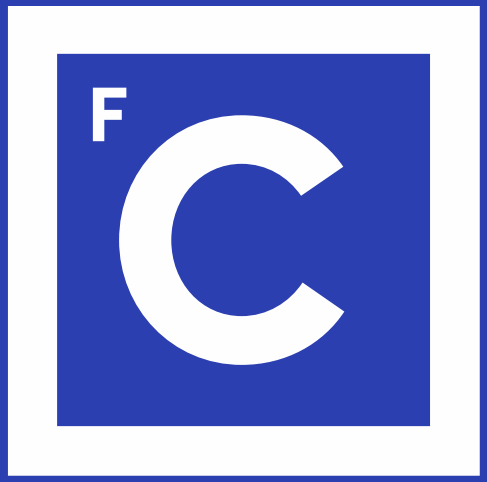


Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

Eng. Energy & Environment

Sustainable Mobility

Program

Topics	#	Contents
Basic concepts and definitions	1	Transportation system; Transports classification; historical evolution;
	2	Introduction to “sustainability and metrics”
	3	Energy conversions, primary energy, final energy, useful energy; Minimum energy and emissions in mobility,
	4	Propulsion technologies, internal combustion engines, electric motors, fuel cells, efficiencies
Characterization of mobility patterns	5	Surveys; Statistics; transport sector share energy & emissions;
Sustainability – Environmental dimension	6	Development of “sustainability and Metrics”
Air quality	7	World Health Organization, Directives, standards for emissions, air quality index
	8	Air quality networks and pollutants covered - local and global emissions
Emission inventories	9	Emission inventory models, micro to macro, motor vehicle dynamics
	10	COPERT 5 fleet model

Program

Topics	#	Contents
Application of metrics of Sustainable mobility	11	Comparing Lisbon and Oporto mobility Screening mobility patterns in University campus
Life cycle analysis in transportation systems	12	Life cycle analysis
	13	Water, land use, resources scarcity and carbon footprint
	14	Carbon footprint in transport
	15	Carbon footprint applied to electric versus diesel technology
Disruptions & consequences	16	COVID19 impact overview

BASIC CONCEPTS

TOPIC #I

BASIC CONCEPTS

- **When addressing "Sustainable Mobility" it is common to ear some terms like:**

✓ Transportation system;

✓ Logistics;

✓ ITS;

✓ Commuting;

✓ Intermodal;

✓ Seamless;

✓ Automous vehicles;

✓ Eletric vehicles;

✓ Biofuels;

✓ Energy consumption;

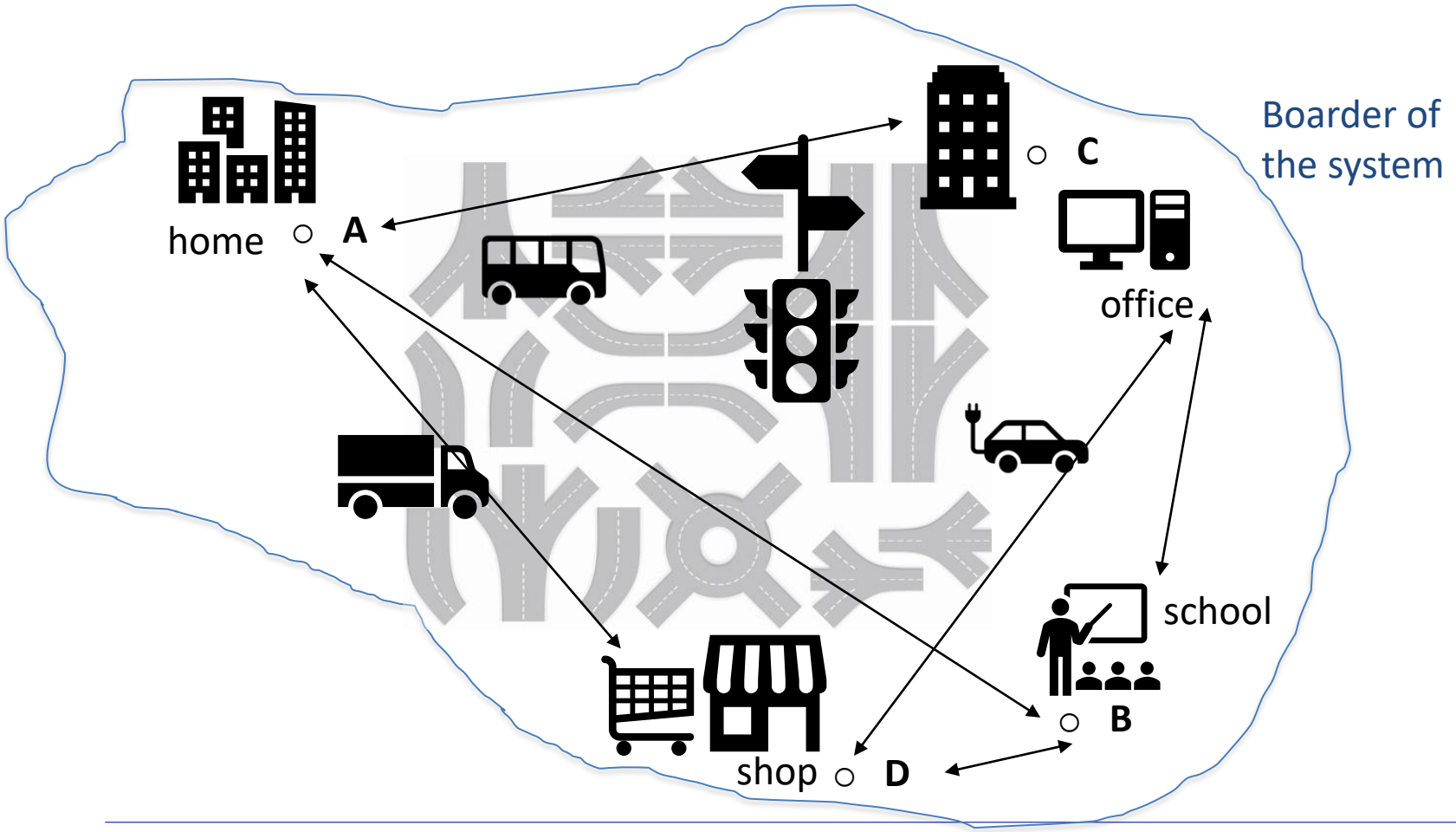
✓ CO_2 emissions;

