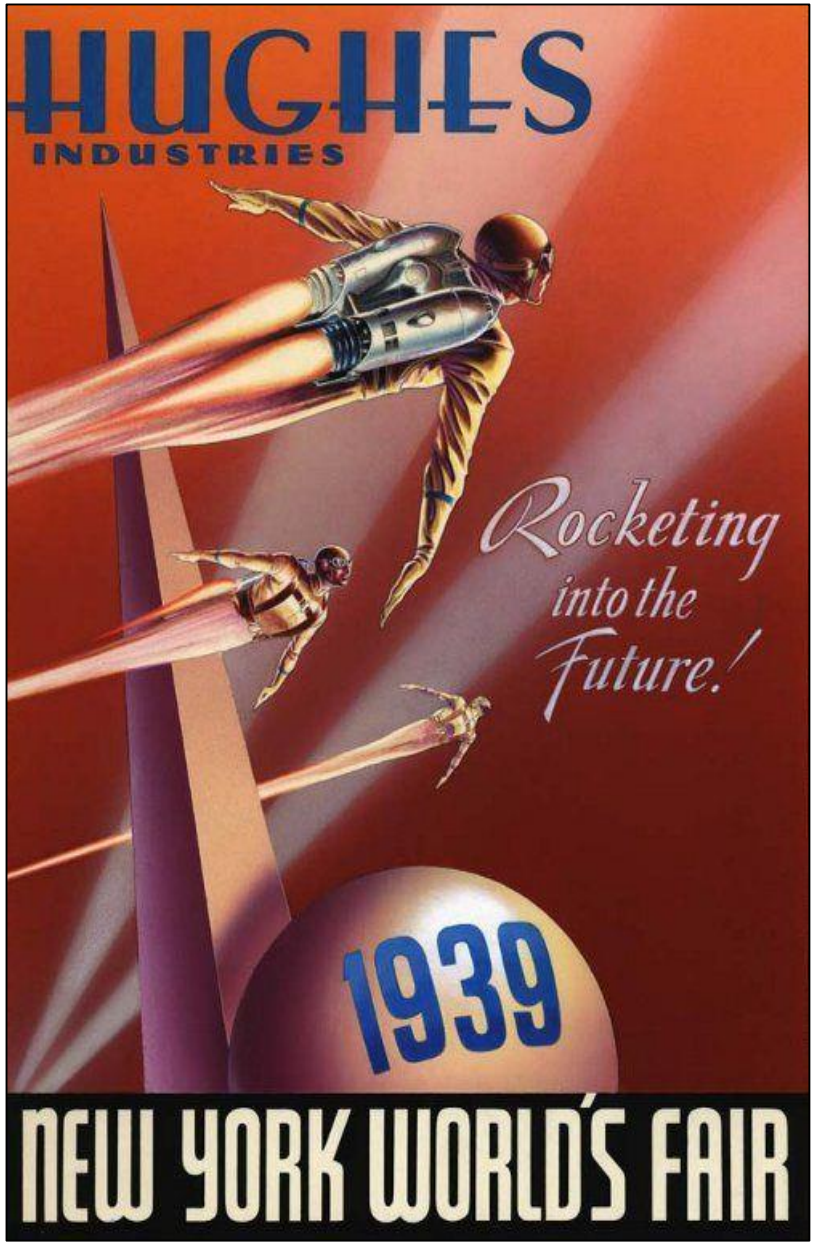
car?



