Modeling Transportation Systems involving Autonomous Vehicles

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version

INTRODUCTION

BACKGROUND

- Autonomous cars' systems are under work
  - Hundreds of km traveled by AVs as tests
  - Operating companies in the quest of the perfect Autonomous cars system
  - Vehicle makers and governments engaged in the development of AV

DESIGN ISSUES => Research Topics

- What are the social and urban impacts of the deployment of AV?
- How to ensure the commercial success of business models based on AV?
- How the AV-based services will coexist with existing modes?

OBJECTIVE

To propose a classification of services based on AVs. To present the developed models and to summarize their findings.

METHODOLOGY

We present

(1)The categories of business models based on AV.

(2)The existing models : Spatial (geographic) and Socio-economic

Then (3) the impacts assessments are summarized.

1. CATEGORIES OF BUSINESS MODELS BASED ON AVS

Based on the Product Value mainly in product content	**Based on the use/ function of the product or service** Value mainly in the use of the product (product-service systems) Product content (tangible) / Service content (intangible)			**Basé sur le service** Value mainly in service content
Pure Product	A: Product-oriented	B: Use-oriented	C: Results oriented	Pure services
Selling products	1. Services oriented to AV	1. Renting/ Leasing	1. Activities management	Selling services
Autonomous vehicles (AV) Equipments of AV Software / models	Maintenance and repair Consumables (batteries..) Taking-back (end-of-life)	Maintenance and repair of the provided product Individual access without ownership	Fleet management Parking places optimization Charging stations	Public transit Goods deliveries Feasability studies...
	2. Advices	2. ¨Product sharing	2. Fonctional results	
	Efficient utilization Adaptation to the context Operating standards	Maintenance and repair of the provided product ensured Shared use of the product at the same time	Parking places availability Charged vehicles availability Reliability of the system	

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KEYS FACTORS OF BM ASSESSMENT

Value for the customer
- Objective value (monetary and non monetary)
- Subjective value (lived experience)

Potential competition
- Direct competitors
- Indirect competitors

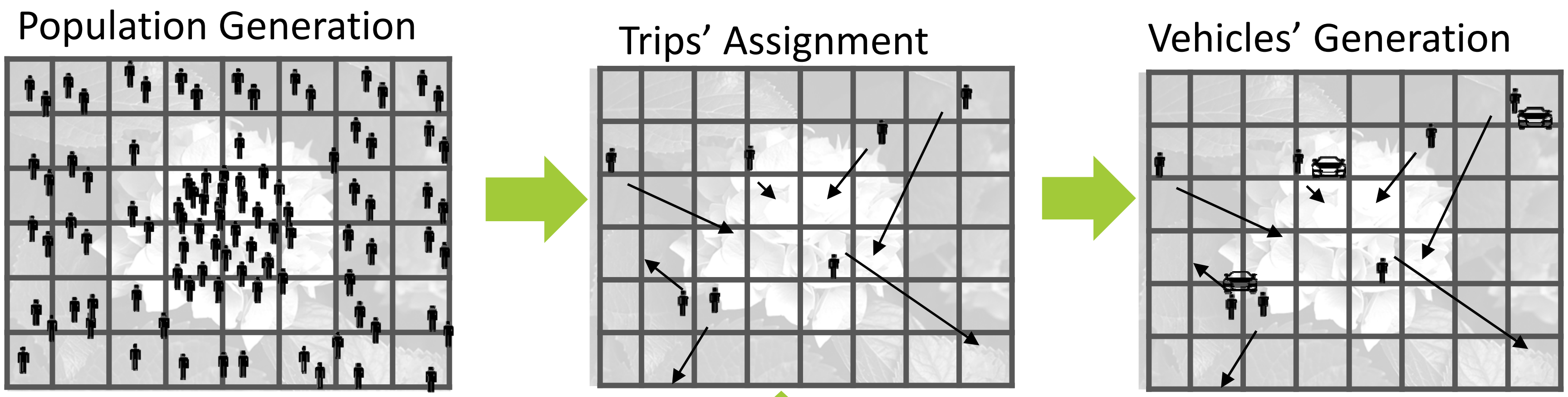
Investment costs
- Initial investment
- Additional transition investment

Business development
- Strategic position
- Loyalty of costumers
- Innovation speed

