A shared fleet of autonomous cars in Canberra

Presentation for Deakin Residents Association - Seminar on Public Transport Futures for Canberra

Kent Fitch, 8 May 2023

bit.ly/427yhBk

v7May23 12:13

Why talk about autonomous cars?

Very likely to be the best approach within 2 - 5 years:

- Cheaper and more convenient than cars or public transport
- Universal, on-demand, 24x7, door-to-door transport
- Reduce congestion
- Suited to Canberra's current and future urban environment

… so it is prudent to start planning for them now

Topics

- Shared assumptions?
- Shared goals?
- The benefits of AVs
- The benefits of a shared fleet of AVs
- Current test deployments
- Outcomes from a Canberra simulation
- Obstacles and timeframes

Shared Assumptions?

1. Everyone should have access to safe and convenient transport whenever they want, regardless of their age, income or health

- Safe
- On-demand, easy to use, quick
- 24x7
- Door-to-door
- Wheelchair-accessible
- Low cost and free for those on low-income
- For people and deliveries

2. Walking and cycling should be safe and convenient

- People should be able to walk and cycle safely
- 24x7
- Door-to-door
- Used in combination with other options when travelling long distances

3. Private car ownership and usage is expensive

RACV Car Running Costs 2022

Category	Average Annual Cost (rounded)
Light cars	$10,300
Small cars	$12,800
Medium cars	$16,400
People movers	$18,900
Electric	$18,500
SUV medium	$16,100

https://www.racv.com.au/content/dam/racv/documents/on-the-road/buying-a-car/racv-car-running-costs-survey-2022.pdf

4. Private car ownership and usage has expensive externalities

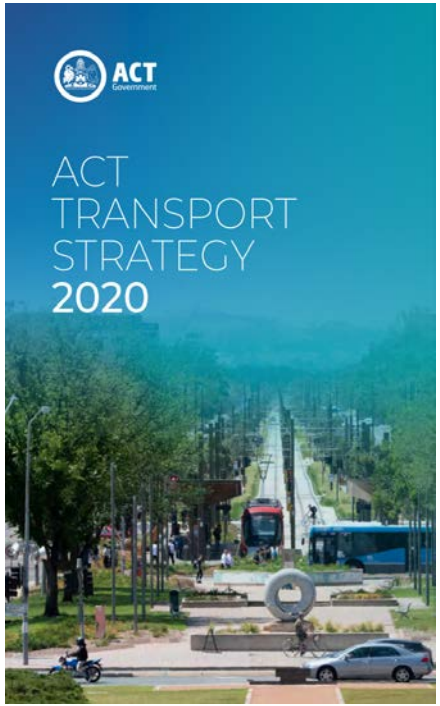
- **Travel congestion**
  - BITRE estimated Canberra's costs at $250M in 2016, $420M in 2030
- **Road construction and maintenance**
  - Productivity Commission estimated at $24B across Australia in 2014
- **Pollution**
  - 11,000 premature deaths/year (Uni Melb Climate Futures, April 2023)
- **Accidents**
  - Infrastructure Australia estimated economic cost of road accidents as $27B in 2017

Shared Goals?

Transport that:

- Provides universal access to safe, reliable, quick, on-demand, 24x7, door-to-door travel
- Costs less than cars or current public transport
- Minimises externalities (environmental, budgetary, health, …)
- Encourages "active" travel
- Encourages a better urban environment

Shared Goals?



Canberrans are generally early adopters of technology. There will be unprecedented opportunities from the emergence of viable electric and autonomous vehicle technology, to contactless and subscription ticketing services, to drone delivery technology.

