The Way Forward for Self Driving Cars

A General Perspective

Quite possibly, the first wide reaching and profound integration of personal robots in society.
-Lex Fridman, MIT


CHANGE CARS FOR
PLUMSTEAD & ABBEY WOOD

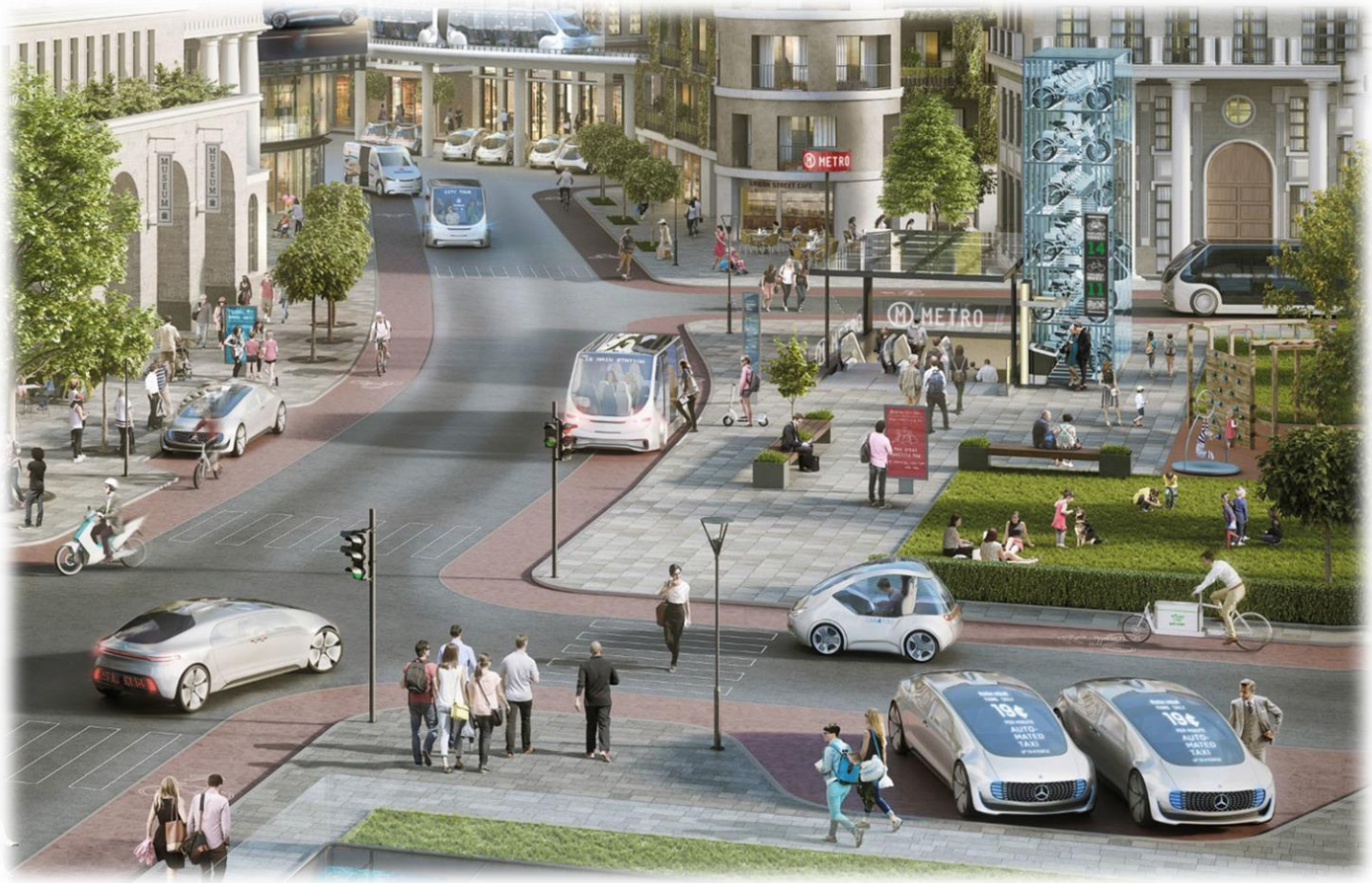
How would you imagine a future with Self Driving Cars?

Do you imagine working on your commute?

Maybe taking meetings on the road?

Do you imagine your groceries delivered?

Do you imagine our cities changed?



Autonomous driving will enable a new "Passenger Economy" worth **US$7 trillion** – according to Intel study

53 Companies have acquired licenses to test Self Driving Cars on California roads

State of California
Department of Motor Vehicles

Offices | Online Services

Permit Holders (Testing with a Driver)

As of April 1, 2018, DMV has issued Autonomous Vehicle Testing Permits (with a driver) to the following entities:

