Considering automated vehicle deployment uncertainty in the design of optimal parking garages using real options

2023 Indiana Housing Conference

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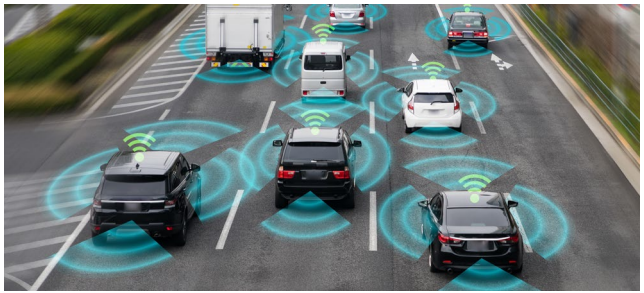
Context

Electrical vehicles

Autonomous vehicles

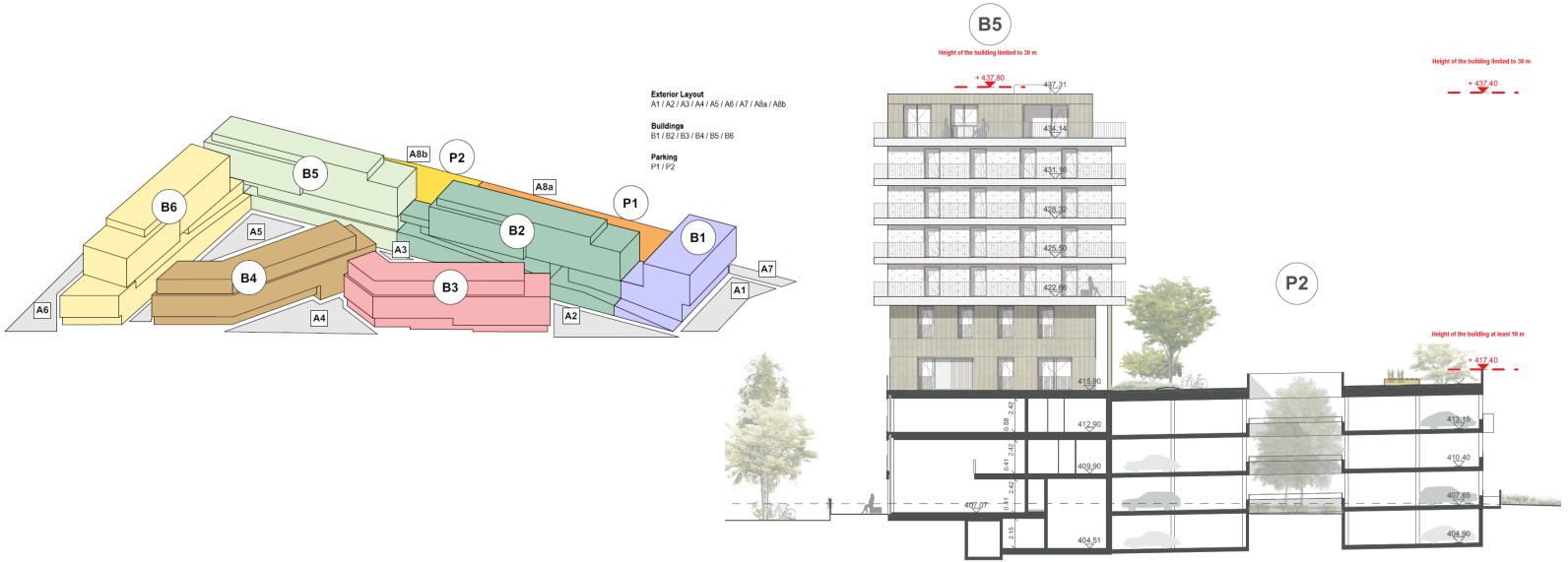


Future of parking garage

Scope

Research Question

With the uncertainty of AV deployment and its effect on parking demand, to what extent is the implementation of flexibility in infrastructure design beneficial?



Elvarsson, Arnór B., Claudio Martani, and Bryan T. Adey. "Considering automated vehicle deployment uncertainty in the design of optimal parking garages using real options." Journal of Building Engineering 34 (2021): 101703.