Chris Steel MLA

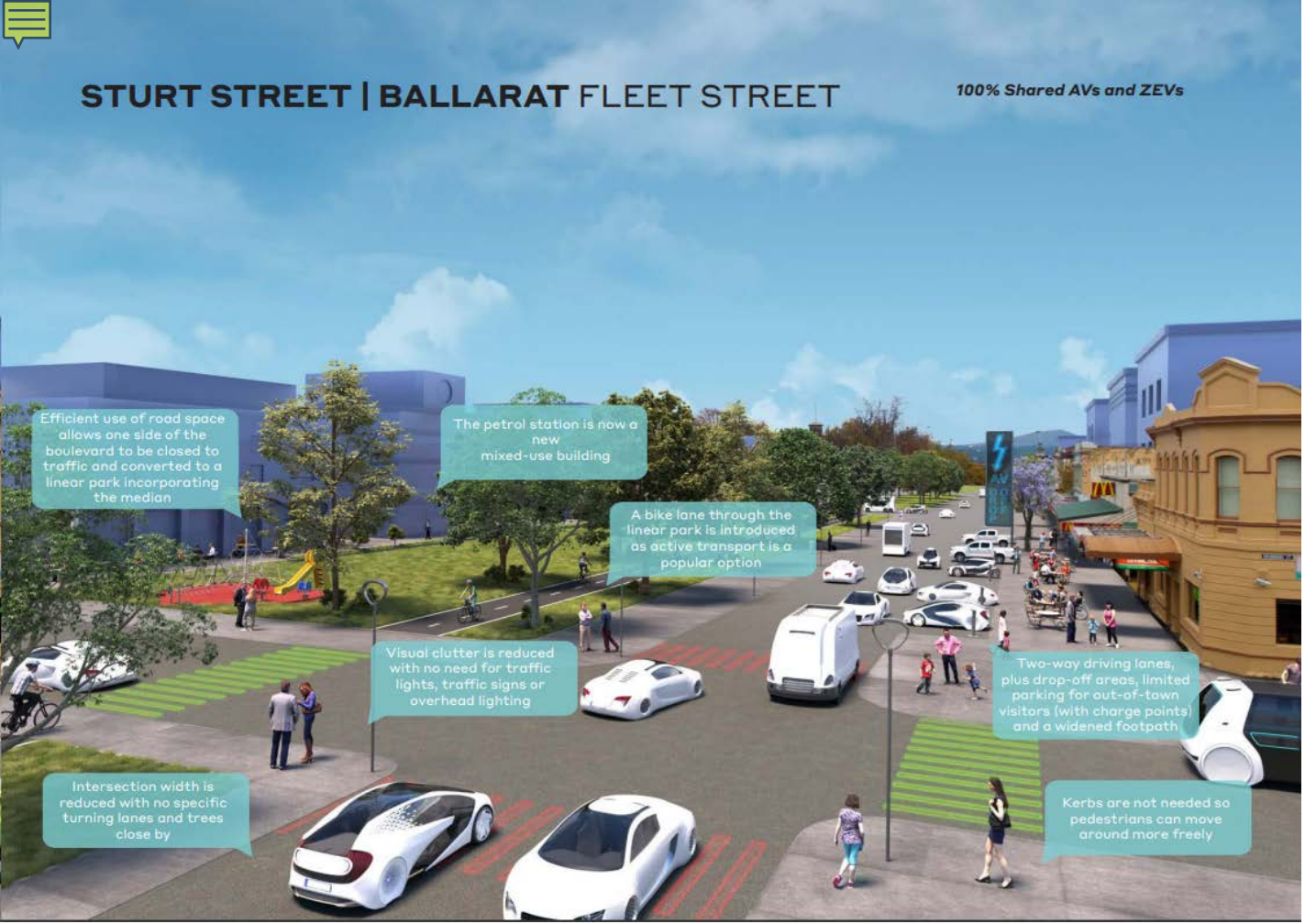
Minister for Transport

The benefits of AVs

- Safety
  - undistracted driver, better monitoring of surroundings, faster reactions
- Travel time can be repurposed
  - as productive work, relaxation, sleep
- Can be used by anyone and for goods deliveries
- Amenable to operation as a shared fleet

The benefits of a shared fleet of AVs

- Accessible to all
- 24x7, on-demand, door-to-door
- Very cheap
  - Private cars are typically 95% idle (unutilised)
  - Fixed costs shared over many more journeys
- Shared trips during peak -> much less congestion
- Many fewer vehicles
  - Car-parks and garages can be repurposed, streets redesigned..



Infrastructure Victoria https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Automated_and_Zero_Emission_Vehicles_-_How_They_Might_Reshape_Our_Streets.pdf