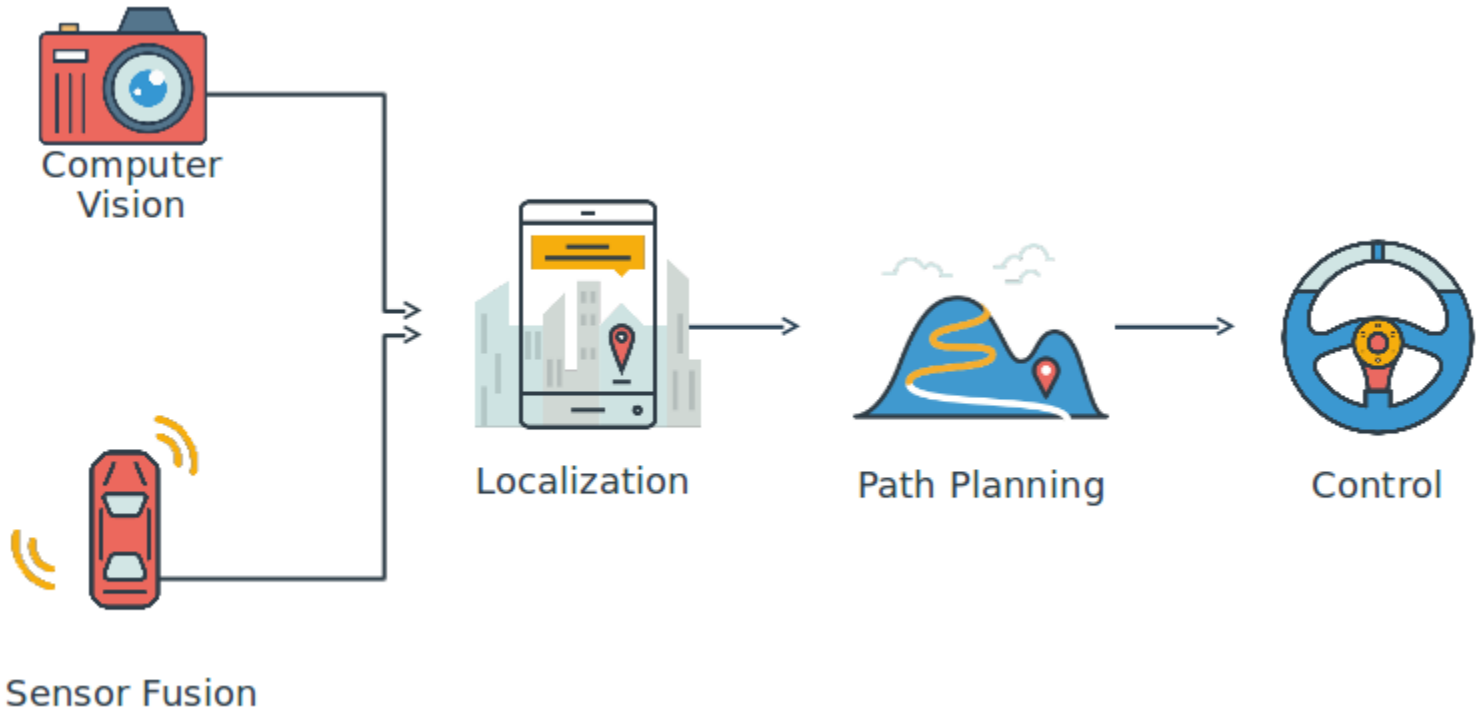
(Permit holders are listed by the date the permit was issued)

- Volkswagen Group of America
- Mercedes Benz
- Waymo LLC
- Delphi Automotive
- Tesla Motors
- Bosch
- Nissan
- GM Cruise LLC
- BMW
- Honda
- Ford
- Zoox, Inc.
- Drive.ai, Inc.
- Faraday & Future Inc.
- Baidu USA LLC
- Valeo North America, Inc.
- NIO USA, Inc.
- Telenav, Inc.
- NVIDIA Corporation
- AutoX Technologies Inc
- Subaru
- Udacity, Inc
- Navya Inc.
- Renovo.auto
- PlusAi Inc
- Nuro, Inc
- CarOne LLC
- Apple Inc.
- Bauer's Intelligent Transportation
- Pony.AI
- TuSimple
- Jingchi Corp
- SAIC Innovation Center, LLC
- Almotive Inc
- Aurora Innovation
- Nullmax
- Samsung Electronics
- Continental Automotive Systems Inc
- Voyage
- CYNGN, Inc
- Roadstar.Ai
- Changan Automobile
- Lyft, Inc.
- Phantom AI
- Qualcomm Technologies, Inc.
- aiPod, Inc.
- SF Motors Inc.
- Toyota Research Institute
- Apex.AI
- Intel Corp
- Ambarella Corporation
- Gatik AI, Inc.

Societal perspective & Consequenses

- Cities expanded
- Lives improved
  - Over 3400 deaths in traffic each day worldwide (acc. WHO in 2015)
  - About 50000 injuries in traffic each day worldwide (acc. WHO in 2015)
- Cost of mobility reduced
- Enabled mobility for:
  - Blind
  - Elderly
  - Young
  - Disabled

Pipeline for a mobile robot (Self Driving Car)



Definitions of Autonomy (by SAE)

- Level 1 – “Hands on” driver assistance systems (Adaptive Cruise Control)
- Level 2 – “Hands off” driver assistance systems (Tesla Model S,≡,X)
- Level 3 – “Eyes off”, but ready to intervene within some limited time
- Level 4 – Fully self driving within a certain area or under certain conditions
- Level 5 – Fully self driving everywhere under all conditions

Top Players

1. Waymo
2. Tesla
3. GM
4. Baidu
5. Ford

? Zoox

Waymo

- Heavy focus on Simulation
  - 25k cars running 24/7
  - 4,4 billion km total
- 8 000 000 km driven on road
  - 0.18 disengagements per 1600 km (1000miles)
- Launched level 4 system in Phoenix Arizona fall of 2017
  - Aiming for ridesharing in certain areas
- Formerly google self driving project (2009-2016)
  - have access to all of googles resources

Tesla

- High focus on vision/camera
  - Internal research on AI
- Struggled after split with Mobileye
- Close to 300k cars on the road
  - Massive fleet learning (when autopilot is engaged)
- Approach: “Enable your car to make money for you when you aren't using it”

GM (Cruise)

- Testing in challenging environment
  - San Francisco
  - New York
- 212 000 km driven on road in 2017
  - 0.8 disengagements per 1600 km (1000 miles)
- 100 years of car manufacturing experience
  - Building the vehicle from ground up
- Acquired Strobe (Lidar company) in fall of 2017
- Deploying self-driving cars as a Commercial service in 2019

Baidu

- The Google of China

- Open sourced a Self Driving Car platform called “Apollo”
  - Aims to sell HD maps as a service

Ford

- Planning to spend US$11 billion on Evs by 2022
- Invested US$1 billion in Argo AI in 2017