✓ NOx emissions;

✓ PM emissions.

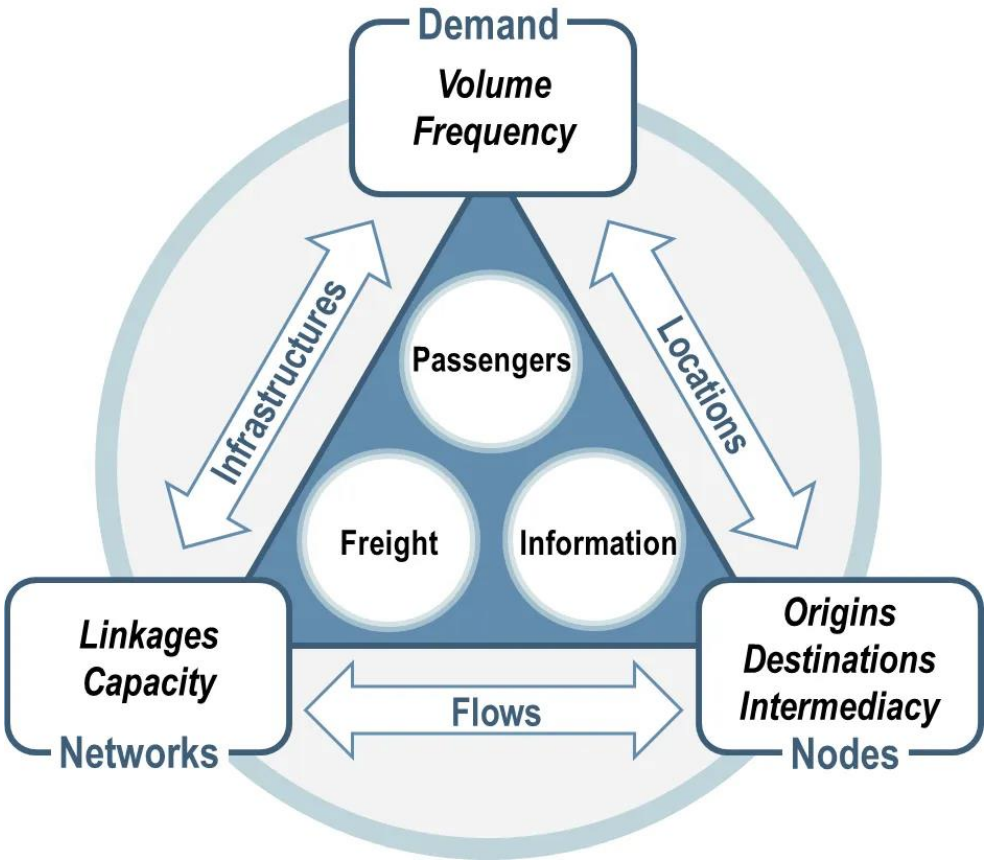
Transportation system

- A transportation system is an infrastructure that serves to move people and goods.



Transportation system

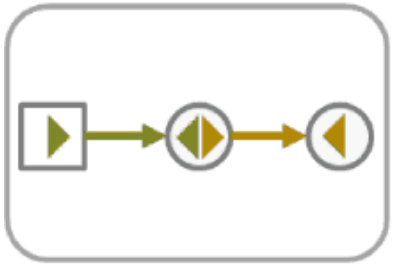
- A transportation system is an infrastructure that serves to move people and goods **efficiently**.



Transportation system composition

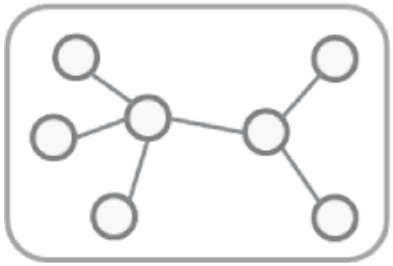
Modes (carriers)

Conveyances (vehicles) used to move passengers or freight.
Mobile elements of transportation.



