

# Autonomous car integration Modeling simulation and complex systems

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USTH M2 ICT - ESILV A5 IOT  
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# Context and topic

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Level	Name	Responsibility for:			Mode coverage
		Vehicle direction & speed	Monitoring environment	Fallback	
0	No Automation	Driver			n/a
1	Driver Assistance	Driver and system	Driver	Driver	
2	Partial Automation	System	System	Driver	Some
3	Conditional Automation	System	System	System	Many
4	High Automation				
5	Full Automation				All

Level of autonomous

As of 2023, Tesla's ADAS Autopilot/Full Self Driving (beta) was classified as **Level 2**

In 2021, Honda was the first manufacturer to sell an SAE **Level 3** car, followed by Mercedes-Benz in 2023

Google Waymo was the first to offer rides in self-driving taxis to the public in limited geographic areas (SAE **Level 4**)

As of 2024, **no level 5** autonomous vehicle has achieved



WAYMO

Why we're here

1.35 million

deaths worldwide due to vehicle  
crashes every year

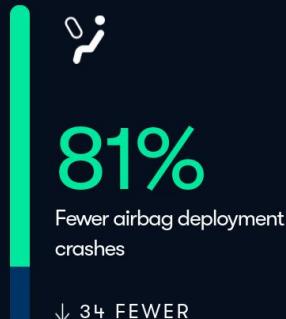
36,096

road deaths in the U.S. in 2019

94%

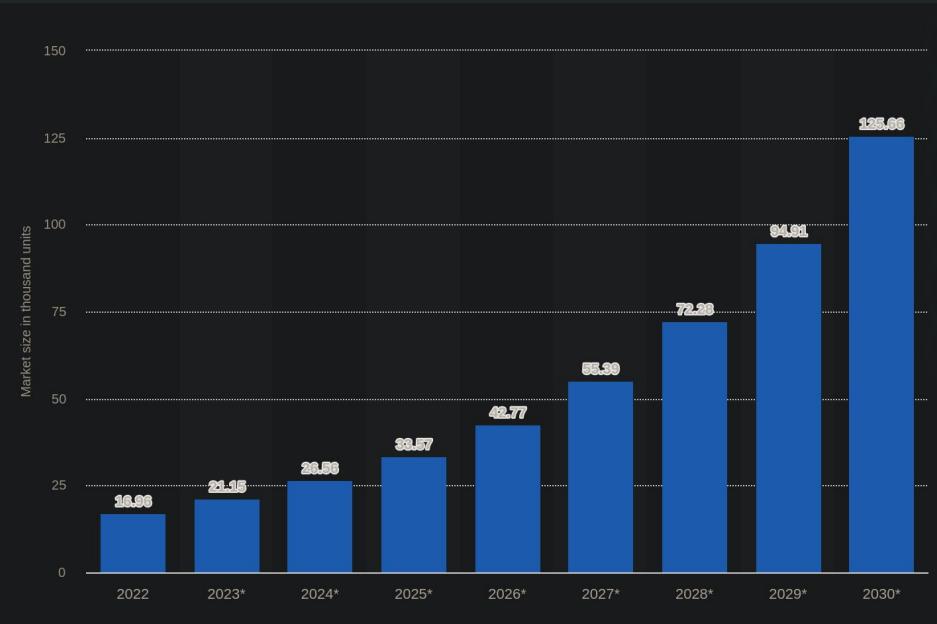
crashes involve human error in the US

In our first 13 million miles:



compared to a human driving the same distance in the cities where we operate. [Learn more](#)

# This market becomes really attractive



Number of autonomous vehicles globally in 2022, with a forecast through 2030 (in 1,000 units)

# Autonomous car market

x2 in 5y

In 2019, there were some 31 million cars with at least some level of automation in operation worldwide. It is expected that their number will surpass 54 million in 2024. Correspondingly, the global autonomous car market is projected to grow as well

How to adapt to that spiking trend? How will the car market evolve? How will innovations, customers and governments influence the market? How much will the new market improve the safety road statistics?

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What financial incentives should be provided to move a city to autonomous cars?

# Goals

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- decrease accidents on the roads
- find the best proportion of car type
- try different financial plans
- adapt it to any city context