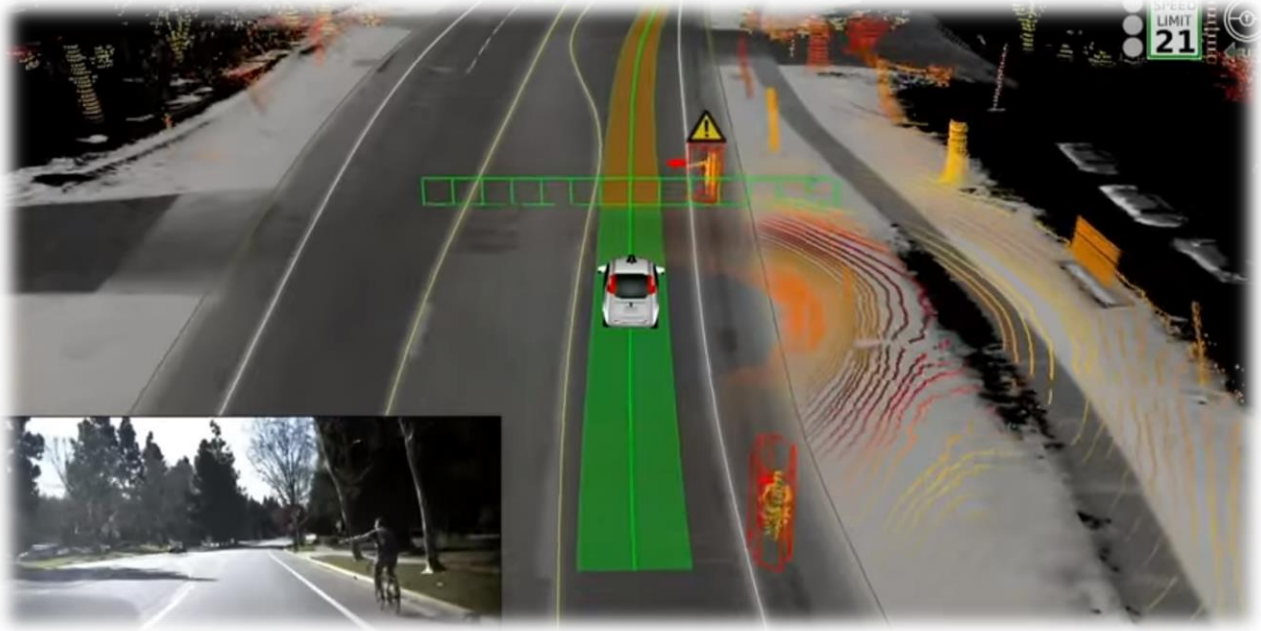
- Working on delivery services with Domino’s and Postmates
- Started testing of level 4 system in Miami
  - ride-hailing and deliveries

Zoox

- Valuated at US$2 billion
- Top talent from Apple, Tesla, Ferrari Nvidia, NASA ++
- Currently in Stealth mode
- Aims to provide the next generation of mobility-as-a-service in urban environments

Observations

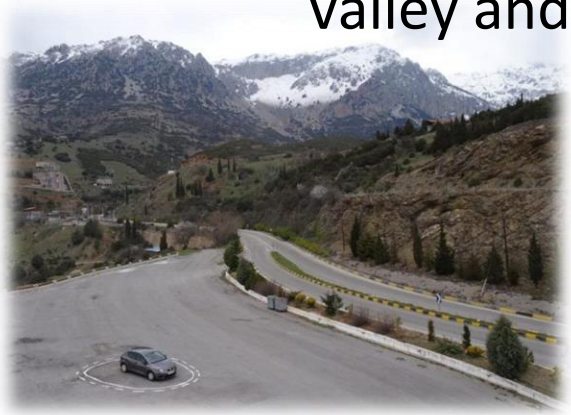
- Machine Learning is a key technology for all players
- All need billions of miles – “Data is the new oil”
- Prediction, Scene understanding and Social interactions as the toughest challenges
- All companies located in Silicon Valley and/or Pittsburgh



Reflections

Some questions arise:

- When will we be able to use self driving cars as a part of our everyday life?
- What paths can be taken to be a part of this billion dollar industry?
- Why is there so much talent on self driving cars focused in and around Silicon Valley and Pittsburgh?



What about road situations not defined by law and regulations?


GRAND
DARPA
CHALLENGE
Autonomous Ground Vehicles


CATERPILLAR
MDV


FINISH
GM
MDV


DARPA URBAN CHALLENGE
SOUTHERN CALIFORNIA LOGISTICS AIRPORT
VICTORVILLE, CA


DARPA
FINISH


CATERPILLAR
DARPA


intel
MDV


CATERPILLAR
19

Winning Teams

Team Stanford

A leader of the second-place team initiated the migration to Google, which would soon become the center of autonomous driving research.

Michael Montemerlo
Planning & Optimization

Sebastian Thrun
Overall Lead

Jesse Levinson
Static Localization & Mapping

Dmitri Dolgov
Planning & Optimization

Anthony Levandowski
Sensors

Team Carnegie Mellon

The ultimate winner of the DARPA Urban Challenge in November 2007.
Their self-driving vehicle executed a three-point turn in traffic.