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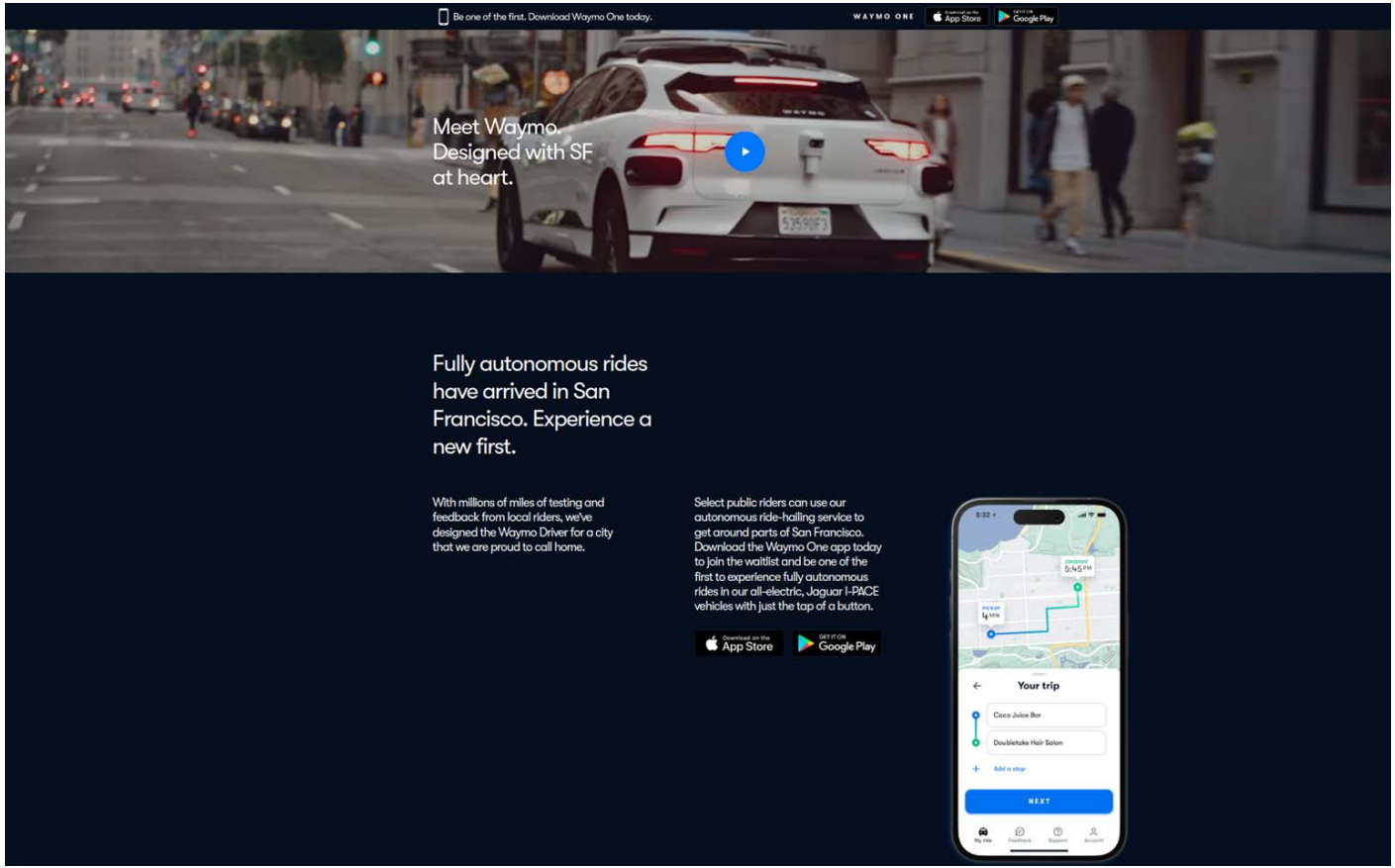
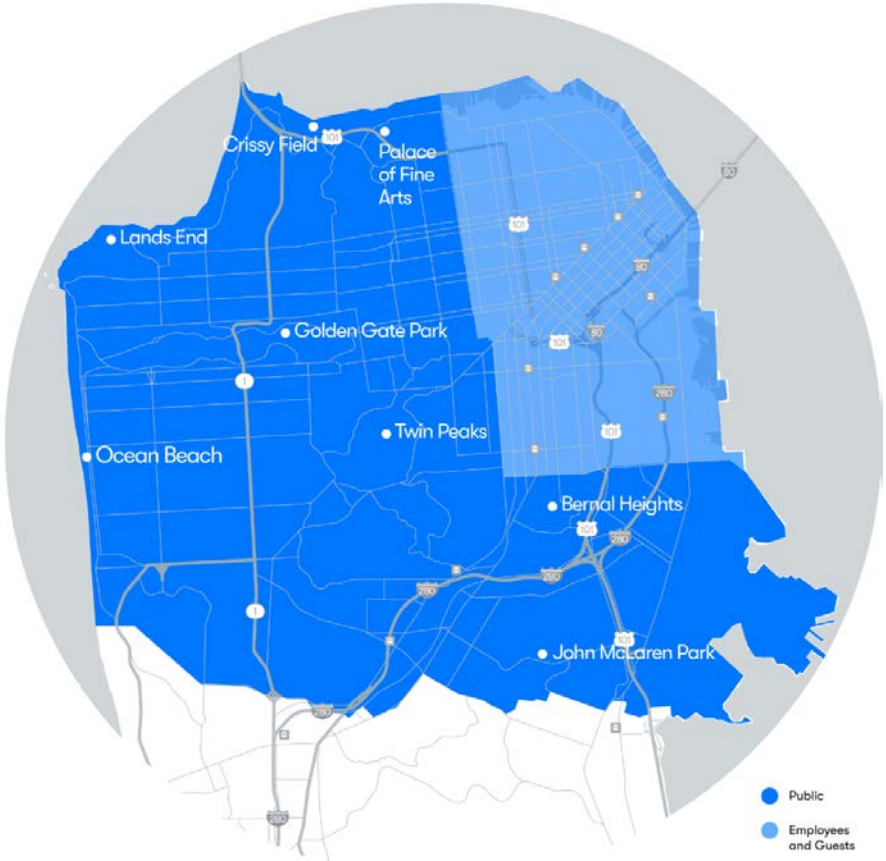
Current AV fleet deployments