# The model

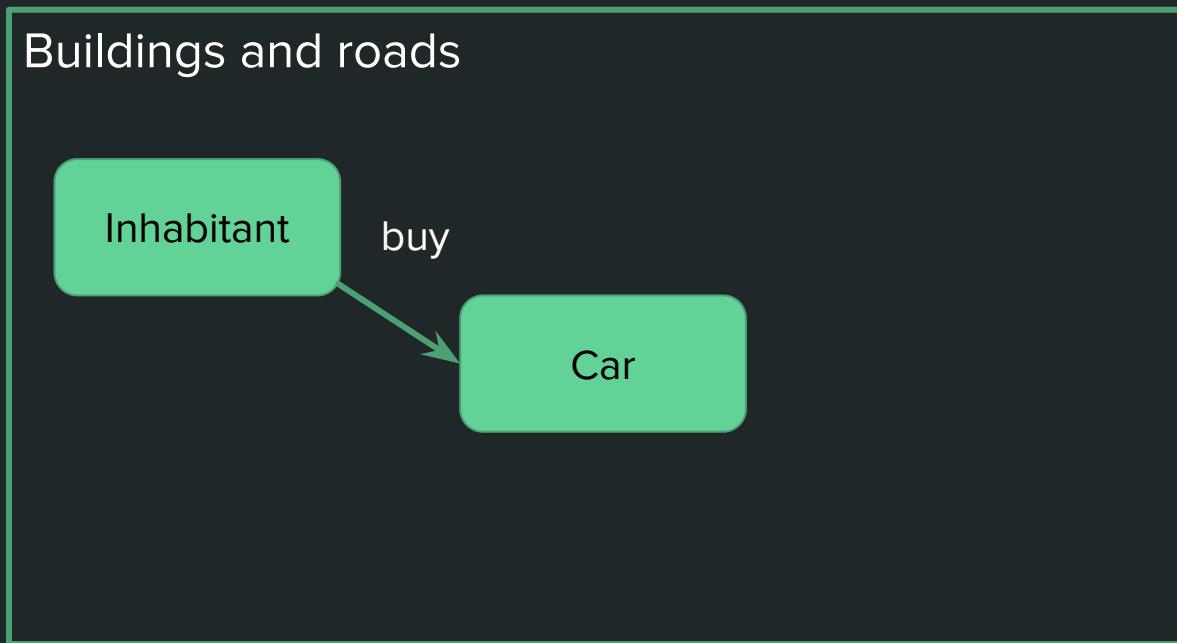
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## Diagram of the interactions between species of the model