Bryan Salesky
Software Lead

Red Whittaker
Overall Lead

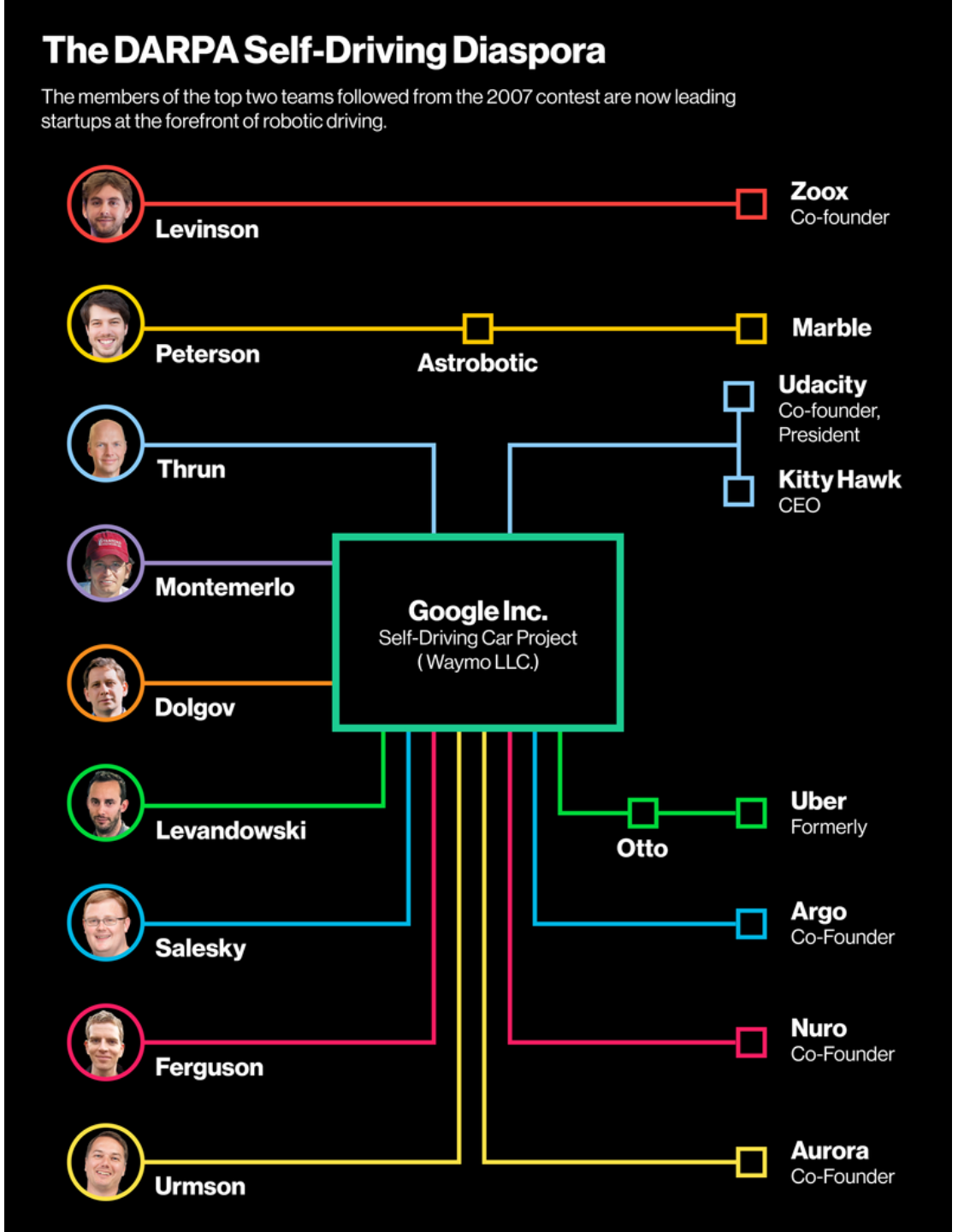
Chris Urmson
Director of Technology

Kevin Peterson
RedTeam Lead

Dave Ferguson
Planning Lead

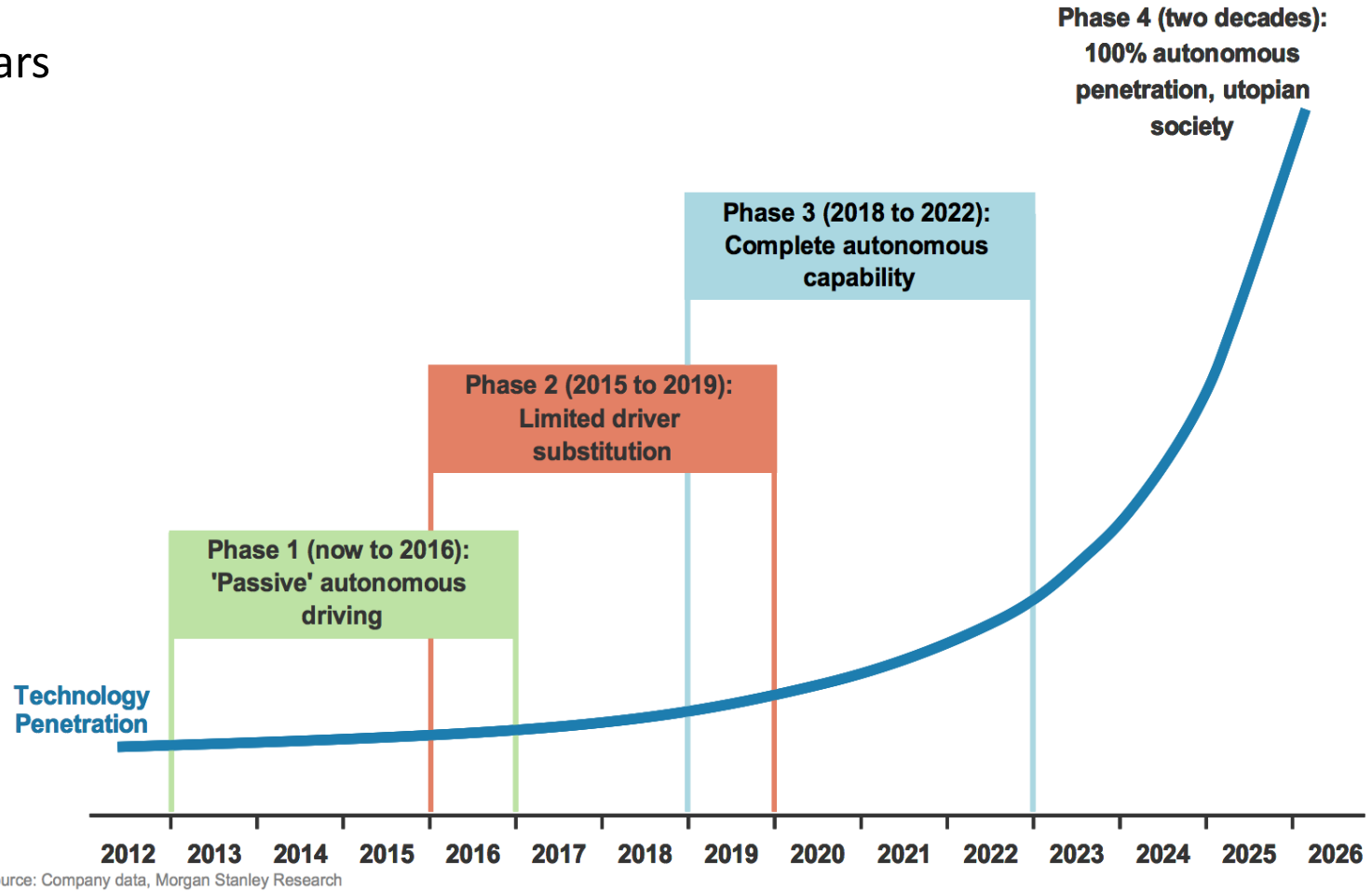
Status 10 years after

TORC



Status on Self Driving Cars today

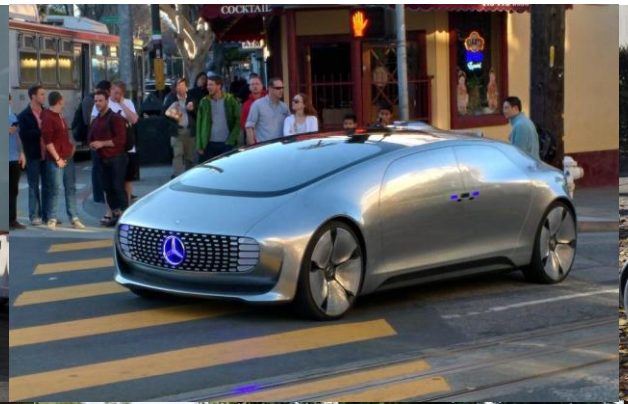
- Level 5 autonomy still far away
  - Most predictions at around 10 years



