Self-driving cars

by Hari Chittilla and Dennis Sun

Question

How would you define a self-driving car?

Definition: What is an autonomous car?

- Autonomous Car: A driverless vehicle capable of fulfilling the main transportation capabilities of a traditional car.

Classifications of Autonomy according to the NHTSA.

- Level 0: The driver completely controls the vehicle at all times.
- Level 1: Individual vehicle controls are automated, such as electronic stability control or automatic braking.
- Level 2: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping.
- Level 3: The driver can fully cede control of all safety-critical functions in certain conditions and the car provides a "sufficiently comfortable transition time" for the driver to do so.
- Level 4: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time.

Purpose

What kinds of things does a self-driving car need to be able to do?

Purpose

- navigate to a given destination based on passenger-provided instructions
- avoid environmental obstacles
- safely avoid other vehicles
- obey the laws of the road

History

E SENTINEL. Phone Broadway 5000 WEDNESDAY, DECEMBER 8, 1926.

NNE SOUGHT ACK, NOT JOHN, HUBBARD PLEA

o Need to Marry to Get a Man's Money, Actress Is Quoted.

By Universal Service.

PITTSBURGH, Dec. 7.—"There e other ways of getting a man's oney than by marrying him."

With these, the words of Anne ldwell, defense counsel today tried show that Miss Caldwell, comely ow girl, knew all the time that hn W. Hubbard, Pittsburgh mil-naire, whom she is suing for 00,000 heart balm, had no inten-n of marrying her. The state-ent was revealed in a deposition of rs. Maude Von Haven, who worked ongside Miss Caldwell in an At-ntic City fashion shop four years o when Hubbard and the plaintiff t met.

"I told her," Mrs. Von Haven tes-fied, "that Jack Hubbard was not marrying man and she answered, here are other ways of getting a an's money besides marrying m.'" Other witnesses were Nor-an Bel Geddes, artist and movie rector, and V. Babcock, former ayor of Pittsburgh and now a unty commissioner. Bel Geddes ested the implication of the de-nse that he and Miss Caldwell ere intimate on a train ride from hicago to California.

The defense scored its strongest oint today with the testimony of . B. Montgomery, assistant clerk f the Traymor hotel in Atlantic ity, who produced the hotel regis-er to show that Hubbard was not egistered there between the latter art of January and the early part f February, 1922, the period in hich Miss Caldwell charged she as with the millionaire in his ho-el room.

Woman, 96, Suing

PASTOR QUITS CHURCH; LAW IS BETTER PAY

Congregations Unfai Preacher Declares in Resignation.

By FRED VAN DEVENDER, Universal Service Correspondent.

CHICAGO, Dec. 7.—The greatest fault of the church today is not the wrangling over sectarianism, but in the treatment of ministers by the individual congregations, the Rev. William Aitchison declared in his resignation as pastor of the First Congregational church of Blue Island, effective Feb. 1.

"The Christian church today is not treating its ministers fairly from either the economic or social point of view," the Rev. Mr. Aitchison declared.

BECOMES BARRISTER.

So, not wishing to be mistreated, the pastor got out of the game and will center his interest in the practice of law, which he has been doing since he passed the bar examination two years ago.

His divided duties between the courts and his church brought down the ire of his immediate superiors, the deacons of the church, and then there came the proverbial straw and the camel's back—or rather the preacher's—was broken.

"In the present state of affairs," the minister declared, "the young man with ambition, integrity and moral character can find far better opportunity in the legal profession than in the church.

SALARIES TOO LOW.

"The fault with the church, as I see them, are not so much in the wranglings over sectarianism, although they are bad enough. The chief fault is in the individual congregations. They are affected to a marked degree by the condition of unrest in the church.

Loses Husband

FANNIE HEASLIP LEA.

Hamilton Pope Agee of Honolulu has been granted a divorce from Fannie Heaslip Lea Agee, authoress, on a complaint charging desertion.

CHURCH NAMES OFFICERS.

Louis Behling was elected to the board of trustees of the St. Matthews Lutheran church at the annual election and business meeting of the church yesterday. Others elected were: Paul Schmidt, member of the church council; Otto Weise, member of the school board, and Henry Weigand, almoner.

'PHANTOM AUTO' WILL TOUR CITY

A "phantom motor car" will haunt the streets of Milwaukee today.

Drivers, it will start its own motor, throw in its clutch, twist its steering wheel, toot its horn, and it may even "pass" the policeman at the corner.