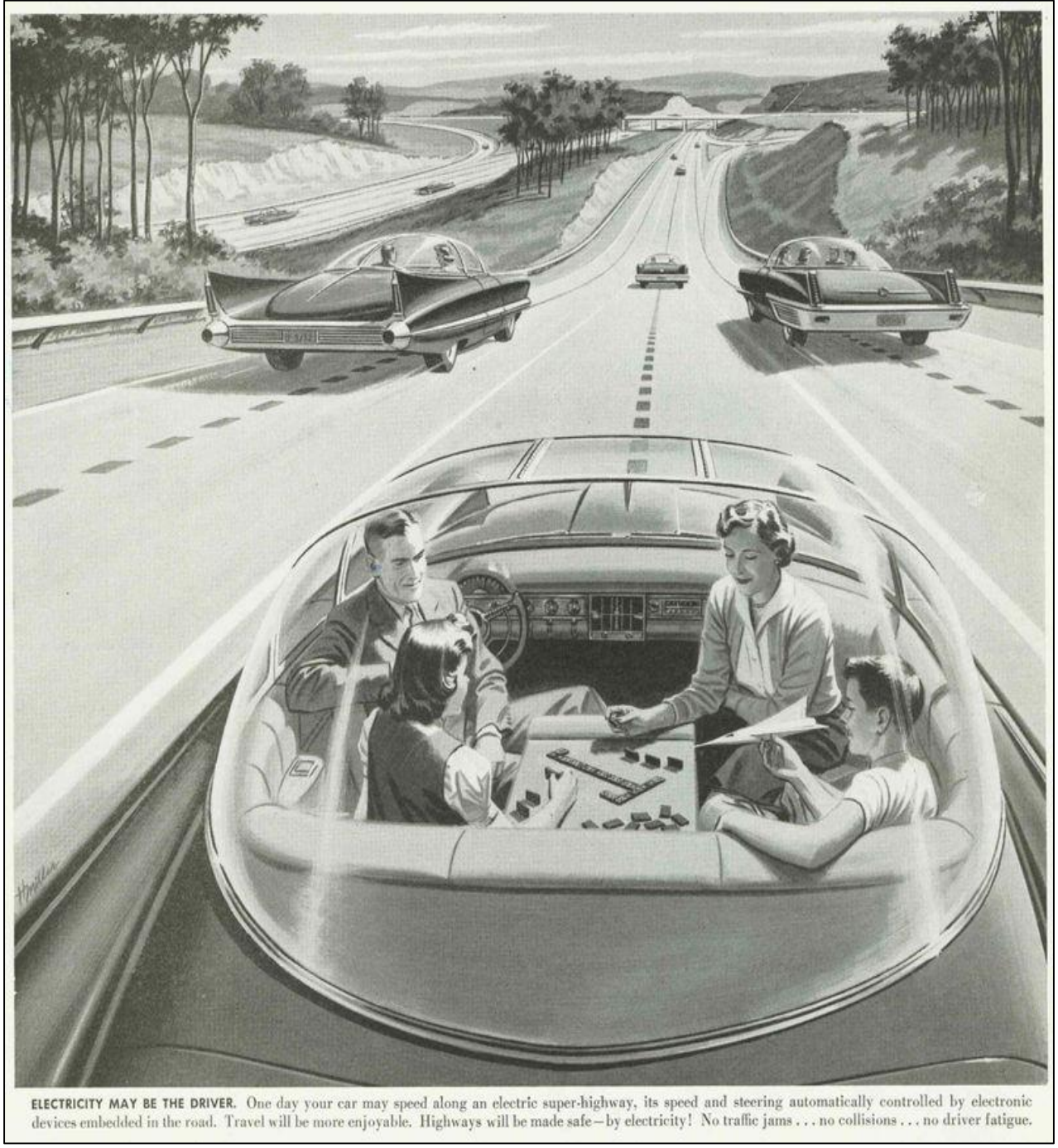
5th AVE NYC

1913

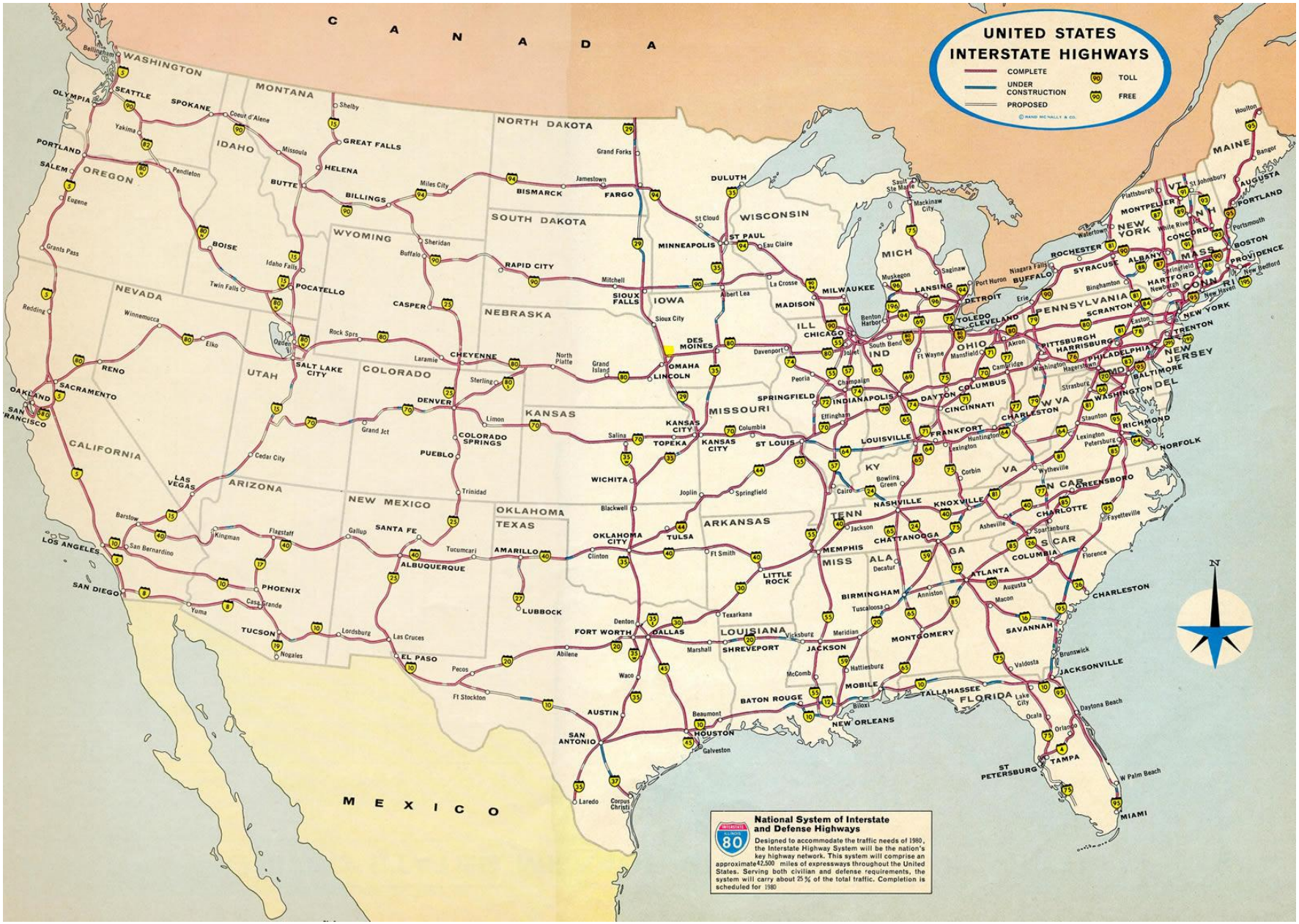
Where is the horse?


HUGHES
INDUSTRIES
Rocketing into the Future!
1939
NEW YORK WORLD'S FAIR


RAILROADS ON PARADE
NEW YORK WORLD'S FAIR-1939
A SUPER-SPECTACLE
Presented by the
EASTERN RAILROADS



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


UNITED STATES
INTERSTATE HIGHWAYS
COMPLETE
UNDER CONSTRUCTION
PROPOSED
TOLL
FREE
© RAND MCNALLY & CO.
C A N A D A
M E X I C O
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
NEW JERSEY
DELAWARE
MARYLAND
SEATTLE
SPOKANE
PORTLAND
SALEM
OLYMPIA
BELLINGHAM
BOISE
BUTTE
HELENA
BILLINGS
GREAT FALLS
MISSOULA
FARGO
BISMARCK
DULUTH
MINNEAPOLIS
ST PAUL
RAPID CITY
SIOUX FALLS
SIOUX CITY
OMAHA
LINCOLN
DES MOINES
CHICAGO
MILWAUKEE
MADISON
DETROIT
TOLEDO
CLEVELAND
BUFFALO
ROCHESTER
SYRACUSE
ALBANY
BOSTON
PROVIDENCE
HARTFORD
NEW YORK
PHILADELPHIA
PITTSBURGH
HARRISBURG
SCRANTON
TRENTON
BALTIMORE
WASHINGTON
RICHMOND
NORFOLK