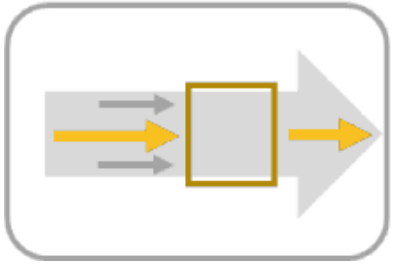
Infrastructures

Physical support of transport modes, such as routes and terminals.
Fixed elements of transportation.



Networks

System of linked locations (nodes).
Functional and spatial organization of transportation.

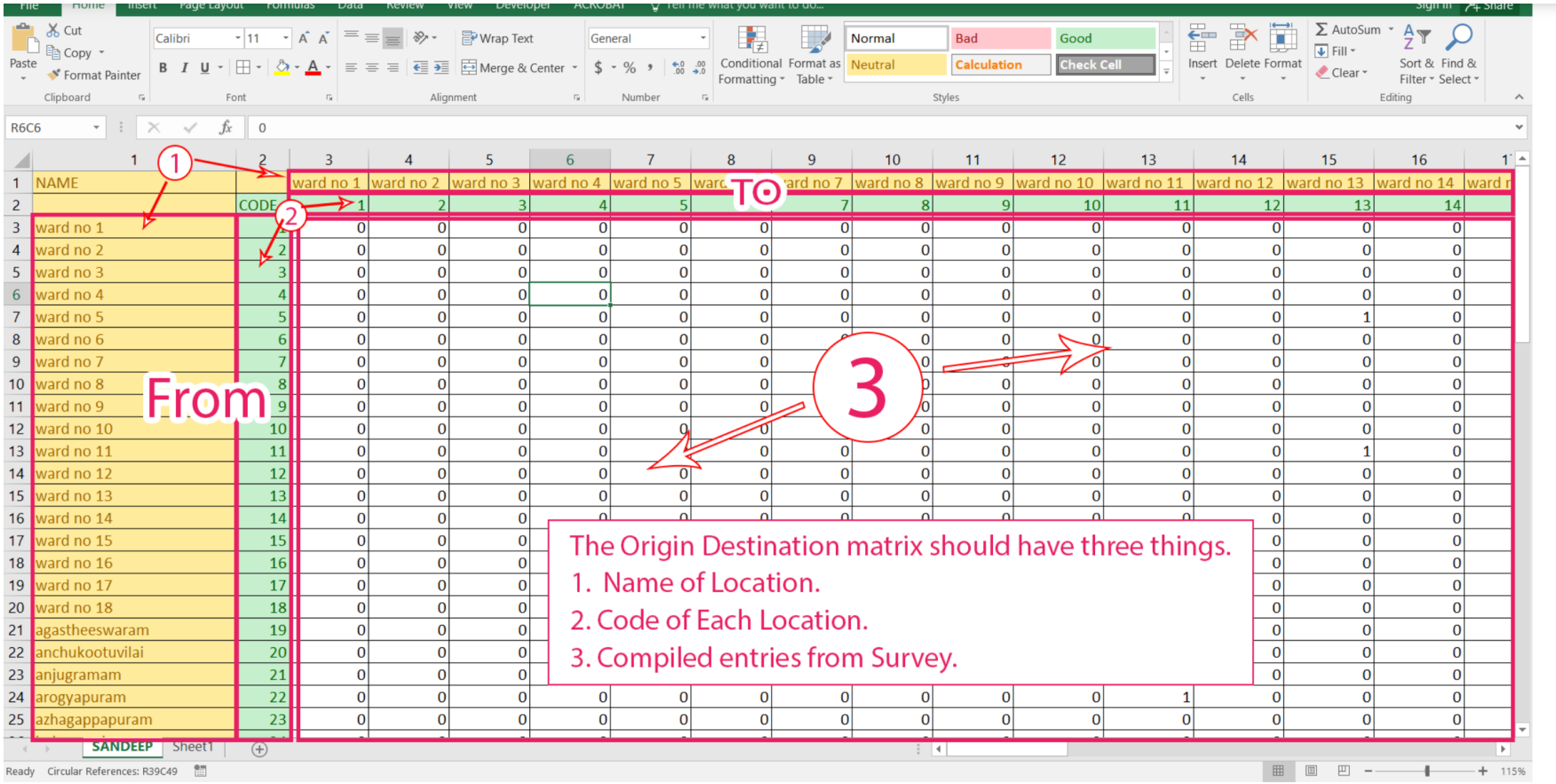


Flows

Movements of people, freight and information over their network.
Flows have origins, intermediary locations and destinations.