Current AV fleet deployments

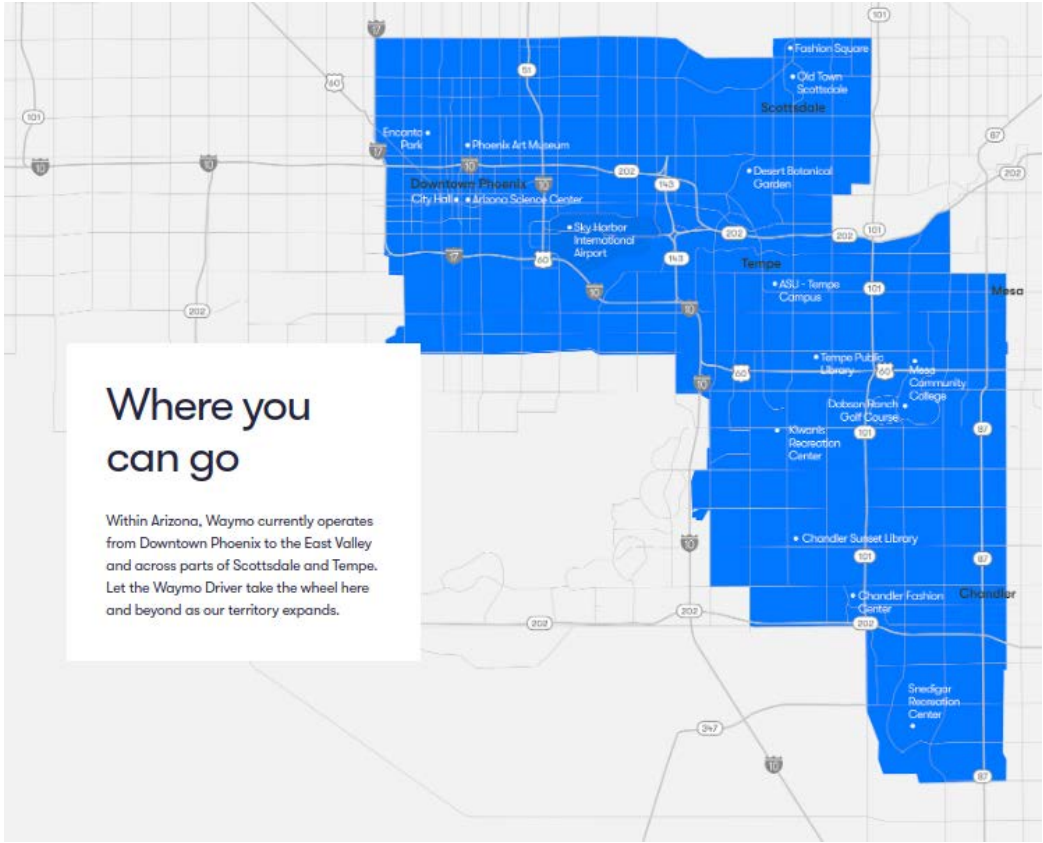
Waymo
San Francisco



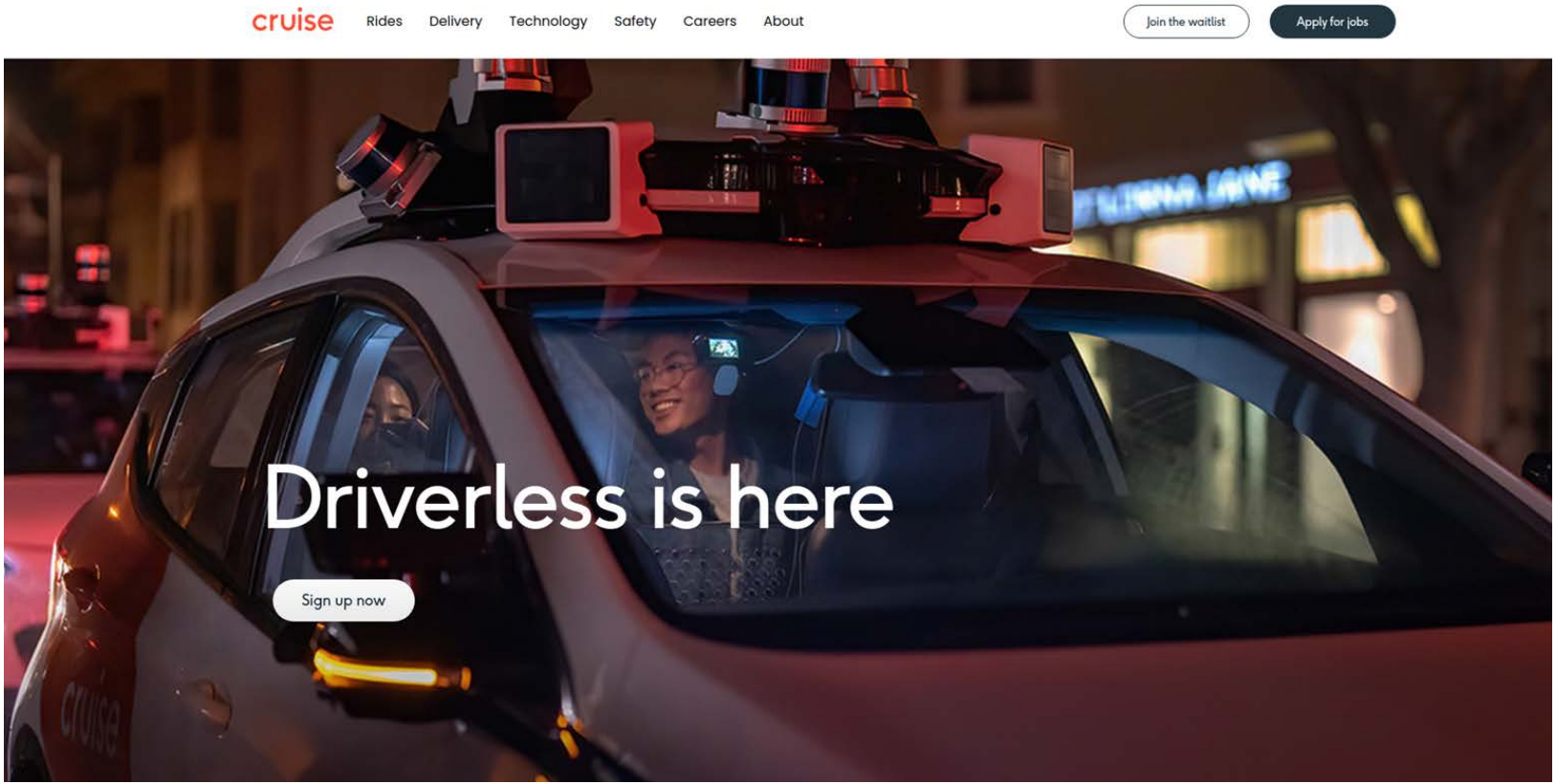
Current AV fleet deployments

Waymo

Phoenix



Current AV fleet deployments



Current AV fleet deployments

Cruise

San Francisco

Current AV fleet deployments

Cruise

Phoenix

Current AV fleet deployments

Cruise

Austin

Cruise
Origin

- Built by GM
- Unit cost $US50K
- 1.6million km life
- Wheelchair accessible
- Mass production this year
- Public-road testing starts this month

Current AV fleet deployments

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Cabs Without a Chatty — Or Any — Driver Are Expanding in China

Baidu is adding more driverless ride-hailing in major cities, and the journeys are reassuringly drama-free.