CHARLESTON
COLUMBUS
CINCINNATI
INDIANAPOLIS
SPRINGFIELD
DAYTON
LOUISVILLE
FRANKFORT
LEXINGTON
NASHVILLE
KNOXVILLE
CHATTANOOGA
MEMPHIS
LITTLE ROCK
ATLANTA
BIRMINGHAM
MONTGOMERY
JACKSON
MOBILE
NEW ORLEANS
BATON ROUGE
SHREVEPORT
DALLAS
FORT WORTH
HOUSTON
AUSTIN
SAN ANTONIO
EL PASO
ALBUQUERQUE
PHOENIX
TUCSON
LAS VEGAS
RENO
SACRAMENTO
OAKLAND
SAN FRANCISCO
LOS ANGELES
SAN DIEGO
SALT LAKE CITY
DENVER
CHEYENNE
KANSAS CITY
ST LOUIS
TOPEKA
WICHITA
TULSA
OKLAHOMA CITY
AMARILLO
LUBBOCK
JACKSONVILLE
TAMPA
MIAMI
ORLANDO
TALLAHASSEE
SAVANNAH
CHARLOTTE
GREENSBORO
RALEIGH
N
National System of Interstate and Defense Highways
Designed to accommodate the traffic needs of 1980, the Interstate Highway System will be the nation's key highway network. This system will comprise an approximate 42,500 miles of expressways throughout the United States. Serving both civilian and defense requirements, the system will carry about 25% of the total traffic. Completion is scheduled for 1980

