Shared Design Framework for Autonomous Vehicles and Land Use Interface

Going in. Moving within. Going out.

Presenter: Swee Y Ku

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Agenda

1. Current progress of AV trials
2. Literature perspectives – pros and cons
3. Singapore context in comparison to case study cities
4. Gaps to be plugged before commercialization
5. Conclusion and further research

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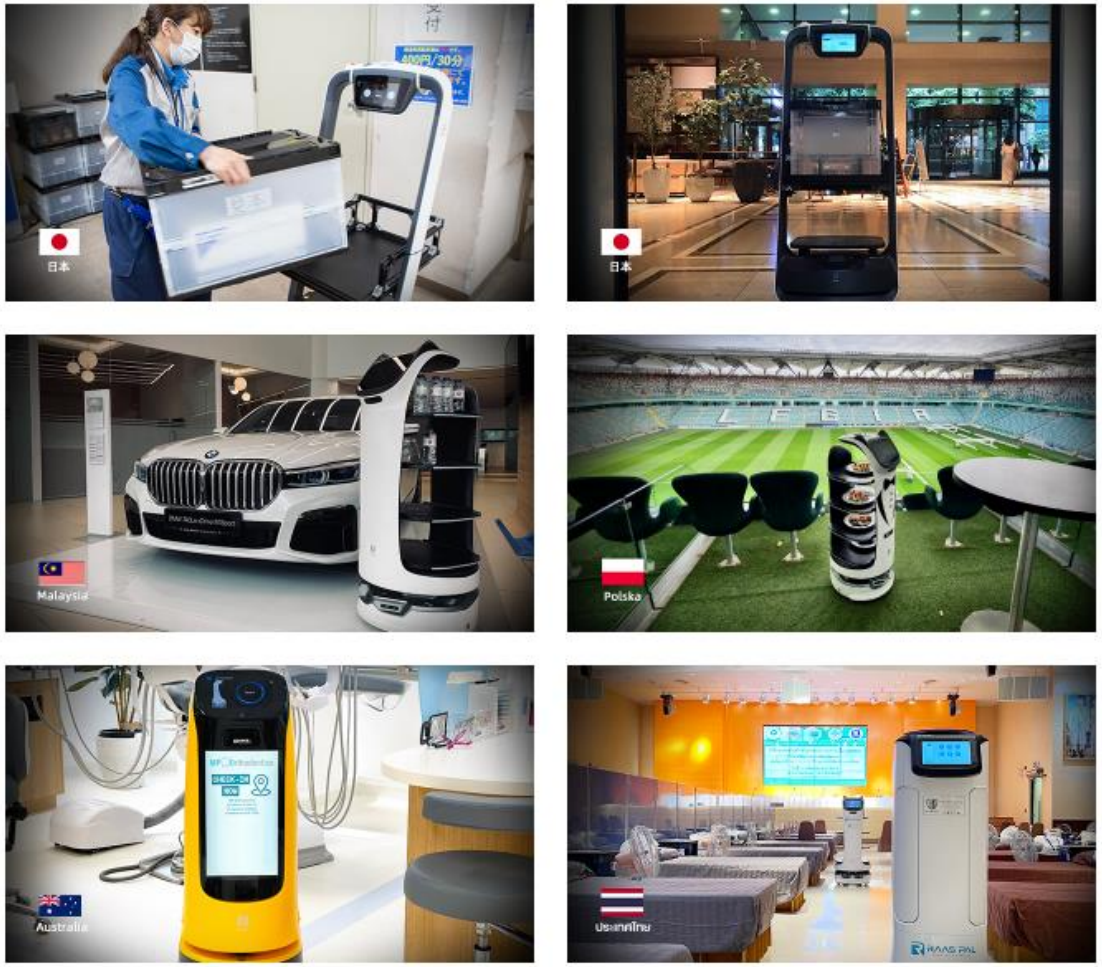
1. Current progress of AV trials