Steps

1. Define service and expected level of service

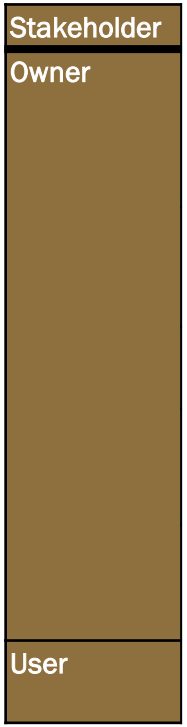
2. Build the objective function

3. Model the uncertainty related to key variables

4. Describe the possible intervention options

5. Evaluate the intervention options

1. Define service and expected level of service



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1. Define service and expected level of service

Stakeholder	Cost	Description
Owner	Construction cost	Initial cost of building is dependent on the excavation costs, needed construction materials and the labor efforts required. The largest difference between parking and residential facilities is the cost of interior.
	Development cost	Costs of use transition include the different instalments to the interior required as well as to the exterior. They also include the labor efforts and material costs.
	Demolition cost	Includes removing the building, and the resulting debris, at the end of a building's life-time
	Rent income	Owner's positive cost due to the user's use of the infrastructure
	Operational costs	A cost dependent on the use and interior of the building
User	Cost of no parking	If parking is removed, users that want to park will be affected, both economically and in terms of comfort

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	Demolition cost	Includes removing the building, and the resulting debris, at the end of a building's life-time	Variable. Dependent on the design
	Rent income	Owner's positive cost due to the user's use of the infrastructure	1'452 CHF/year per parking spot*
			263 CHF/year/sq.m. for residential use*
	Operational costs	A cost dependent on the use and interior of the building	600 CHF/year per parking spot**
			35 CHF/year/sq.m. for residential use**
User	Cost of no parking	If parking is removed, users that want to park will be affected, both economically and in terms of comfort	500 CHF/person**

* Source: Wüest & Partner, 2016 | ** Source: Estimate made by authors

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2. Build the objective function

Objective function: difference between benefits and costs over the garage's life-time (T)

$$Z_i = \sum_{t=0}^{T} (d_t \cdot \sum_i (B_{i,t} - C_{i,t}))$$

$$B_{i,t} = B_{p,t} + B_{r,t}$$

Where: (p) is the income from the rent of parking spots and (r) is the rent from the rent of apartments

$$C_t = C_{c,t} + C_{dem,t} + C_{dev,t} + C_{op,t} + C_{user,t}$$

Where: Construction (c), demolition (dem), development (dev), operational (op) and user (user) costs

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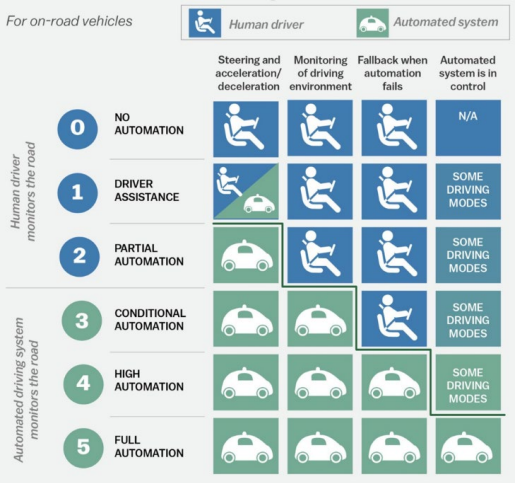
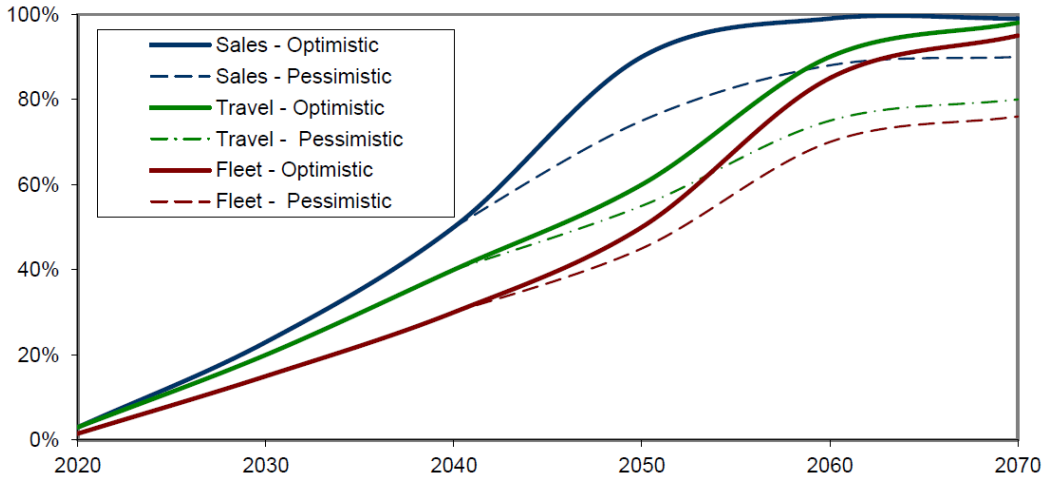
3. Model the uncertainty related to key variables



