Evaluation of models for implementing Physical Internet standards via simulations of Complex System: "Using drones for the last mile"

5th IPIC Rijksuniversiteit Groningen 2018

López-Molina, L; Cervera Paz, A; Rodríguez Cornejo, V.M.; de Miguel Rodríguez, J; García García, R; Montañes del Río, M.A.

Introduction

In this work, we put forward a model to analyse the impact of a hypothetical scenario

in which a group of businesses
in the Cadiz area

is cooperating in the implementation of common standards that enable them to incorporate a PI system for their last mile deliveries.

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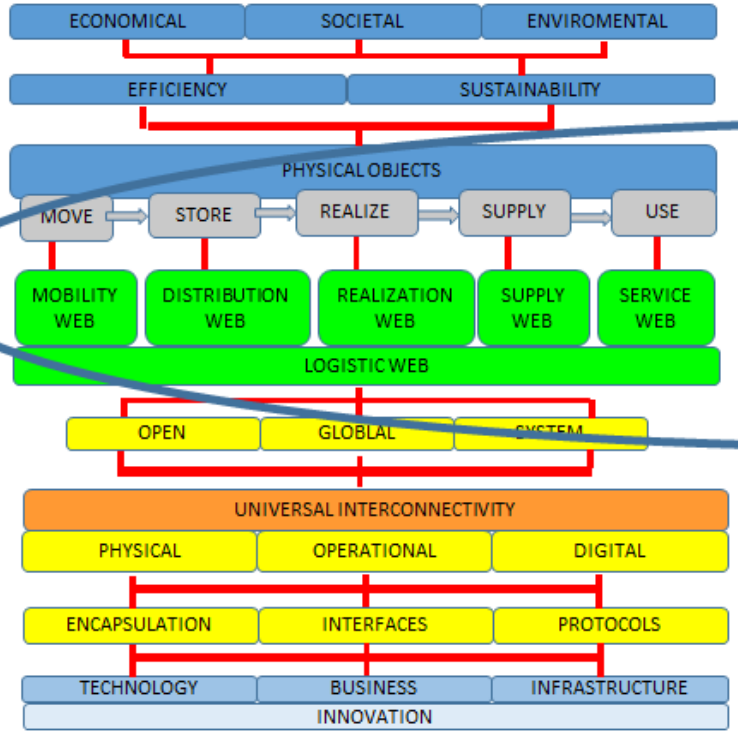
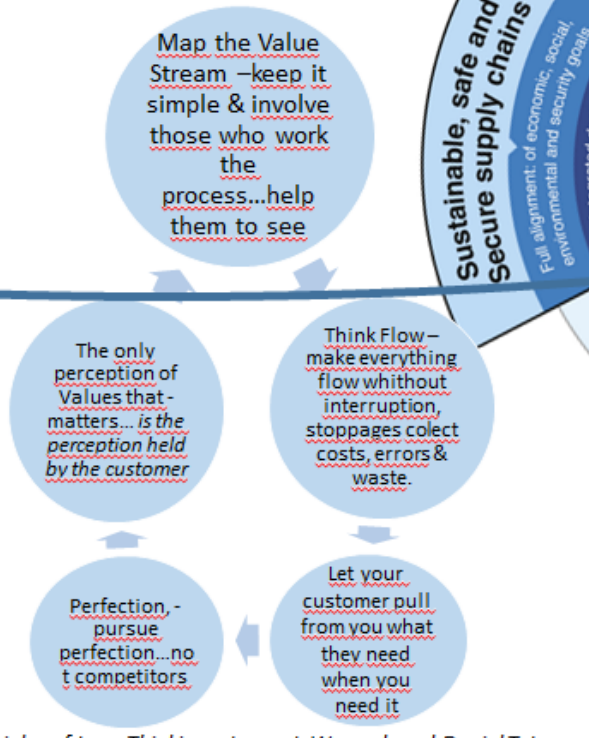
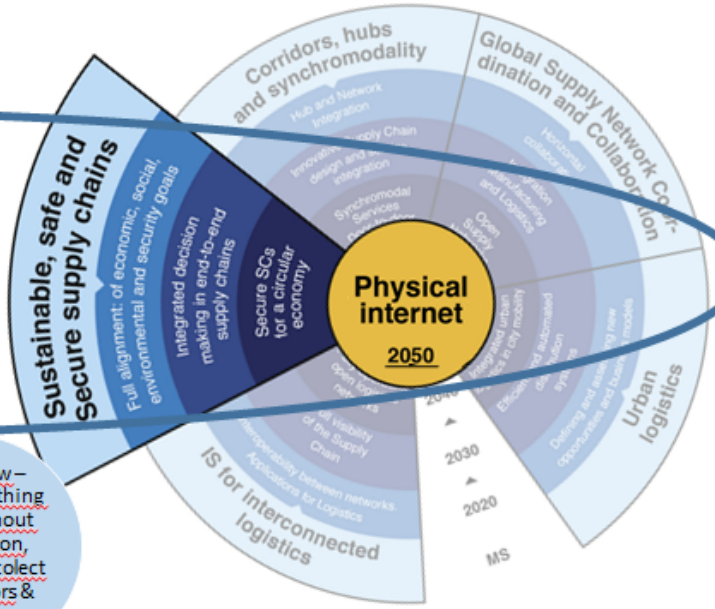
Background: Interaction between LEAN & PI



