

To cite this work:

Jlassi , S. , Tamayo , S. and Gaudron , A. (2019). Simulation Applied to Urban Logistics: A State of the Art. . In City Logistics 3: Towards Sustainable and Liveable Cities. Doi:10.1002/9781119425472.ch4

Sarra Jlassi
Simon Tamayo
Arthur Gaudron

SIMULATION APPLIED TO URBAN LOGISTICS: A STATE OF THE ART



groupe pomona



MAIRIE DE PARIS



RENAULT
Passion for life



- 
- **Modelling Vs Simulation**
 - **Research method**
 - **Findings**

- Synthetic view of the reviewed publications

- Simulation techniques (choices, advantages, drawbacks)

- Software solutions

- **Synthesis of the research opportunities**
 - **Conclusions**
- 



MODELLING vs SIMULATION

Modelling Vs Simulation

Model

- » Representation of the system
- » Described with influence diagram or using mathematics
- » A good model is a judicious trade-off between realism and simplicity

WIVER
Sonntag
(1985)
(Germany)

FRETURB
Routhier
&Toilier
(2007) (France)

CityGoods
Gentile
&Vigo (2013)
(Italy)

Simulation

- » Operation of the model
- » Relates to techniques, methods and tools to understand:
 - ✓ how systems behave over time
 - ✓ estimate and evaluate systems performances
- » What If Questions



RESEARCH METHOD

Research Method

INITIAL KEYS

Urban
City
Last mile

SPECIFIC KEYS

Logistics
Distribution
Delivery
Planning
Goods distribution
Goods movements

Freight movements
Freight transport
Freight demand
Transportation Routing
Delivery spaces/areas/bays
Loading/unloading bays