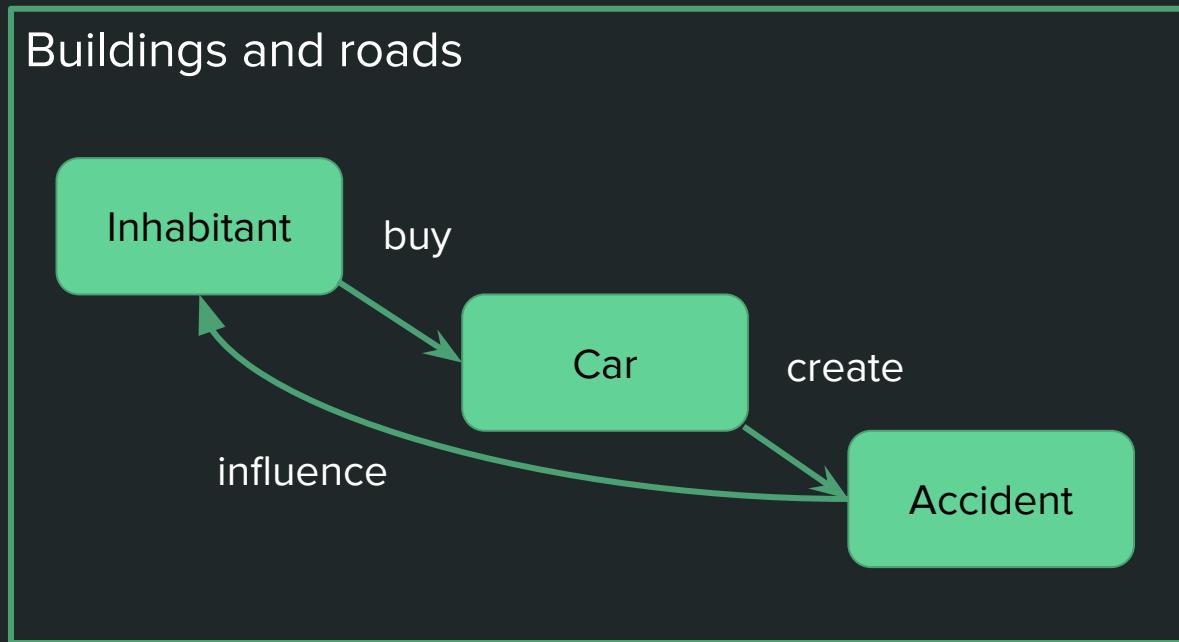
Buildings and roads

Inhabitant  
Clients of the market

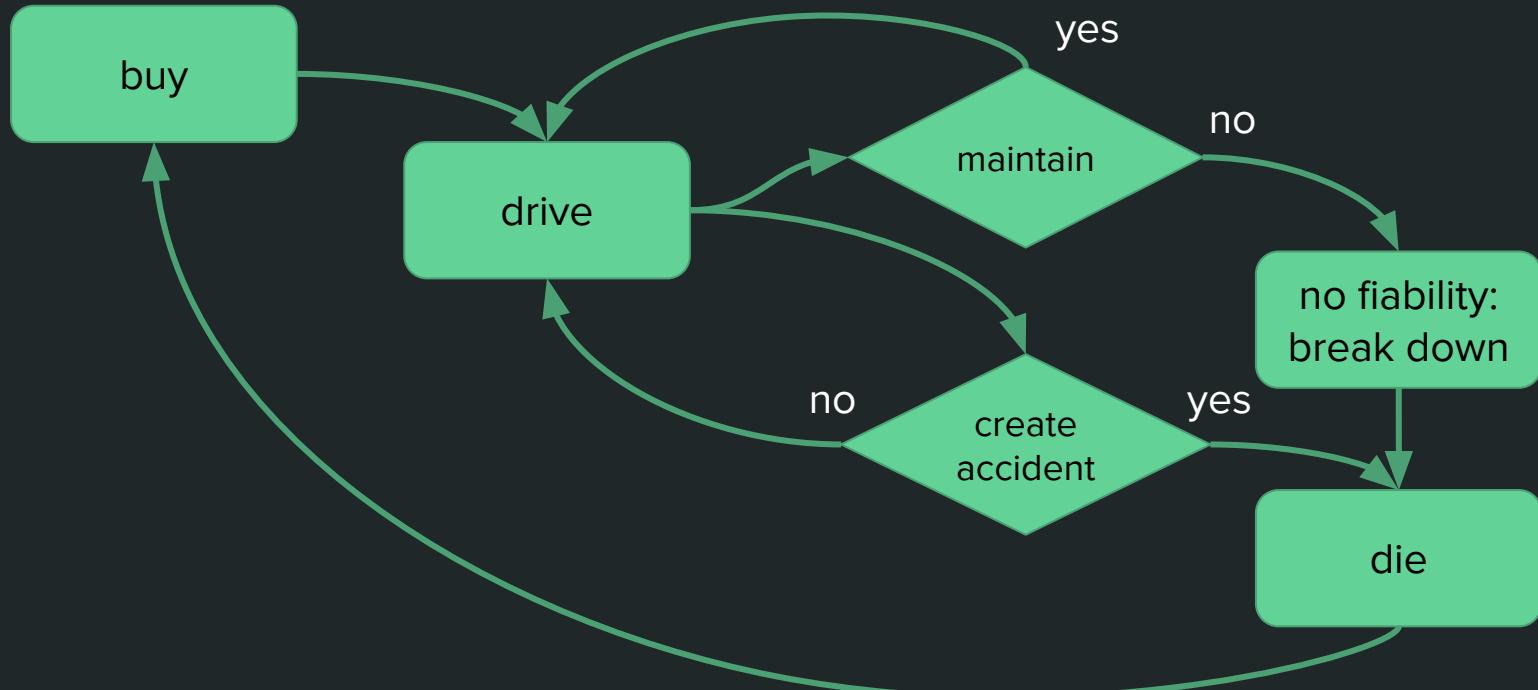
## Diagram of the interactions between species of the model



## Diagram of the interactions between species of the model



## Cars lifespan actions flowchart



# The experiments

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init

population size 200

starting money per person 9000.0

proba delta money   0.05

proportion of car\_type   0.01

delta

manual base car cost 50000.0

autonomous base car cost 10000.0

delta car cost   0.10

base salary per cycle 10.0

proba delta salary   0.03

delta car fiability 0.001

proba maintain car   0.05

proba autonomous create accident   0.01

ratio\_prefered\_car\_type   0.10

more

base car speed 13.88888888888889

base inhabitant speed 1.38888888888888

accident radius 10.0

Monitors

length\_accident: 53

length\_car: 200

ratio\_car\_type: 0.505

new\_car: 321

# The parameters

**Initial parameters** can depend on the experiment city (city scale, average incomes, car condition)

**Delta parameters** add randomness between agents to make it more realistic

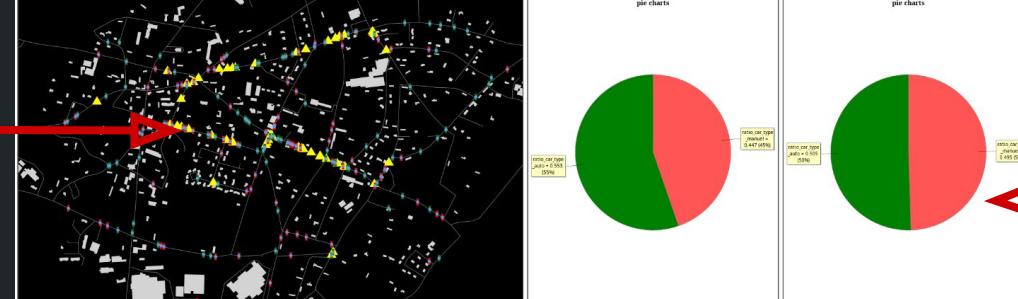
*delta of 0.2 will give a value range of 0.8 to 1.2*