The "master mind" that will guide the machine as it prowls in and out of the busy traffic will be a radio set in a car behind. Commanding waves sent from the second machine will be caught by a receiving set in the "ghost car."

The tour, conducted by the Achen Motor company, will start at 11:30 a. m. from the company's rooms at Oneida and Jackson streets, will go west on Oneida to Broadway, north to Martin, west to Elchth, south to Grand, west to viaduct, where it will "about face" and return on Grand to Eighth, south to Sycamore, then east to Broadway and back to the sales rooms. Tomorrow the car will visit Milwaukee-Downer and the Normal school.

WEDNESDAY, DECEMBER 8, 1926. 91 Mason Street

LAWYER QUITS DIVORCE POST WITH COUNTY

Walter Wallschlaeger Was Suspended by Wengert Nov. 27.

Walter Wallschlaeger, suspended as divorce counsel Nov. 27 by Dist. Atty. Eugene Wengert, on charges of incompetency and offensive conduct toward women and girls visiting his office, handed his resignation to the district attorney yesterday.

Mr. Wengert sent word at once to the county civil service commission that a hearing on the charges against Mr. Wallschlaeger will be unnecessary.

The action of Mr. Wallschlaeger came as a surprise, as he had announced last week that he would fight the charges and prove they were unfounded.

He was given an opportunity to resign by Mr. Wengert before the charges were filed, but refused.

The civil service commission is expected to announce an examination in the near future for the purpose of filling the vacancy. The position pays $4,200 a year.

Civic Service Board Will Not Waive Quiz

The appointment of a supervisor of annexation must be made after an examination and can not be made without examination under the "expert" section of the city service rules, it was decided at a meeting of the city service commission last night. The commission was asked to waive examination to permit appointment of Arthur Werba, now a provisional appointee, to the position. Reclassification of eighteen minor offices in the city hall was voted.

Augusta Gezelschap's Funeral to Be Today

Divorcing Dick

Mary Hay.

NEW YORK, Dec. 7.—(Universal)—Richard K. Bartheimess, of motion picture fame, arrived here today on the Majestic and announced he will leave for the coast Saturday.

He admitted freely that Mary Hay, dancer and his wife, is in Paris to get a divorce. He almost wept when he admitted it.

109 FOREIGNERS ENROLL AT 'U'

By Special Correspondent.

MADISON, Wis., Dec. —Exactly 109 students from 24 foreign countries are enrolled at the University of Wisconsin this semester, according to a tabulation made by Scott H. Goodnight, dean of men.

China, as usual, has sent far

FAKED ST SIGN NETS

Salesman Is by Fictiti for $129,00

City government and Chicago were a novel swindle cago yesterday.

The victim is a sign company wh worth of street a wants or ordered $17,000 as a comm man who pretende signs.

The salesman, kn a year ago offere company to L. J. tendent of signs street department, chased none, but ten on street depa was sent to Roche name was signed. $17,000 was paid was to get $20,000 ment was made.

The first of the Chicago. Green and explained that intended for Mil been misdirected, asked the Chicago to send the signs til Milwaukee ne more shipments ca sent to the ware officials.

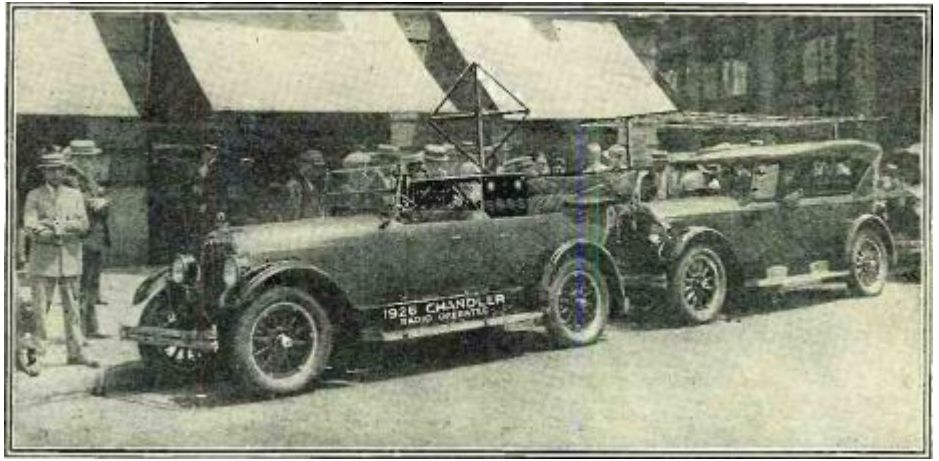
Yesterday officia pany, wondering not made, learned not been ordered Milwaukee nothin transaction.