1. Didi's five-hour drive
2. Waymo's free taxis
3. Toyota's e-Palette at Olympics Village
4. Vacuum cleaners and delivery bots
5. Cruise, Pony.ai, AutoX, WeRide, Zoox…

- Countries trialling AV technology:

US, China, Australia, South Korea, Japan

over 10 European countries… Singapore



Source: https://www.pudurobotics.com/customer/Others/Others

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1. Current progress of AV trials

Source: https://youtu.be/wqfqquWucb8

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2. Literature perspectives - negatives

Downsides	Areas	Reasoning
Economic	Government budgets	Convenience may reduce the usage of mass public transport (e.g., trains, buses). Reduction in revenue from parking and traffic fines.
	Millions of jobs lost	Reduced need for drivers (trucks, taxis, buses), traffic police officers etc. Can be retrained in AV-related vocations.
	Financial losses	City governments and building owners investing in AV infrastructure and technologies risk rapid tech obsolescence and system failures.
Environmental	More congestion	Greater accessibility will lead to increased demand for car trips.
	Redundant carparks	Reduced car park demand, many will be costly to repurpose.
Security	Hackers and bad actors	System controls could be hacked, bring entire transport system to standstill.
	Privacy and surveillance	Monitoring of individuals' locations. Malicious intent by individuals or groups/organisations.

2. Literature perspectives - positives

Benefits	Areas	Reasoning
Economic	Lower operating costs and reduced total cost of ownership	• Save on salaries of truck drivers, overtime and nightshift workers. • Passenger commute time can be used for productive work. • Reduced parking costs. • Reduction in driver-influenced accidents, lower insurance fees, maintenance expenses. • Shared ownership can reduce idle time.
	Create more high-skilled jobs	AV fleet management, operations, repairs and upgrades.
Environmental	Less emissions from cars and trucks	Reduced fuel consumption, assuming 100% EV fleet.
	Less congestion	Reduced car population, ride and car sharing convenience. AV fleet route optimization can balance traffic flow.
Social	Accessible to more people	• Increase accessibility for low-income households. • Improve travel for elderly, young, those with mobility issues.

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3. Singapore context in comparison to case study cities

- 728 km^2, 5.45 million population, >12,000 carparks, roughly 1.4 million parking lots across public and private housing, open air and curb-side carparks, retail malls, offices, industrial buildings (Lin, 2021)
- ~8,300 people per km^2, one of the highest population densities in the world, mostly living in **high-rise** buildings
- AV road trials since 2014 (Kelleher, 2017), Centre of Excellence for Testing & Research of Autonomous Vehicles (CETRAN) opened 2017, 1.8 hectares AV test circuit
- Land transport Authority (LTA) acknowledges potential AV benefits. Published roadmap for AV deployment (no target dates)
- 2030 Agenda for Sustainable Development, Sustainable Development Goals (SDGs) and Green Plan 2030 to reduce carbon emissions:
  - ✓ "Car-lite" precincts in 10 towns around Singapore
  - ✓ Encourage EV use by introduction of 60,000 charging stations
  - ✓ Aim to make all towns EV-ready by 2030

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1 Singapore

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Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

Singapore's top rating on policy and legislation reflects the further efforts it has taken to encourage the use of AVs. In January 2019, the city-state's government published its TR68 draft national standards for such vehicles as well as a voluntary AI governance framework, with the latter updated in January 2020 with real use-cases and consideration of how AI must generate consistent results.[26]

AV test sites in most countries and jurisdictions are either closed or tend to occupy relatively small areas, but in October 2019 Singapore expanded its testing area to cover all public roads in western Singapore, around 1,000 kilometers (620 miles) making up one-tenth of the city state's total.[27] It also started retraining 100 bus drivers as AV bus safety operators, as part of its target to serve three new towns with driverless buses from 2022. March 2019 saw Volvo launch a 12-metre AV electric bus with Singapore's Nanyang Technological University, which could be used to serve these areas. Such work is supported by Singapore's excellent road infrastructure, rated the best in the world in the World Economic Forum's *Global competiveness report*.