Foundations of the Physical Internet, Montreuil



The 5 Principles of Lean Thinking - James J. Womack and Daniel T. Jones



ALICE Road Map Physical Internet 2

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Background: Why Drones

In the 4th IPIC we presented how to improve Logistic using Lean Manufacturing with PI

After using the model, we needed to reduce the lead time of the deliveries goods in cities

VSM results that the current method of transport should change

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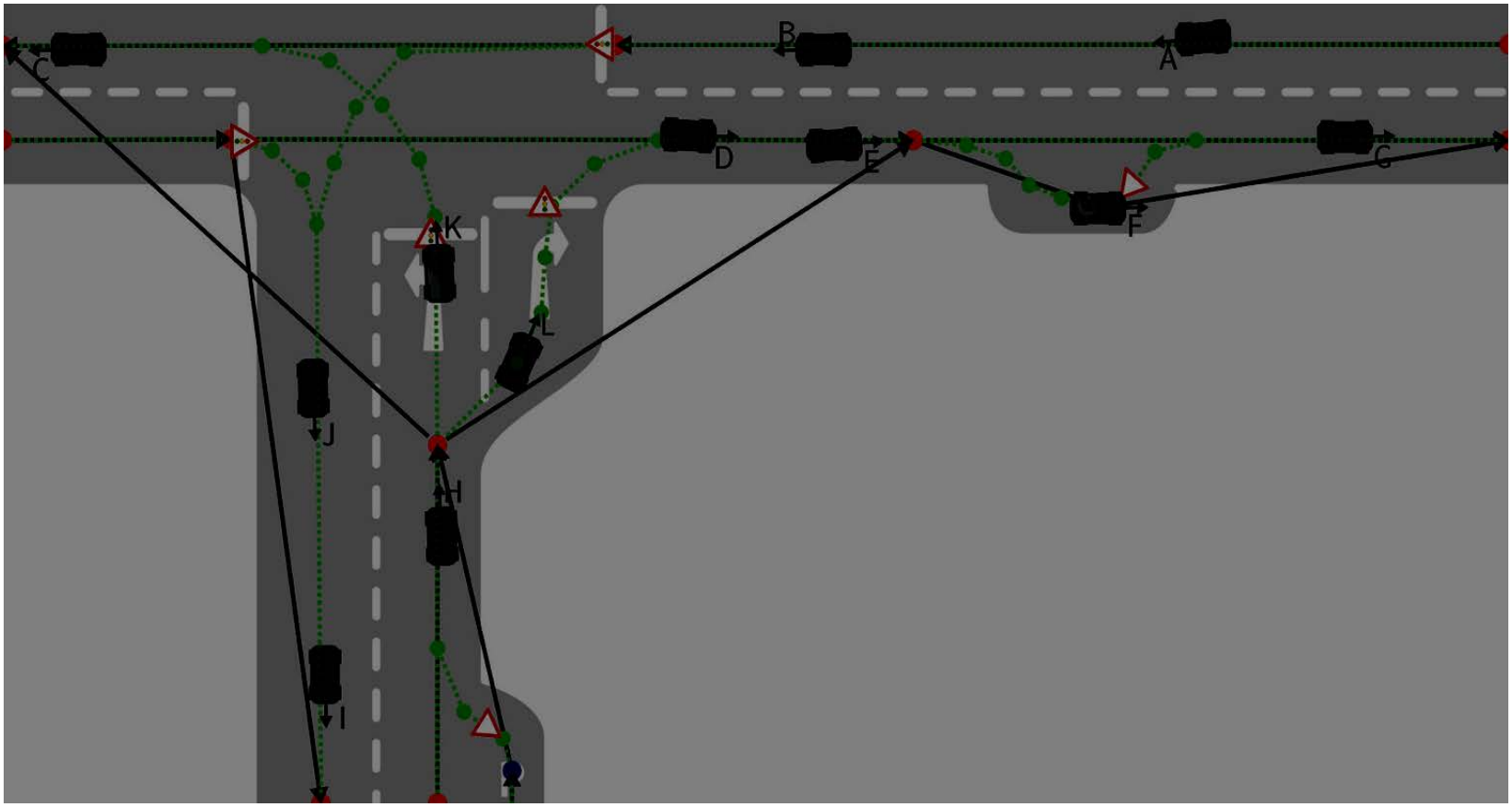
Method of transport should change