Police Fun $100 Re

The Milwaukee benefit fund rece terday for $100,

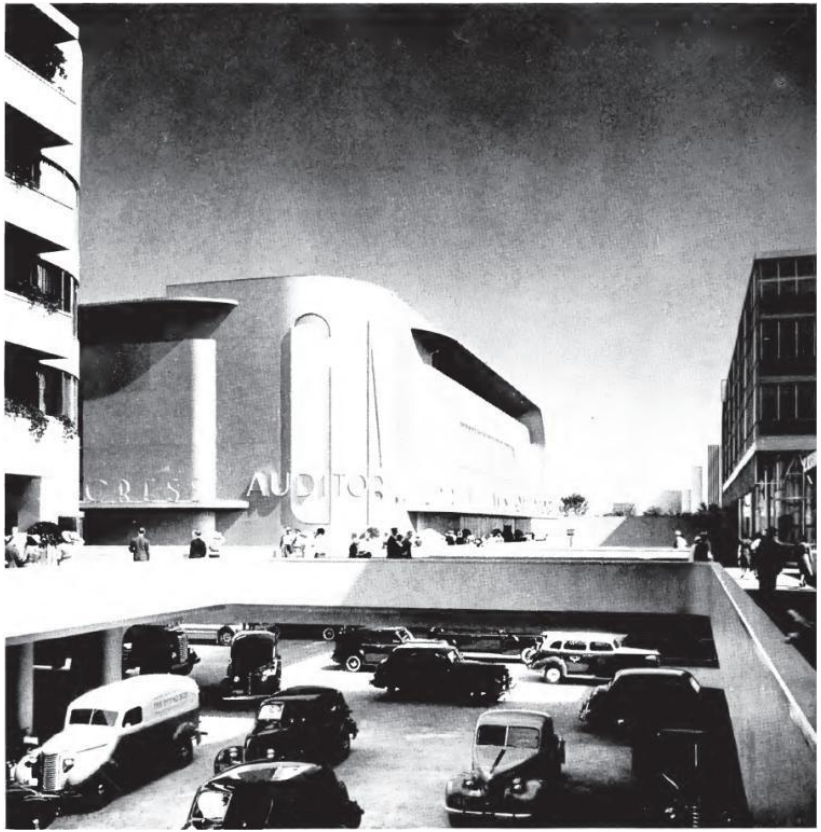
Linrrican Wonder

- Houdina Radio Control, 1925
- Made by Francis P Houdina
- Traveled up Broadway and down Fifth Avenue through the thick of the traffic jam



Futurama

- sponsored by General Motors at the 1939 World's Fair
- radio-controlled electric cars
  - propelled via electromagnetic fields



RCA Labs

- 1953- RCA Labs built a miniature car guided and controlled by wires
- 1958- Full sized system made
  - developed in collab. with General Motors

Mercedes Benz

- 1980’s- vision-guided Mercedes-Benz robotic van
  - designed by Ernst Dickmanns and his team at the Bundeswehr University Munich
- achieved a speed of 39 miles per hour (63 km/h) on streets without traffic

History

- Carnegie Mellon’s Navlab and ALV projects in 1984
- Mercedes-Benz and Budeswehr University Munich’s EUREKA Promethius Project in 1987
- Others:
  - Continental Automotive Systems, IAV, Autoliv Inc., Bosch, Nissan, Renault, Toyota, Audi, Volvo, Peugeot, AKKA Technologies, Vislab from University of Parma, Oxford University, Google
    - these companies were more prevalent 2010-2015

DEMO I, II, and III

- US-funded military efforts
- demonstrated the ability of unmanned ground vehicles to navigate miles of difficult off-road terrain

The Grand Challenges (I, II, and III)

- a fundamental problem in science or engineering, with broad applications, whose solution would be enabled by the application of high performance computing resources that could become available in the near future
- Grand Challenges were US policy terms set as goals in the late 1980s for funding high-performance computing and communications research

DARPA Grand Challenge (2004)

- DARPA (Defense Advanced Research Projects Agency)
- March 13, 2004 in the Mojave Desert
- No cars finished
- Sandstorm from CMU traveled furthest: 11.78 km (7.32 mi)

Grand Challenge II (2005)