Transportation system composition

NODES Origin –Destination matrix

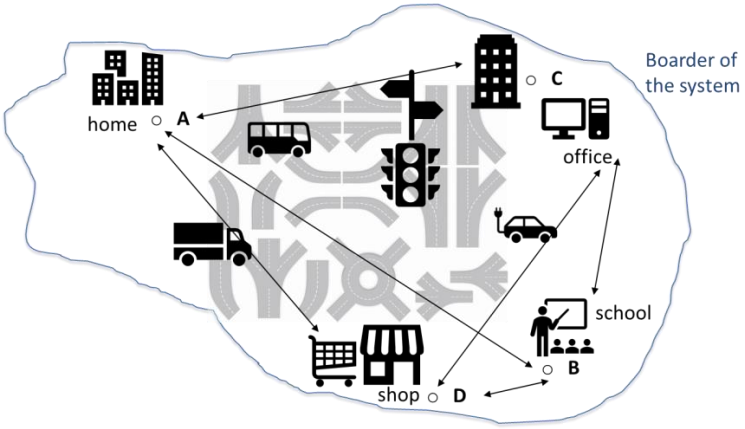


NAME	CODE	ward no 1	ward no 2	ward no 3	ward no 4	ward no 5	ward no 6	ward no 7	ward no 8	ward no 9	ward no 10	ward no 11	ward no 12	ward no 13	ward no 14
		1	2	3	4	5		7	8	9	10	11	12	13	14
ward no 1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 5	5	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ward no 6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 11	11	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ward no 12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ward no 18	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
agastheeswaram	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
anchukootuvilai	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
anjugramam	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
arogyapuram	22	0	0	0	0	0	0	0	0	0	0	1	0	0	0
azhagappapuram	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Prepare the Origin Destination Matrix

Transportation system composition

NODES Origin –Destination matrix

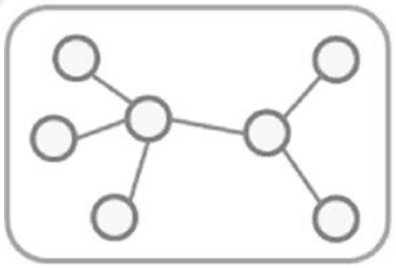


e.g Info n^{er} trips per day (flows and nodes)

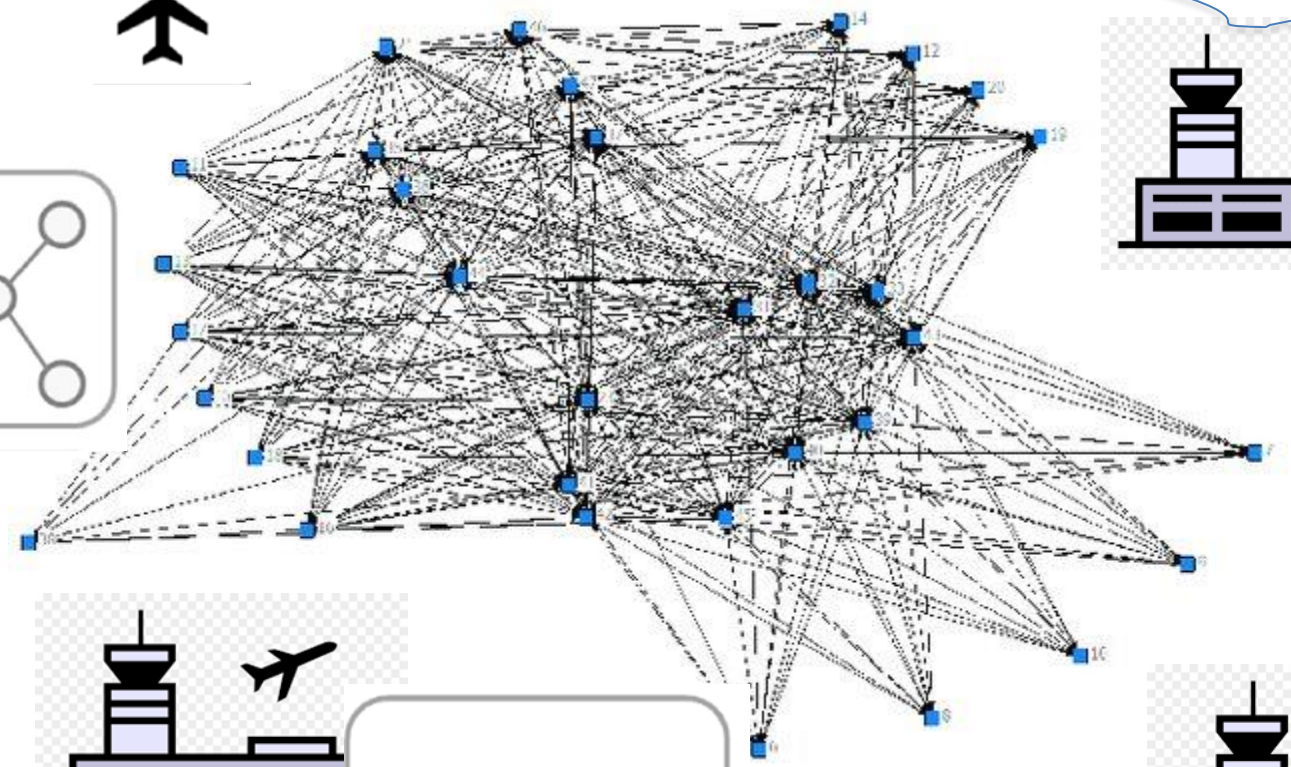
		DESTINATION				SUM
		A	B	C	D	
ORIGIN	A		65	28	28	121
	B	69		12	83	164
	C	100	60		217	377
	D	86	127	63		276
SUM		255	252	103	328	**938**