Early Driver Assistance Features

- Curved Dash Oldsmobile 1901 - 04
- Model T Ford – 1908 (mass produced in 1913)
- Power windshield wipers -- 1922
- Power Brakes – 1935 (estimated)
- Automatic Transmission – 1939
- Air Conditioning -- 1939
- Power Windows -- 1941
- Power Steering – 1951
- Cruise Control – 1958
- Seat Belts – 1958
- Crumple Zones – 1959
- Side Mirrors (standard feature) 1960's
- Fuel Injection (computers in cars) – 1968
- Anti-Lock Brakes – 1970's (autos)
- Airbags – 1973/74
- OnStar – 1997

Advanced Driver Assistance Systems

- Adaptive cruise control (ACC)
- Glare-free high beam and pixel light
- Adaptive light control: swiveling curve lights
- Automatic parking
- Automotive navigation system traffic information.
- Automotive night vision
- Blind spot monitor
- Collision avoidance system
- Crosswind stabilization
- Driver drowsiness detection
- Driver Monitoring System
- Electric vehicle warning sounds
- Electronic stability control
- Emergency driver assistant
- Intersection assistant
- Hill descent control
- Intelligent speed adaptation
- Lane centering
- Lane departure warning system
- Lane change assistance
- Parking sensor
- Pedestrian protection system
- Rain sensor
- Surround View system
- Tire Pressure Monitoring
- Traction control system
- Traffic sign recognition
- Turning assistant
- Vehicular communication systems
- Wrong-way driving warning

Advanced Driver Assistance Systems

- *Onboard computer system*
- *GPS*
- *LIDAR*
- *Radar*
- *Cameras*
- *Sensors*
- *Bluetooth*
- *Wireless communications*


TOPLINE
SCANIA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How Soon?????

- An Estimated $80 Billion invested by private industry (August, 2018)
- Connected Vehicle Technology already in many new automobiles
- 55 Automobile and Tech Manufacturers Testing AV
- GM – 450 fully autonomous vehicles in San Francisco (June, 2019)
- Truck Platooning Pilots in Europe and USA spring and summer of 2019 – testing continues

- *"Speaking at a conference on artificial intelligence yesterday, Tesla CEO Elon Musk updated his timeline prediction for a fully self-driving car to 2 years. He also predicts that another year after that cars will be significantly better drivers than humans." (2017)*

- *"The Institute for Highway Safety predicts that only half of all cars will have the (connected/autonomous) technology by 2026." (2018)*

- *Expert members of the Institute of Electrical and Electronics Engineers (IEEE) predicts up to 75% of vehicles will be autonomous in 2040 (IEEE, 2012-09-05)*

- *Do we have an AV capable of driving from San Francisco to Washington DC (today)? No. But we will in two years" (Dan Ammann CEO GM Cruise -- ITS America Conference June, 2019)*