Demand
Traffic
Parking
Commercial movements
Decision support
Supply chain

Initial key **AND** Specific Key **AND** *Simulation*

40 RESULTS

CLASSIFICATION

Year

Type of stakeholder

Output Criteria

Simulation techniques

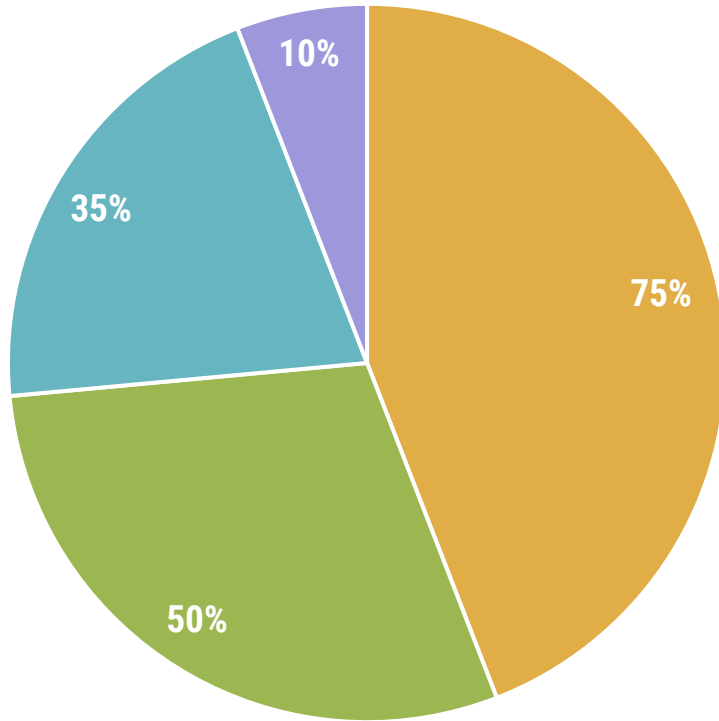
Country

type of publication



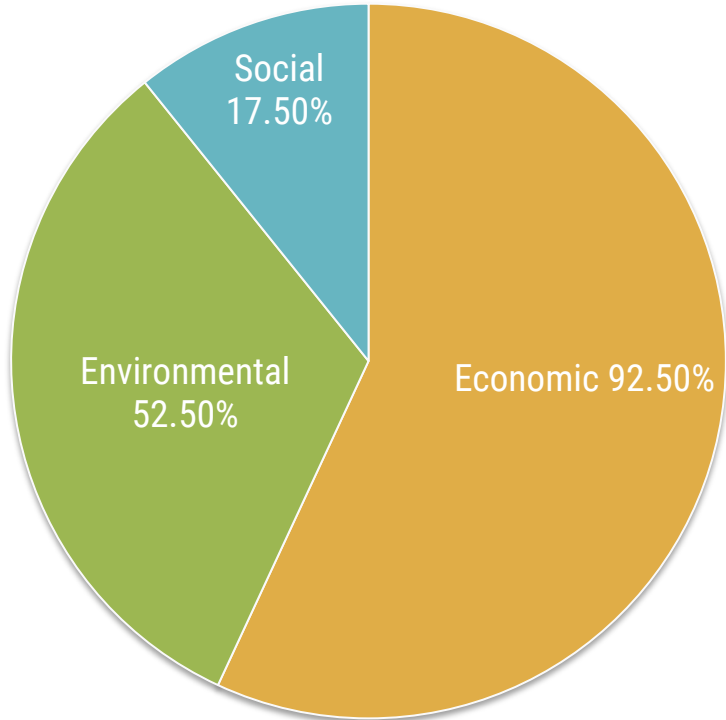
FINDINGS

Stakeholders

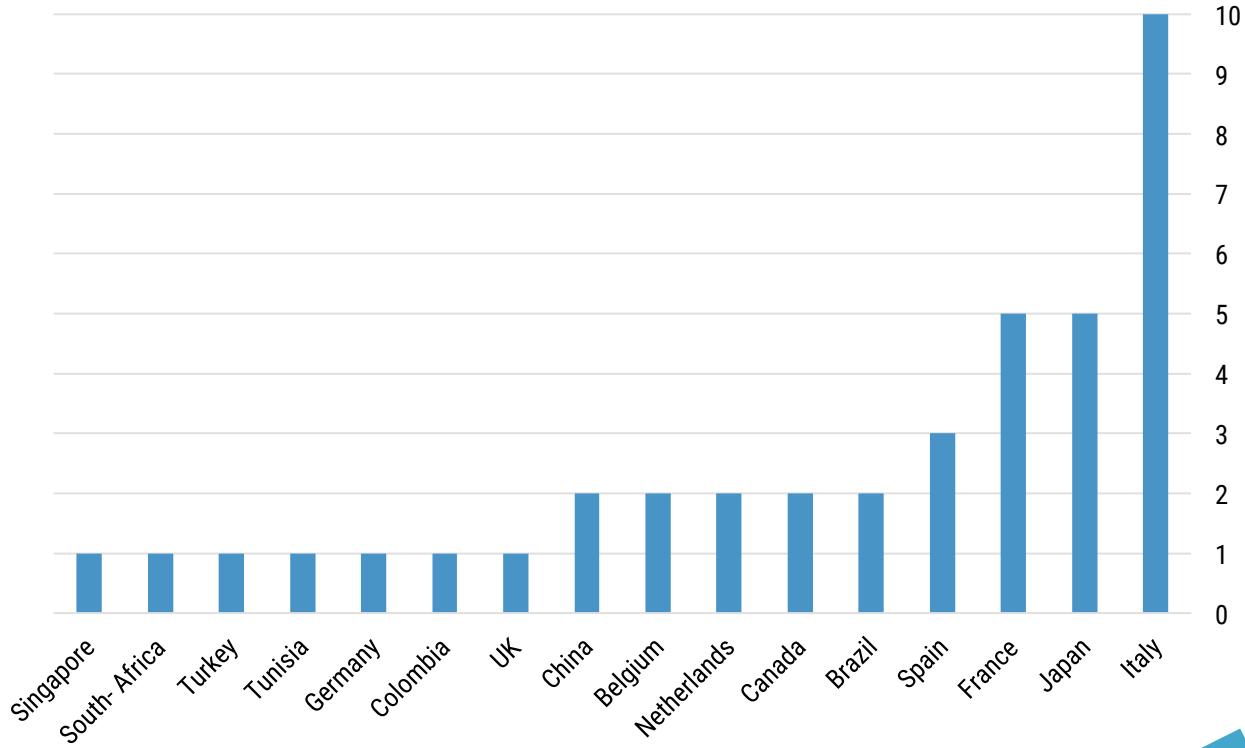


- Local authorities
- Carriers
- Shippers/Receivers
- Residents

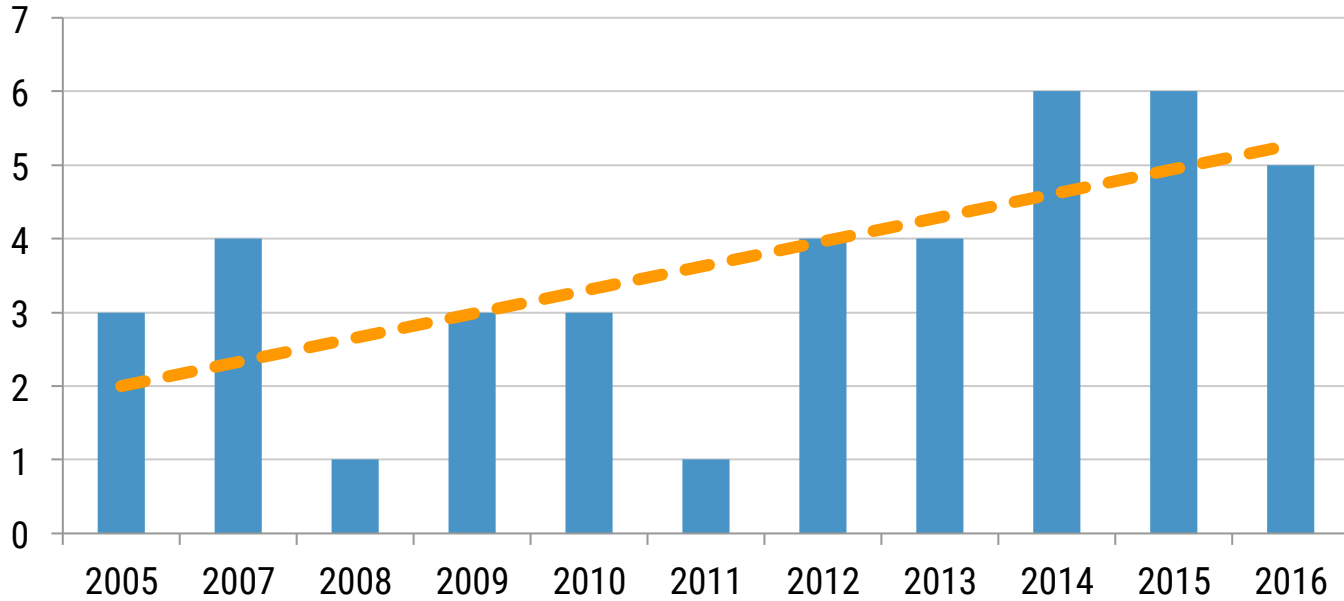
Output criteria



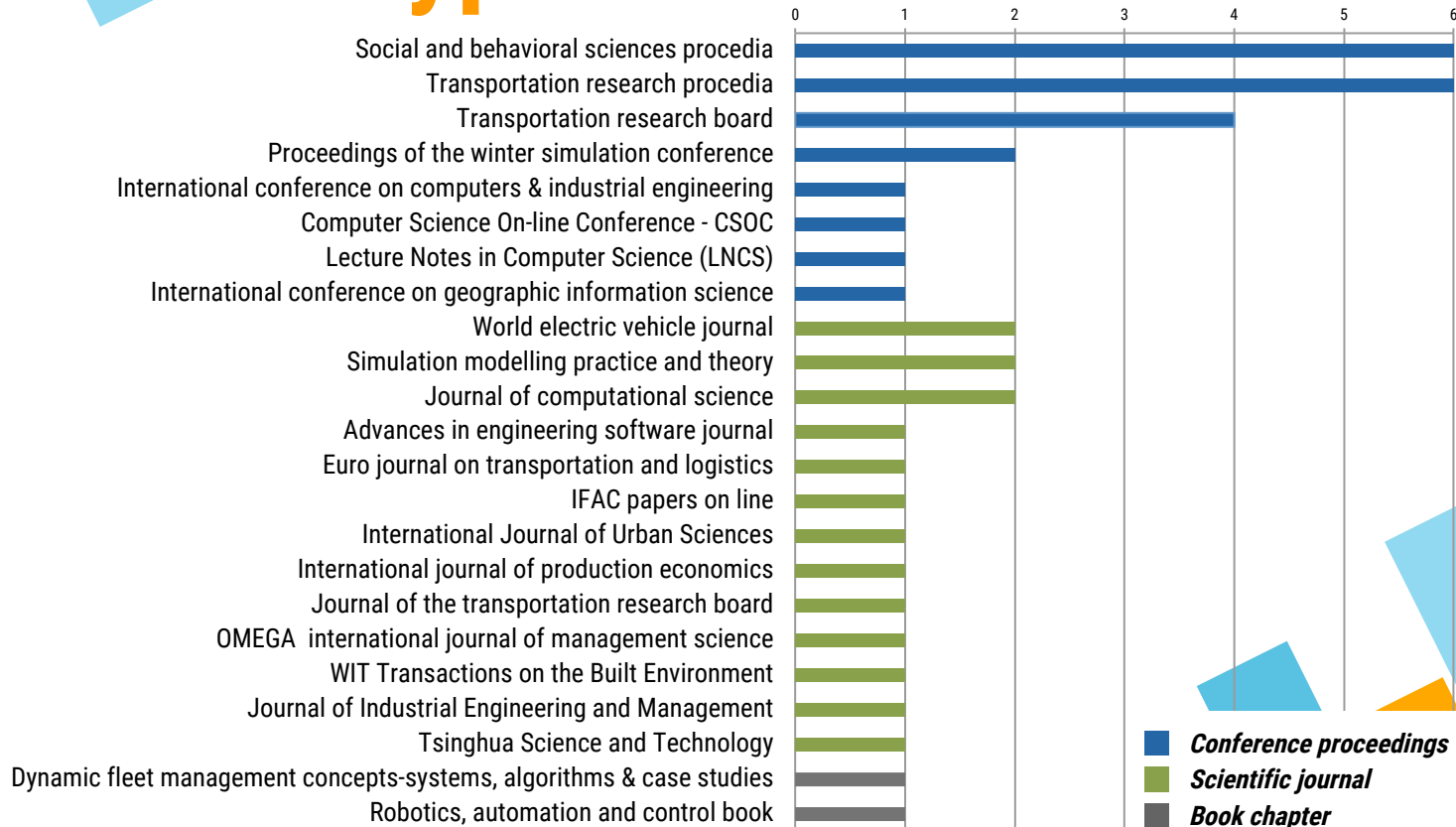