- 6:40am on October 8, 2005

Vehicle	Team Name	Team Home	Time Taken (h:m)	Result
Stanley	Stanford Racing Team	Stanford University, Palo Alto, California	6:54	First place
Sandstorm	Red Team	Carnegie Mellon University, Pittsburgh, Pennsylvania	7:05	Second place
H1ghlander	Red Team		7:14	Third place
Kat-5	Team Gray	The Gray Insurance Company, Metairie, Louisiana	7:30	Fourth place
TerraMax	Team TerraMax	Oshkosh Truck Corporation, Oshkosh, Wisconsin	12:51	Over 10 hour limit, fifth place

Grand Challenge III (2007) aka Urban Challenge

- November 3, 2007 at the site of the now-closed George Air Force Base
- 96 km (60 mi) urban area course, to be completed in less than 6 hours
- obey all traffic regulations while negotiating with other traffic and obstacles and merging into traffic

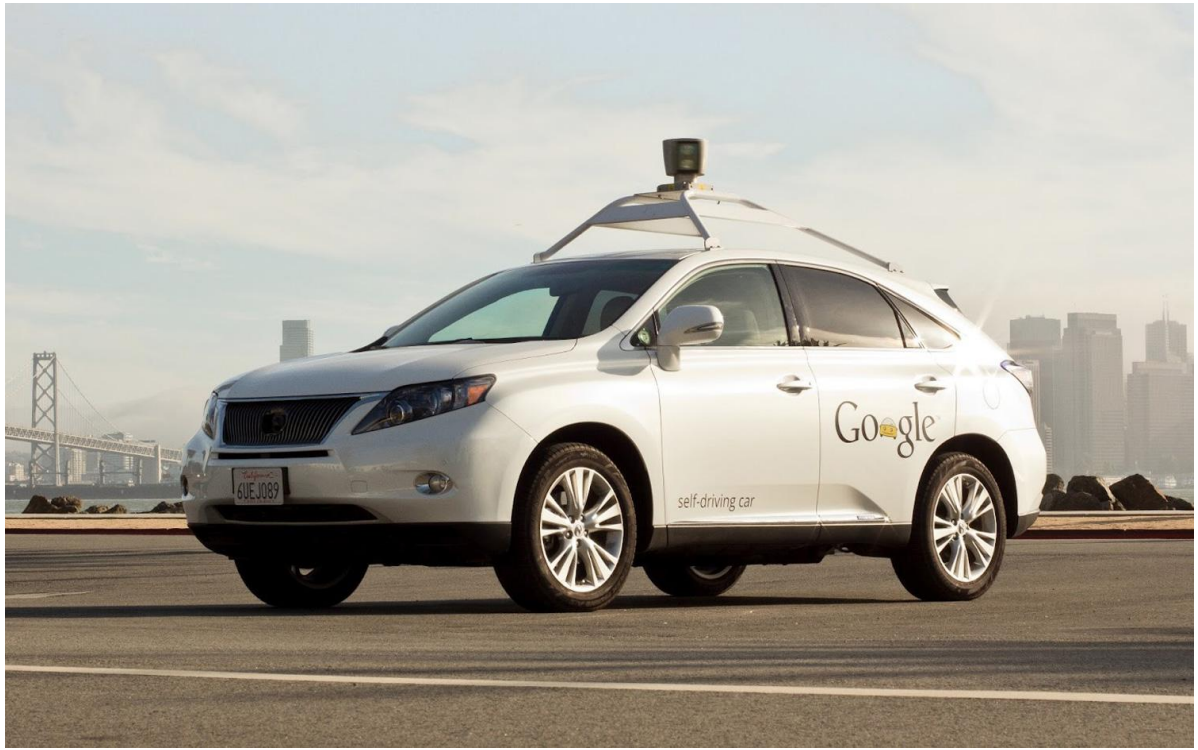
Team Name	ID#	Vehicle	Type	Team Home	Time Taken (h:m:s)	Result
Tartan Racing	19	Boss	2007 Chevy Tahoe	Carnegie Mellon University, Pittsburgh, Pennsylvania	4:10:20	1st Place; averaged approximately 14 mph (22.53 km/h) throughout the course[6][7]
Stanford Racing	03	Junior	2006 Volkswagen Passat Wagon	Stanford University, Palo Alto, California	4:29:28	2nd Place; averaged about 13.7 mph (22.05 km/h) throughout the course[8]
VictorTango	32[9]	Odin	2005 Ford Hybrid Escape	Virginia Tech, Blacksburg, Virginia	4:36:38	3rd Place; averaged slightly less than 13 mph (20.92 km/h) throughout the course[6]
MIT	79	Talos	Land Rover LR3	MIT, Cambridge, Massachusetts	Approx. 6 hours	4th Place.[10]
The Ben Franklin Racing Team	74	Little Ben	2006 Toyota Prius	University of Pennsylvania, Lehigh University, Philadelphia, Pennsylvania	No official time.	One of 6 teams to finish course
Cornell	26	Skynet	2007 Chevy Tahoe	Cornell University, Ithaca, New York	No official time.	One of 6 teams to finish course