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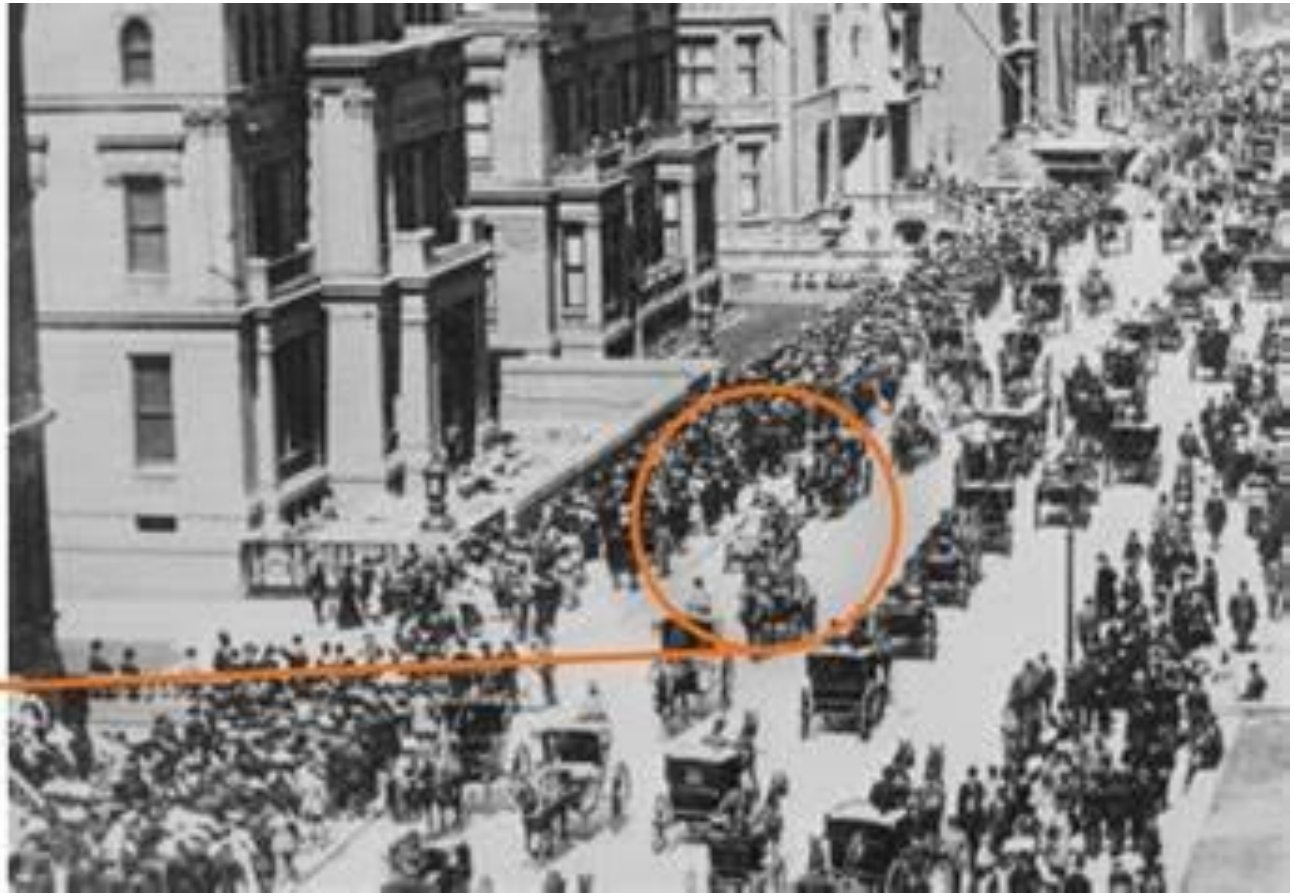