**More parameters** can be updated to precisely impact the result of the experiments

# Results

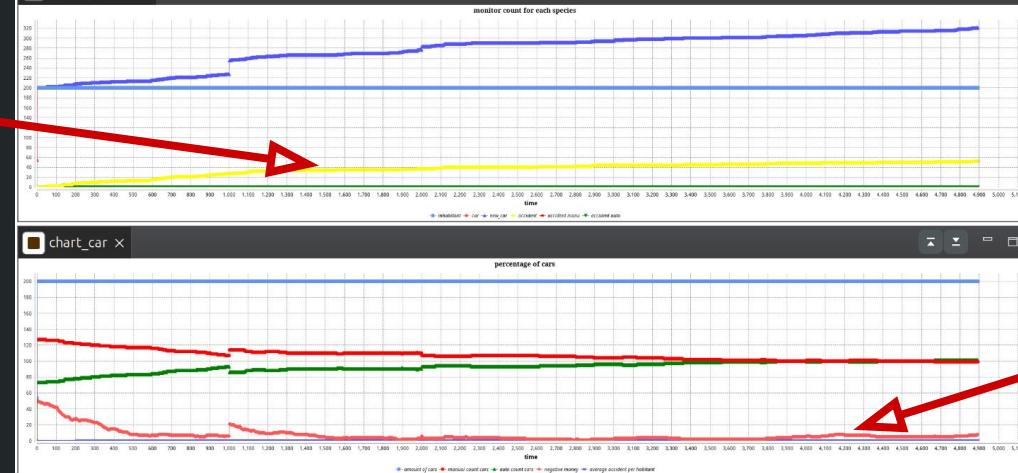
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Least accident  
possible



A stable number of  
accident but an  
increase in car.

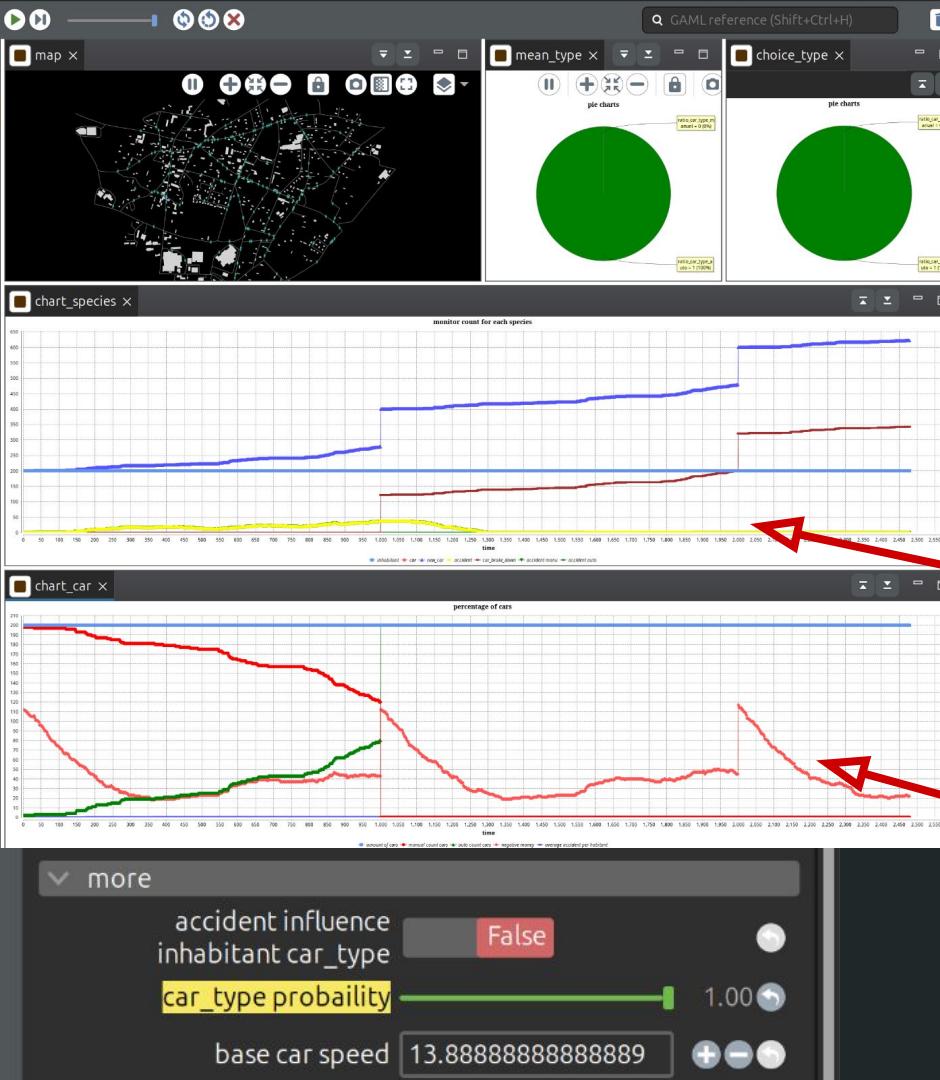
Change of car due to  
break down



A switch of the  
proportion of car  
type

An affordable car  
price for  
everyone

What are we expecting?