Singapore's February 2020 budget included S$6 million (US$4.3 million) to support AV test-beds. With the aim of phasing out all internal combustion engine vehicles by 2040, it pledged to expand the number of EV charging points from 1,600 to 28,000 by 2030. An EV early adoption incentive scheme running until December 2023 cuts the purchase cost of such vehicles by an average of 11 percent.[28] While the budget has cut annual road taxes for EVs, it also started phasing in a usage tax of S$700 (US$500) a year for fully-electric vehicles, in advance of a distance-based usage tax to compensate for the loss of fuel excise duties.[29] "I think Singapore is ahead of the curve in thinking through the budget consequences of EVs," says Satya Ramamurthy, Partner, Head of Infrastructure, Government and Healthcare, KPMG in Singapore and Indonesia.

March 2020 saw South Korean vehicle maker Hyundai announce a global innovation center that will open in Singapore in 2022, while Chinese vehicle electronics company Desay has set up its first overseas research and development center to work on AVs. However, UK consumer manufacturer Dyson cancelled its plans to open a factory for EV vehicles in Singapore.

Ramamurthy says that the country's market size makes it difficult to attract vehicle manufacturing, but it has major strengths including people's acceptance of new technologies, recognized by its leadership of the consumer acceptance pillar. AVs are also expected to be integrated into Singapore's land transport master plan for becoming a '45-minute city' with 90 percent of journeys completed in this time by 2040.[30] Private AV ownership is not the priority: "That is consistent with the 'car-lite' policy of Singapore. AV adoption and development will be significantly focused on freight movement and public transport in the first instance, rather than for personal transport."

Quality of roads top five

Source: World Economic Forum, *Global competiveness report* (2019)

> "AV adoption and development will be significantly focused on freight movement and public transport in the first instance, rather than for personal transport."
>
> **Satya Ramamurthy**
> Partner, Head of Infrastructure, Government and Healthcare
> KPMG in Singapore and Indonesia

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Country or jurisdiction	Rank 2020	Rank 2019	2020 score
Singapore	1	2	25.45
The Netherlands	2	1	25.22
Norway	3	3	24.25
United States	4	4	23.99
Finland	5	6	23.58
Sweden	6	5	23.17
South Korea	7	13	22.71
United Arab Emirates	8	9	22.23
United Kingdom	9	7	21.36
Denmark	10	n/a	21.21
Japan	11	10	20.88
Canada	12	12	20.68
Taiwan	13	n/a	19.97
Germany	14	8	19.88
Australia	15	15	19.70
Israel	16	14	19.40
New Zealand	17	11	19.19
Austria	18	16	19.16
France	19	17	18.59
China	20	20	16.42
Belgium	21	n/a	16.23
Spain	22	18	16.15
Czech Republic	23	19	13.99
Italy	24	n/a	12.70
Hungary	25	21	11.66
Russia	26	22	11.45
Chile	27	n/a	11.28
Mexico	28	23	7.42
India	29	24	6.95
Brazil	30	25	5.49

3. Singapore context in comparison to case study cities

Case Study	Economic	Social	Technology	Legal	Stakeholders	Built Environment
Seattle	✓	✓	✓	✓	✓	✗
Zug	✓	✗	✓	✓	✗	✗
Adelaide	✓	✓	✓	✓	✓	✓
Singapore	✗	✗	✓	✗	✓	✗

References:

Seattle: Driverless Seattle: How Cities Can Prepare For Automated Vehicles | Key Findings and Recommendations | Tech Policy Lab. (2017). https://techpolicylab.uw.edu/news/driverless-seattle/

Zug: Bösch, P. M., Ciari, F., & Axhausen, K. W. (2018). Transport Policy Optimization with Autonomous Vehicles. Transportation Research Record: Journal of the Transportation Research Board, 2672(8), 698–707. https://doi.org/10.1177/0361198118791391