Transportation system example

Air transport mode



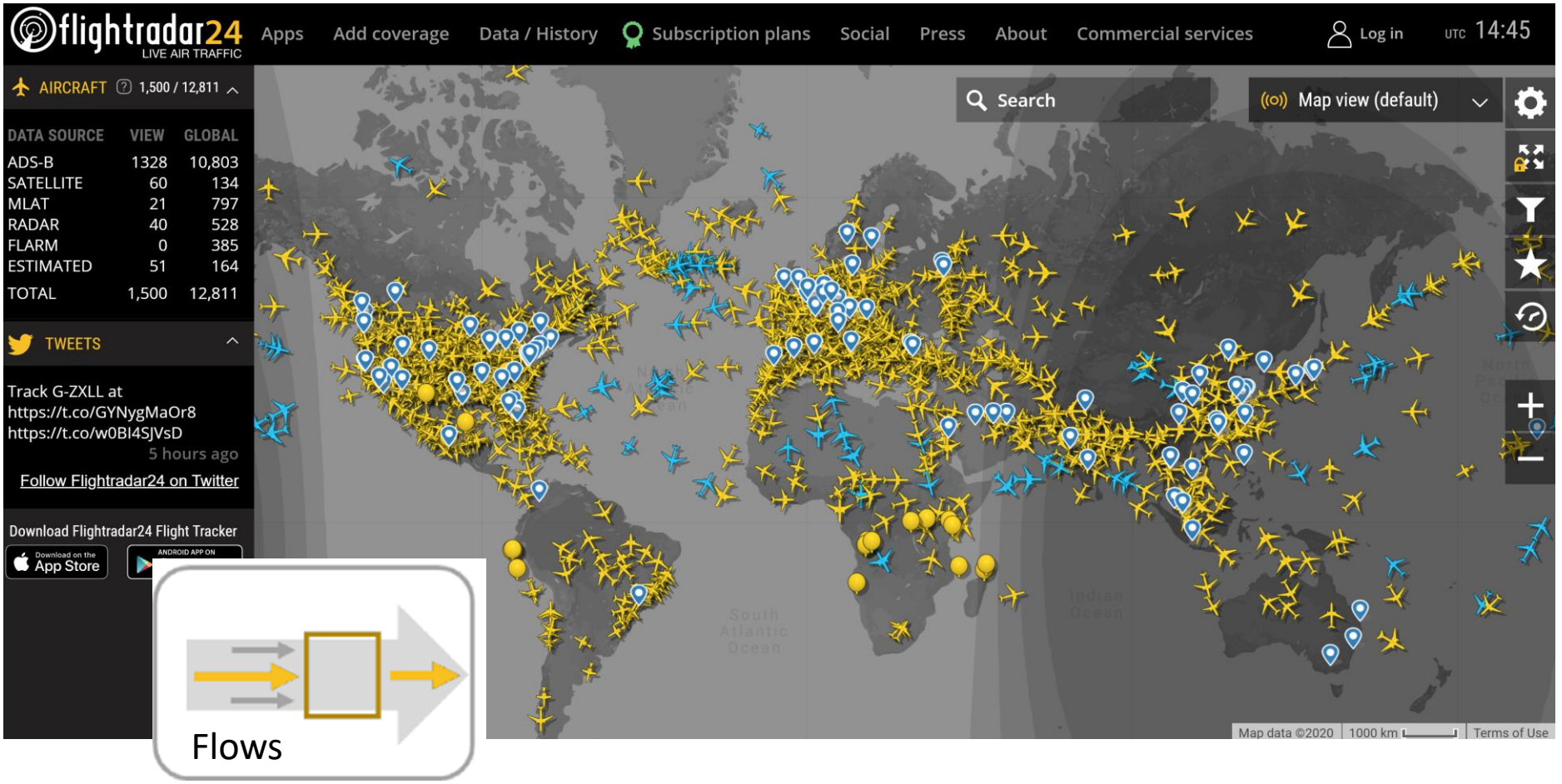
Network
Routes



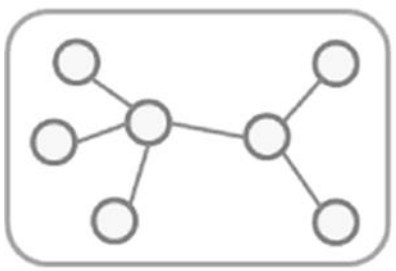