Source: Company data, Morgan Stanley Research

Status on Self Driving Cars today

- Autonomous technology will be implemented incrementally
  - Taxi and delivery services in certain areas will be the first to come



Status on Self Driving Cars today

- Self driving cars is a complex problem beyond autonomy alone
  - The fully autonomous vehicle of the future is going to require lots of new technologies across many different categories.

THE FUTURE OF TRANSPORTATION STACK

COMET LABS

SERVICES

ROUTE PLANNING
SPATIAL, CITIViZ, waze, CommuteMaster, X, moovit, Citymapper

PARKING
Waypals, Cloud Parc, Aware, SpotHero, PEARL, seeveder, Parko, FenSens, LUXE

CAR HAILING + POOLING
TESLOOP, lyft, RideCell, 滴滴

OTHER: AFTERMARKET, REPAIR, RENTAL
CARVUE, upshift, WRENCH PATROL, zipcar, Getaround, URGENT.LY, Tantalum, bitkar

SAFETY & SECURITY

PHYSICAL CAR & DRIVER SAFETY +ACCIDENT DETECTION
drivebetter, splitsecond, nexar, GUARDIAN Optical Technologies, phrame, LyfeLens, SMART AUTOLABS, tourmalinelabs, iproc, eLSys, FORESIGHT

EMOTION, FATIGUE & ALCOHOL DETECTION + DISTRACTION AVOIDANCE
CORTEX LABS, eyeris, ALMA, CARMA, saverone, SMART Wheels, Radiomize, EASYC, carvi

CYBERSECURITY
CYMOTIVE, cognomotiv, ARGUS, Olympus Sky, Karamba Security, TRILLIUM, Arilou

INTRUSION, TRACKING & RECOVERY
tracknstop, nonda, gmt Connect, ROADEYE, caruma

IN-CAR INTELLIGENCE + ASSISTANCE

VEHICLE DIAGNOSTICS & PREDICTIVE MAINTENANCE + SENSOR-BASED VEHICLE SAFETY
TrueMotion, BRAIQ, IQ, metromile, LIGHT METRICS

PASSENGER-FOCUSED SENSORS (INCLUDING USAGE-BASED INSURANCE)
Cartics, Zubie, nauto, SONICLUE, PREDICTSYSTEMS, NEBULA, engie

INFOTAINMENT + DISPLAY
Link Motion, HUDIFY, CARROBOT, swedspot, OverDrive, ROAV, FICONIC solutions, RIGHTWARE, PELAGICORE, CLOUDCAR

PERSONAL / VOICE ASSISTANCE
navidek, AUTOMATIC, dash, GRIN, cariq

NAVIGATION ASSISTANCE + PEDESTRIAN ANALYSIS & COMMUNICATIONS
WAYRAY, PERCEPTIVE AUTOMATA, navdy, hudly

AUTONOMY

AUTOMATION SYSTEM
AutoX, drive.ai, POLYSYNC, OXBOTICA, dryx, ARGO AI, AIMOTIVE, PILOT, cruise, nuTonomy, Vector.ai, BWV, MOMENTA, cognivue, AIDRIVING

MAPPING, SIMULATION, & IMAGE RECOGNITION / ANNOTATION
ivi, minds.ai, NOMOKO, Mapper.ai, CARMERA, TOMTOM, IMPROBABLE, UDACITY, DEEPMAP, understand.ai, Civil Maps

AUTONOMOUS VEHICLE MAKER + TOOLS
nuro, WAYMO, ZOOX, FARADAY FUTURE

INFRASTRUCTURE + CONNECTED CAR

SENSOR NETWORKING INFRASTRUCTURE (V2V, V2X) - LPWA, CELLULAR, WIFI
DIGIMONDO, SAVARI, ZIFISense, EVVOS, Actility

CONNECTED CAR - DATA, PLATFORM, SOFTWARE
ACTIVESCALER, INRIX, SPARC, mobiliuz, carvoyant, vinli, otonomo, bright box, VEHICLE DATA SCIENCE, mojio

FLEET + TRAFFIC MANAGEMENT
BESTMILE, synovia, Fleetmatics, urban engines, Motionlogic, Travel Ai, Automile, Zendrive, GLYDEL, locoNav, Immense Simulations, MOTORWAY BUDDY, mentis, FR, Brisk Synergies

OTA CAR SOFTWARE UPDATION + SMART PHONE ENABLEDTELEMATICS
FIXD, DRIVEBOT, VOYOMOTIVE, ZENE, anyqa

INTELLIGENT MANUFACTURING

NEW/ADVANCED MATERIALS
NAWA TECHNOLOGIES, SIRRUS, AQUARIUS, NANOSTEEL

RAPID PROTOTYPING - 3D PRINTING, MODULARIZATION, OPEN SOURCE
Carbon, nanocore, DIVERGENT, OSVehicle, stratasys, VADER

ADVANCED / AUTOMATED ASSEMBLY LINE
Grabit, SYMBIO, CLEARPATH, ROBOMOTIVE, rethink robotics.