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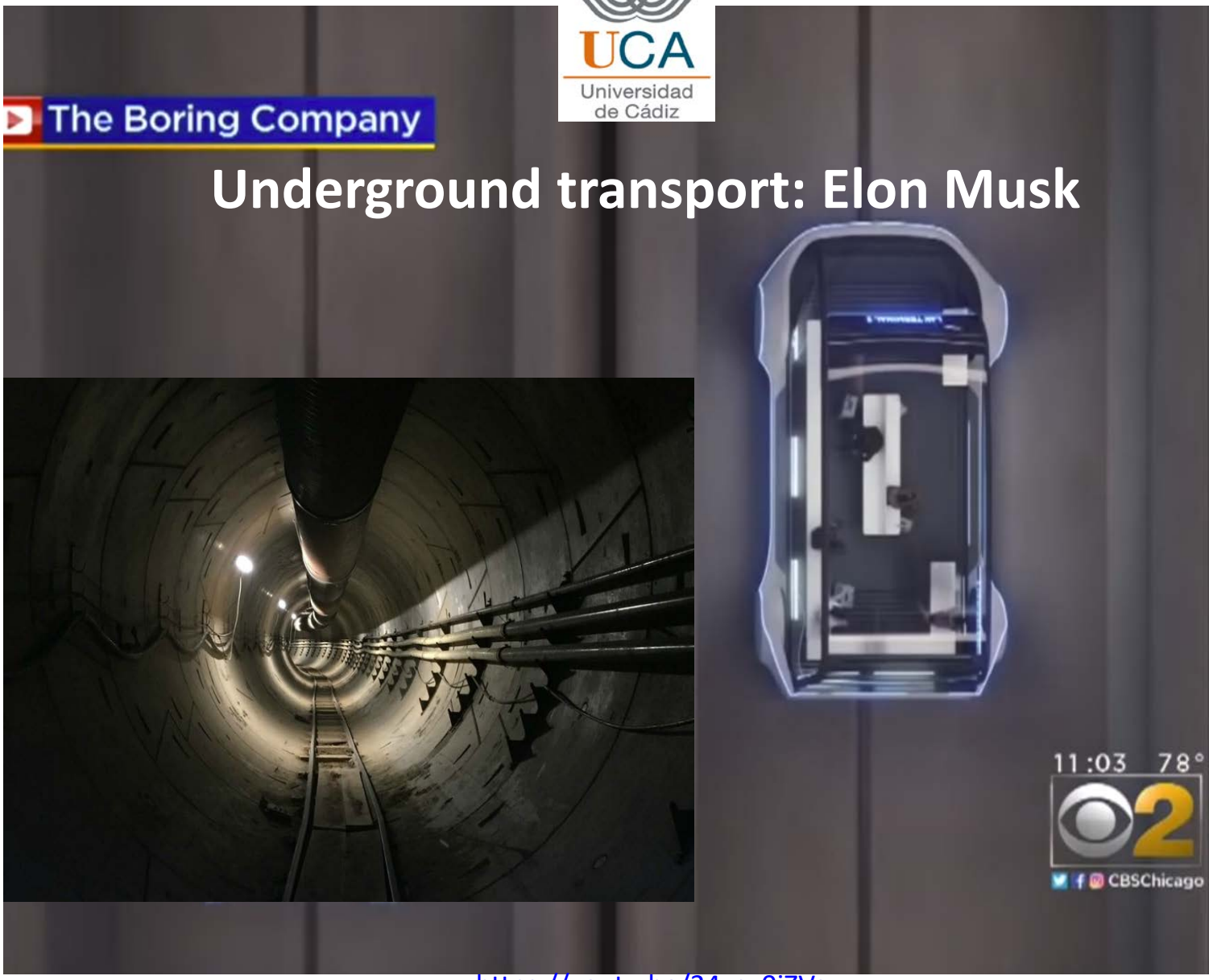
Underground transport: Elon Musk



https://youtu.be/24yqz0jZVaw

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Airtransport: Dezeen (Mark Dytham)