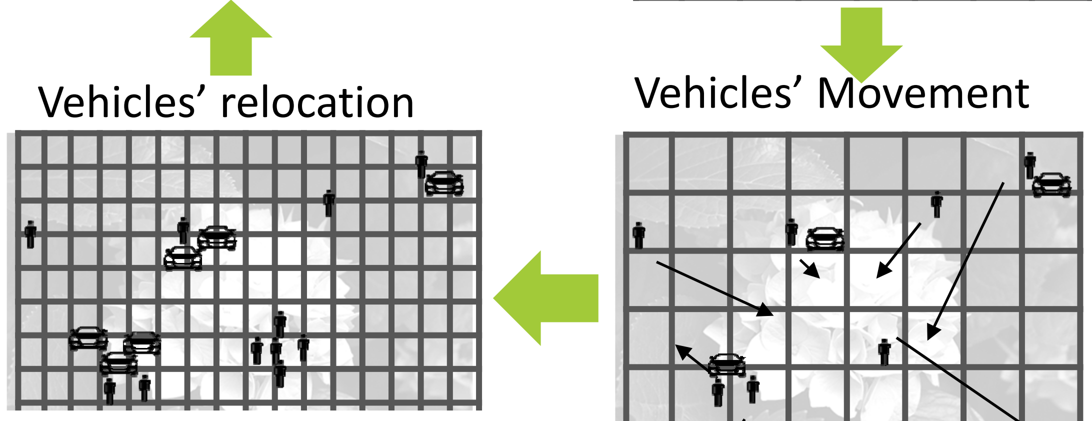
Operating costs
- Tangible costs (fixed and variables)
- Uncertainty costs

Environmental impacts
- Emissions
- Congestion

2.1. MODELING SHARED AVS : AGENT BASED MODELS (FAGNANT & KOCKELMAN'S MODEL)



Fagnant & Kockelman, 2016. Dynamic Ride-Sharing and Optimal Fleet Sizing for a System of Shared Autonomous Vehicles.
Fagnant & Kockelman, 2014. The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios.
Fagnant & Kockelman, 2015. Operations of a shared autonomous vehicle fleet for the Austin, Texas Market.



$$Block\ Balance = SAVs_{Total}\left(\frac{SAVs_{Block}}{SAVs_{Total}} - \frac{Demand_{Block}}{Demand_{Total}}\right)$$

DEVELOPMENTS OF FAGNANT & KOCKELMAN'S MODEL

The model was developed by other authors through adding complementary modules:

- **Electric infrastructure and charging strategies**

Chen, D., Kockelman, K. & Hanna, J. 2016. Operations of a shared, autonomous, electric vehicle fleet: implications of vehicle & charging infrastructure decisions. *TRB 95th annual meeting Proceedings*.

- **Users' incomes**

Zhang, W. et al. 2015a. The performance and benefits of a shared autonomous vehicles based dynamic ridesharing system: an agent. Washington DC.

- **Ridesharing strategies**

Zhang, W., et al. 2015a. The performance and benefits of a shared autonomous vehicles based dynamic ridesharing system: an agent. Washington DC, United States : s.n., 2015a.

- **Parking with different pricing strategies**

Zhang, W. & Guhathakurta, S. 2017. Parking Spaces in the Age of Shared Autonomous Vehicles: How Much Parking Will We Need and Where? *TRB 96th Annual Meeting.*

2.2. SOCIO-ECONOMIC MODELS

Market penetration

	Reference	Target Year
Technical studies	Audi	2017
	Ford	2018
	Google	2018
	Tesla	2023
Scientific papers	Victoria Transport Policy Institute	2020
	Lavasani	2025

Market saturation

References	Target Year
Victoria Transport Policy Institute	2060
Lavasani	2060

2.2 POTENTIAL CUSTOMERS

Age

Men

Non-Motorized

Urban areas

High incomes

2.3. PRODUCTION COSTS

Investment costs (Purchase costs)

- Bansal et al. (2016): $23 950 in 2025
- SimMobility (2015): $15 000

O&M costs

- Burns et al. (2013): $0.25/km
- SimMobility (2015): $0.20/km
- American Automobile Association: $0.30/km
- Fagnant et al. (2016): $0.62/km

3. IMPACTS OF SAVS

Mobility impacts
- Fleet sizes reduced by 75% to 90%
- Vehicle-Kilometers traveled increased by 7 to 20%

Urban parking
- Closely dependent on the market penetration
- Space savings about 90% for all autonomous, and insignificant if only 50/% of the fleet is autonomous
- Moving the parking to less dense areas allows more savings

Accidents
- AVs can save Americans $76 billions dollars each year (Li, 2016)
- More than 90% of crashes are caused by the driver (NHTSA, 2008; 2012, ONISR, 2016)

Environmental impacts
- Less vehicles so less pollution
- Less life span so better performance
- Sharing vehicles save about 5% of energy
- Electric vehicles implies high demand for electricity

CONCLUSION

- **Different forms of services based on AVs are possible**

- **Existing models focus on shared AVs (pure service).**

- **They focus on the supply operations without detailing the demand side**

- **More detailed studies required on the demand inclination and adoption, as well as on the production costs.**

- **The urban and social impacts of AVs are promising.**