MATERIAL CHARACTERIZATION & TESTING
SynTouch, SASTRA, VIDI, OPTOFIDELITY

ONBOARD SENSORS

LOCATION - GIS, PRECISION POSITIONING, PATH PLANNING
swift NAVIGATION, radiosense, EXO TECHNOLOGIES

VISION / CAMERA
DEEP VISION, Carnegie Robotics, machines with vision, ROADSENSE, DEEPSCALE, Chronocam, VAYAVISION

LIDAR
face, INNOVIZ, PHANTOM INTELLIGENCE, VOYAGE, QUANERGY, AEYE, TRILUMINA, LeddarTech, Velodyne LiDAR, STROBE

RADAR
OCULii, TOPOSENS, RFISEE, 6TH SENSE, SDS

SPECIALTY VEHICLES

2-WHEELERS
mobike, smarthalo, superpedestrian, Zagster

PUBLIC TRANSPORT
nauya, Varden Labs, AURO, EASY MILE

TRUCKS / FREIGHT
JAYBRIDGE ROBOTICS, OTTO MOTORS, PELOTON, TESLA, FLEXPORT, TRUELITE TRACE, STARSKY ROBOTICS

FLIGHT
WRIGHT ELECTRIC, ZUNUM Aero, ZEE, JOBY, Kitty Hawk, LILIUM AVIATION, AEROMOBIL

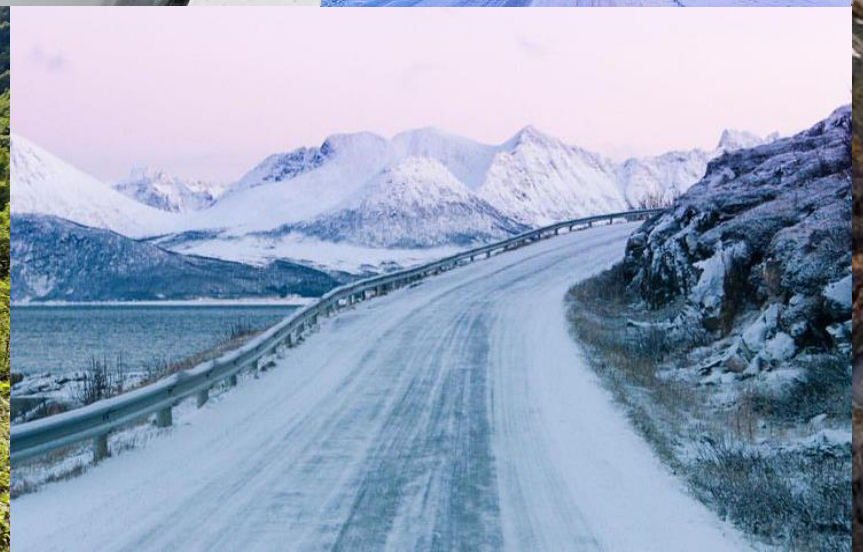
OTHER: HYPERLOOP, PERSONAL MOBILITY
hyperloop one, ninebot, WHILL

What About Norway?







Advantages in Norway

- Challenging roads and complicated terrain
- Arctic conditions and varying weather
- Strong academic environment in cybernetics
- High adaptation rate of new technologies
- Focused on environmental issues and innovation
  - Our zero emission goals aligns with the benefits of a future where autonomous vehicles are integrated in society
- The highest density of electric cars in the world
  - 5-7 years ahead of other countries when it comes to converting the car park to be fully electric
- The Norwegian Ministry of Transport just issued a Law on testing of self driving vehicles

Predictions

- A high stake competition will create talent in the field of the competition
- If such a competition has a fixed set of hardware, the challenge will be about the software
- Working with hardware similar to what’s used in self driving cars would create relevant competitive competence in the field

Roborace

Proposal

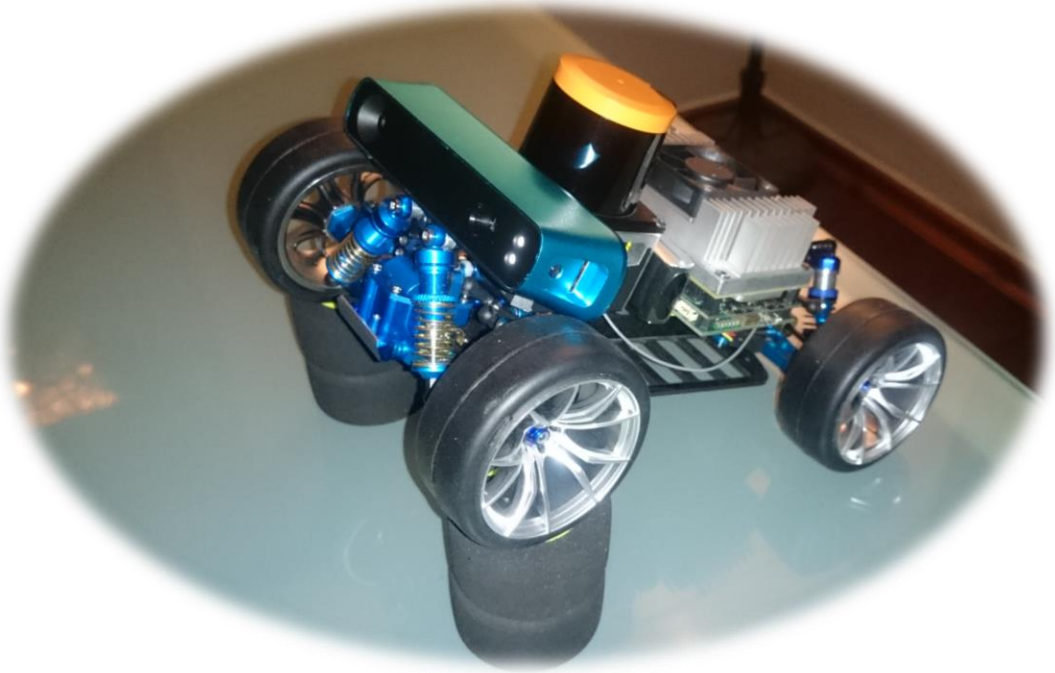
A Norwegian challenge where;