Infrastructure –
Airports/Terminals

Transportation system example

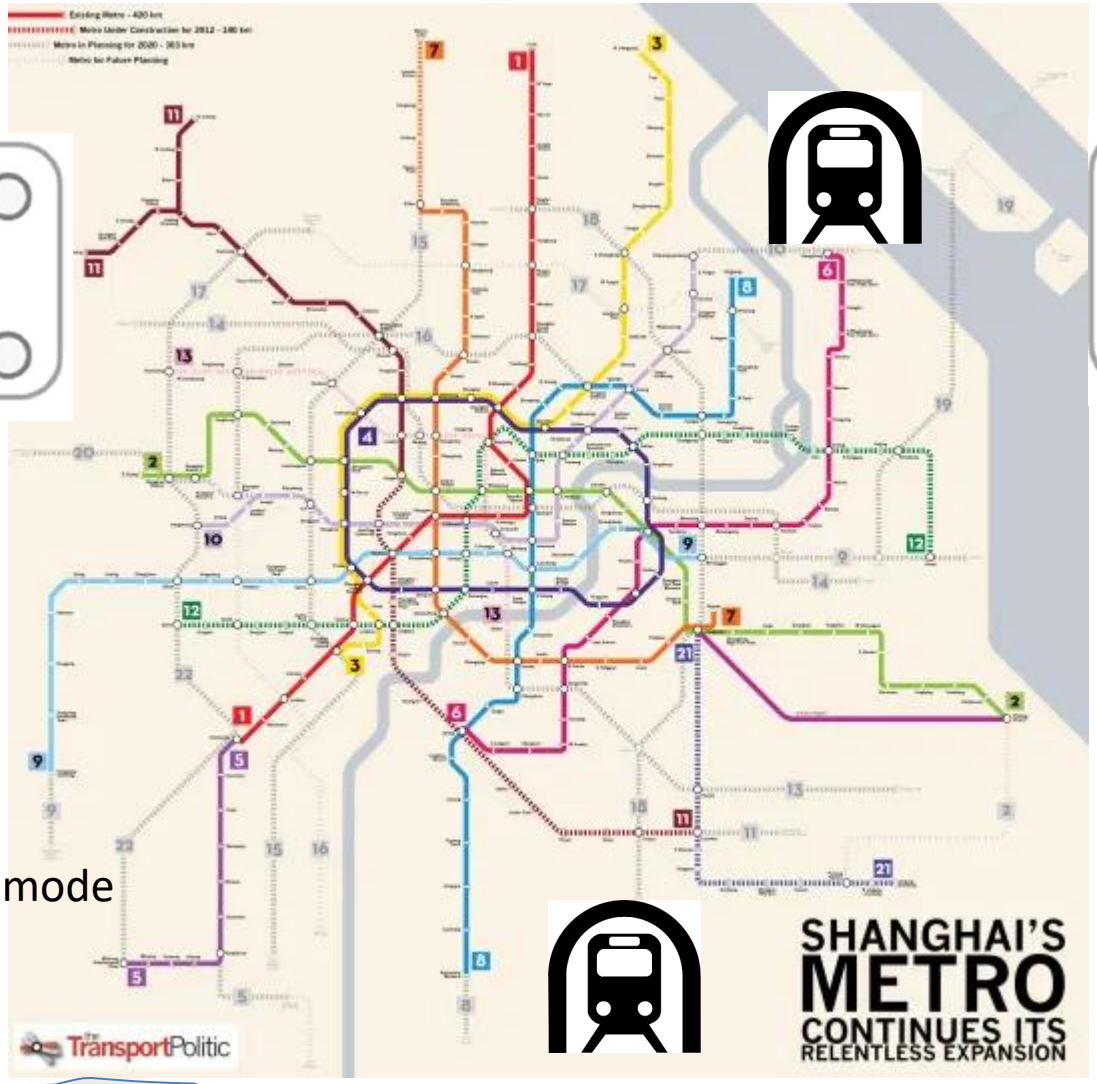
https://www.flightradar24.com/38.72,-9.13/2

