

It's 2021 - Where's My Autonomous Vehicle?



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 Twitter: @maththrills
 <https://www.youtube.com/milfordrobotics>
 <http://www.tinyurl.com/milfordm>
 <https://goo.gl/rczslc>

Professor Michael Milford
Australian Research Council Laureate Fellow
Acting Director, QUT Centre for Robotics

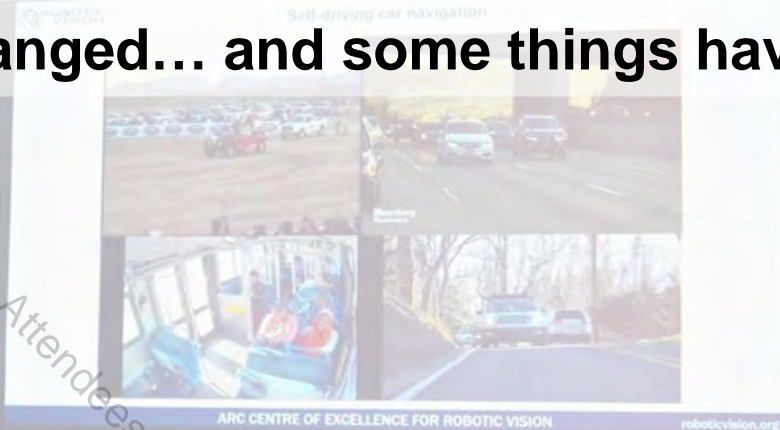
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Some things have changed... and some things haven't

**Carmageddon
2017**





Introductions



Introduction to an autonomous vehicle



Key components, including talent

2021

Current state of play



The future?

Robotics, Automation & Autonomous Vehicles at QUT



ARM
Advanced Robotics
for Manufacturing
HUB

ARC Industrial
Transformation Training
Centre for Collaborative
Robotics in Advanced
Manufacturing



ARC Industrial
Transformation
Training Centre
for Joint
Biomechanics



Australian Research Council's
Special Research Initiative for
Excellence in Antarctic Science:
Securing Antarctica's
Environmental Future' (SAEF)
research program



Collaborations and Connections with Over 100 Leading International Companies, Startups and Universities



Where Our Talent Goes | The Top Companies, Startups and Universities Around the World

Dr Will Maddern
Leader Autonomous Car Project



Head of Mapping & Localization
Nuro.AI



Jake Bruce



Google DeepMind

Dr Adam Jacobson



CATERPILLAR

Dr Ben Upcroft
VP of Technology
Oxbotica



OXBOTICA
robotics & autonomous systems

Dr Andrew English



OXBOTICA
robotics & autonomous systems

Dr Alex Bewley



UNIVERSITY OF OXFORD


↓

WAYVE

↓

Google AI

Dr Stephanie Lowry
Visual Localization
Winner of a prestigious \$900k+ Swedish Starting Grant



ÖREBRO UNIVERSITET

Siganfo Foundation Medal

Dr Liz Murphy



Dr Fangyi Zhang



Alibaba.com

↓

QUT

Dr Fan Zeng



blackmobi

Umesh Mutubandara & Graeme Dicks



Dr Dana Rezazadegan
Lecturer in Faculty of Science, Engineering and Technology



SWINBURNE
UNIVERSITY OF TECHNOLOGY

ÖREBRO UNIVERSITET



Siganfo Foundation Medal

Apple → Google [x] →

Professor Chris McCool



UNIVERSITÄT DUISBURG ESSEN

Dr Zetao Chen

ETH zürich

↓

f



RHEINMETALL GROUP

Lyro Robotics Startup, multiple alumni



Adam Tow, James Sergeant, Mirren King-Smith, Peter Kujala
Dorabot, Shenzhen China & Brisbane



dorabot

Dr David Ball



BOSCH
Deepfield Robotics
A Bosch Start-up Company

↓

nuTonomy

↓

WAYMO

Dr Damien Dusha



WAYMO

Dr Sareh Shirazi
Lecturer in Data Science
EXETER



Dr Zongyuan Ge



Dr Patrick Ross



UBER

Dr Inkyu Sa



Dr Donald Dansereau



Dr Huu Le



CHALMERS

Dr Marcus Eich



Continental

Owen Bawden, Ray Russell & Jason Kulk



Carnegie Mellon University

NATIONAL ROBOTICS ENGINEERING CENTER

REC

↓

LOCOMOTION

And other destinations including:



Doug Morrison



amazon

IBM

↓

MONASH University

ETH zürich

Stanford University

↓

THE UNIVERSITY OF SYDNEY

Sean McMahon

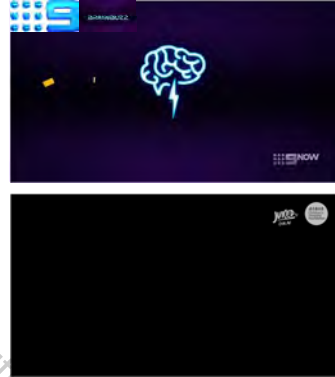


LAING O'Rourke

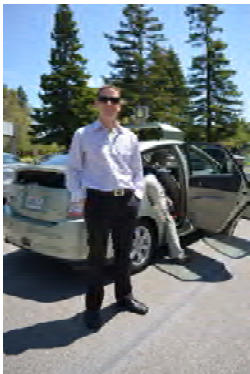
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Intern Precision AI (medical tech)

Specific (Public) AV-related Projects & Activity



Extensive Access to AV Companies over a Decade



Brief Introduction to an Autonomous Vehicle

Major financial and health impacts, plus hundreds more

Sensors

Compute and on-board artificial intelligence

Supervising safety driver

Commercially deployed for years in non-road environments

> The levels of Autonomous Vehicles



<https://www.theverge.com/2016/9/28/13076948/self-driving-car-poll-autonomy-kelley-blue-book>

Self-Driving Cars

THE VERGE TECH · SCIENCE · CULTURE · CARS · REVIEWS · LONGFORM · VIDEO · MORE ·

TECH · TRANSPORTATION · CARS

Intel predicts a [redacted] self-driving future

Over half a million lives will be part of the 'passenger economy'

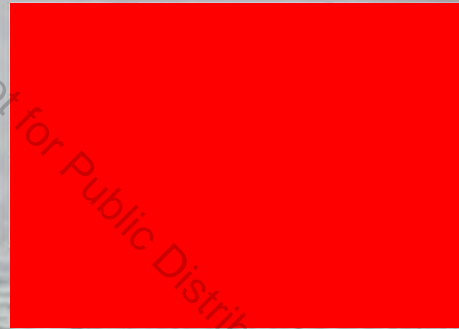
by Kirsten Korosec | Jun 1, 2017, 4:21pm EDT

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Why?

Why?