# Case 1: no maintenance, no free\_will, from manual to autonomous

No more  
accidents

Adding debt to  
buy a new car



## Case 2: maintenance, free\_will, from manual to autonomous

Still accidents

Still debt,  
Gap is increasing  
between car types

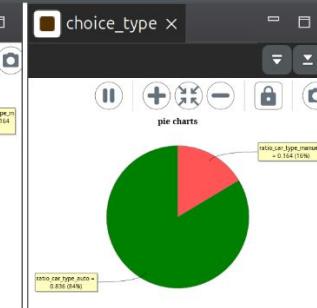
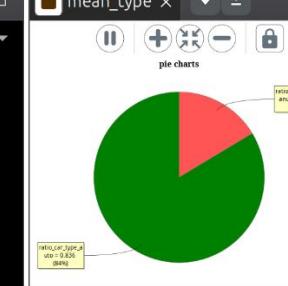
Model autonomousintegration/Exp... X

Models

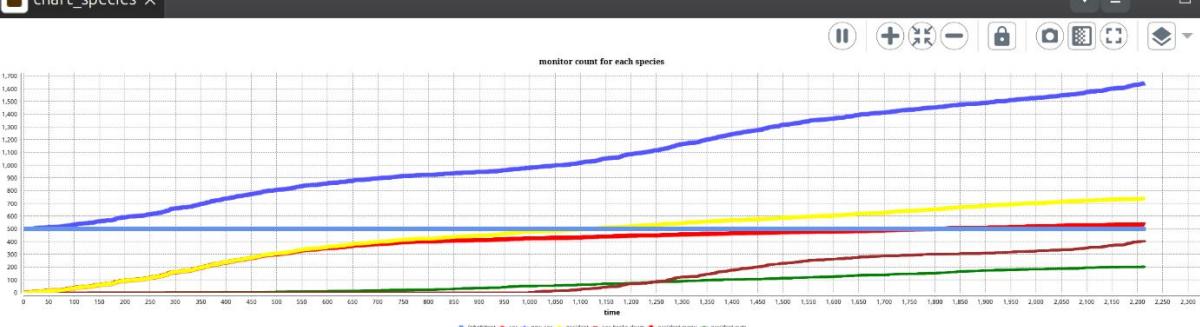
map X



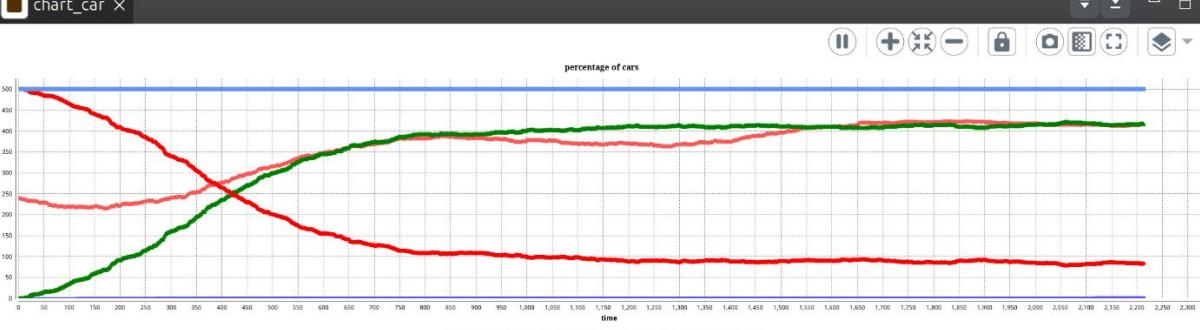
mean\_type X



chart\_species X



chart\_car X



Monitors

length\_car: 500

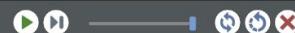
# Issues during implementation

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Choices to focus on the types of the cars, to focus on the accidents.  
Mostly understanding the impact of the financing.

File Edit Search Experiment Agents Views Support

⌚ Simulation 0: 1402 cycles elapsed [03:53:40]



GAML reference (Shift+Ctrl+H)