Adelaide: Kellett, J., Barreto, R., Hengel, A. V. D., & Vogiatzis, N. (2019). How Might Autonomous Vehicles Impact the City? The Case of Commuting to Central Adelaide. Urban Policy and Research, 37(4), 442–457. https://doi.org/10.1080/08111146.2019.1674646

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AVs Navigating Residential Multi-Storey Car Park (MSCP)

The challenge of the

AV – Built Environment Interface

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Navigating Residential MSCP

A typical multi-storey car park in a public housing estate

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Entrance to a Hotel's PUDO, MSCP and Loading Bay

The challenge of the

AV – Built Environment Interface

* PUDO = Pick Up Drop Off

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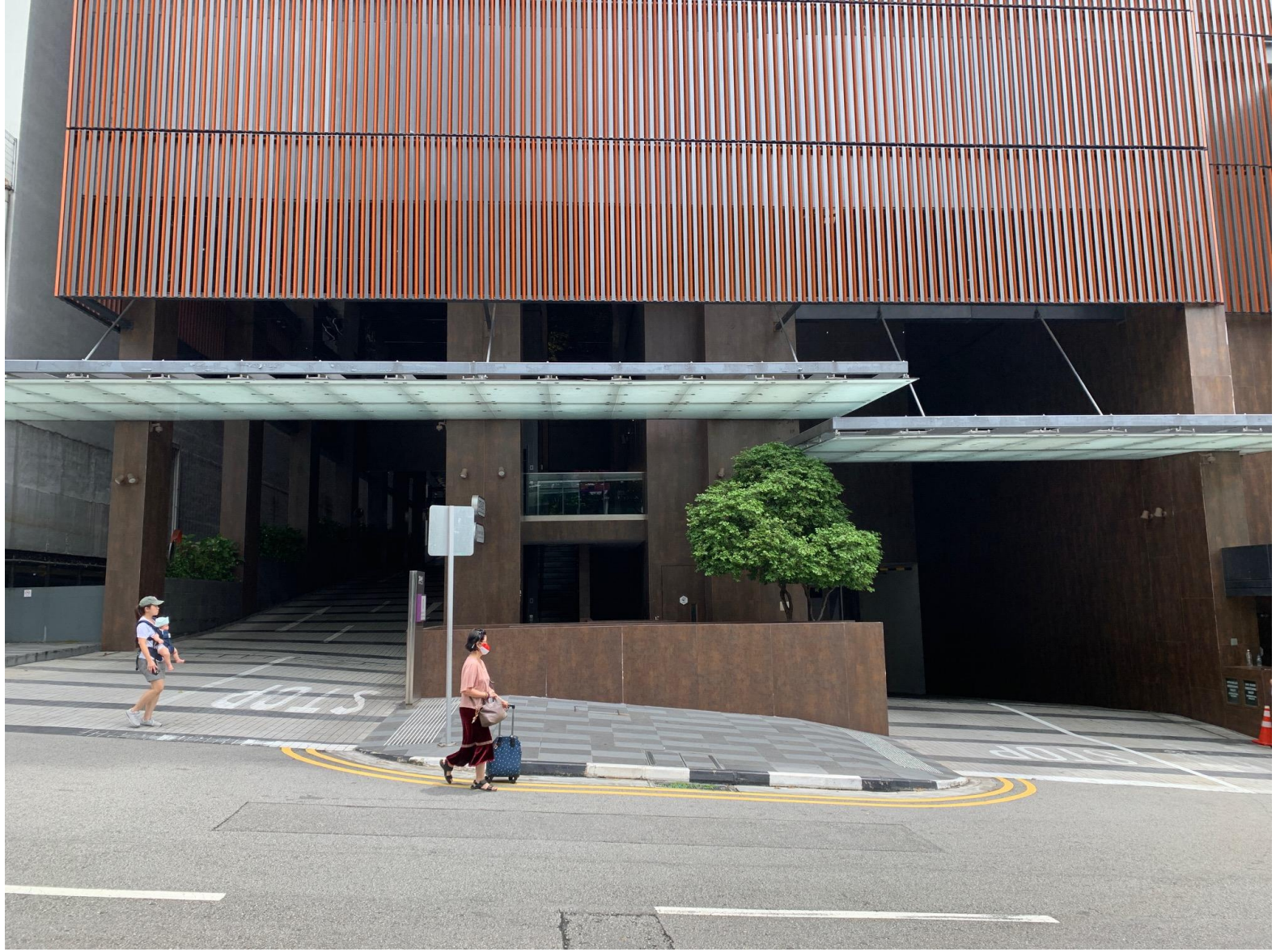