The Picture is Not That Simple

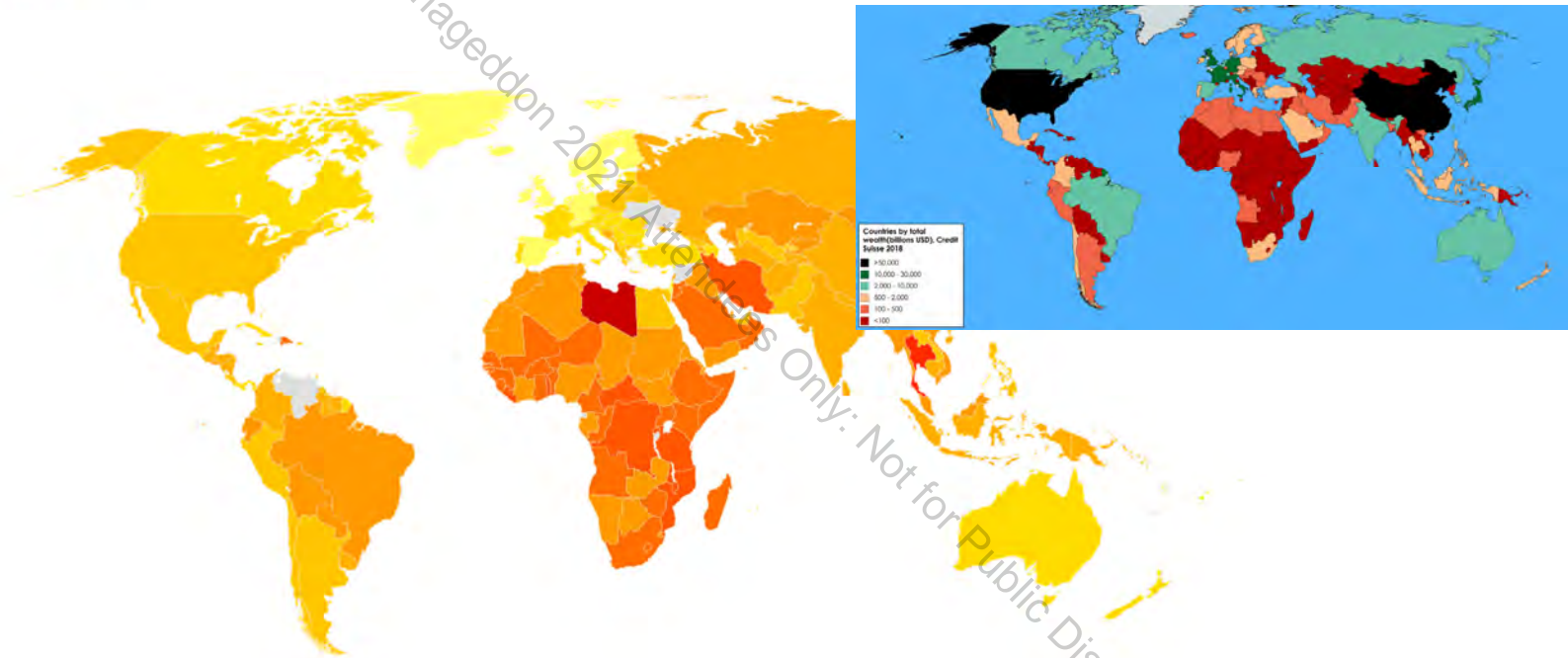


Image from: [https://en.wikipedia.org/wiki/List_of_countries_by_traffic-related_death_rate#/media/File:Road_traffic_accidents_world_map - Death - WHO2013.svg](https://en.wikipedia.org/wiki/List_of_countries_by_traffic-related_death_rate#/media/File:Road_traffic_accidents_world_map_-_Death_-_WHO2013.svg)
[https://en.wikipedia.org/wiki/List_of_countries_by_total_wealth#/media/File:Countries_by_total_wealth\(billions_USD\)_Credit_Suisse_2018.png](https://en.wikipedia.org/wiki/List_of_countries_by_total_wealth#/media/File:Countries_by_total_wealth(billions_USD)_Credit_Suisse_2018.png)

Components



Sensing

iDS:

5:

For Public Distribution

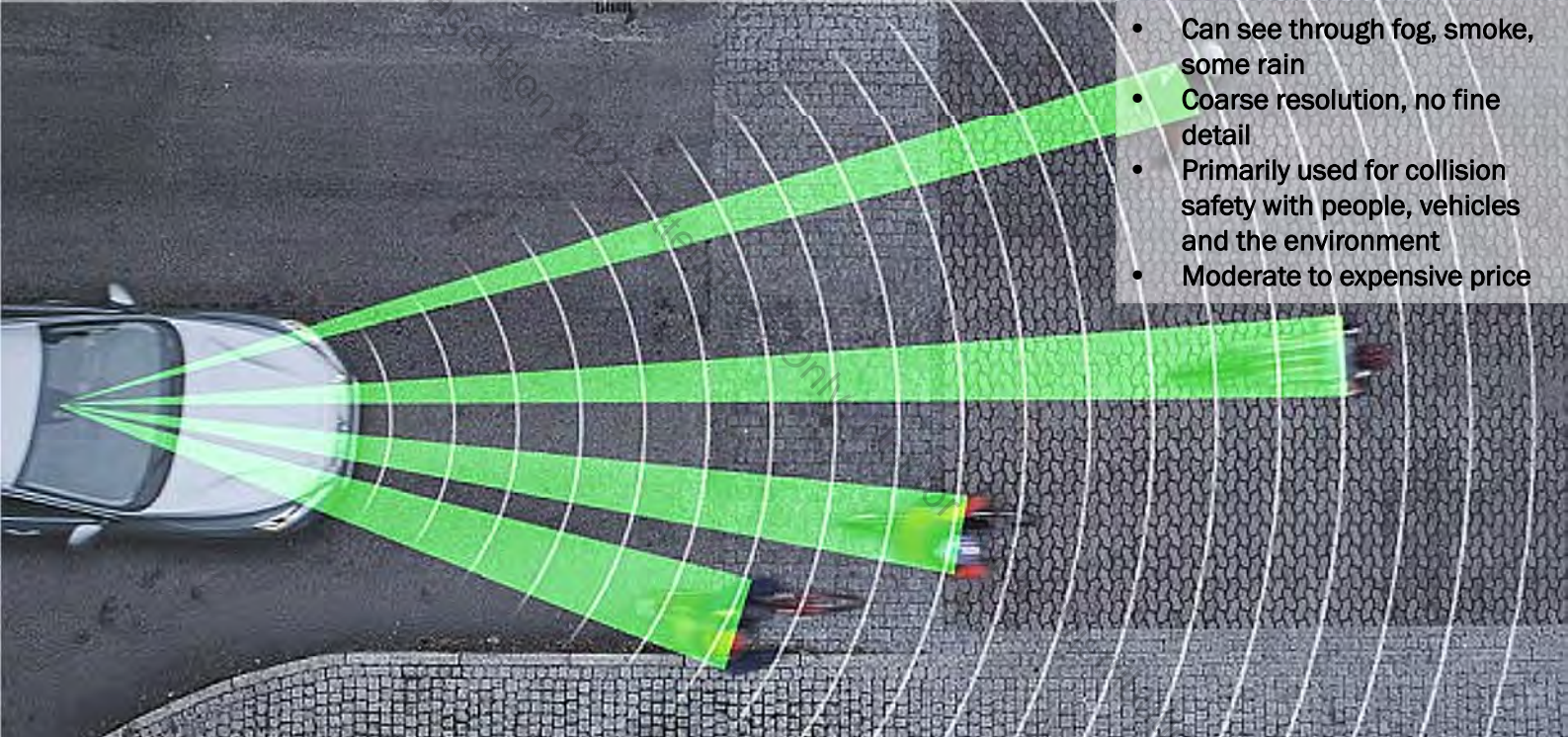
GPS

CAMERA-BASED GPS

QUT

- Provides position, good for journey planning
- Satellite-based, not 100% reliable (tunnels, urban canyons)
- “Autonomy-enabling” still not universally available (drop outs, accuracy, latency)
- Almost universal assumption that it can't be used as primary source of positioning information