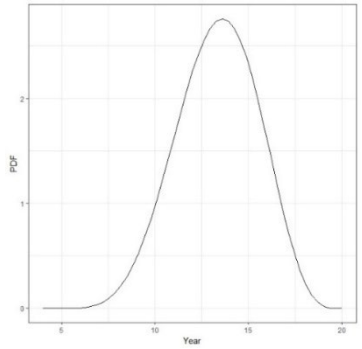


Technology → Legislation → Drop in parking

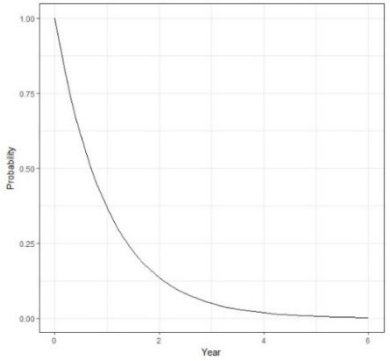
Litman, T. (2018) *Autonomous vehicle implementation predictions*, Victoria Transport Policy Institute.

3. Model the uncertainty related to key variables

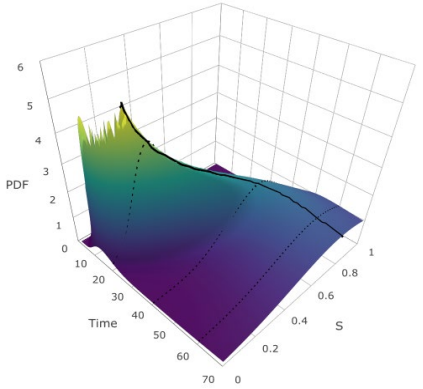
Technology



Legislation



Drop in parking



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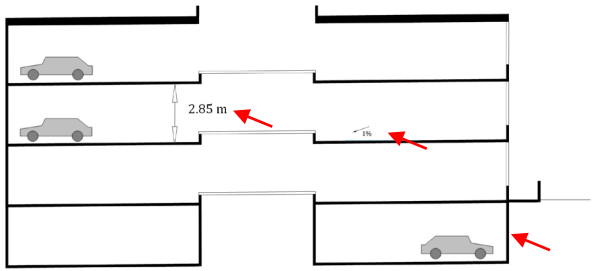
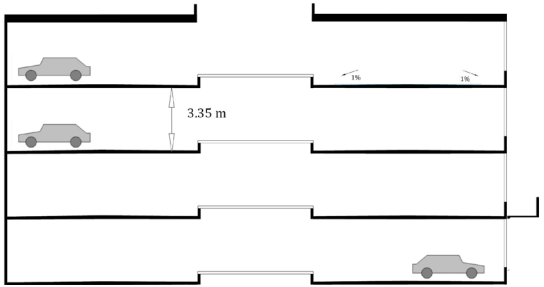
4. Describe the possible intervention options

Traditional design



Flexible design



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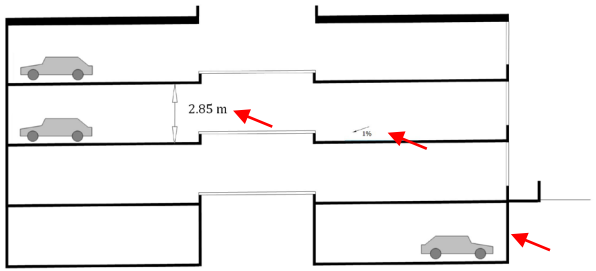

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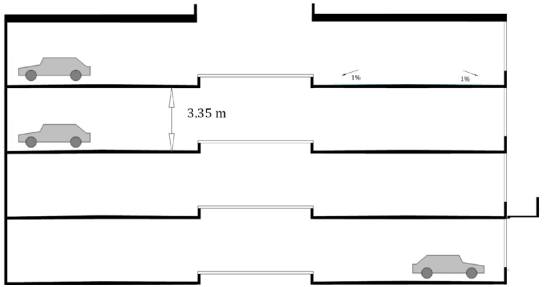