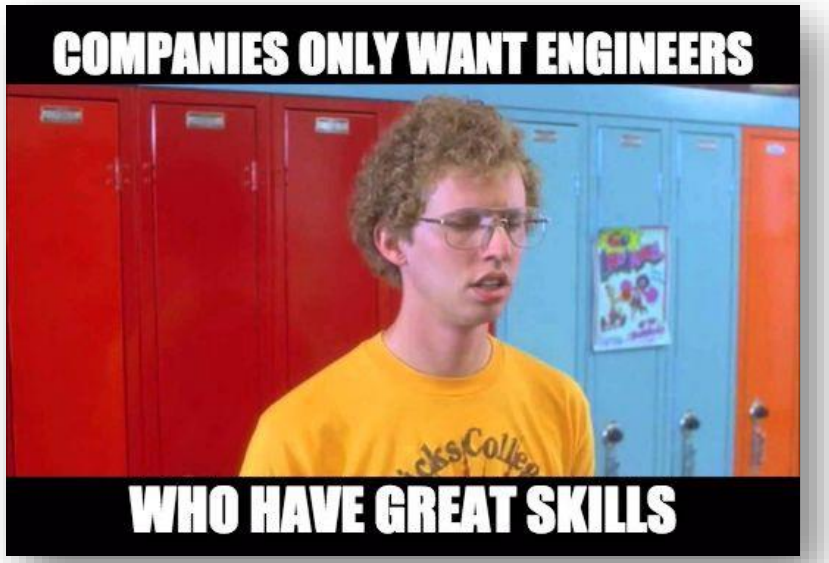
1. There is a fixed set of hardware requirements close enough to what is used in self driving cars today
2. The vehicle is compatible with existing robot championships (Folkrace class)
   - RobotSM (Sweden) – Birth place of Folkrace
   - Robotex (Estonia) – Europe's largest robot competition
3. There is a high stake/high reward
4. Participation is open for everyone
   - Norwegians or people studying in Norway
5. It is held annually
6. It is organized in such a way that it will facilitate research on the challenges for self driving cars

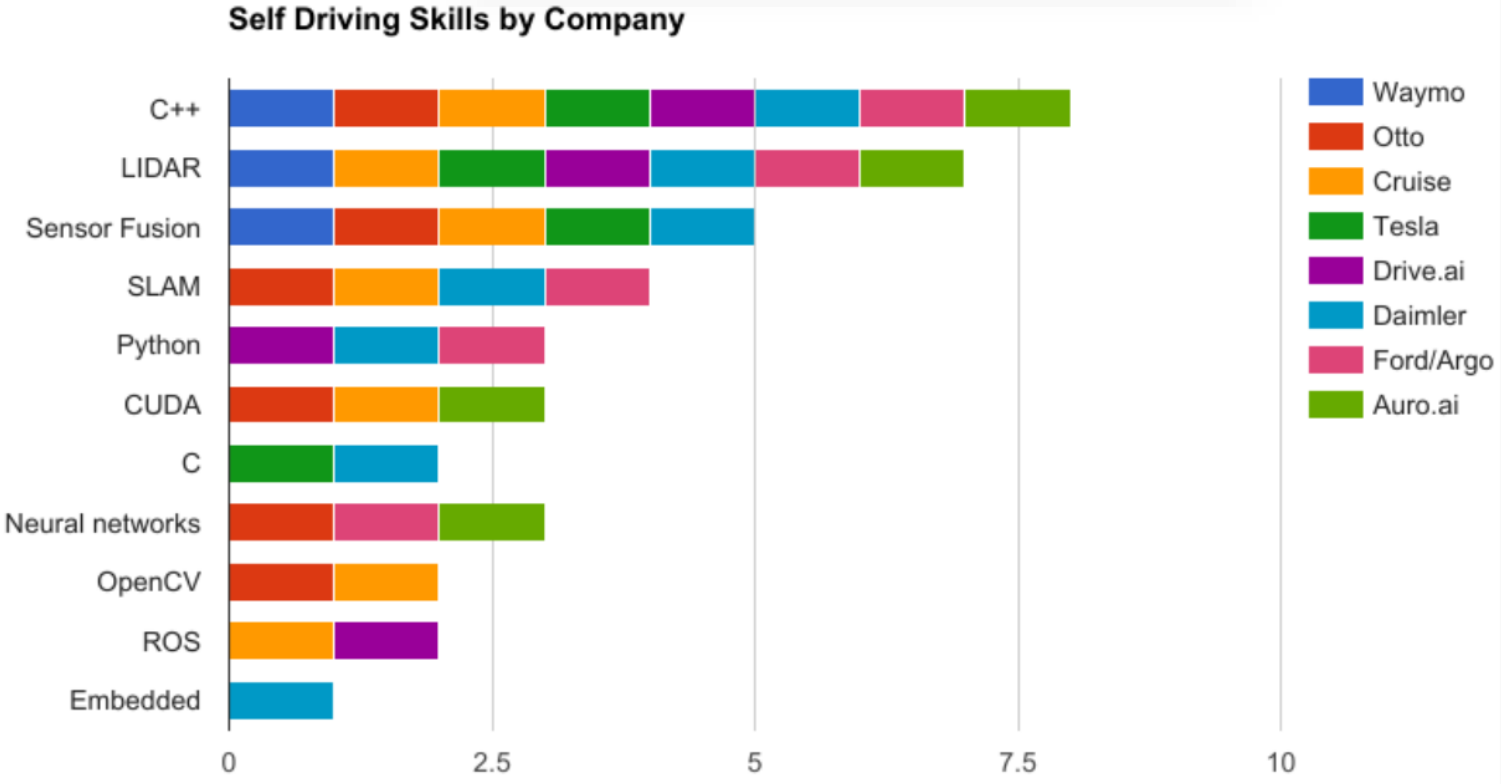
Will facilitate competence and talent in the field of self driving vehicles

Reaper – A realistic Approach to Self Driving Cars

- Nvidia Jetson TX1
- Hokuyo UST-10LX (Lidar)
- Structure IO
- Team Associated RC18
- Scanse Sweep (Lidar)
- Front facing Camera
- All parts Titanium, Aluminum, Carbon