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Drones in our current life

The use of drones in the future is another emerging factor and

seen from the point of view of the life cycle of an industry

it is at the creation and diffusion of knowledge phase

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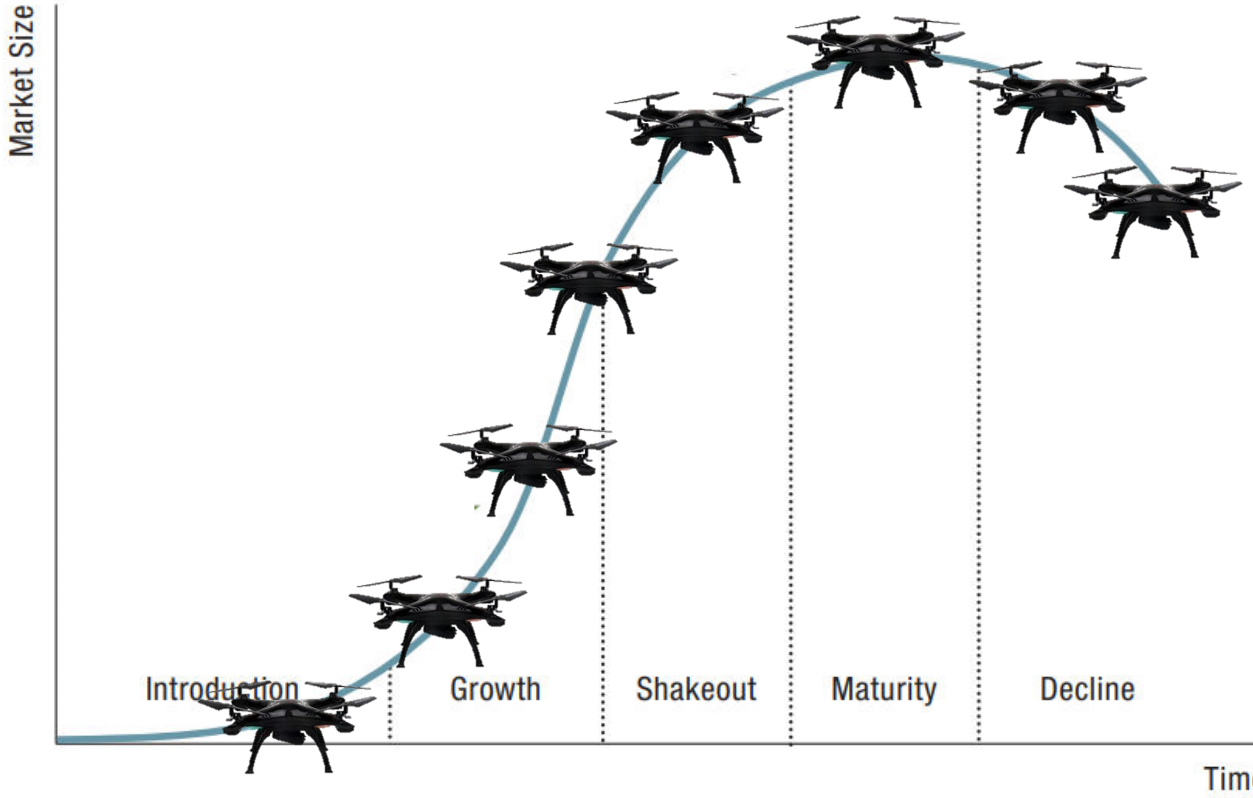
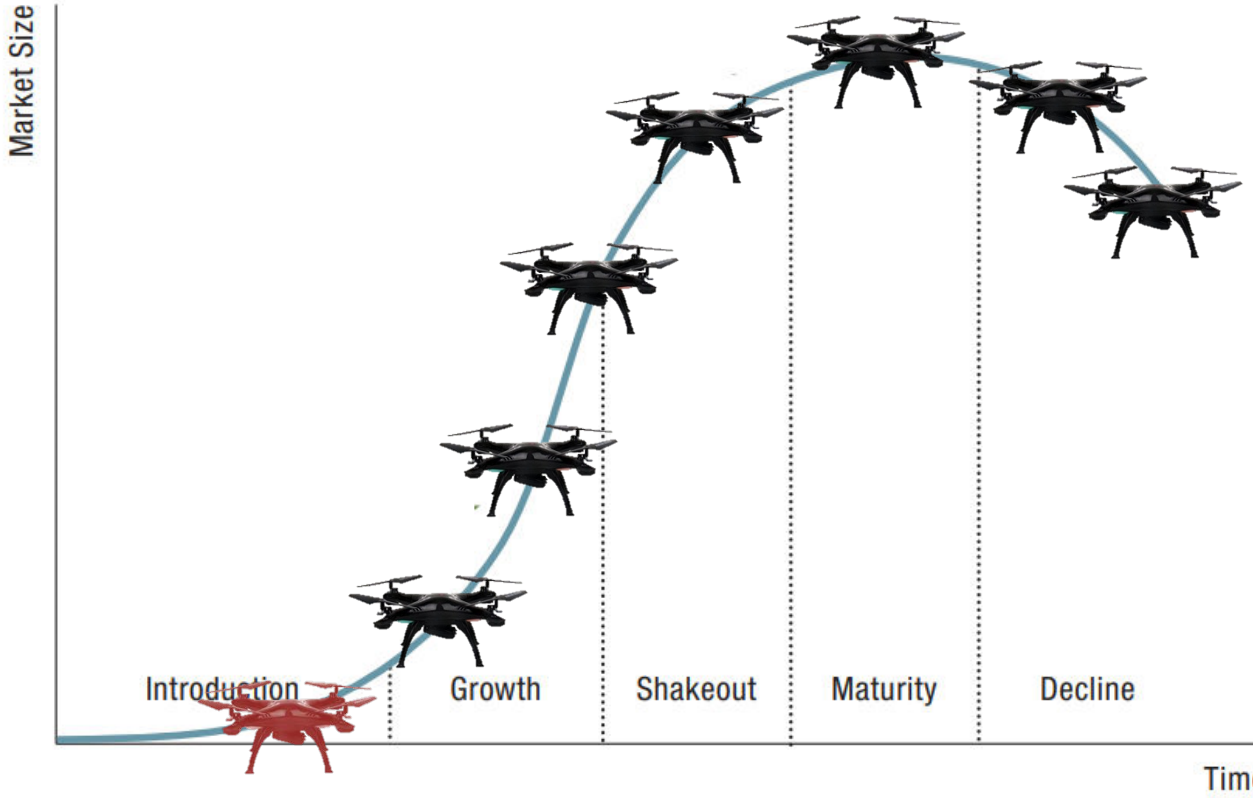
Life cycle of an industry