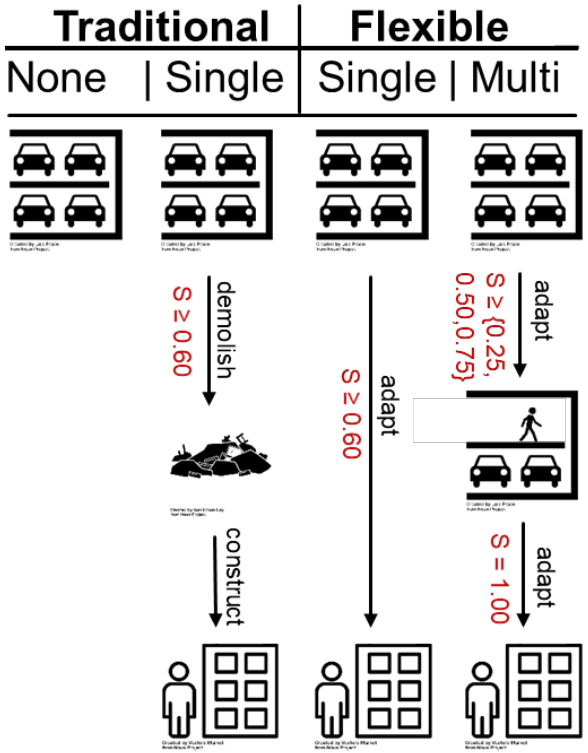

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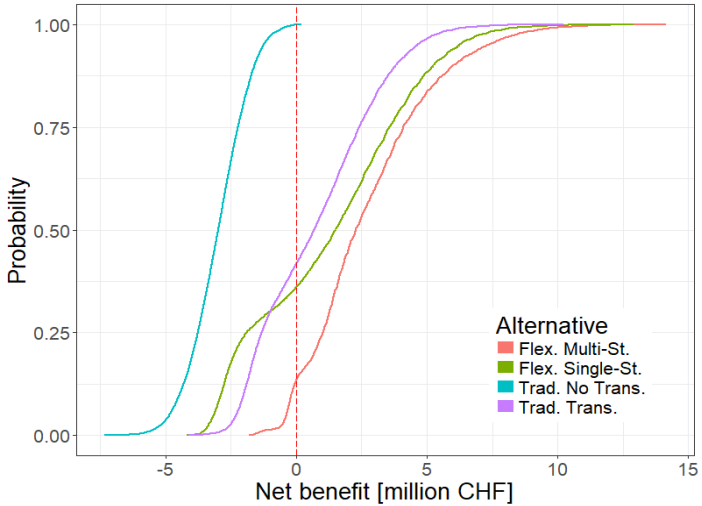

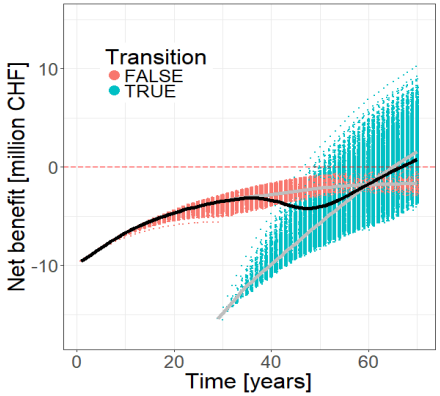

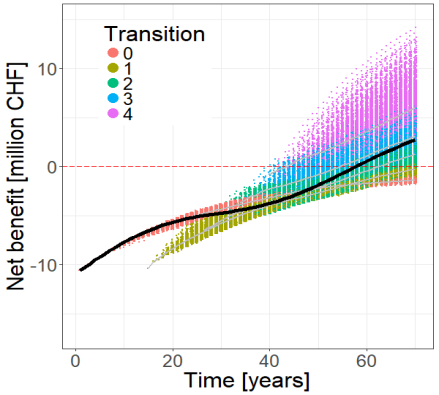

	Traditional		Flexible	
Use transition	No transition	Transition	Single-Stage (SS)	Multi-Stage (MS)
Net benefit	-3'005'697 CHF	756'504 CHF	1'260'248 CHF	2'722'191 CHF
Mean transition time [years]	-	47.6	47.6	34.2 / 44.5 /52.1 / 58.6

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Conclusions

This research advances the domain of infrastructure management by **introducing a methodology grounded in Real Options theory**. This approach aims to identify potential designs and intervention strategies for parking garages in response to the uncertainties surrounding the future of mobility.

Following the proposed methodology, owners can **enhance their capacity to assess the net benefits of their decisions** while considering the potential changes in critical uncertain contextual conditions.

The findings from the case study of the Swiss parking garage indicate that the infrastructure owner would gain advantages by proactively **preparing for the shift to autonomous vehicles through a flexible design and a multi-stage intervention strategy**, despite the need of a more substantial initial investments.

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Thank you

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