Single address: 366 Orchard Road
Double entrance, multiple pathways to
PUDO and Loading Bay

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Single address: 366 Orchard Road
Double entrance, multiple pathways to
PUDO and Loading Bay

Office Tower
PUDO and Loading Bay in the basement

The challenge of the
AV – Built Environment Interface

* PUDO = Pick Up Drop Off

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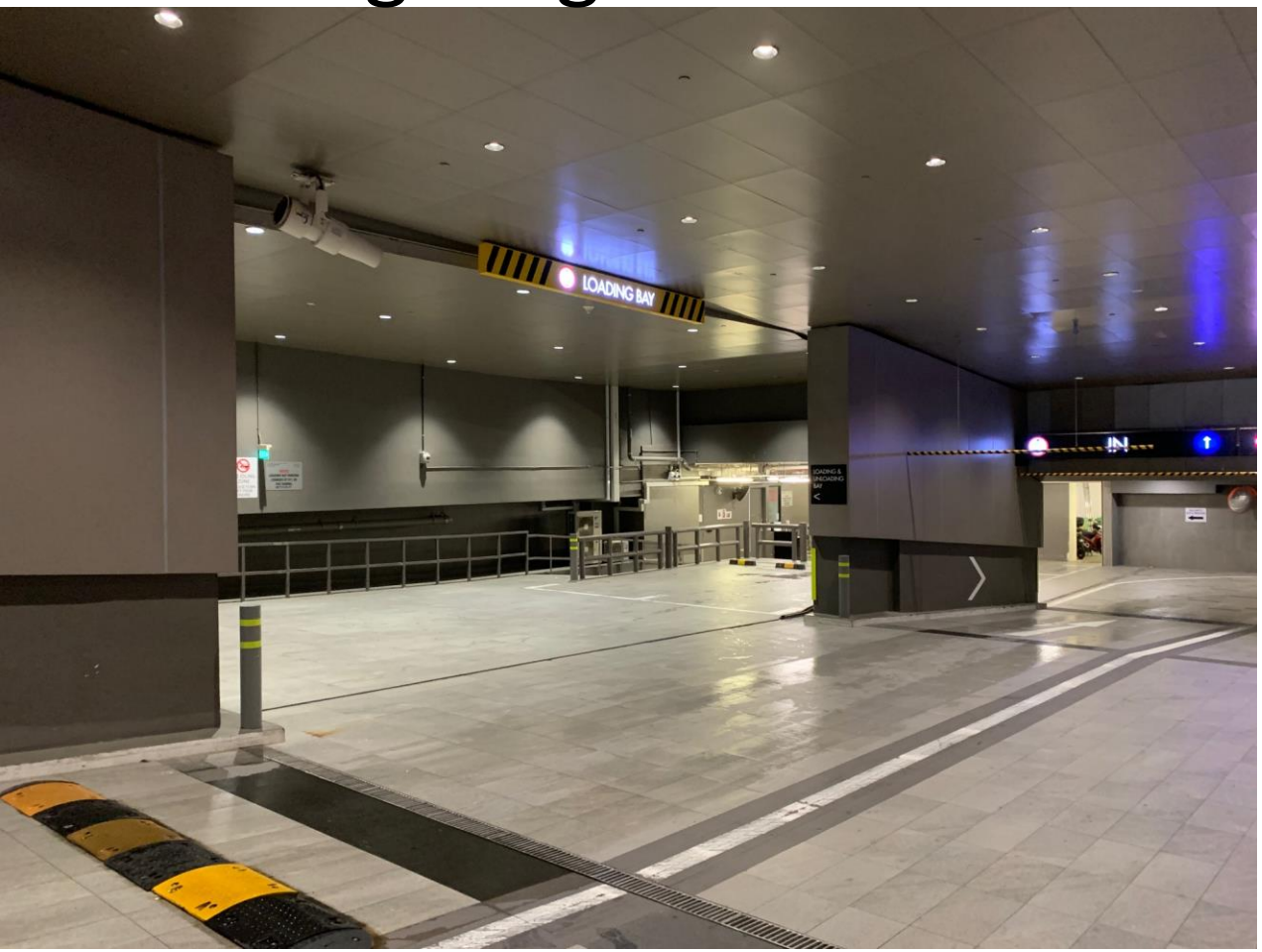
Navigating Office PUDO and Loading Bay