Google

Google’s Technology

- $150,000 in equipment including a $70,000 LIDAR system
- The range finder mounted on the top is a Velodyne 64-beam laser. This laser allows the vehicle to generate a detailed 3D map of its environment.
- The car uses data collected from these mechanisms to drive itself.

Google’s Technology



How it works: Lidar system

- Laser + radar
- The system detects obstacles and tells the car when to avoid them to navigate safely.
- It uses a 3D point cloud output provide the necessary data for robot software to determine where potential obstacles exist in the environment and where the car is is located relative to those obstacles.

How it works: Velodyne

- Company started experimenting with laser distance in 2005 with the DARPA Grand Challenge
- Since then, they have vastly reduced the size of the sensor and weight while improving its performance.
- It is a premier lidar system

How does communication among driverless cars work?

- vehicles and roadside units as the communicating nodes
    - DSRC devices- 5.9 GHz band with bandwith of 75 MHz- range of 1000m

Communication among driverless cars cont.

- Smart intersections
  - intersections with no lights that communicate for autonomous cars
  - 2012- University of Texas in Austin

Google’s Track Record

- As of July 2015, Google’s cars have been involved in 14 “minor accidents”.
  - only one had resulted in minor injuries
- They’ve logged 1.7 million miles, and Google claims not a single collision was caused by the self-driving mechanisms

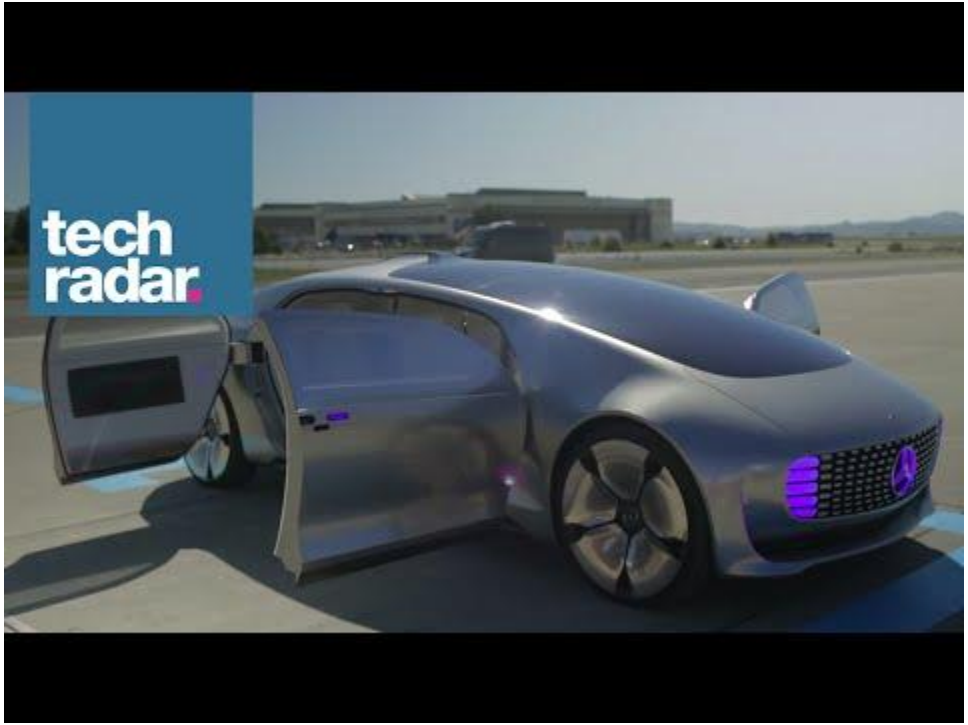
Are we going to see Google on the road soon?

Google plans to make these cars available to the public in 2020.