Model autonomousintegration/Exper... × Models

map ×



Parameters for simulation Simulation 0

init

population size 200

starting money per person 12000.0

proba delta money 0.50

proportion of car\_type 0.10

delta

manual base car cost 10000.0

autonomous base car cost 15000.0

delta car cost 0.10

base salary per cycle 10.0

proba delta salary 0.50

delta car fiability 0.001

proba maintain car 0.50

more

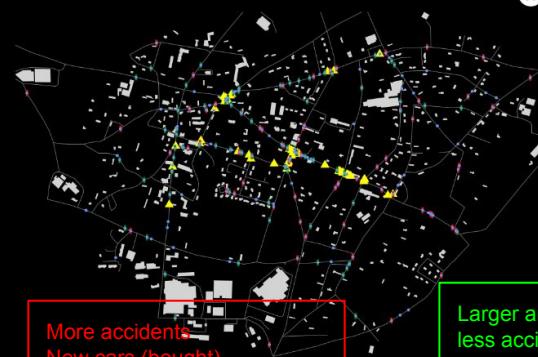
base car speed 13.8888888888889

base inhabitant speed 1.38888888888888

Interactive console Console X



```
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sender: {index=0, speed=1.38888888888888, heading=203.
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```



More accidents  
New cars (bought)  
More auto  
Less manual

Larger amount of auto means  
less accident and less new  
cars

chart\_species ×



chart\_car ×



File Edit Search Experiment Agents Views Support

Simulation 0: 7312 cycles elapsed [10:09:20]

Model autonomousintegration/Experiment visual x

Parameters for simulation Simulation 0

&gt; init

&gt; delta

&gt; more

Monitors

length\_accident: 50

length\_car: 200

ratio\_global\_choose\_car\_type: 0.24

max\_car\_cost: 11000.0

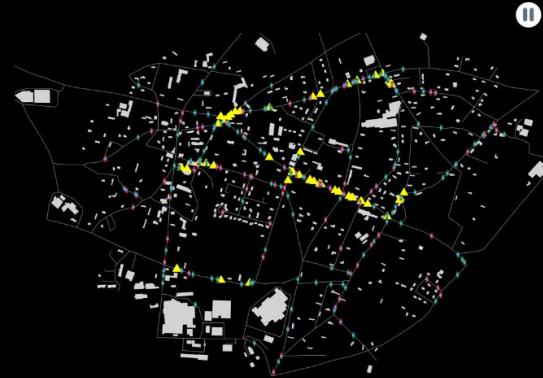
new\_car: 308

ratio\_car\_type: 1.631578947368421

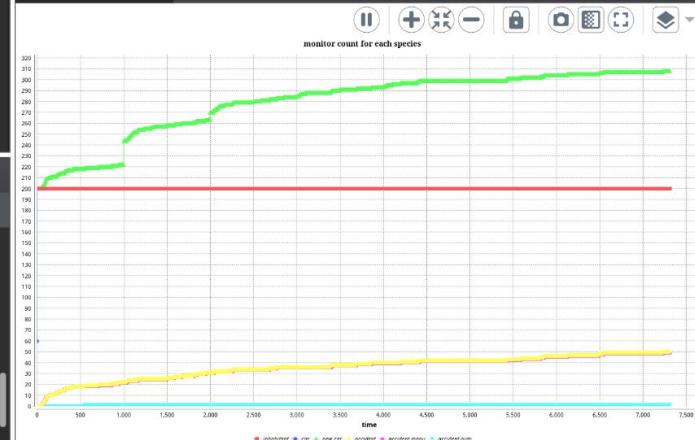


GAML reference (Shift+Ctrl+H)

map x



chart\_species x



chart\_car x



Interactive console

Console x



```
sender: {index=0, heading=106.84758577113503, speed=1.38
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sender: {index=0, heading=219.7324128436496, speed=1.388
sender: {index=0, heading=356.0759685547371, speed=1.388
```

File Edit Search Experiment Agents Views Support

⌚ Simulation 0: 12482 cycles elapsed [17:20:10]

Model autonomousintegration/Experiment visual

Parameters for simulation Simulation 0

init	
delta	
manual base car cost	10000.0
autonomous base car cost	10000.0
delta car cost	0.10
base salary per cycle	10.0
proba delta salary	0.50
delta car fiability	0.001
proba maintain car	0.00

> more

Monitors

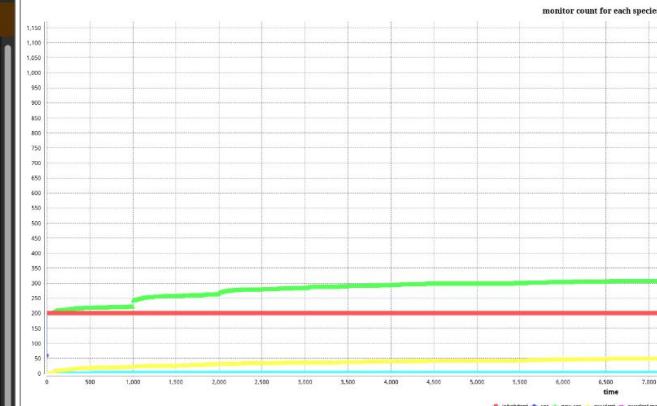
- length\_accident: 134
- length\_car: 200
- ratio\_global\_choose\_car\_type: 0.625
- max\_car\_cost: 11000.0
- new\_car: 1115

Interactive console



```
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sender: {index=0, heading=292.50762784465467, speed=13.88
sender: {index=0, heading=345.9659801758, speed=13.888888
```

chart\_species x



No  
maintenance

chart\_car x



File Edit Search Experiment Agents Views Support

Simulation 0: 4748 cycles elapsed [06:35:40]

Model autonomousintegration/Exper... X Models

**init**

- population size: 200
- starting money per person: 9000.0
- proba delta money: 0.50
- proportion of car\_type: 0.01

**delta**

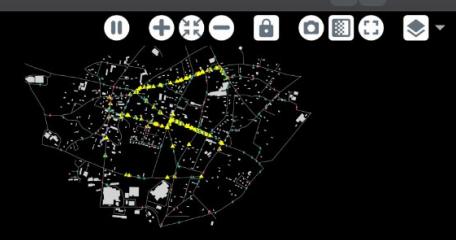
- manual base car cost: 10000.0
- autonomous base car cost: 10000.0
- delta car cost: 0.10
- base salary per cycle: 10.0
- proba delta salary: 0.50
- delta car fiability: 0.1
- proba maintain car: 0.00
- proba autonomous create accident: 0.00
- ratio\_preferred\_car\_type: 4.40

**more**

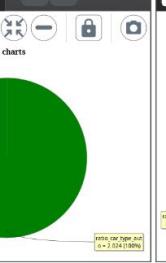
Interactive console Console X