Countries



Nb of publications in time



Types and sources





SIMULATION TECHNIQUES



Simulation Techniques

Five main simulation techniques to address urban logistics problems

- » **Instance Generation Simulation (IGS)**
tests on configurations of a problem
- » **Monte Carlo Simulation (MCS)**
make use random sampling and statistical analysis
- » **Discrete Event Simulation (DES)**
systems evolve in a discrete space where time is driven by events
- » **Agent Based Simulation (ABS)**
several agents with independent behaviors are involved
- » **System Dynamics (SD)**
real-world processes are represented in terms of stocks, flows and delays



Types of problems

Reviewed problems classified into 5 categories:

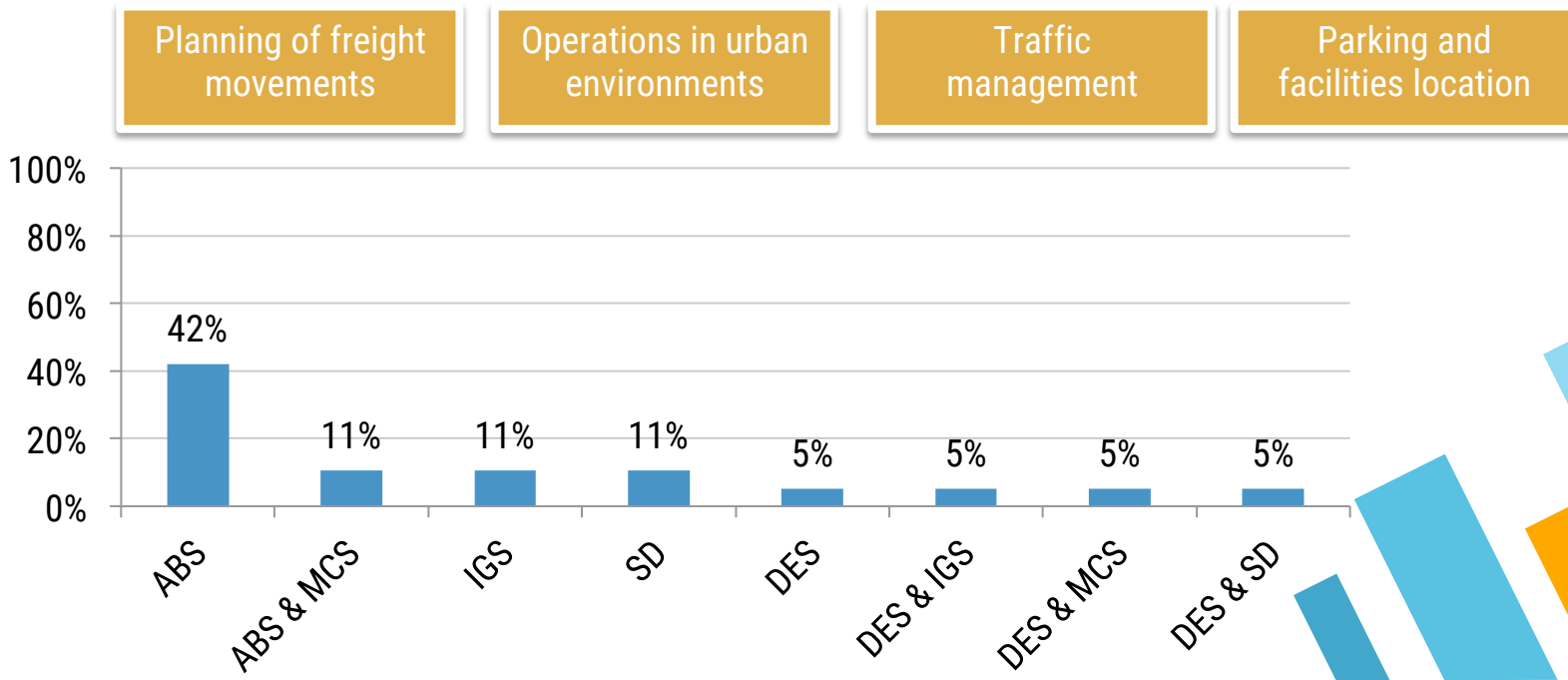
1. Transportation, network and infrastructure problems: 52.5% of the publications
2. Urban consolidation & mutualisation problems: 22.5% of the publications
3. Vehicle routing problems: 17.5% of the publications
4. Intermodality problems: 15% of the publications
5. Electromobility problems: 7.5% of the publications