Life cycle of an industry



General reasons to introduce drones for logistics I

We must add that in recent years there has been an increase in e-commerce.

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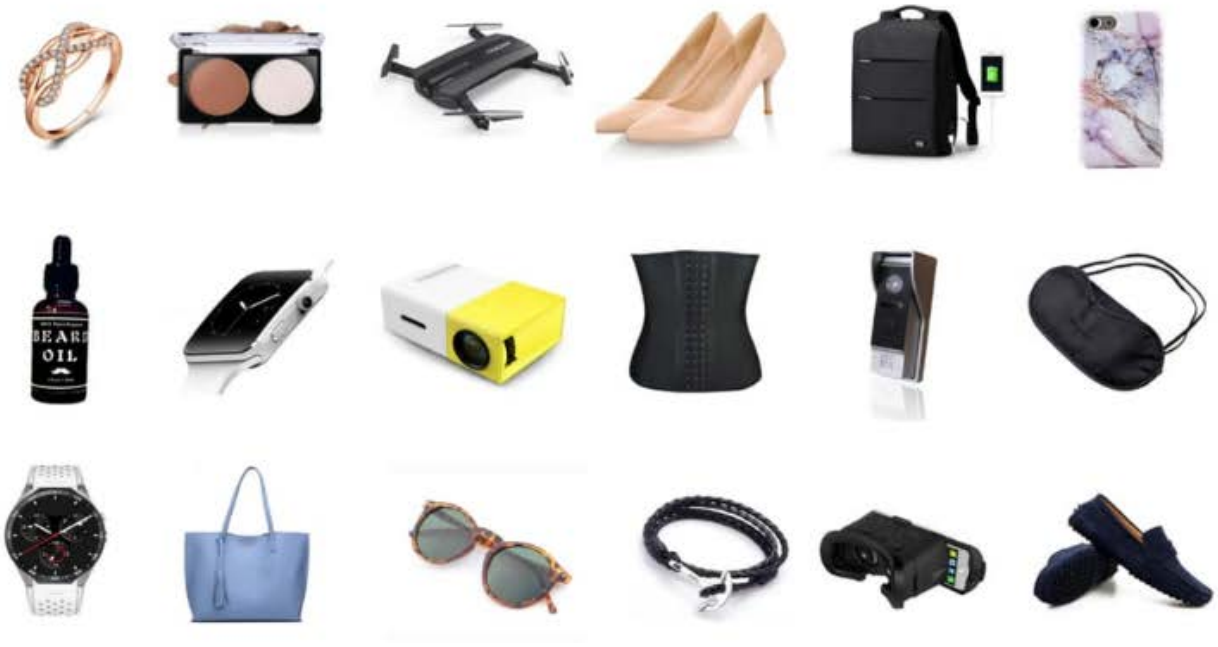

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General reasons to introduce drones for logistics II

….increase in e-commerce,

with this requiring a large deployment to reach the end clients.

Businesses have been fighting to be the best and fastest in their deployment for last mile deliveries

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How drones will change cities I