Loading Bay

Passenger PUDO

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AVs Navigating Industrial Multi-Storey Car Park (MSCP)

The challenge of the

AV – Built Environment Interface

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Navigating Industrial MSCP

Source: https://youtu.be/fGErc--l1aY

4. Gaps to be plugged before commercialization

- Studies on AVs mainly technology-focused
- Social science investigations have focused on positives and negatives of AV integration, commuter perception and effects on traffic volume, car ownership

Literature analysis reveals a lack of discussion on the interface between AVs and the built environment, such as:

- Assessing the current built environment for AV compatibility/readiness
- Developing a design framework for adaptation of current buildings and development of new buildings to ensure AV compatibility and avoid obsolescence

The development of a framework is crucial to ensuring smooth AV adoption via efficient integration in high density urban settings like Singapore

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4. Gaps to be plugged before commercialization

1. Laws and statutes – Singapore's statutes for AV trials
2. Land use master plan – planning for future carpark redundancy, extended PUDO* points and loading/unloading bays, urban sprawl
3. Economics – municipal revenues, COEs, ERPs, public transport subsidies
4. Jobs – traffic police, insurance agents, ticketing aunties/uncles, taxi/bus drivers, truck drivers, maintenance workers
5. "AV – Built Environment Interface"

* PUDO = Pick Up Drop Off

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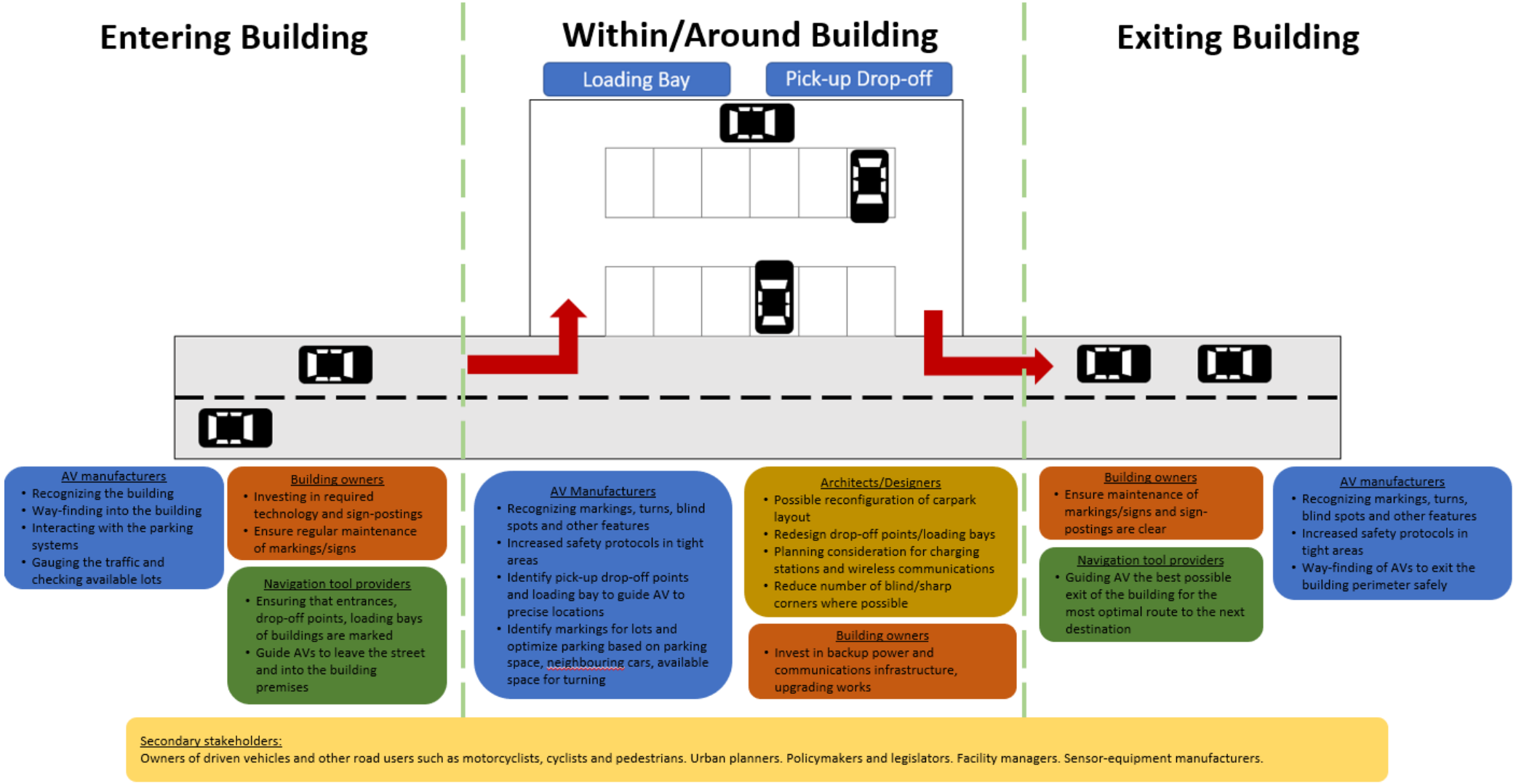
4. Gaps to be plugged before commercialization

Proposal for a shared design framework



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4. Gaps to be plugged before commercialization