Other Companies involved (since 1987)

Mercedes-Benz	Audi
General Motors	Volvo
Bosch	Peugeot
Nissan	Uber
Renault	Google
Toyota	Tesla

Mercedes Benz



Audi

Tesla’s Current Auto Pilot

Potential advantages

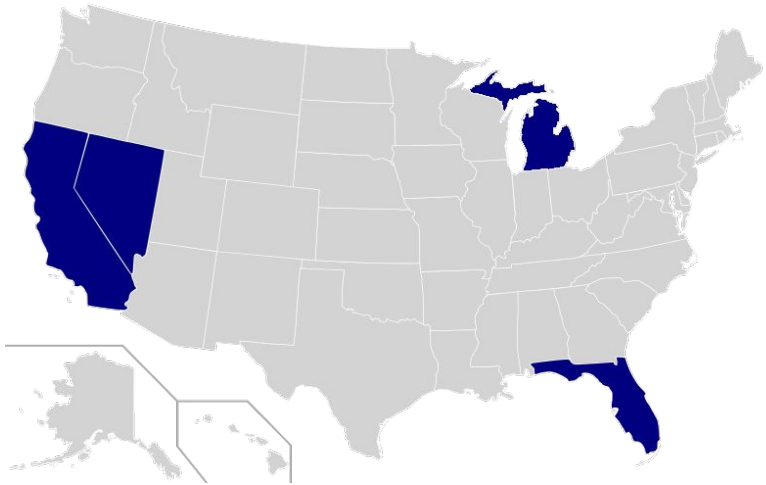
- being able to get things done while in traffic or on the road
- increase road capacity
- fewer traffic collisions. Experts estimate 300,000 lives can be saved per decade
- higher speed limits
- reduction in traffic police
- removal of limitations on drivers — age and sobriety won’t be an issue

Potential obstacles

- Liability for damage
- Resistance by individuals to forfeit control of their cars
- Software reliability
- Implementation of legal framework and establishment of government regulations for self-driving cars
- Drivers being inexperienced if situations arose requiring manual driving
- Loss of driving-related jobs
- Loss of privacy

Legislation

In the United States, state vehicle codes generally do not envisage — but do not necessarily prohibit — highly automated vehicles.



Public Opinion

What do you think?

Would you be comfortable with an autonomous vehicle?

Public Opinion

- of 2,006 surveyed consumers, 49% would be comfortable
  - Accenture, 2011
- of 17,400 owners, 37% would be interested purchasing a self driving
  - 2012, J.D. Power and Associates
  - dropped to 20% if the technology costs $3000 or more
- of 1,000 German drivers, 10% undecided, 44% skeptical, 24% hostile
  - 2012, automotive researcher Puls

Discussion: Liability

- Situation: If a traditional automobile gets hit by a driverless car, who is responsible?
- Opinion?
- Take a minute talk with the person next to you and decide what you think.

Discussion: Children

- Situation: Driverless cars may one day be able to pick a child up from school and take him home if the laws permit
- Opinion?

Discussion: Licenses

- If driverless cars are a thing of the future, will driver licenses be a thing of the past?
- Opinion?
- Take a minute talk with the person next to you and decide what you think.
-

Discussion: Morals

- If there was a choice to swerve into a schoolbus and potentially kill the children onboard but save the driver, or divert the car to kill the driver but save the children, how should the car be programmed?
- A real life application of The Trolley Problem
- Opinions?
- Take a minute talk with the person next to you and decide what you think.
-

Discussion: Jobs

- Will there still be a demand for auto insurance? What about public transportation and taxi jobs, just to name a few?
- Opinion?

Predictions: Possible Developments

- By 2016, Mercedes plans to introduce "Autobahn Pilot" aka Highway Pilot, the system allows a car to automatically pass someone while driving on a highway.
- By early 2017, the US Department of Transportation hopes to publish a rule mandating vehicle-to-vehicle (V2V) communication.
- By 2018, Elon Musk expects Tesla Motors to have developed mature serial production version of fully self-driving cars, where the driver can fall asleep behind the wheel.

Predictions: Possible Developments

- By 2018, Nissan anticipates to have a feature that can allow the vehicle maneuver its way on multi-lane highways.
- By 2020, Volvo envisages having cars in which passengers would be immune from injuries.
- By 2020, GM, Mercedes-Benz, Audi, Nissan, BMW, Renault, Tesla, Google and Toyota all expect to sell vehicles that can drive themselves at least part of the time
- By 2020, Google autonomous car project head's goal to have all outstanding problems with the autonomous car be resolved.

Questions?

Thanks

- Dr. Ming Lin