Mark Dytham architect in Dezeen

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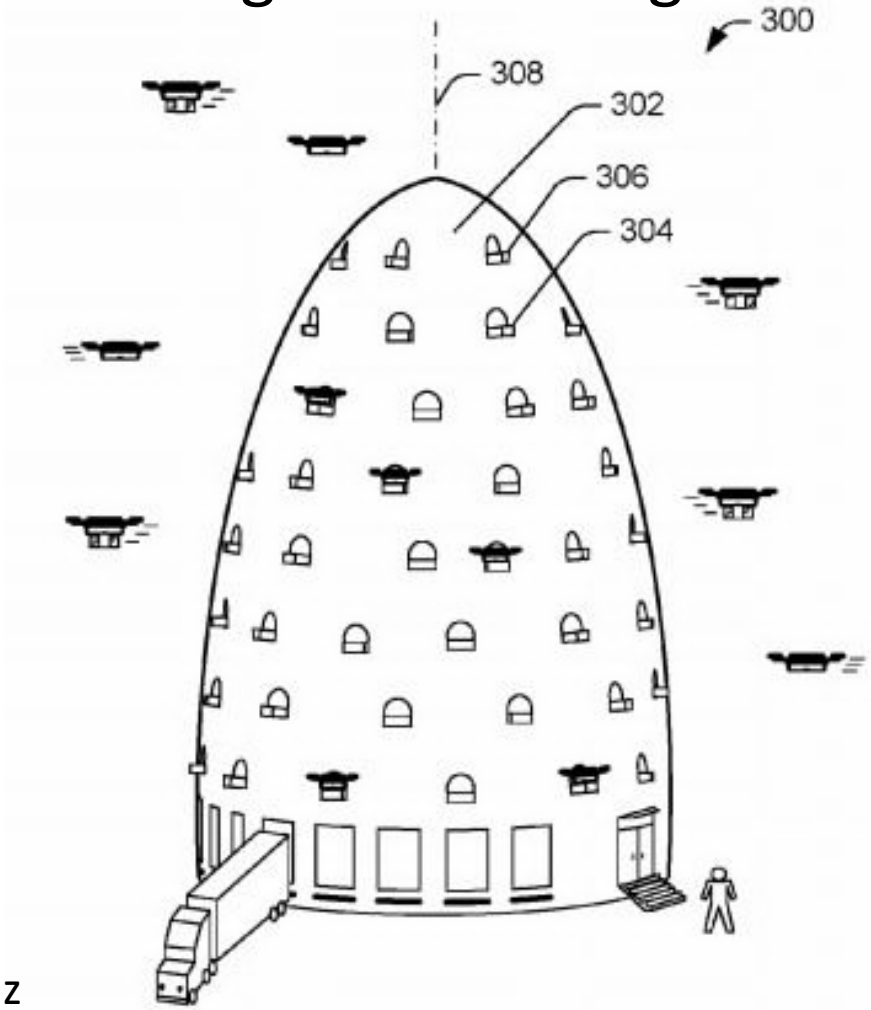
Patent of logistics building of Amazon



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The process to introduce it

Initially we don’t propose that the buildings of the cities have to change so fast

But we raised an earlier step, through airways that reach intermediate delivery points

The evolution from the present to our proposed could be:

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7 Intermediate stations to delivery products I

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7 Intermediate stations to delivery products II

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The reality nowadays: 14 companies delivery this kind of package (7+7)

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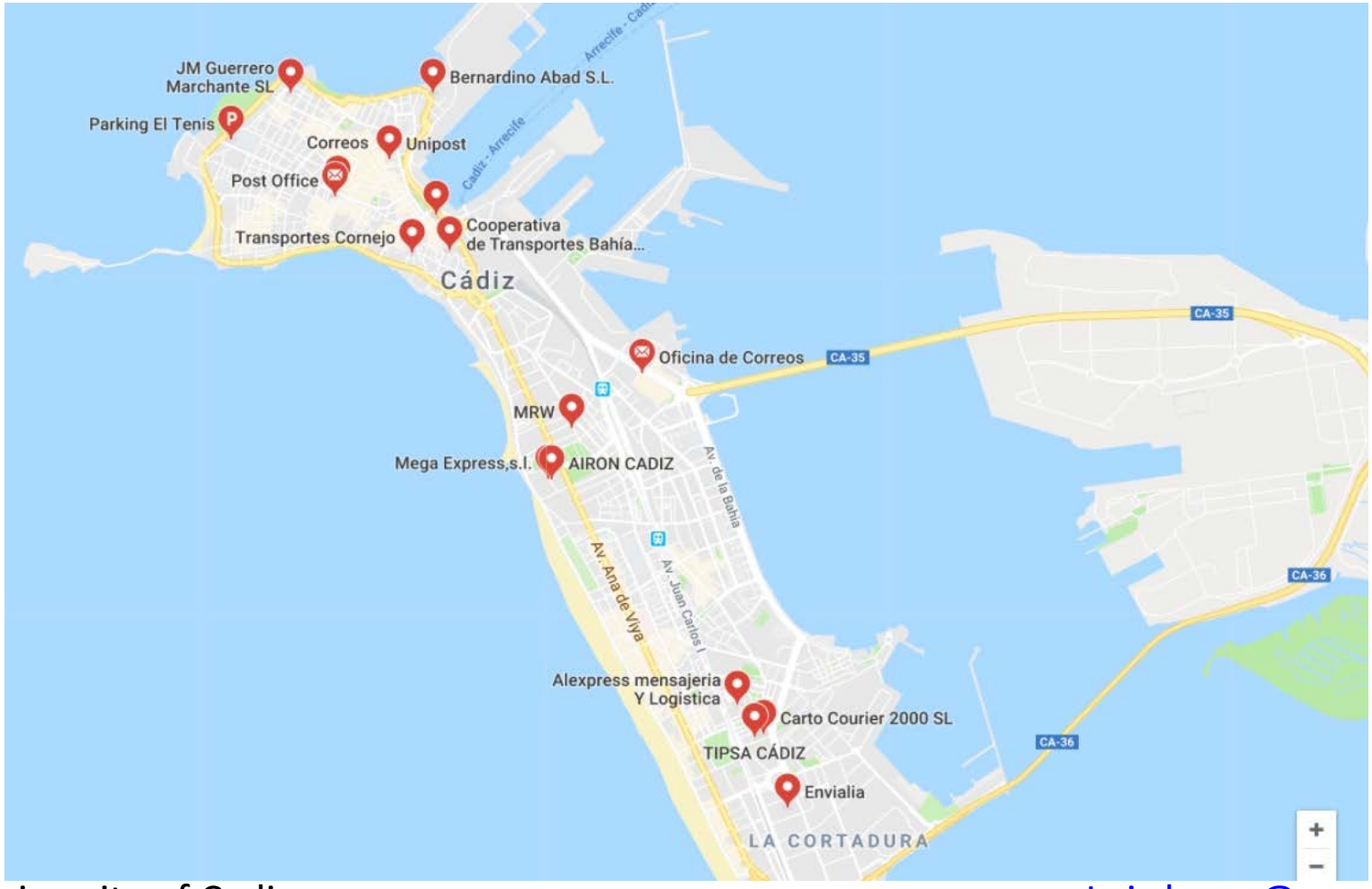
The reality nowadays: 14 companies delivery this kind of package