RADAR



- Can see through fog, smoke, some rain
- Coarse resolution, no fine detail
- Primarily used for collision safety with people, vehicles and the environment
- Moderate to expensive price

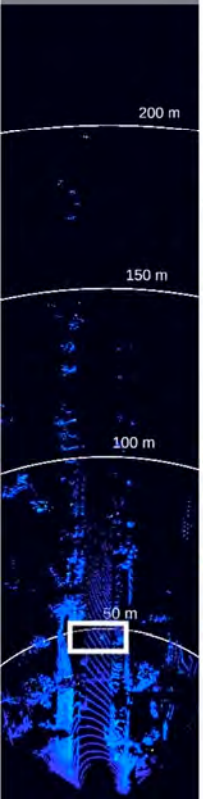
LIDAR

- 3D scan of range to all line of sight objects in all directions
- Medium resolution, high range accuracy
- Disrupted by heavy rain, particulates
- Good for detecting vehicles, pedestrians, mapping and positioning
- Expensive

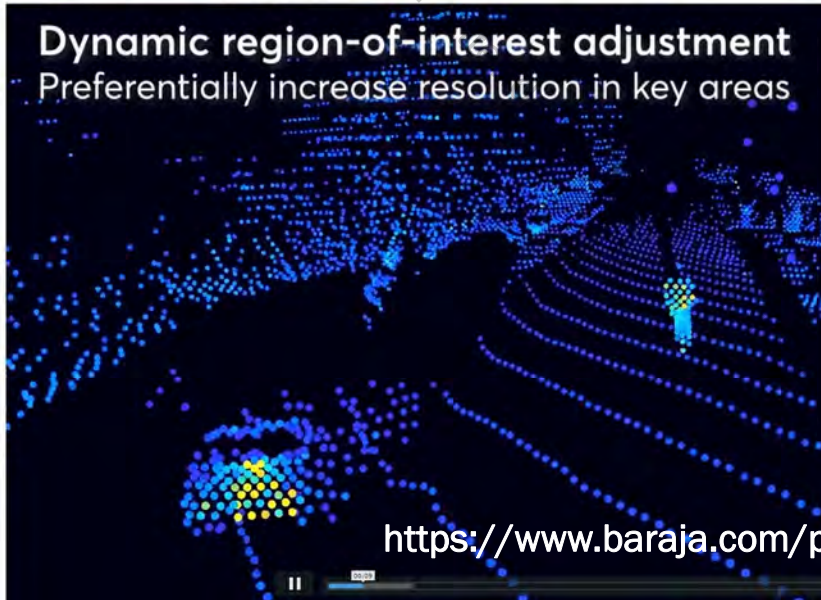


In-car photo by Michael Milford. Google Self-driving Car, Velodyne

Still some innovation in the area e.g. Baraja



Dynamic region-of-interest adjustment Preferentially increase resolution in key areas



Driverless car start-up Baraja worth \$145m after latest fundraising

FINANCIAL REVIEW



Michael Bailey
Financial Review Editor

Jun 28, 2019 — 11:45am

Like Share

Autonomous vehicles may be years from exiting the roads but investors see promise in Australian player Baraja, valuing the light detection and ranging (LIDAR) provider at \$145 million after a recent fundraise which made one founder a contender for the *Financial Review* Young Rich List.

Baraja has taken the type of telecommunications grade laser that powers the internet and applied it to a LIDAR system, which measures the distance of surrounding objects for driverless cars.

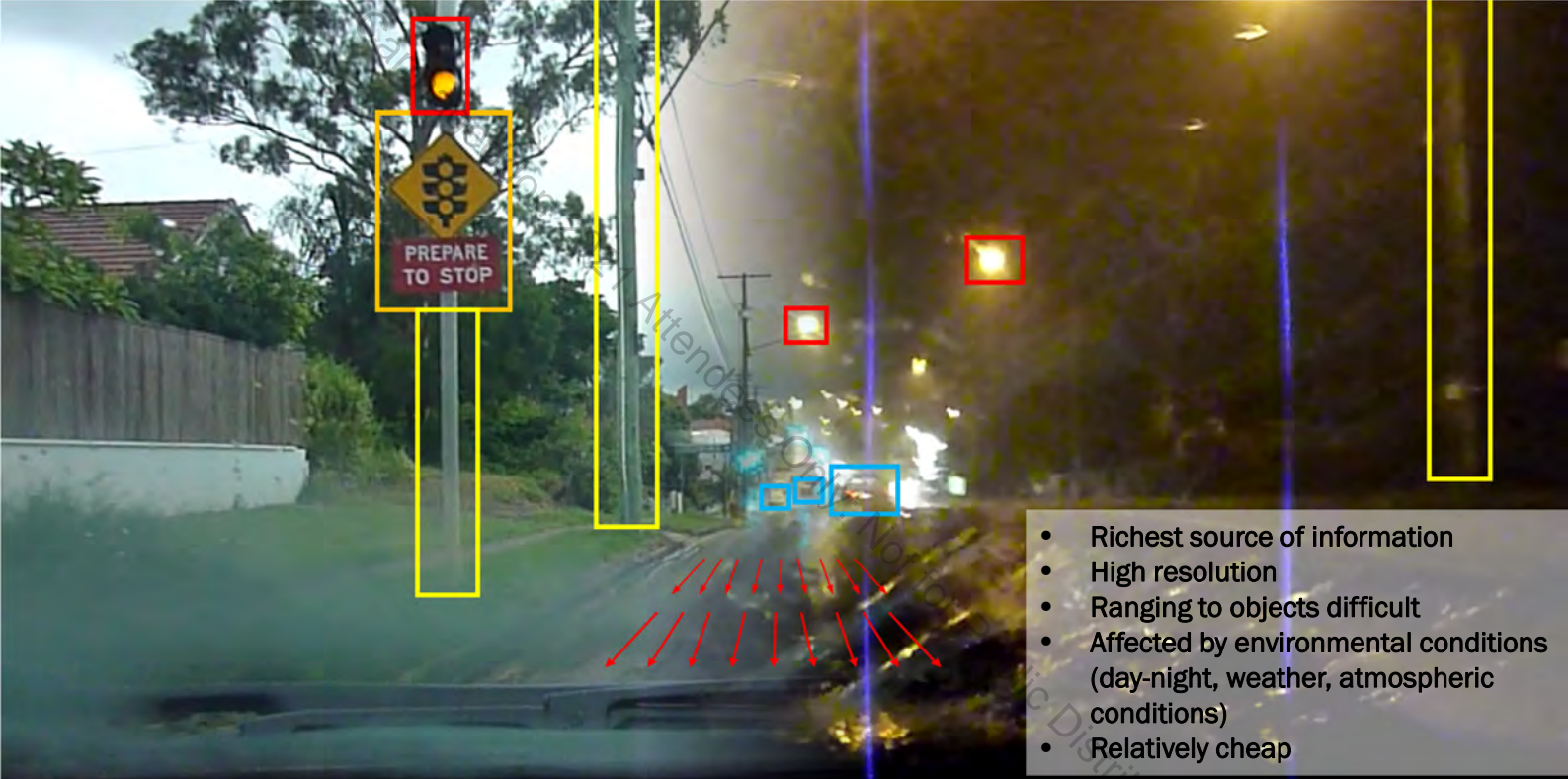


Shane Pollock (left) and Michael Bailey (right) of Baraja, an Australian LIDAR technology, say self-driving cars is still years from the mainstream before the world's first autonomous vehicles. *Financial Review*