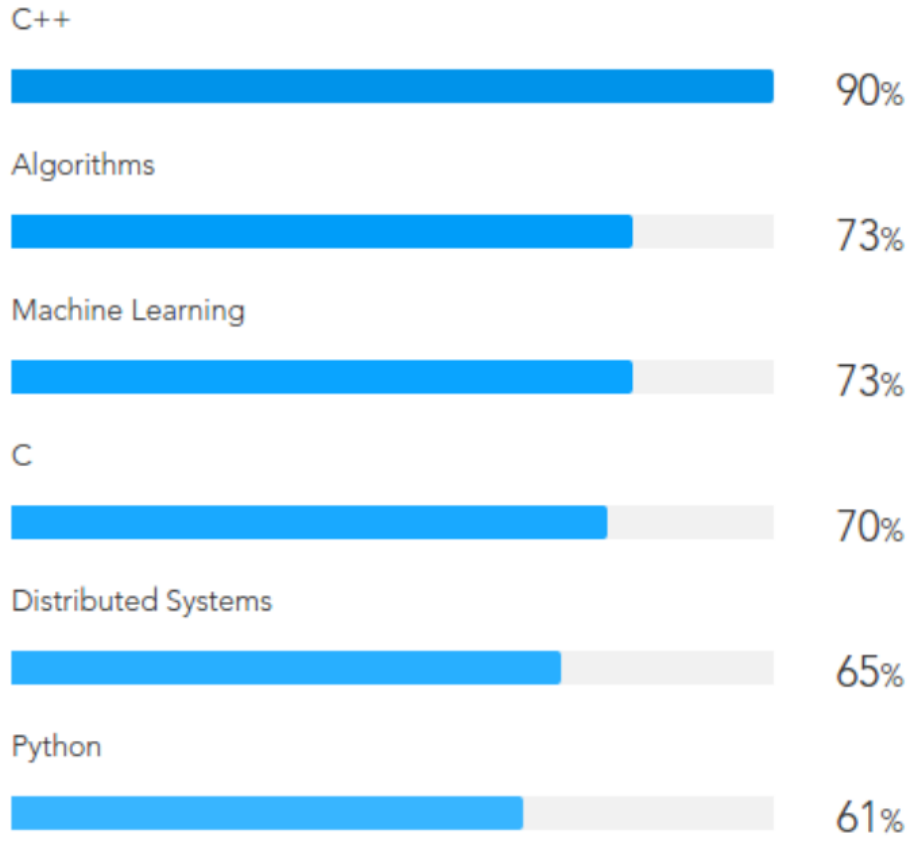




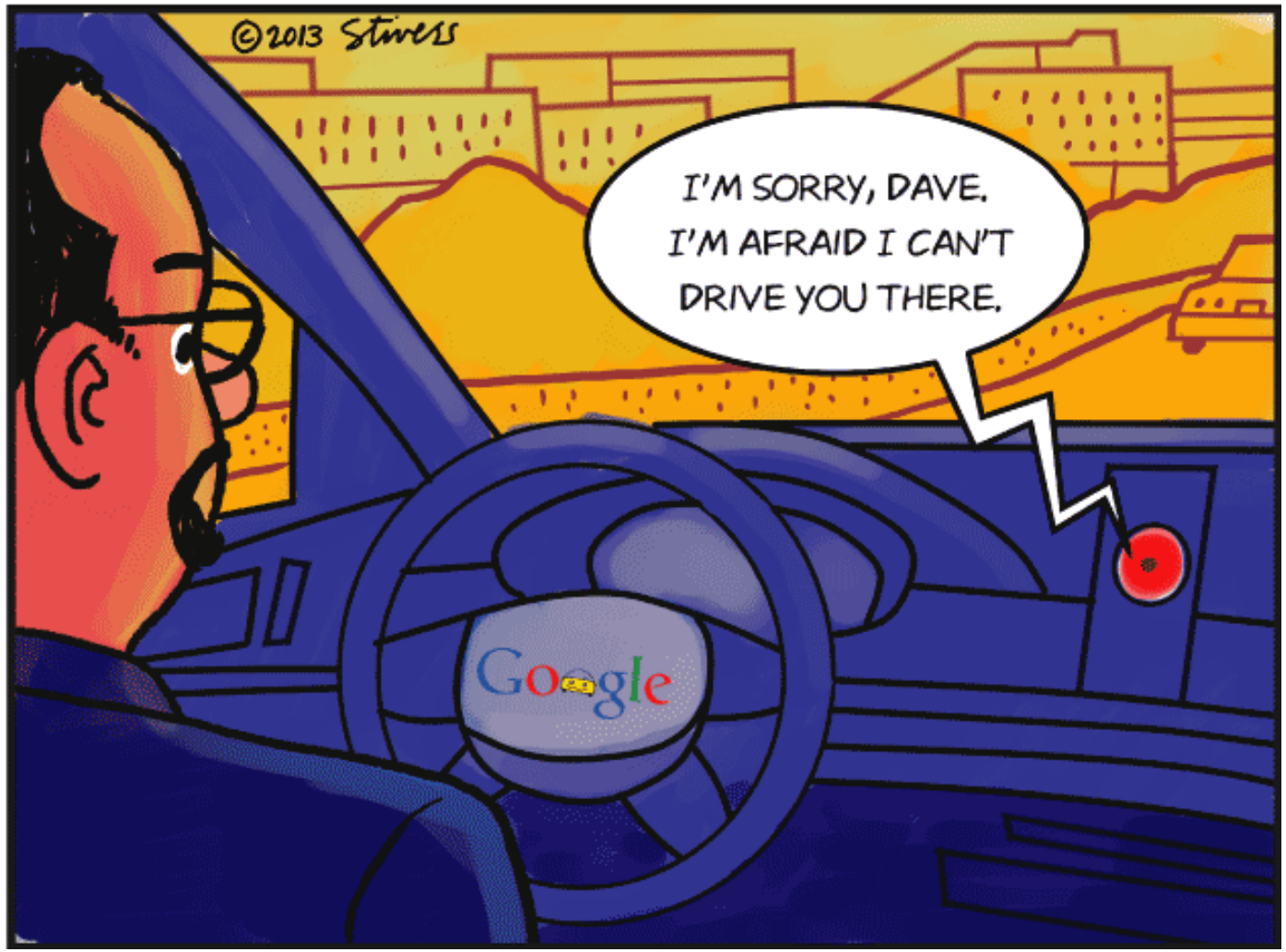


What are the major skills prerequisites for Self Driving Car Engineers jobs?

90% of applicants need to know C++ (from recent job postings). 73% also need to know Algorithms. Other top required skills include Machine learning, C, Distributed systems, Python.



Questions?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I'M SORRY, DAVE.
I'M AFRAID I CAN'T
DRIVE YOU THERE.
Google