The total of the percentages does not add up to 100%

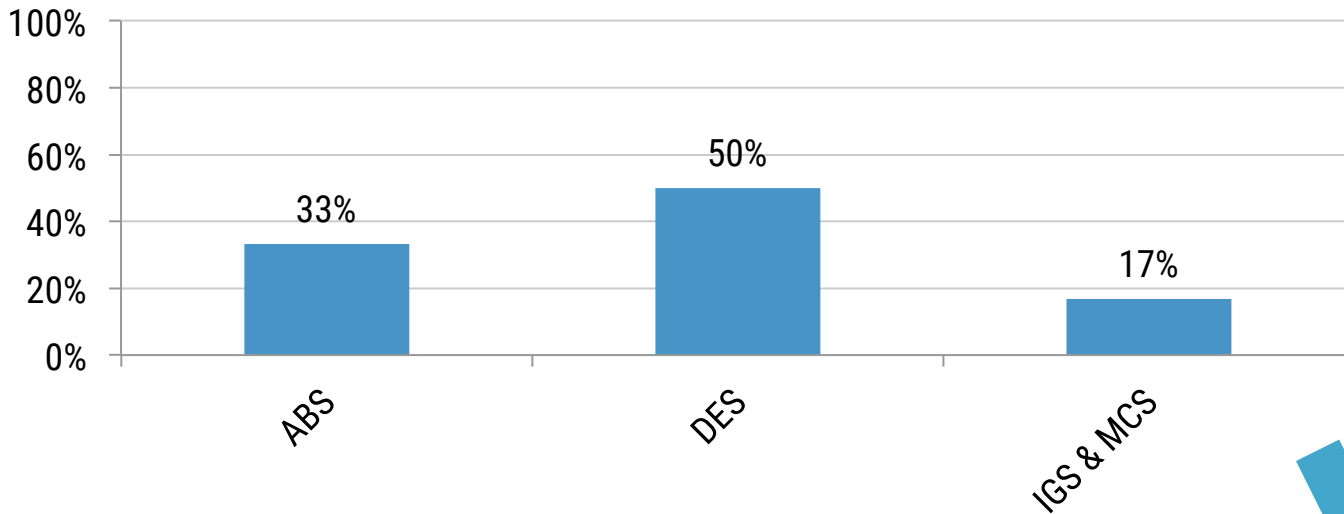
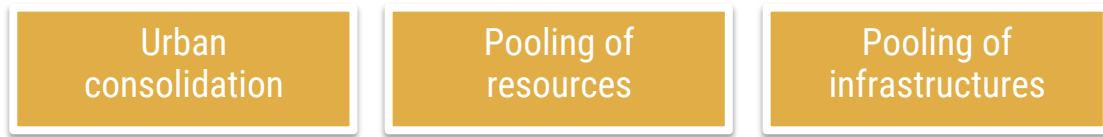
Types of problems & simulation techniques

1 - Transportation, network and infrastructure problems: 52.5% of the publications



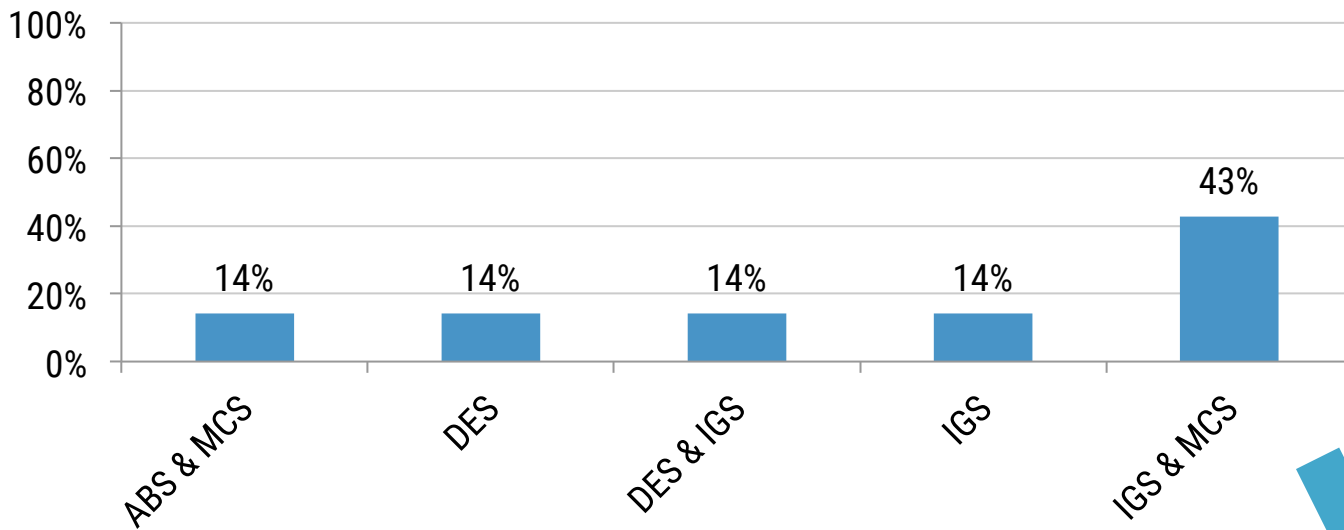
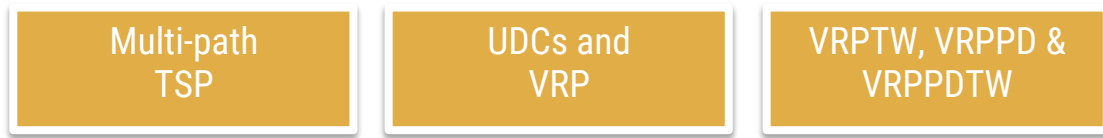
Types of problems & simulation techniques