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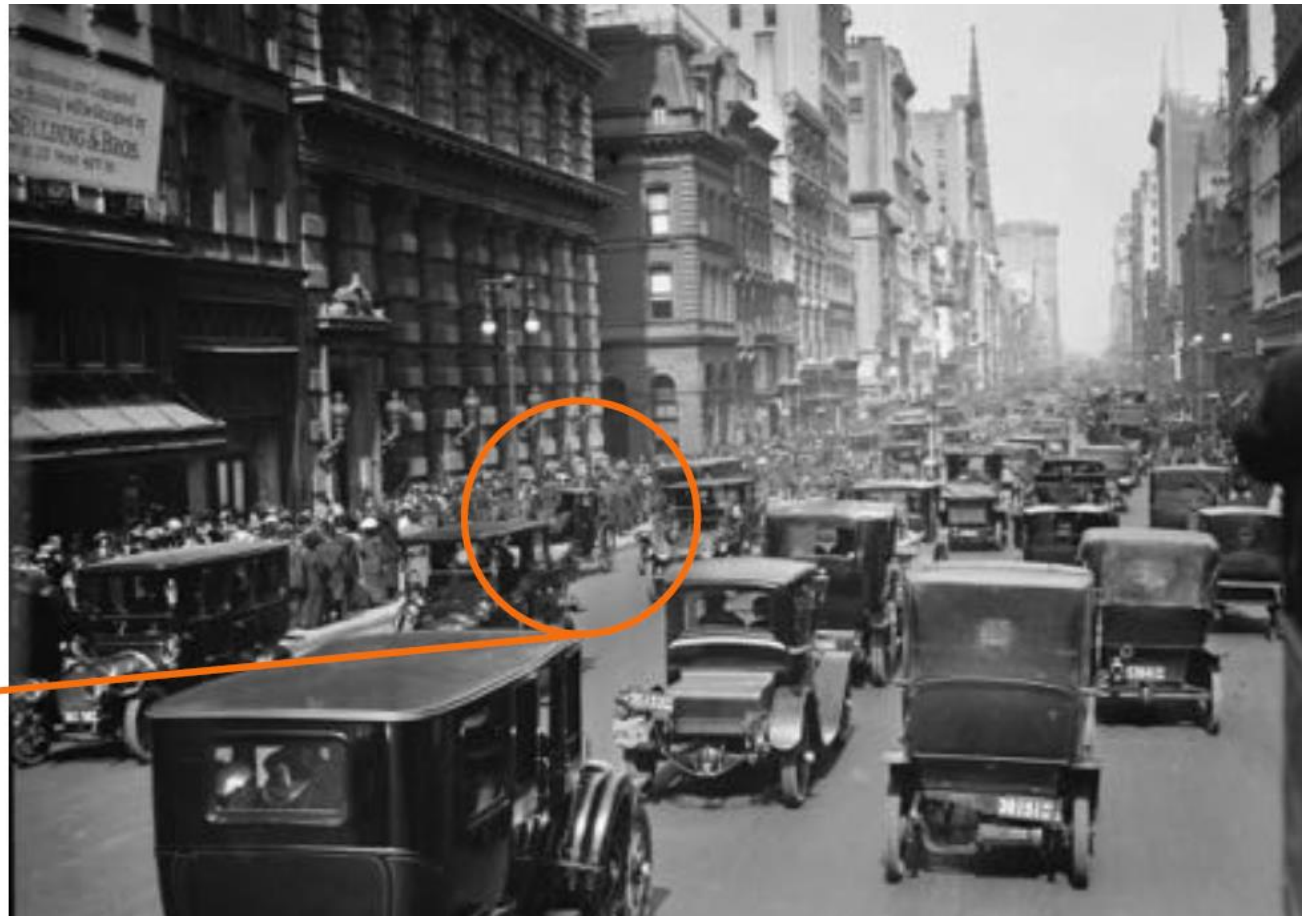


Benefits

- Increased Mobility
- Comfort
- Higher Speed Limits
- Virtual Valet
- Reduction in Traffic Enforcement Needs

Benefits

- Crash Reduction
  - 93% of traffic crashes are due to human error
  - 37,133 automobile related fatalities in 2017

- 2010 NHTSA Statistics
  - 32,999 Vehicle Related Fatalities
  - 3.9 million injuries
  - 24 million vehicles damaged

The economic costs of these crashes (2010) totaled **$242 billion**. Included in these losses are lost productivity, medical costs, legal and court costs, emergency service costs (EMS), insurance administration costs, congestion costs, property damage, and workplace losses. (NHTSA 2015)

Issues (Level 2/3)

Rear-End Collision Between a Car Operating with Advanced Driver Assistance Systems and a Stationary Fire Truck, Culver City, California, January 22, 2018