```
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sender: {index=0, heading=203.11778347107184, speed=13.88
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sender: {index=0, heading=39.7324128436493, speed=13.888
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sender: {index=0, heading=23.120595882035595, speed=13.88
sender: {index=0, heading=23.12059588203732, speed=13.88
sender: {index=0, heading=20.68969218820856, speed=13.88
sender: {index=0, heading=238.14100217482093, speed=13.88
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```

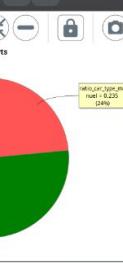
map X



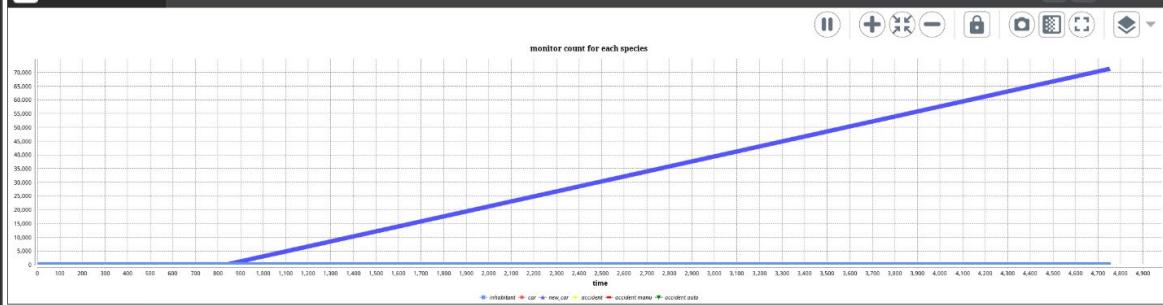
mean\_type X



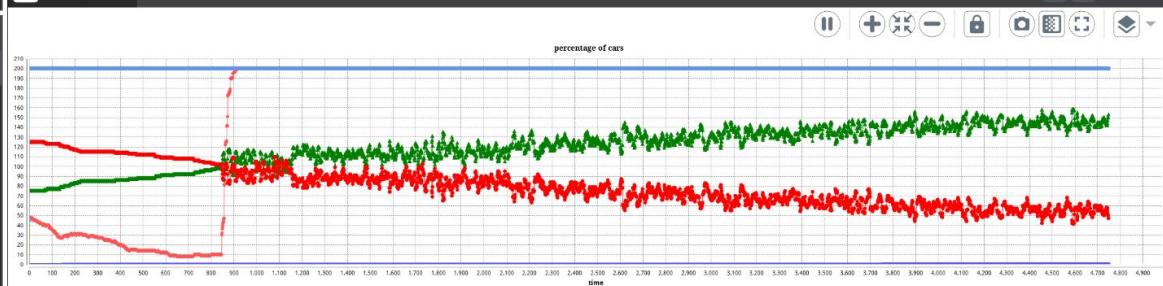
ratio\_type X



chart\_species X



chart\_car X



# Results

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- The **low accident probability** of autonomous car has a high impact on the **attractiveness** of these new models
- The price of the car has almost **no impact** compared to other parameters
- Revenues of the residents might affect on a long-term basis but not on the percentage of **maintenance by accidents**
- Cost and depts