- Stakeholders:
    1. Landlords/Investors
    2. Facility Managers
    3. Asset Managers
    4. Tenants
    5. Visitors
    6. Delivery/Transport Companies
- For Landlords:
    1. upgrade buildings to ensure their properties can integrate with AV technology and anticipate future building regulations
    2. make provisions for carpark space to be adaptively reused in future

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5. Conclusion and further research

1. Create framework to assess existing buildings
2. Create guidelines for design of new buildings
3. Case studies of geofenced sites: single buildings, hospitals, universities, airports
4. Case studies of building typologies: high rise warehouses, shopping centers, office blocks, mixed developments
5. Setting Vehicle-to-Infrastructure communications standards

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Collaborate with us!

We welcome collaboration partners:

1. To create the assessment checklists, guidelines, scorecards
2. Participate in the research and expert interviews
3. Co-development of intellectual property
4. Project sponsorship grants

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Source: www.suss.edu.sg/giving/sustainable-built-environment-fund

Thank you!

Researcher:

Ku Swee Yong

HP: +65 9615 3543 . Email: syku001@suss.edu.sg

https://www.linkedin.com/in/swee-yong-ku-ipa/

Supervisor:

Sheila Maria Arcuino Conejos, PhD, RAIA, FMP

Senior Lecturer and Head, Master of Built Environment, Graduate Diploma in Facilities Management, BSc in Facilities and Events Management and BSc in Facilities Management Programmes - School of Science and Technology

https://www.suss.edu.sg/about-suss/faculty-and-staff/detail/sheila-maria

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