<https://www.baraja.com/product/>

50m





VISION (CAMERAS)

A range of other sensors



Accelerometers, IMUs



Wheel encoders



Sonar, throttle, fuel mix,
power draw, all sorts of other
instrumentation



**Example Sensor Configurations
(all captured on public roads or with approval)**







Camageddon 2020 attendees Only: Not for Public Distribution



nuro

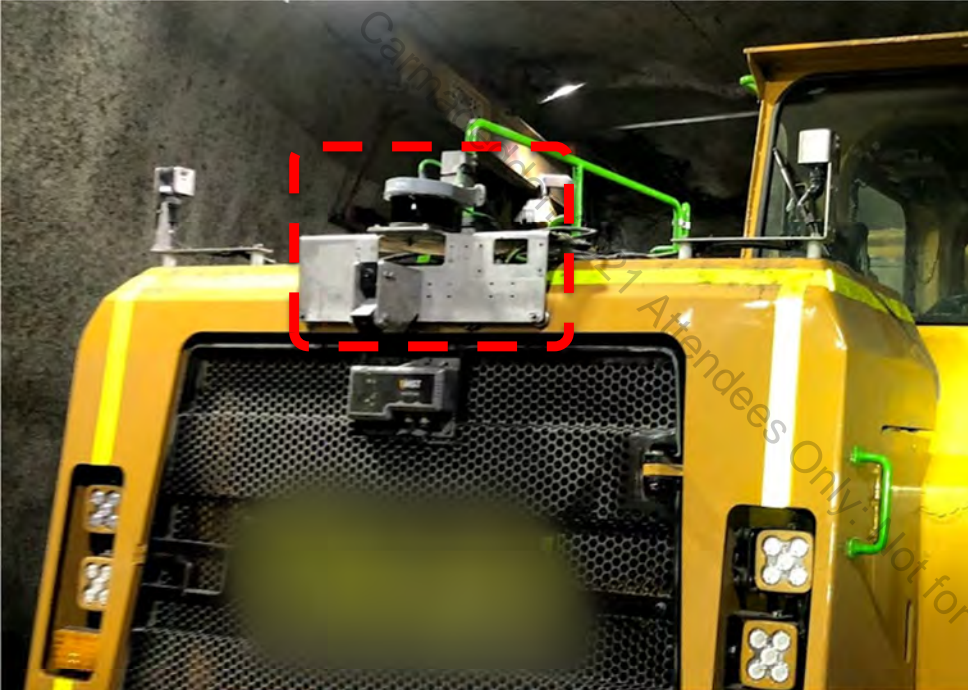
nuro



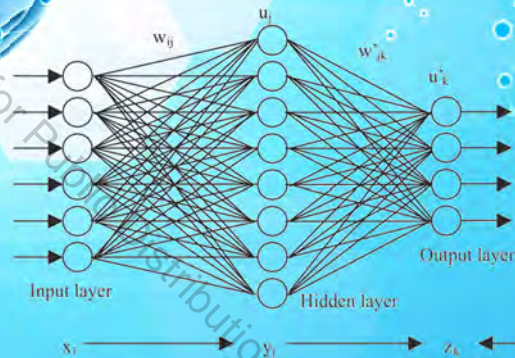
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Attendees Only: Not for Public Distribution