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Why Cadiz is ideal for this simulation?

There are two main reasons

The designation of Cadiz to simulate flight paths for last mile deliveries:

1.- Own physiognomy of the City
2.- The highest population density in Andalusia (Spain)

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Own physiognomy of the City

The highest population density in Andalusia I

10,399 inhabitants per square kilometer

Population density metrics. Data: Eurostat. Calculations by Rae (2018).

Lived density in Europe I

Country	Land Area (Sq Km)	Arithmetic Density	Built-up Density ('Lived Density')	Max 1km population	Population 2011	% of 1km cells populated
Monaco	2	18,067	18,067	12,564	36,133	100.0
Andorra	468	182	1,525	9,300	85,406	12.0
Malta	316	1,316	1,382	11,421	415,891	95.3
Spain	505,634	93	737	53,119	46,814,568	12.6
Netherlands	37,321	446	546	23,485	16,627,680	81.6
England	130,279	405	531	20,477	52,697,866	76.2
San Marino	61	420	493	2,034	25,629	85.2
Italy	301,289	197	453	22,113	59,369,049	43.5
Liechtenstein	160	223	447	1,947	35,775	49.8
Belgium	30,544	358	434	29,100	10,939,956	82.5
Romania	238,262	90	402	19,179	21,387,361	22.3
Switzerland	41,289	191	385	21,456	7,899,058	49.6
Greece	129,639	83	379	28,880	10,801,047	22.0
Germany	357,473	224	376	23,379	80,004,386	59.5
Hungary	93,067	107	368	10,451	9,923,425	29.0
Slovakia	49,134	110	358	15,379	5,391,770	30.7
Cyprus	9,487	88	319	5,439	839,063	27.8
Bulgaria	111,073	66	312	23,934	7,364,570	21.3
Luxembourg	2,634	192	308	7,213	505,682	62.3

Population density metrics. Data: Eurostat. Calculations by Rae (2018).

Lived density in Europe II

Country	Land Area (Sq Km)	Arithmetic Density	Built-up Density ('Lived Density')	Max 1km population	Population 2011	% of 1km cells populated
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But only 13% of them are lived in. This means that the 'lived density' for Spain is in fact 737 people per km². Cádiz is in the top twenty in the country, with 10,399 inhabitants per square kilometer.

Methodology to create the airways

It does this in order to be more competitive and to comply with the challenges of Europe 2030.

The model is described using the ODD standard (general design information)

which is commonly used for model description in fields such as ecology, sociology and economics.