2 - Urban consolidation & pooling problems: 22.5% of the publications



Types of problems & simulation techniques

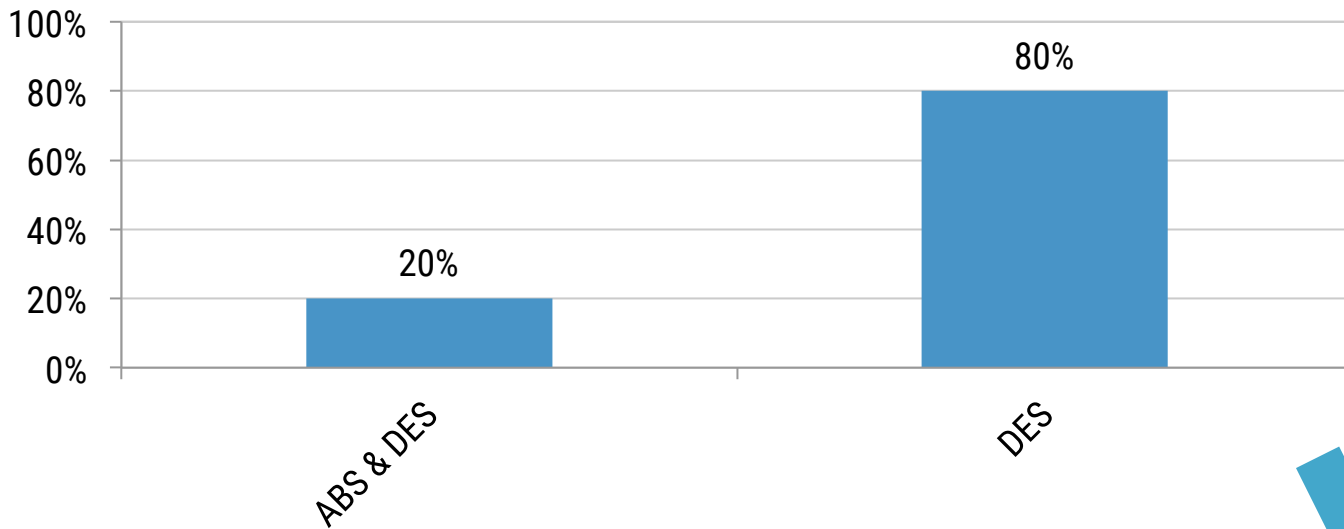
3 - Vehicle routing problems: 17.5% of the publications



Types of problems & simulation techniques

4 - Intermodality problems: 15% of the publications

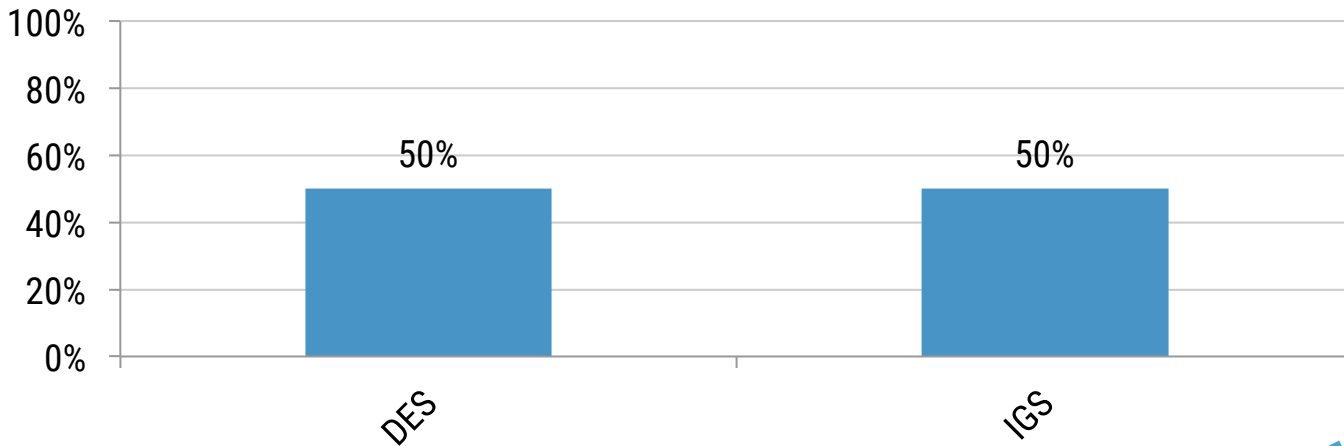
Logistics networks integrating different transportation services, designed to move goods from origin to destination in a timely manner and using multiple modes of transportation (Dotoli et al. 2010)