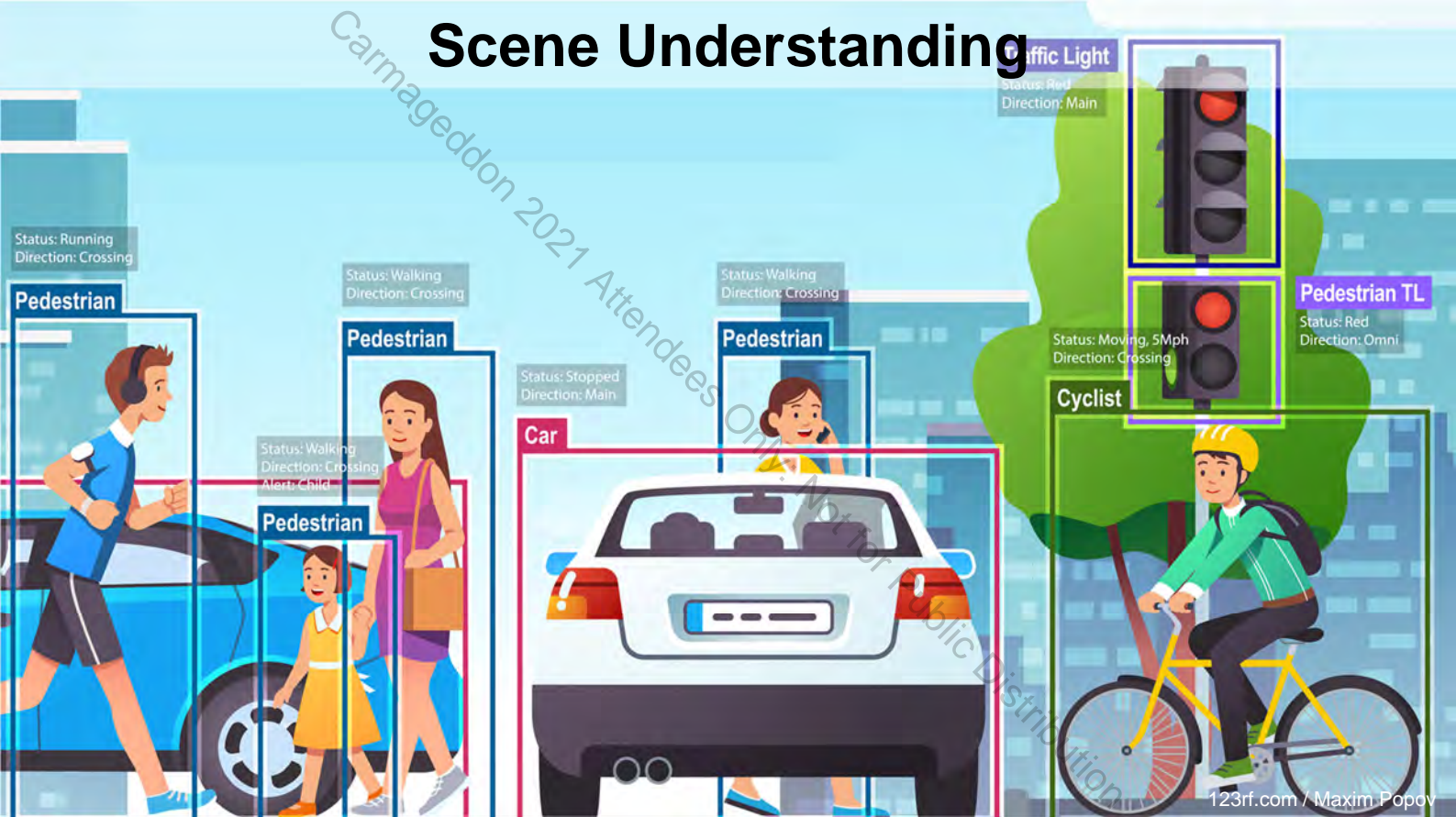


Onboard Driving Intelligence



Positioning and Localisation

Scene Understanding



Carmageddon 2021 Attendees Only

Traffic Light
Status: Red
Direction: Main



Pedestrian TL
Status: Red
Direction: Omni



Status: Moving, 5Mph
Direction: Crossing

Cyclist



Status: Running
Direction: Crossing

Pedestrian



Status: Walking
Direction: Crossing

Pedestrian



Status: Walking
Direction: Crossing
Alert: Child

Pedestrian



Status: Stopped
Direction: Main

Car



Status: Walking
Direction: Crossing

Pedestrian

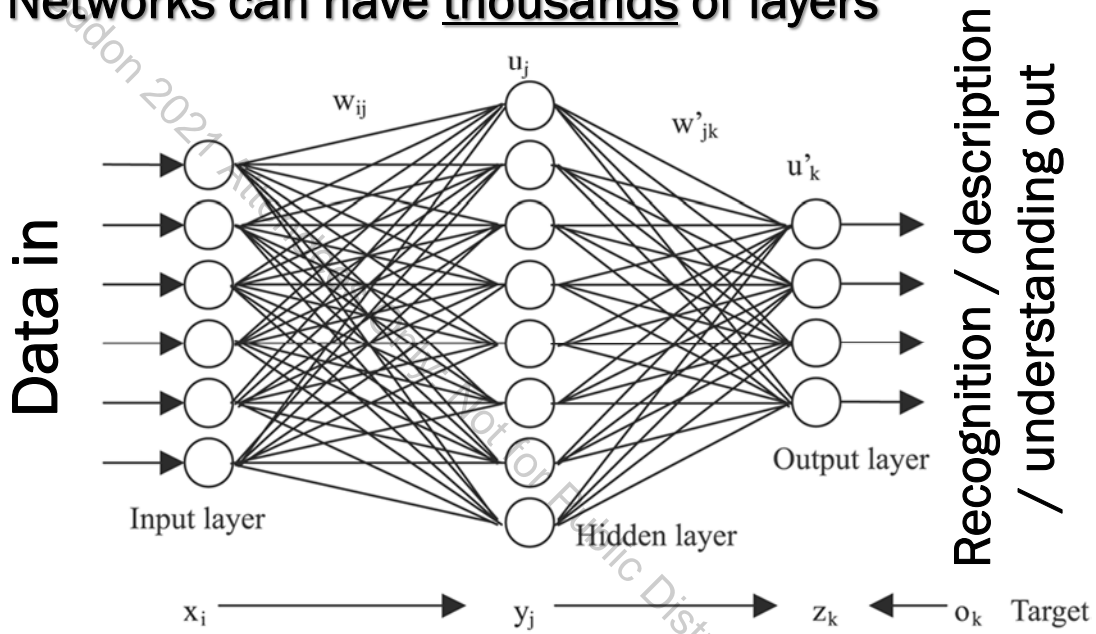


Deep Learning - Modern Neural Network-based AI

Networks can have thousands of layers

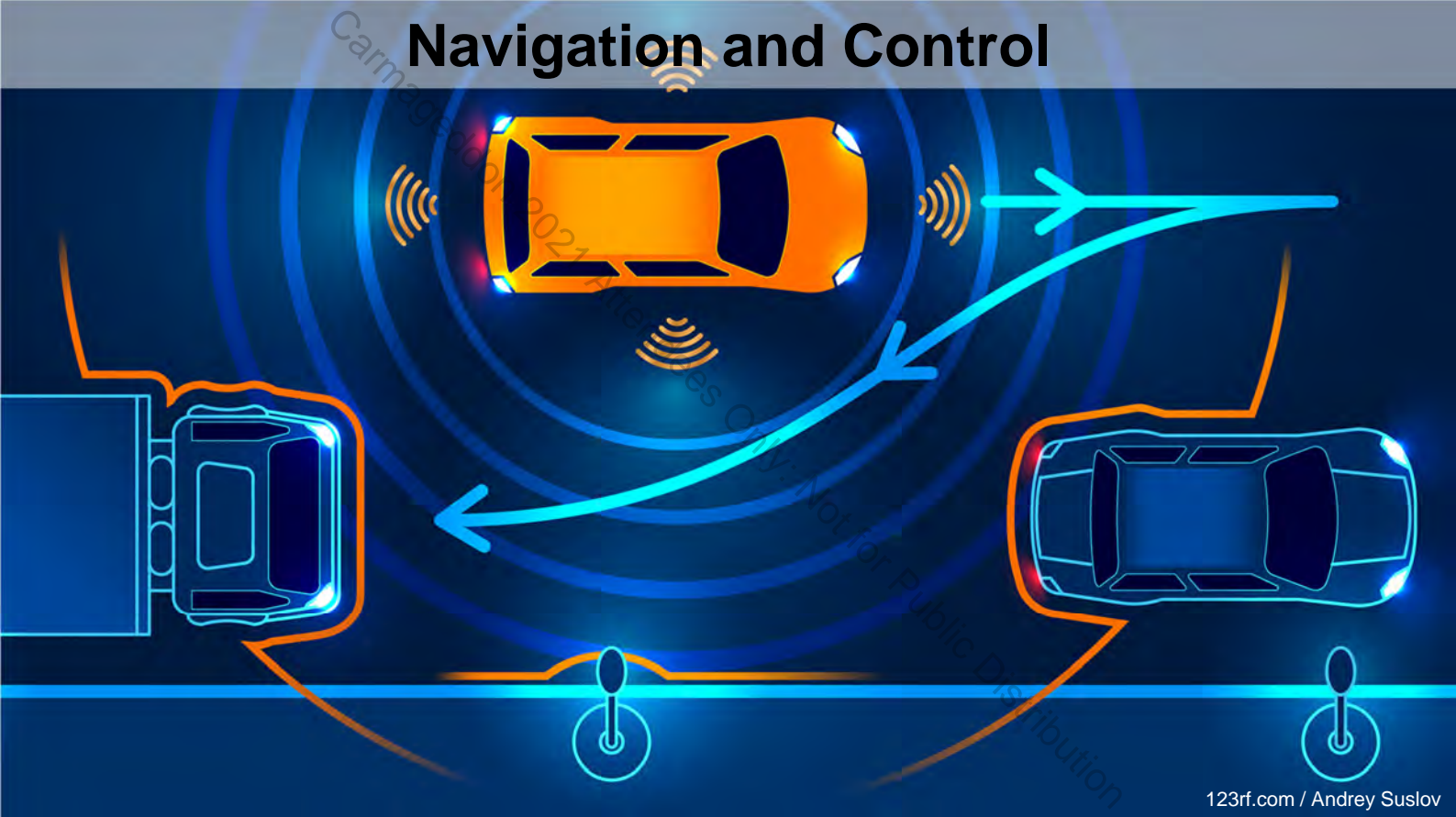


Bio-inspired only in a very loose sense



<http://www.extremetech.com/wp-content/uploads/2015/07/NeuralNetwork.png>

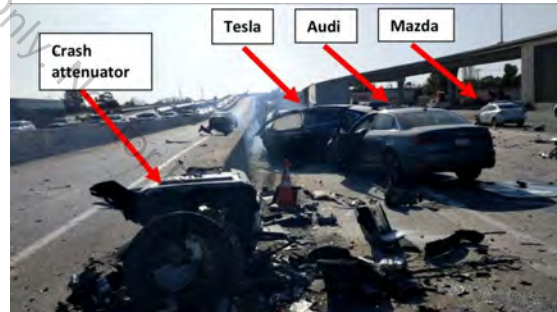
Navigation and Control



Current State of Play



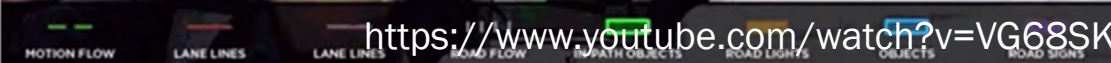
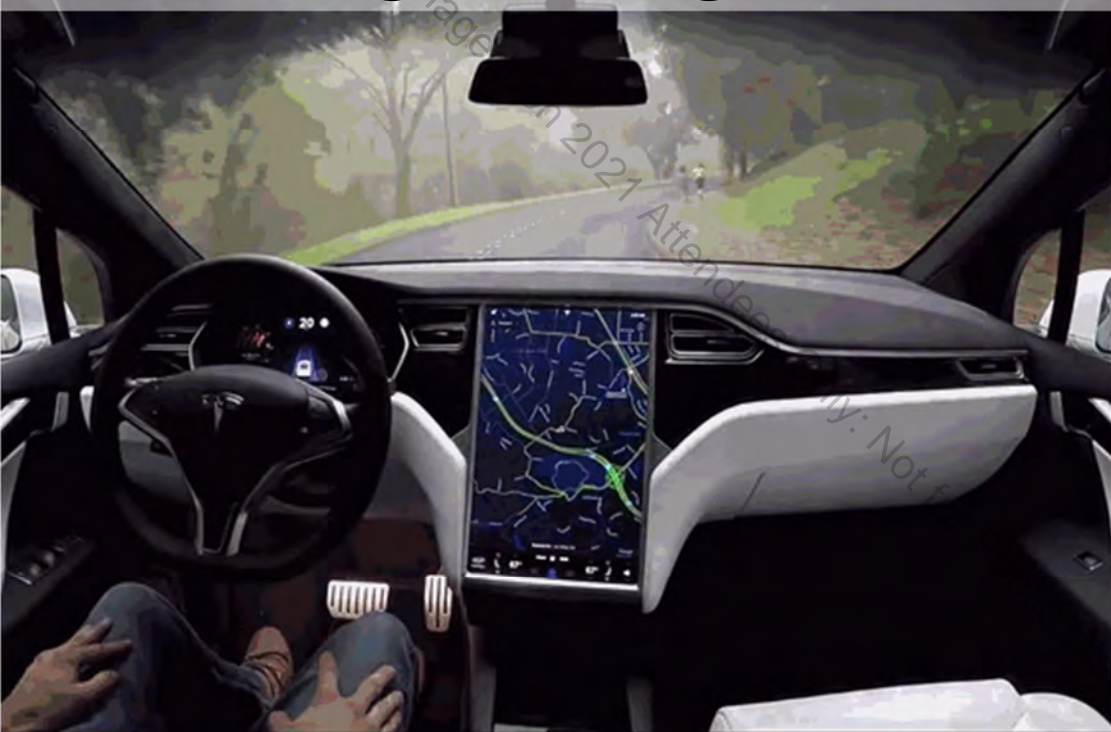
High Profile Incidents and Low Profile Benefits



123rf.com / Tomasz Wyszolmirski

<https://www.forbes.com/sites/bradtempleton/2019/05/03/lawsuit-over-tesla-autopilot-fatality-unlikely-to-win-but-it-uncovers-real-issues/#57b4a8f76034>

The Big Challenge: Human Interaction



<https://www.youtube.com/watch?v=VG68SKoG7vE>

Car AI Example: Extreme “Corner Cases”



<https://www.youtube.com/watch?v=GihuUYmoMXU>

Onflow Effects

BUSINESS INSIDER AUSTRALIA

TECH MONEY & MARKETS BRIEFING IDEAS EXECUTIVE LIFE RESEARCH

TECH INSIDER

Uber lost \$5.2 billion in 3 months. Here's where all that money went.

GRAHAM RAPIER, TROY WOLVERTON
AUG 10, 2019, 5:59 AM

Research and development: \$US3.06 billion (\$US2.6 billion from stock-based compensation)

Self-driving cars

'Peak hype': why the driverless car revolution has stalled

As Uber parks its plans for robotaxis, experts admit the autonomous vehicle challenge is bigger than anticipated



Source: Global AI Report 2020



DeepMind A.I. unit lost \$649 million last year and had a \$1.5 billion debt waived by Alphabet

PUBLISHED THU, DEC 17 2020 7:11 AM EST | UPDATED THU, DEC 17 2020 9:21 AM EST

Uber

Uber Eats avoids landmark ruling on workers' status by settling case with delivery rider