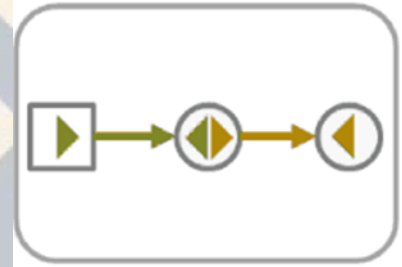


Transportation system example



Network
Routes

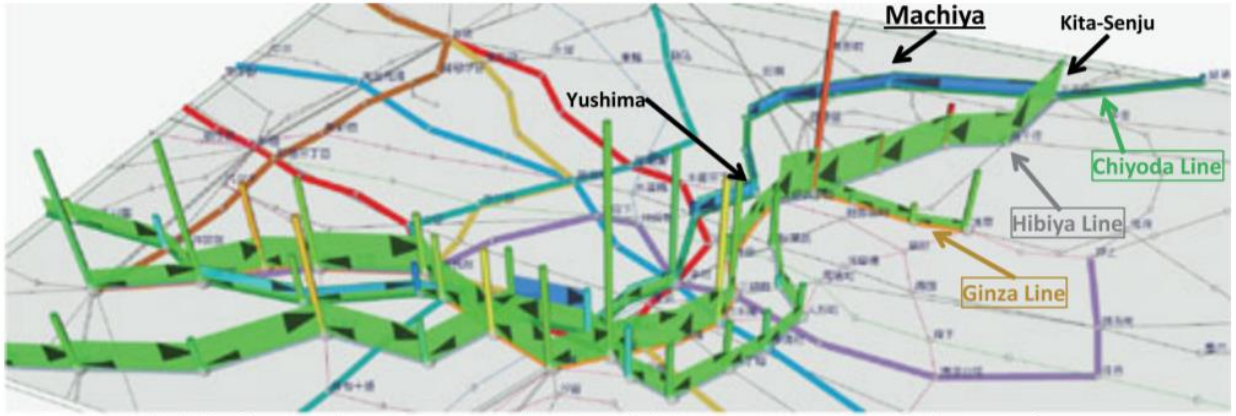




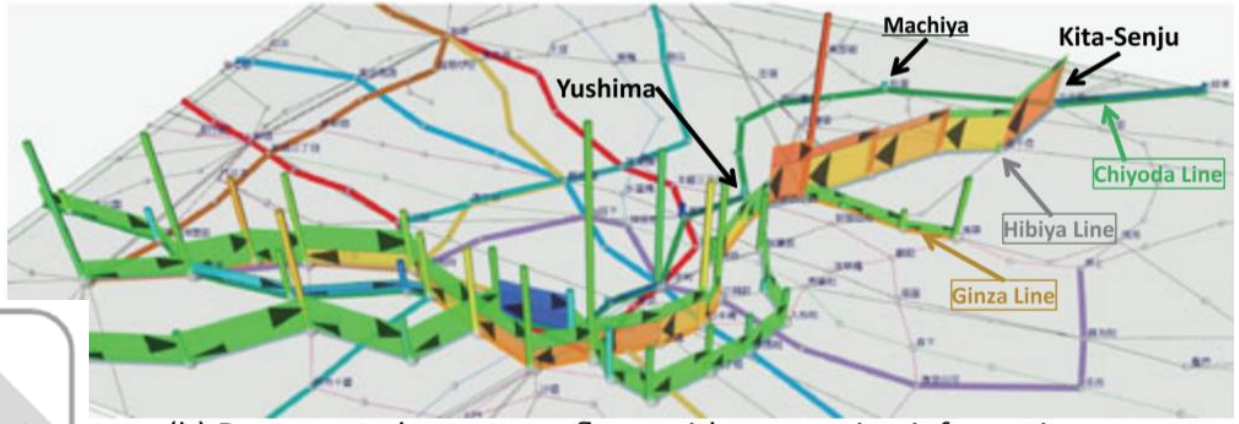
Infrastructure –
Stations & railways

railway transport mode

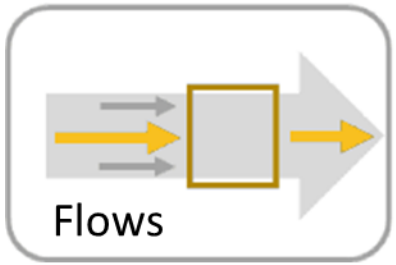
Transportation system example



(a) Estimated passenger flows without suspension information



(b) Recomputed passenger flows with suspension information:
Sections from Kita-Senju to Yushima on the Chiyoda Line are suspended from 9:59 to 10:37.