A screen showing the travel path through an intersection onboard a robotaxi equipped with Baidu's autonomous driving platform Apollo in Beijing on Nov. 10. *Source: Bloomberg*

By Bloomberg News
December 19, 2022 at 9:30 PM GMT+11

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Opinion | Anjani Trivedi

China's DriveGPT Is Here. Time to Play Catch-Up

Beijing's regulation has put its autonomous-vehicle industry way ahead of competitors. Entry-level offerings won't cut it any more.

Streets ahead. *Photographer: Lam Yik/Bloomberg*

By Anjani Trivedi
April 25, 2023 at 7:00 AM GMT+10

BLOG | JANUARY 04, 2023

Mobileye Kicks Off AV Pilot in Germany

In a key step, Mobileye has successfully passed TÜV SÜD's AV-Permit process to operate NIO ES8 vehicles with AV technology on German streets.

NIO ES8 equipped with cameras, radar and lidar sensors, of the type to be used in an autonomous vehicle test in Germany.

With the start of the year 2023, Mobileye has taken a key step on the road to the autonomous future of mobility: Mobileye obtained a permit recommendation from TÜV SÜD, an independent third-party for testing, certification, auditing and advisory service in Germany, enabling Mobileye to operate its AV technology on German streets. The permit makes way for Mobileye to expand the pilot phase in Germany and operate Mobileye Drive™-equipped NIO ES8s with a responsible safety driver on all roads in Germany.

Kick-Off for Mobility-as-a-Service (MaaS) Projects in Munich and Darmstadt

With the official recommendation, Mobileye is taking the next step in realizing new mobility concepts in Germany and beyond. NIO's ES8 was chosen by Mobileye in 2021 as the vehicle platform for Mobility-as-a-Service (MaaS) offerings underway with various partners in Munich and Darmstadt, as well as in other projects around Europe. NIO ES8s equipped with Mobileye's self-driving hardware and software are planned to be used in a robotaxi service as well as in the integration of on-demand shuttles into local public transport in Germany. Following the regulations adopted by European Union and German authorities for safe autonomous driving (AV) testing and deployment in 2022, the pilot stage for these services on German roads will accelerate throughout 2023. A safety driver will be behind the wheel until all needed approvals and permits are obtained for the vehicle to be entirely unmanned.

Full Self Drive

High risk/reward

Would a fleet of AVs work in Canberra?

How many would be needed?

How long would you need to wait?

What would they cost?

Findings from Canberra Simulation

34,000 cars operating in a shared fleet can provide 1.1m daily journeys…

… with 95% of journeys start within 1 minute of being requested, 99% within 3 minutes

… at a cost for a 10.6km (average) journey of $4.63 peak, $2.94 off-peak

… employing 2800 FTE

… reducing congestion with an average car occupancy of between 2 and 2.5 people for peak trips to popular destinations

… returning an operating surplus (~$100M/pa) after financing and all costs

Findings from Canberra Simulation

Base Model: [http://canberraautonomouscars.info/model.html]

- **Journey counts and distribution modelled on the 2017 Household Travel Survey, inflated to 2022 population estimates**
- **1.1 million passenger journeys per week day, 770K passenger journeys other days**
- **Peak period: weekdays, 7am-9am, 3pm-6pm**
  - **Seat is hired during peak (that is, a passenger may be sharing the journey with up to 3 others to the same or nearby or on-route destination)**
  - **Entire car is hired out of peak (that is, 4-5 people may travel as a group for the same cost as 1 person)**

Findings from Canberra Simulation

Base Model, continued:

- Shared fleet of 34,000 cars (Canberra's passenger fleet is ~265K)
- An additional 5% (1,700) cars purchased as spares
- Each car:
  - Purchase cost $65K, 3 year life, $14K residual value
  - Financing rate 4%
  - Fixed annual costs $4K
  - Per-km cleaning & maintenance costs 5.5 cents/km
  - Real-world max range 410 km, operated between 25% and 80%
  - Electricity usage 140 Wh/km costed at 12 cents/kWh, 85% efficiency

Findings from Canberra Simulation

Base Model, continued:

- **Installation of 1,200 x 120 kW charging stations**
  - **Distributed at 9 locations across Canberra**
  - **Each charging station:**
    i. **Purchase cost $70K, 10 year life, no residual value**
    ii. **Fixed annual costs $2K**
  - **Consumes ~2.1GWh/day (about 25% of current ACT usage)**
- **Other Fixed system costs: $15M/pa**

Findings from Canberra Simulation

Fares:

- **Peak: $0.40 flag fall, $0.40/km**
  - **typical 10.6km trip: $4.62**
- **Off peak: $0.30 flag fall, $0.25/km**
  - **typical 10.6km trip: $2.94**

	Public Transport [1]		Private Car [2]		Shared fleet of autonomous vehicles [3]
	Fare	Actual cost	Excluding parking	Including parking	Fare and actual cost
Daily commute 24km round trip parking in Parliamentary Triangle	$6.44	$21.54	$17.00	$33.00	$11.44
Daily commute 16km round trip parking in Belconnen Town Centre	$6.44	$21.54	$11.36	$22.36	$7.92
Night out in Civic for 2 people travelling together, 24km round trip night parking Canberra Centre	$10.20	$43.08	$17.00	$20.00	$7.26
Weekend family trip to the Belconnen Mall, 20km round trip, 2 adults, 2 children free parking	$16.08	$86.16	$14.20	$14.20	$6.16