Settlement by Australian arm of company comes before federal court could rule whether sacked delivery rider Amita Gupta was an employee or a contractor



'Nobody is winning': businesses go cold on food delivery platforms

Consolidation

and its co-founder has some unusually sensible and honest things to say about the industry, unusual only because the industry is stuffed with charlatans.

Amazon Buys Self-Driving Company Zoox For \$1.2B And May Rule The World

Forbes

Brad Templeton Senior Contributor
Transportation
I cover robocar technology & previously worked on Google's car team.

The Failure Of This Self-Driving Truck Company Tells You All You Need To Know About Self-Driving Vehicles

JALOPNIK

Erik Shilling
3/20/20 9:30AM · Filed to: SELF-DRIVING CARS

244 4



Screenshot: Starry Spangis

yahoo!finance Search for news, symbols or companies

Uber sells self-driving unit Uber ATG in deal that will push Aurora's valuation to \$10B

Kirsten Korosec
8 December 2020 · 6-min read

THE VERGE
Cruise acquires Voyage in another autonomous vehicle merger
Detroit, urban testing meets low-speed retirement community testing
By [Erickson](#) · [Roberts](#) · [Gonzalez](#) · See 10 days, 11 hours left



Behind-the-scenes talent flow is highly predictive of what is happening

Consolidation of Key Players



Self-Driving Car Project



But New Players Are Still Emerging and Funding is Still There!

AI pioneer Raquel Urtasun launches self-driving technology startup with backing from Khosla, Uber and Aurora

Kirsten Korosec @kirstenkorosec / 8:00 PM GMT+10 • June 8, 2021



Comment



Image Credits: Waabi via Natalia Dolan

investments from Uber and Aurora. Waabi has raised \$83.5 million in a Series A round led by Khosla Ventures, with additional participation from Uber, 8VC, Radical Ventures, OMERS Ventures, BDC and Aurora Innovation, as well as leading AI researchers Geoffrey Hinton, Fel-Fel Li, Pieter Abbeel, Sanja Fidler and others.



SPACs keep rolling as autonomous vehicle startup Aurora targets blank-check debut with \$13B valuation

Kirsten Korosec @kirstenkorosec / 11:38 PM GMT+10 • July 15, 2021



Comment

Image Credits: Aurora

Aurora Innovation, the autonomous vehicle startup that acquired Uber's self-driving unit in December, is going public via a merger with special purpose acquisition company Reinvent Technology Partners Y.