Types of problems & simulation techniques

5 - Electromobility problems: 7.5% of the publications

Using zero emission vehicles to deal with pollution (emissions), noise and other nuisances due to freight transportation in city centres





Simulation techniques advantages and drawbacks

**The different choices of simulation techniques
are detailed based on:**

- Arguments in reviewed publications
- Email survey (amongst the authors)



Simulation techniques advantages and drawbacks

ABS

- ⊕ Useful to better understand real-world systems
- ⊕ Allows interaction different urban entities: freight carriers, truck drivers, retailers and local authorities
- ⊕ Allows evaluating and improving the objectives of different stakeholders
- ⊕ Useful when there is little knowledge about the global interdependencies between coexisting stakeholders
- ⊗ **Agent based modelling is harder to develop**



Works aiming to evaluate the performances of UDCs are usually tackled with ABS



Simulation techniques advantages and drawbacks

DES

- ⊕ Useful for problems containing networks of queues
- Simulate systems involving traffic and lead times



All the papers dealing with intermodal transportation systems (ITS) make use of DES



Simulation techniques advantages and drawbacks

MCS

- ⊕ **Problems with significant uncertainties, whenever there is need of estimations, forecasts and/or decisions**
- ⊕ **Most of the reviewed publications use MCS to simulate the variability of urban freight demand, behavior of actors, and duration of operations**
 - **The main applications involve facility location decisions and scheduling**



Simulation techniques advantages and drawbacks

IGS

⊕ **Publications dealing with vehicle routing problems and network design**

💡 **Publications implementing IGS intend to model only important scenarios of a system and in most cases pay particular attention to travel times**



Simulation techniques advantages and drawbacks

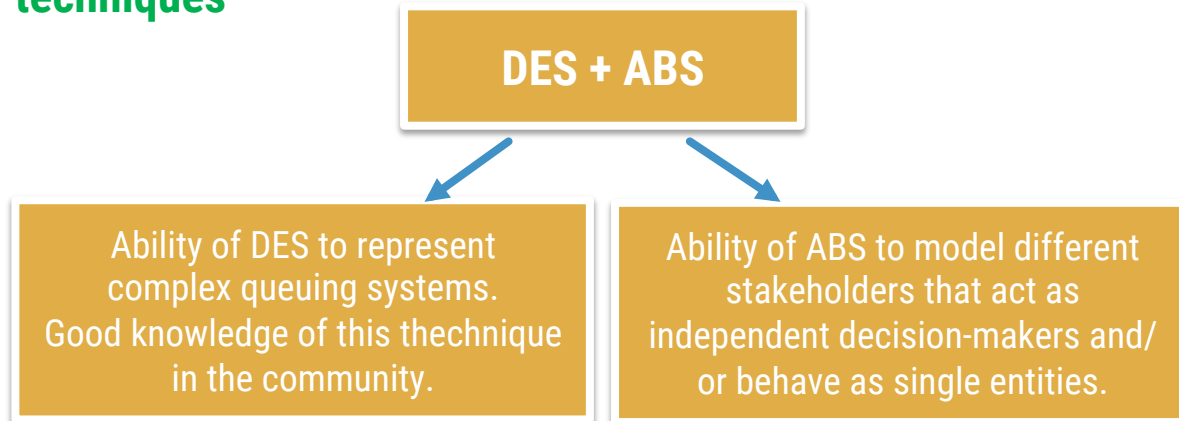
SD

- ⊕ **Focuses more on the behavior of the system rather than the individuals composing it**
- ⊕ **Rabelo, et al., (2005) SD is suitable for high level strategic modelling, because**
 1. **it proposes a holistic approach of systems, integrating many subsystems**
 2. **it focuses on policies and system structure**
 3. **it make use of feedback loops to represent the effects of policy decisions.**
- ⊕ **DES tends to look at the smaller detail of a system (microscopic), whereas SD tends to take a more overall perspective (macroscopic) (Maidstone (2012))**