Full details at https://canberraautonomouscars.info/

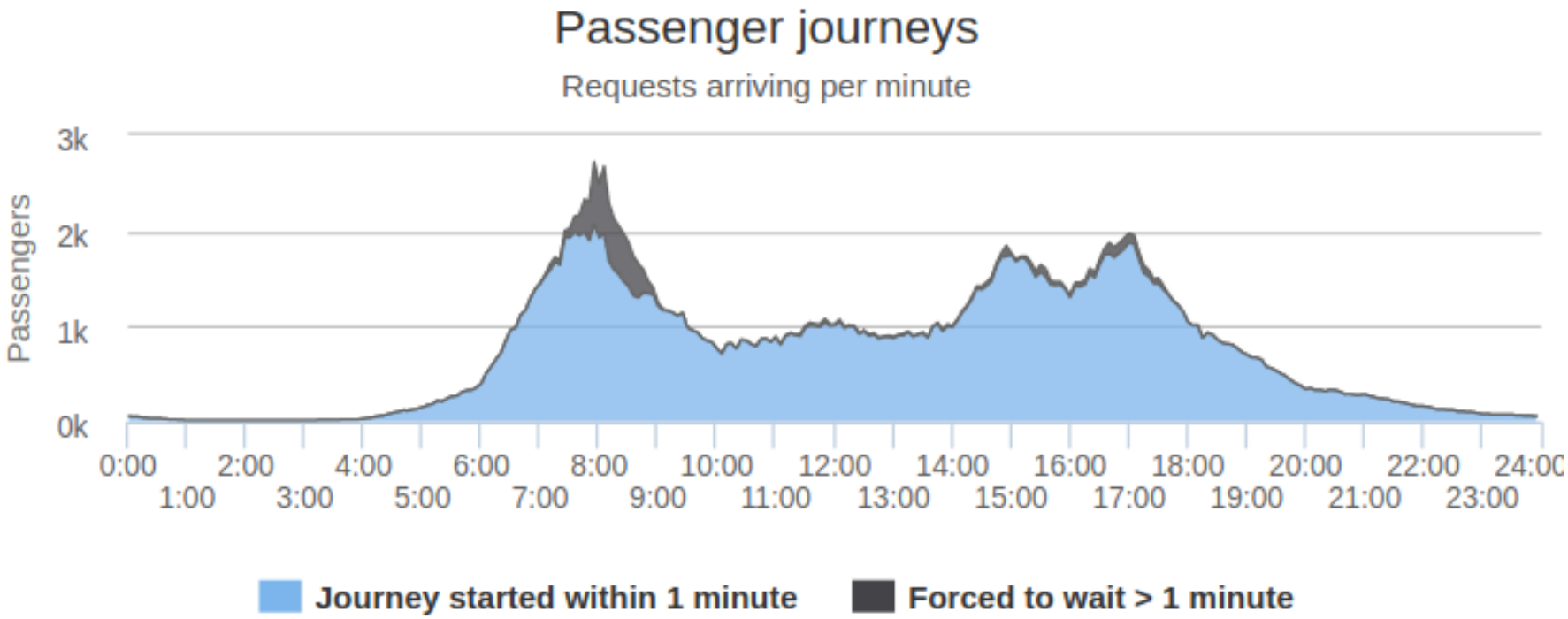
Findings from Canberra Simulation

[http://canberraautonomouscars.info/sim.html]

Wait times:

1 minute or less:	95.4%
1-2 minutes:	3.3%
2-3 minutes:	0.7%
3-5 minutes:	0.5%
over 5 minutes:	0.1%

Findings from Canberra Simulation



Findings from Canberra Simulation

Passengers per trip-leg:

1	80%
2	10%
3	4%
4	6%

Findings from Canberra Simulation

Average passenger per car occupancy in morning peak:

- **To Civic 2.4**
- **To Parkes 2.5**
- **To Barton 2.3**
- **To Russell 2.3**
- **To Belconnen 2.4**
- **To ANU 2.0**

Canberra average for **work** related trips from latest Household Transport Survey: 1.1

Obstacles and timeframes

1. Technology
   - *Will* eventually be ubiquitous and low cost, but when?
     2023? 2025? 2028?
2. Infrastructure
   - Dependencies vary by approach, but probably minimal
3. Regulatory/Legislative
   - Liability, privacy, …
4. Community acceptance
5. Ownership, operation and governance
6. Economic disruption
   - Businesses/careers in traditional transport
   - Income forgone car rego/licencing/parking/fines: $280m, fuel excise: $190m
7. Transition
   - Uneven rollout, coexistence with human drivers

https://canberraautonomouscars.info/

Canberra Autonomous Car Simulation

Home | Run the simulation | About the model

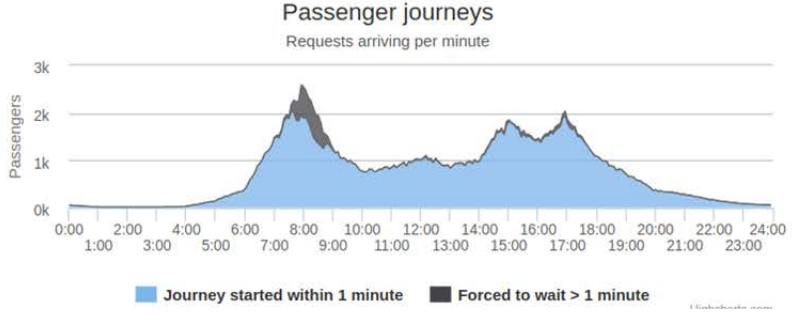
This is a simple simulation of the operational characteristics of an autonomous car fleet in Canberra. It investigates the performance of such a fleet providing the transport needs of citizens under a variety of conditions using parameters which you may specify yourself.