Traditional Automotive is Quietly Persisting

- Limited autonomy feature set can help differentiate automotive product from competitors
- Possibly more solvable technically
- Easier to compete with “limited” budgets and investment

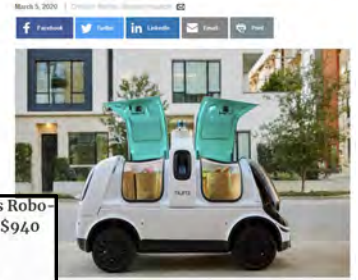
Diversification, Pivots and Specialization and Current Narratives



Niche Area Play Example: Nuro.AI



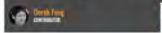
Nuro To Start Deliveries For Walmart And Domino's **BISNOW**



SoftBank Gives Nuro's Robo-Delivery Tech A Hefty \$940 Million Boost

- Automated delivery
- Partnering with major supermarket and food chains
- Point of differentiation: several exploitable advantages with no passengers

Nuro R2: US authorities approve completely driverless car for road tests

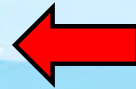


Autonomous van will begin del area in the 'coming weeks'.

Despite setbacks, coronavirus could hasten the adoption of autonomous vehicles and delivery robots



The (Commercial) AV Holy Grail: Widespread, unrestricted Level 4+ Autonomous Vehicles



If technology
doesn't bridge the
gap to feasible
Level 4+ AVs

“Fallback” Scenarios

Autonomous

Autonomous delivery
vehicles

These are
nowhere near as
lucrative...

what are the
implications of
these fallback
scenarios?

vehicles in off-
road, defence,
agriculture

Talent

(arguably the most) crucial
component of technology fields
including Autonomous Vehicles,
Artificial Intelligence, and Robotics



An Incredible Landscape for Talent in the Field

allure Network
GIZMODO AU

Car Tech Online Science & Health Cameras Computing Gaming Entertainment

Uber Reveals [REDACTED] Bonus Dispute Between Fired Engineer And Google

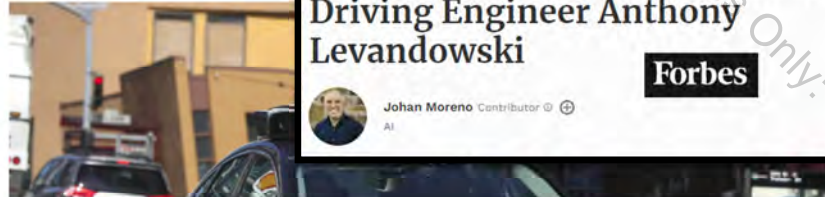
Kate Conger
Jun 29, 2017, 9:00am · Filed to: anthony

Jan 20, 2021, 01:35am EST | 3,350 views

Trump Pardons Embattled Self-Driving Engineer Anthony Levandowski

Forbes

Johan Moreno Contributor



GOOGLE POLICY TECH

THE VERGE

Ex-Google and Uber engineer Anthony Levandowski must pay Google \$179 million

Levandowski filed for bankruptcy protection in response

By Thomas Ricker | @Trucky | Mar 5, 2020, 6:24am EST

f t SHARE

Known as “Funny Money” in the industry



TC
TechCrunch

Waymo case reveals Levandowski got \$250 million in Uber stock for Otto

The Talent Flow is Changing “Somewhat”

**Back to
Australia**

**Other non-AV areas
e.g. Robotics**

The Future?