Simulation techniques advantages and drawbacks

Hybrid simulation

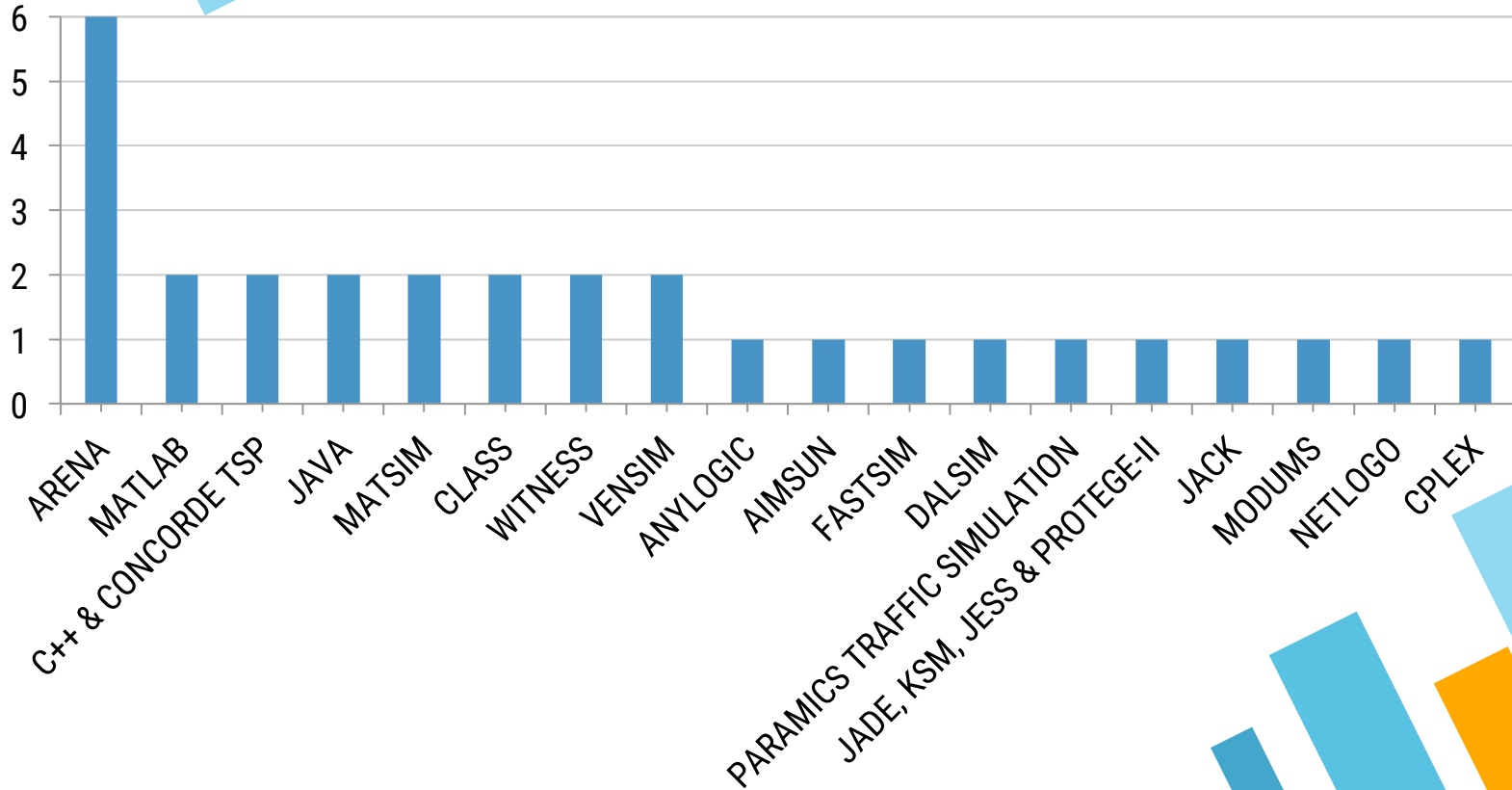
- + Provide better representation of the reality
- + More efficient computing environment by capitalizing on advantages of both techniques





SOFTWARE SOLUTIONS

Software choices





Software choices

Why ARENA?

- ⊕ **Surveys on simulation software shows the usability of Arena® is an attractive feature (easy to use with available reference literature) (ORMS, 2015; Abu-Taieh, 2005)**
- ⊕ **Capacity for dealing with large-scale and modular systems (Fanti et al. (2015))**

Our email survey amongst the authors that use Arena indicated that:

- They were Arena® users beforehand.
- Simul8, Simio, Witness and Anylogic are software solutions of equivalent quality.
- A default choice: software already available in their institution.



Research opportunities

what remains to be simulated?

- » **Lack of traffic micro-simulation**
- » **E-commerce**
- » **Regulations regarding vehicles (sizes, weights, load factors and/or engine types) and restrictions of access (restricted areas and/or time windows)**
- » **Alternative fuel vehicles (electric, hybrid, natural gas, and fuel cell vehicles): Study the needs and investments (infrastructure and/or fleets)**
- » **Absence of statistical analysis in order to validate the reviewed simulations**



ACKNOWLEDGMENTS

The authors would like to thank

Pr. A. Comi

Pr. P. Cortés

Pr. J. W. Joubert

Dr. M. Marinov

Dr. L. K. de Oliveira

Dr. G. Iacobellis

Pr. J. Gonzalez-Feliu

Pr. G. Gentile

Dr. L. Delaître

For their constructive feedback



THANKS FOR YOUR ATTENTION

Any questions?

You can find me at

- sarra.jlassi@mines-paristech.fr
- www.chairelogistiqueurbaine.fr