The computational requirements of this model are much larger than a normal web page. Even using a modern browser on the latest desktop hardware, it may take a minute or two to run. A system running the equivalent of a Core-i5 or i7 processor with 4GB of memory and the most recent version of Chrome, Firefox, Safari or IE10/IE11/Edge is recommended.

More information about this simulation is available here.

Edit simulation settings or Run simulation using current settings [34000 cars, 1100000 journeys]

Default 2022 Model



Passenger stats

1,102,502 journeys, most (49,885) starting from Parkes

Peak period journeys: 522,206
Off peak journeys: 580,296
Average journey length: 10.6 km

Passengers per trip leg		
	1	79.80%
	2	10.15%
	3	4.14%

Discussion

Presentation url: bit.ly/427yhBk

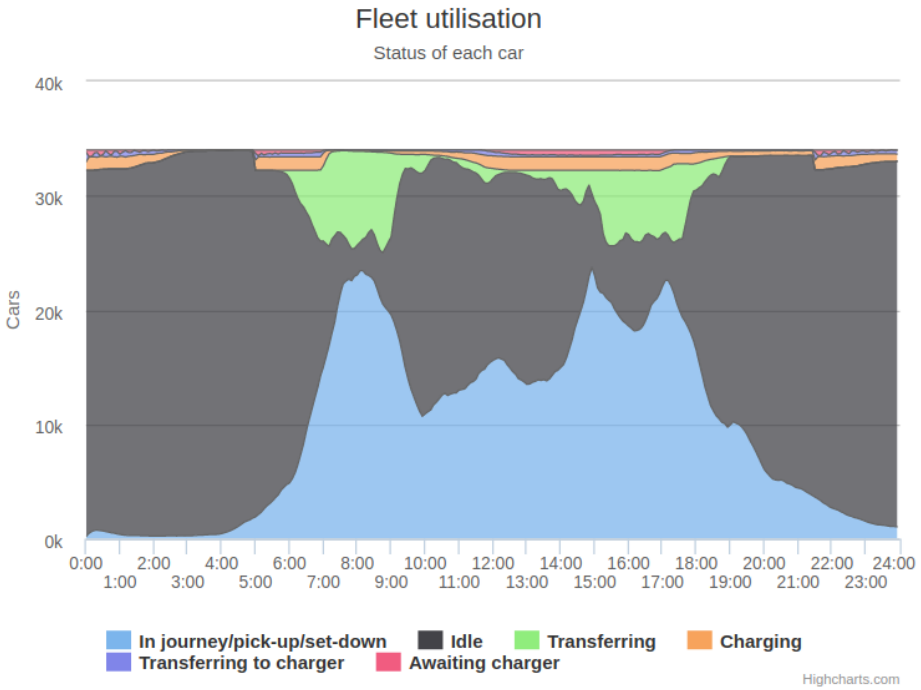
support slides follow:
not intended to be shown unless something relevant comes up in discussion

Findings from Canberra Simulation

Base Model, continued:

Workforce full-time equivalent summary (2785 in total):

- **Cleaning and charging general staff: 1900**
- **Cleaning and charging management: 130**
- **Mechanics and electricians: 600**
- **Mechanics and electricians management: 90**
- **Corporate management, admin, technical specialist: 65**



Fleet stats

	Total	Av per car	Max any car
Passenger journeys	1,102,306	32.4	135
Passenger trips (occupied)	852,046	25.1	38
Trip time (min)	15,125,540	444.9	714
Trip distance (km)	9,933,501	292.2	493
(Includes within-suburb pickup/set-down distance of 676,222 km - 7% of trip km)			
Transfers (unoccupied)	257,507	7.6	16
Transfer time (min)	3,191,485	93.9	201
Transfer distance (km)	2,330,952	68.6	168
Charges	70,248	2.1	3
Charging time (min)	987,501	29.0	51
Charger wait time (min)	195,645	5.8	32
Charge transfer time (min)	333,735	9.8	34
Charge transfer distance (km)	194,951	5.7	25
TOTAL DISTANCE (km)	12,459,404	366.5	

Transfers as a percentage of total distance travelled: 20.3%
Average time spent idle: 59.9%