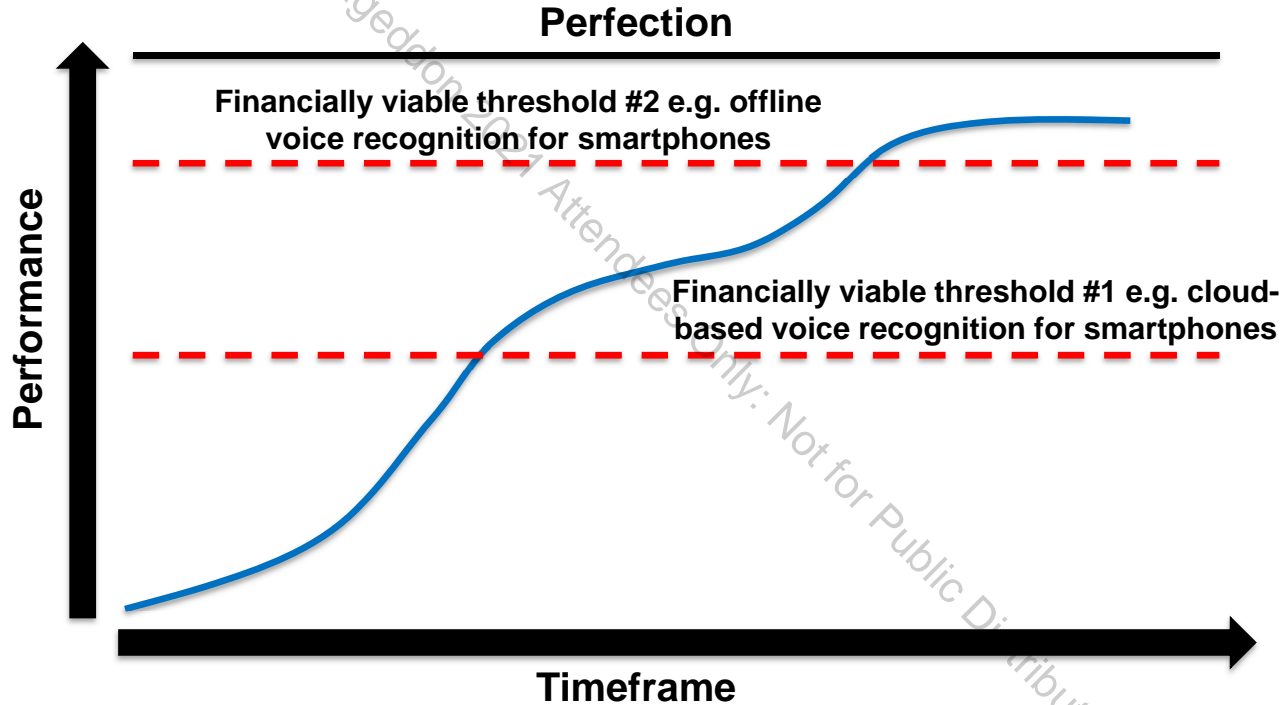


The Classic Hype Cycle Implicitly Assumes Eventual Success

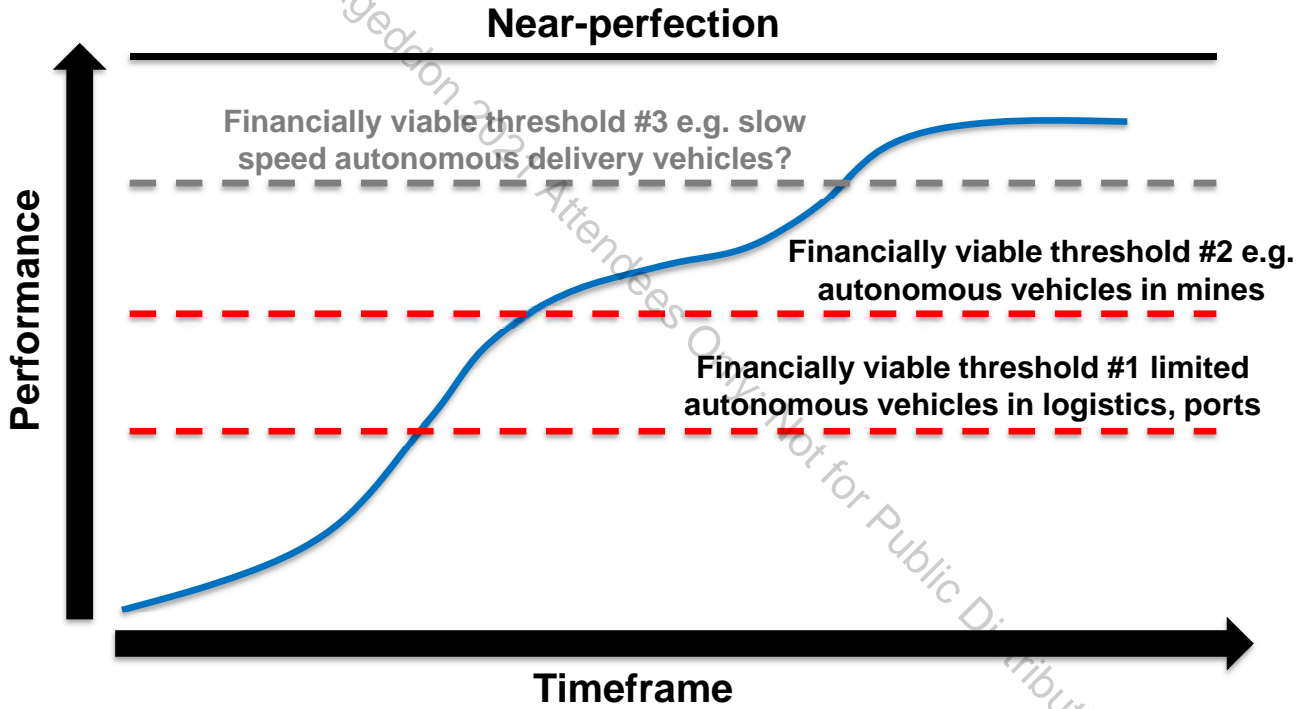


Attribution: Jeremykemp at English Wikipedia

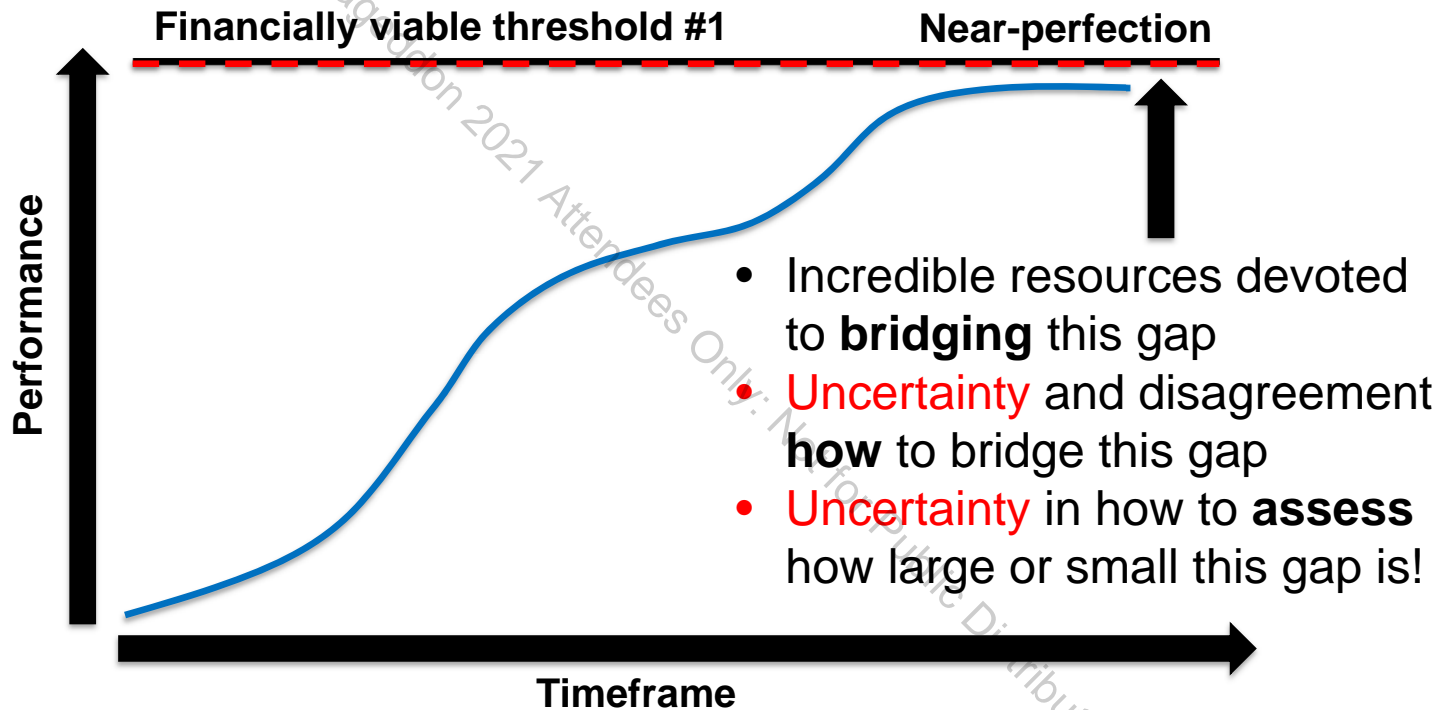
Progress Charts – Typical Technology

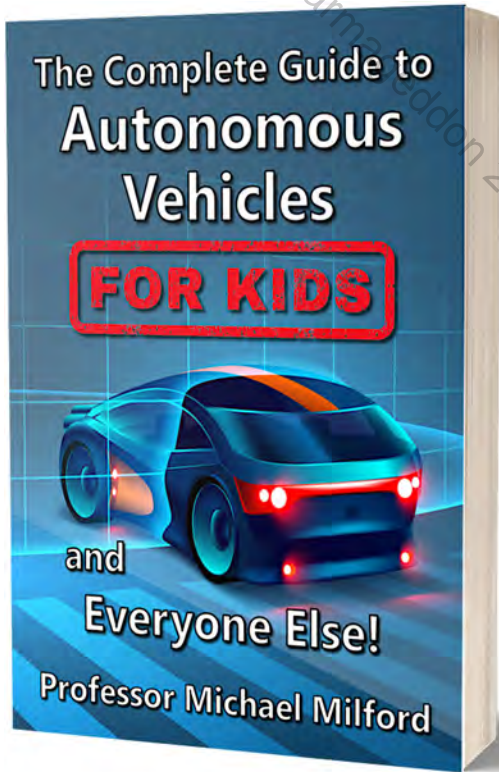


Progress Charts – General AV Technology



Progress Charts – Widespread, Passenger-Carrying Robotaxis










COMING

SOON!

KICKSTARTER

It's 2021 - Where's My Autonomous Vehicle?



 michael.milford@qut.edu.au
 Twitter: @maththrills
 <https://www.youtube.com/milfordrobotics>
 <http://www.tinyurl.com/milfordm>
 <https://goo.gl/rczslc>

Professor Michael Milford
Australian Research Council Laureate Fellow
Acting Director, QUT Centre for Robotics