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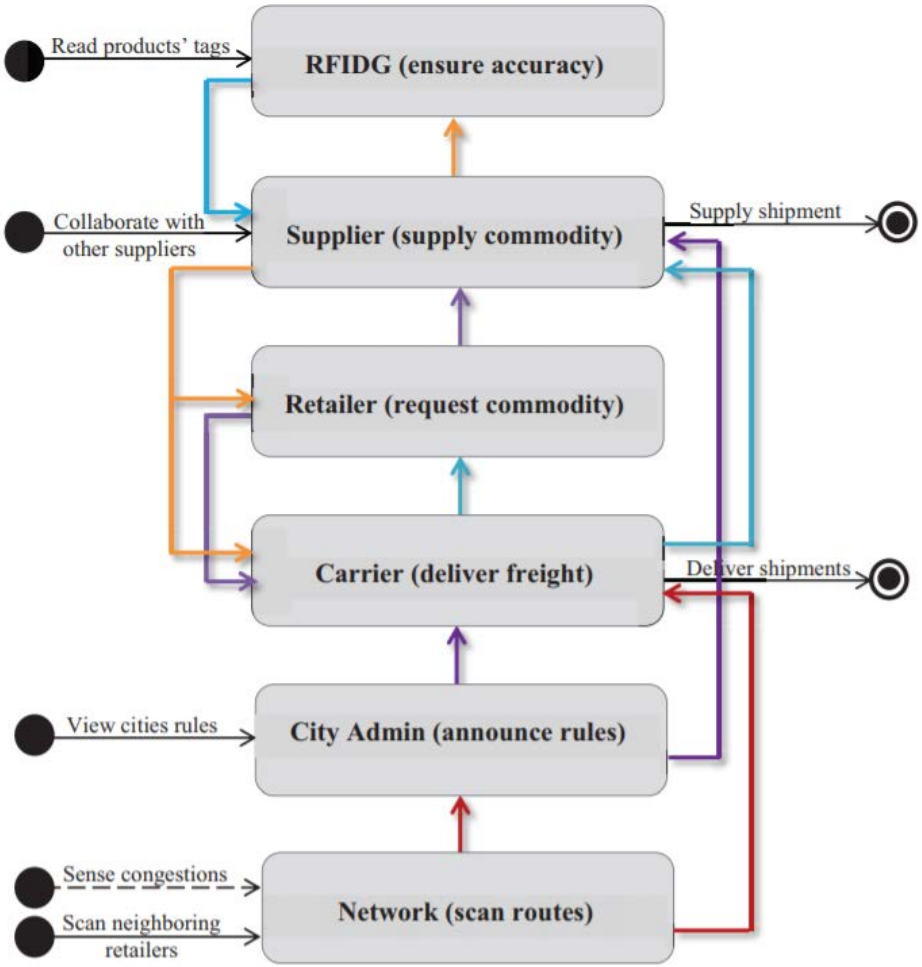
Global UML level of agents (ODD)



The model is described using the ODD standard

We have adopted this approach when developing a simulator that allows us

to design a network of flight paths

in the improvement of the last mile deliveries

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3 points outside the Residential area to receive the goods

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Discussion

To design the flight paths we had to answer three main questions

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Question 1

What is the starting information to gather for this type of studies?

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Question 2

Which are the factors that would need to be determined prior to the in-depth work with the multi-agent model?

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Question 3

The current legislation prohibits drones flying over urban centers, how could the authorities be convinced to implement the necessary legal modifications?

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Question 1 (part 1)

What is the starting information to gather for this type of studies?

1. Maximum weight of merchandise up to 3kg
2. Maximum load size of 150x150cm
3. Maximum flight time of up to 30 minutes or 2 hours with a hybrid vehicle
4. Cruising speed of 53km/h at full load
5. Fueled using an electric battery (for hybrid plus a mixed auxiliary tank petrol/oil)

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Question 1 (part 2)

What is the starting information to gather for this type of studies?

6. Drone maintenance every 50 hours of flight
7. Point-to-point flight plans (up to 100 waypoints)
8. Transmission of video and control from up to 50km using 3g/4g (120ms latency)
9. Autonomous takeoff and landing
10. Drone diameter of 200cm

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Question 2 (part 1)

Which are the factors that would need to be determined prior to the in-depth work with the multi-agent model?

1. Approximate size of the fleet operating simultaneously
2. Expected number of deliveries per hour
3. Minimum recommended safety distance between drones in flight
4. Approximate size of the launch pads and/or their distribution

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Question 2 (part 2)

Which are the factors that would need to be determined prior to the in-depth work with the multi-agent model?

5. Cruising speed factoring in wind speed
6. Range of heights at which the drones would fly (maximum and minimum)
7. Parameter for quantifying route deviations due to gusts of wind
8. Areas of the map that should be avoided (public squares, marketplaces, etc.)

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Question 3

How could the authorities be convinced to implement the necessary legal modifications?

We are part of an expert committee of different institutions (public and private, police, fire department, security companies, universities) which tries to give advice to the National Agency (Agencia Española de Seguridad Aérea “AESA”) regarding air security to modify the current air norms about urban areas

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Conclusion

After the design we confirm that the technical viability is possible. We will finish work on airway at the end of this year.
But is it economically beneficial?
Also will the cost to send the merchandise by drone be less than to send it by the current methods of transport?

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Future Work

Show the design of the airways

Economically beneficial. Is it viable?

We have to convince our authorities of the desirability of drones in the urban logistics

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Thank you very much!

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López-Molina, L; Cervera Paz, A; Rodríguez Cornejo, V.M.; de Miguel Rodríguez, J; García García, R; Montañez del Río, M.A.

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Luis.lopez@uca.es