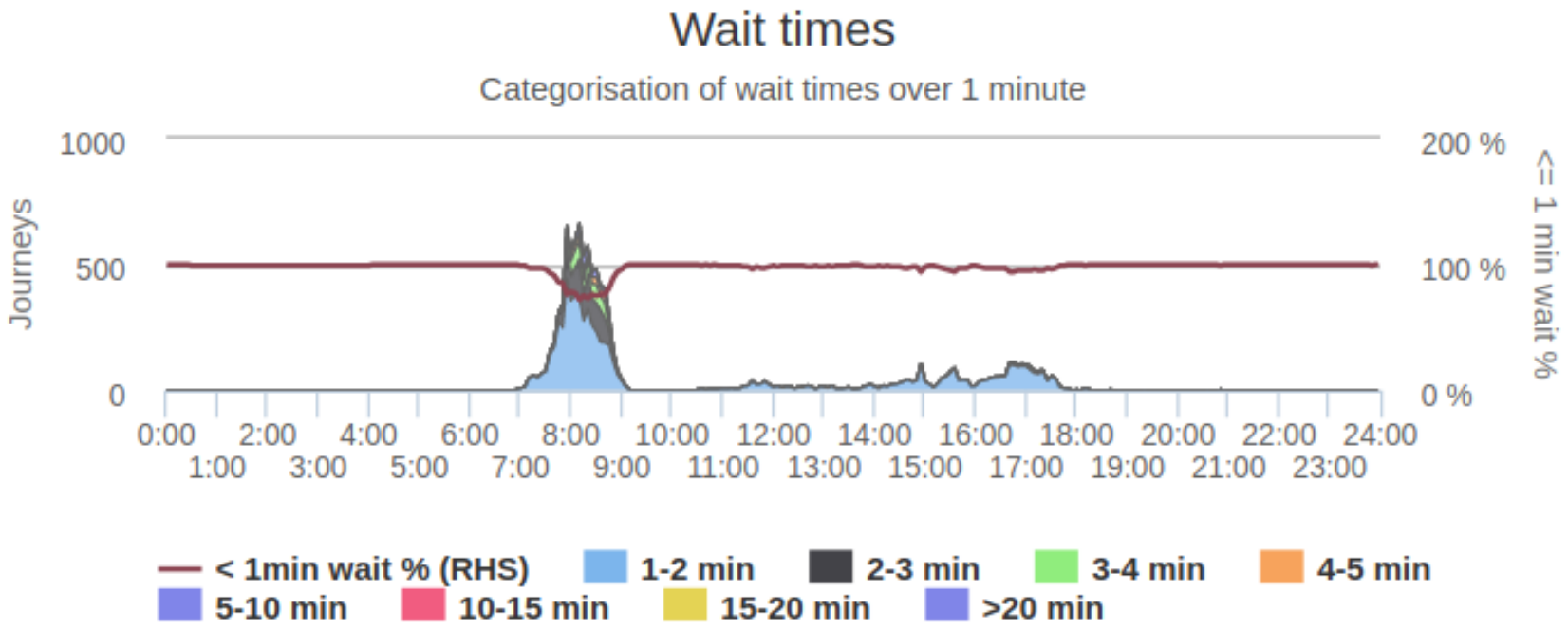
Peak period passenger journey service and car travel distance
Completed passenger service distance: 5,299,374 km (private car equivalent)
Car travel distance: 5,434,629 km
Ratio of car-travel distance : passenger service distance: 1.0

Annual income and expense summary for the default model

	$M		Note
Fare income		**$1282**	
Expenses		**$1155**	
Lease or capital & interest		$674	
Cars	$663.3		
Chargers	$10.1		
Workforce		$192	FTE: 2785
Cleaning and charging operational	$110.0		FTE: 1970
Cleaning and charging management	$13.0		FTE: 130
Mechanics/electricians operational	$51.0		FTE: 600
Mechanics/electricians/fleet management	$9.0		FTE: 90
Admin, technical specialist and management staff	$8.5		FTE: 65
Parts		$90	
Car tyres	$34.0		
Per-km related parts and consumables	$38.3		
Non per-km related parts and consumables	$17.0		
Charger parts and consumables	$0.6		
Insurances, rego, comms, workshop		$104	
Electricity		$87	
Other		$8	
Charger rent	$0.6		
Office rent, equipment repairs and replacements, facilities, consumables and contracted services	$7.5		
Operating Surplus		**$127**	

FTE: "full-time equivalent" number of staff

Findings from Canberra Simulation



Financials

Costs

	Annual	Per day Average all days
Per Charger		
Capital and interest	$8400	$23.01
Maintenance & rent	$2000	$5.48
Per Car		
Capital and interest (includes spares)	$19509	$53.45
Per-km travelled maintenance	$7078	$19.39
Non per-km (insurance/rego/fleet management..)	$4000	$10.96
Power	$2544	$6.97
Pro rata charger costs	$367	$1.01
Pro rata fixed system	$441	$1.21
Total Costs	**$33939**	**$92.98**

Revenue per *weekday* per car

	Per car
Flag falls, peak	$6.16
Per-km fares, peak	$61.97
Flag falls, off peak	$5.11
Per-km fares, off peak	$46.78
Total Revenue	**$120.02**

Revenue per *non weekday* per car

	Per car
Flag falls	$6.81
Per-km fares	$59.86
Total Revenue	**$66.67**

Net position

	Per car per day	Days per year	Per car per year
Weekday total costs	$94.02	250	$23505
Weekday total revenue	$120.02	250	$30004
Weekday surplus	**$26.00**	**250**	**$6499**
Non-weekday total costs[*]	$90.73	115	$10434
Non-weekday total revenue[*]	$66.67	115	$7667
Non-weekday surplus[*]	**$-24.06**	**115**	**$-2767**
Annual Surplus Per Car			**$3732**

* Crudely assumes non-weekday traffic has the same hour-distribution but only 70% of the journeys as week day traffic, and that non-weekday per-km costs are somewhat more than 70% of weekday per-km costs. All non-weekday traffic is off-peak.
More details....

Annual Surplus of fleet: $127M

A more detailed annual income and expense summary based on the default model settings is available here.