Level 2/3 issues

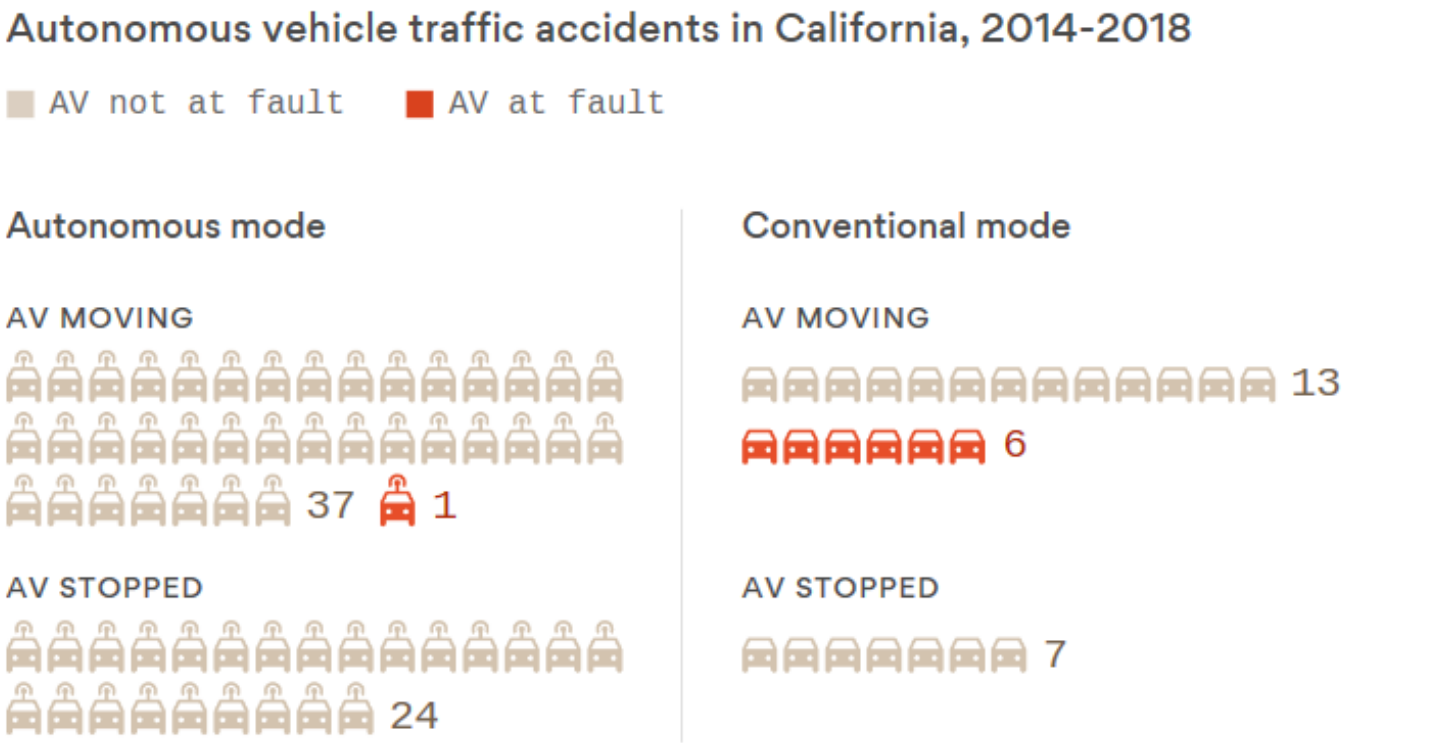
"The driver said that he received an owner's manual when he bought the car but did not read it. A salesman at the Tesla dealership instructed him on how to use the technology"

Traffic-Aware Cruise Control is designed for your driving comfort and convenience and is not a collision warning or avoidance system. It is your responsibility to stay alert, drive safely, and be in control of the vehicle at all times. Never depend on Traffic-Aware Cruise Control to adequately slow down Model S. Always watch the road in front of you and be prepared to take corrective action at all times. Failure to do so can result in serious injury or death.

Traffic-Aware Cruise Control cannot detect all objects and may not brake/decelerate for stationary vehicles, especially in situations when you are driving over 50 mph . . . and a vehicle you are following moves out of your driving path and a stationary vehicle or object is in front of you instead.

Level 4 & 5

People cause most California autonomous vehicle accidents



Data: State of California Department of Motor Vehicles; Note: As of August 24, 2018; Icon: Guilhem/The Noun Project; Chart: Andrew Witherspoon/Axios

Issues Level 4 & 5

- Liability
- Manual Override
- Software Issues
- Loss of Jobs
- Education
- Policy

Infrastructure Needs & Impacts

- Communication
  V to V, V to I, V to X
- Transportation Management Center
- Transmitting and Transferring Data (Security?)
- Lane Management
- Integrity of Existing Infrastructure

Ehang 184 – capable of flying 62 mph for 23 minutes with a 220lb capacity. First passenger flights took place in China 2017/18