# Improvements

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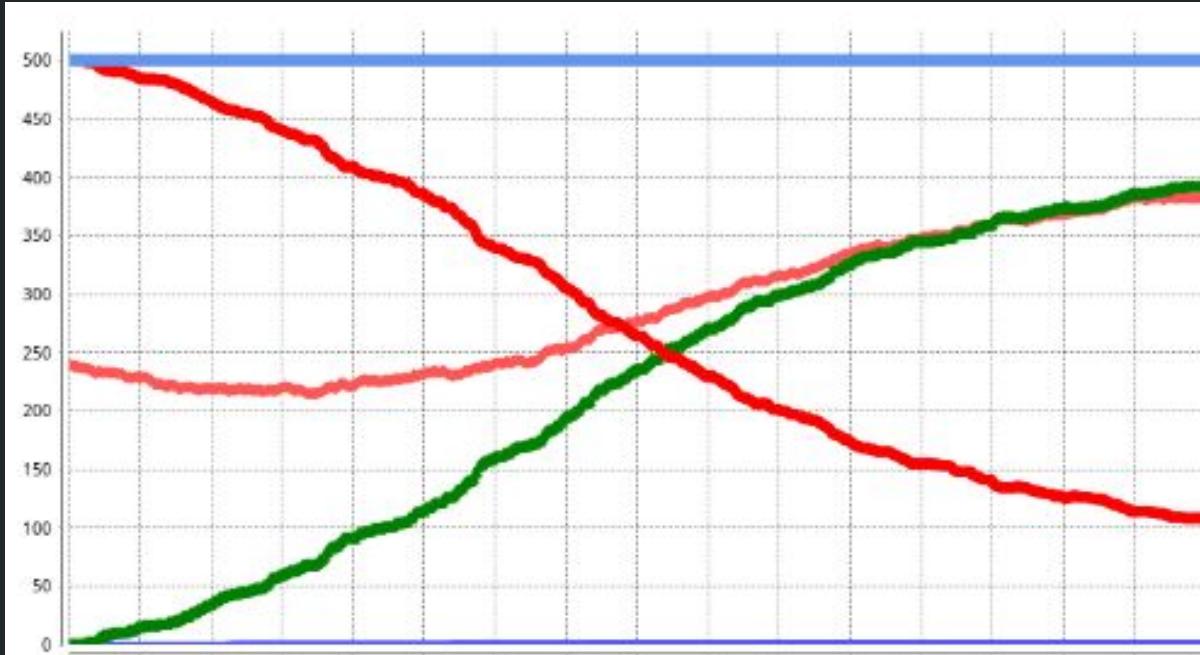
- find **realistic parameters** for the model per city (probabilities, prices, salaries, maintenance recurrence)
- **memory optimisation** for running better model performance
- implement different speed of car based on **urgency and respect of the law**
- matrix of **probability for levels** of autonomousness,
- with different **schelling population** (the moderns, the olds, the mids to buy auto)
- population is starting with a relative wealth depending on their neighborhood and their building.
- start by walking and increase **car desire**
- cars can go out by themselves to **train and analyse** data, to turn and speed up by themselves.

# Conclusion

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This model can help understand and prepare a **market share shift**.

We might be able to predict the influence of the next innovation.



⌚ Simulation 0: 5253 cycles elapsed [3 days 14:05:27]

Model autonomousintegration/Exper... X Models



GAML reference (Shift+Ctrl+H)



### Parameters for simulation Simulation 0

- proba maintain car: 0.00
- proba create accident: 0.50
- proba autonomous create accident: 0.05
- ratio\_preferred\_car\_type: 1.45

### more

- accident influence inhabitant car\_type: False
- car\_type probability: 1.00
- base car speed: 13.888888888888888
- base inhabitant speed: 1.3888888888888888
- accident radius: 10.0
- min car in accident: 02

### Monitors

- length\_car: 500
- ratio\_global\_choose\_car\_type: 1.0
- mean\_global\_choose\_car\_type: 1.0
- ratio\_car\_type: 1.0

Interactive console Console X

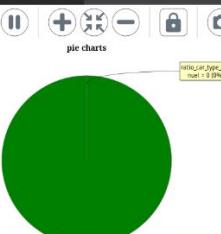


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sender: {index=0, heading=23.120595882037108, speed=13.88
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sender: {index=0, heading=103.42722876594958, speed=13.88
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sender: {index=0, heading=42.72874245281506, speed=13.88
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sender: {index=0, heading=220.34674210848434, speed=13.88
```

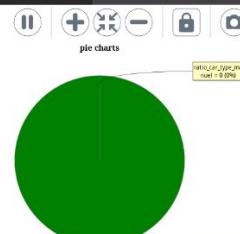
map X



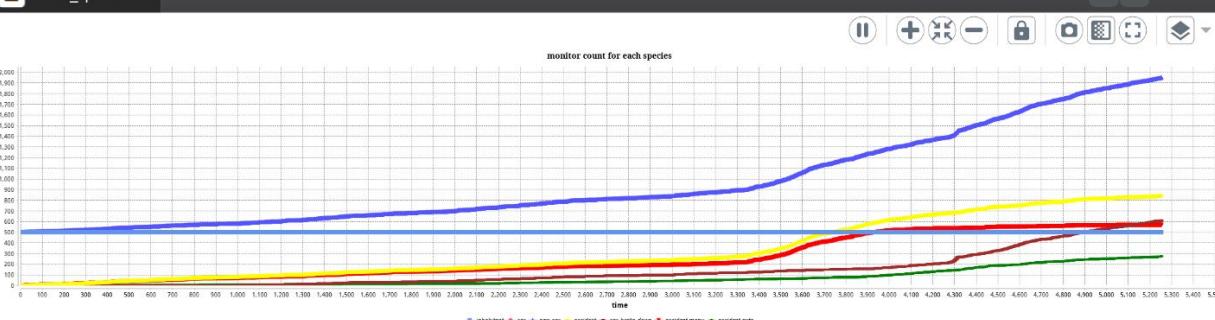
mean\_type X



ratio\_type X



chart\_species X



chart\_car X