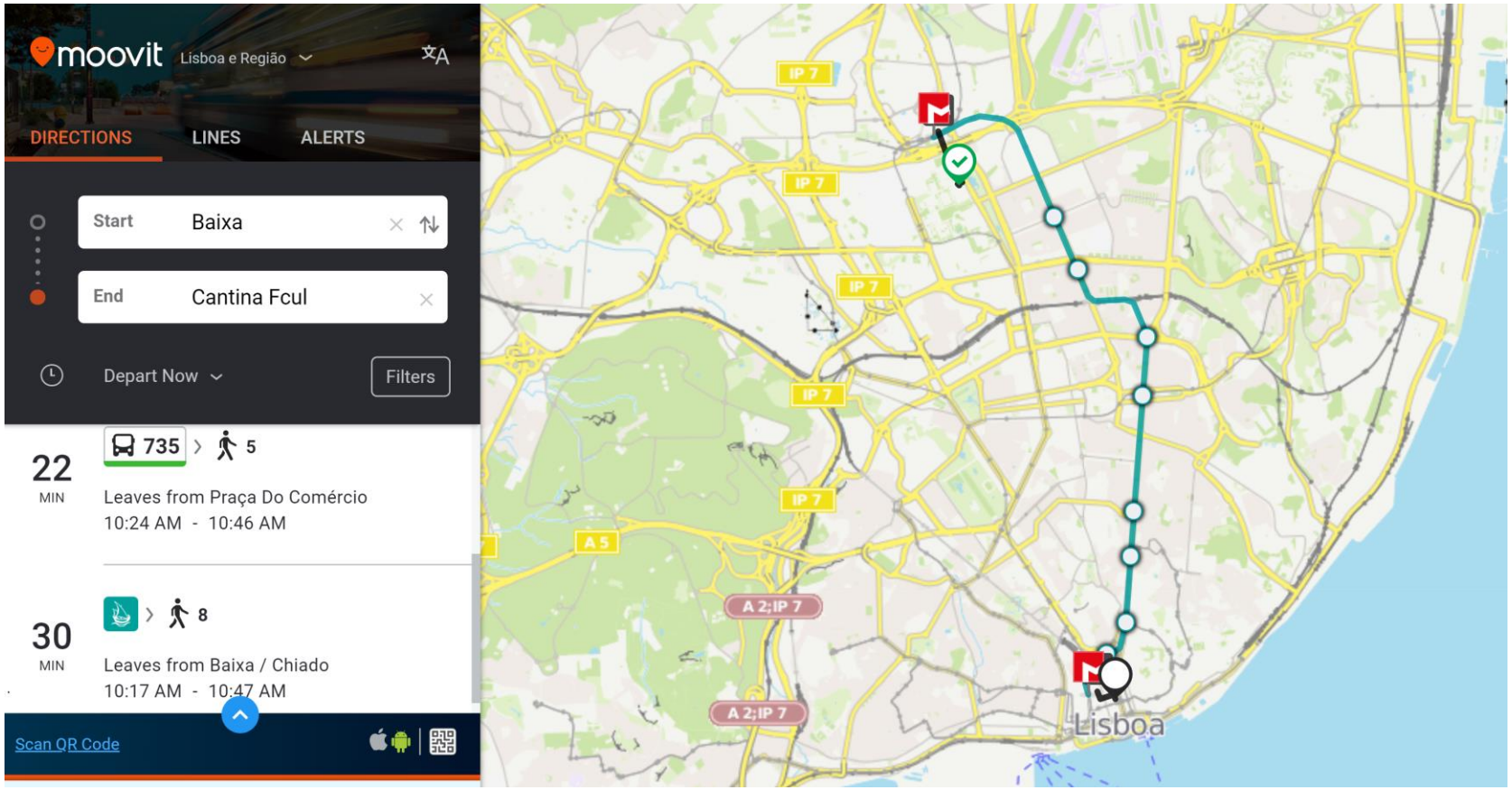
Transportation system Logistics

- Transportation…is moving people or goods from an origin to a destination;

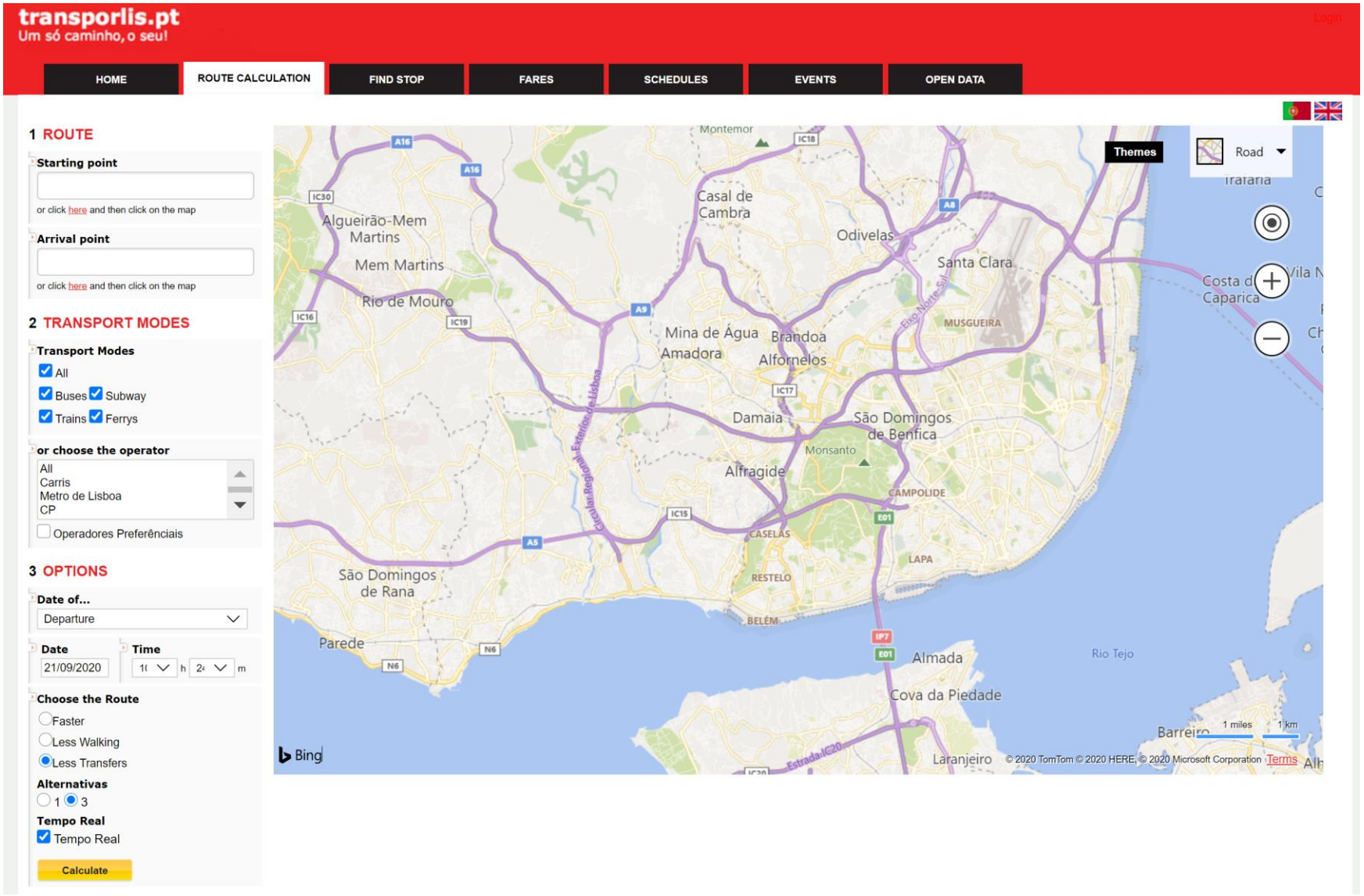
- Logistics….is management of flows between origin and destination, i.e. optimization of modes, routes and schedules with a target objective. For example:

Fastness Cost **Fuel consumption** Comfort Security

Transportation system Logistics



Transportation system Logistics

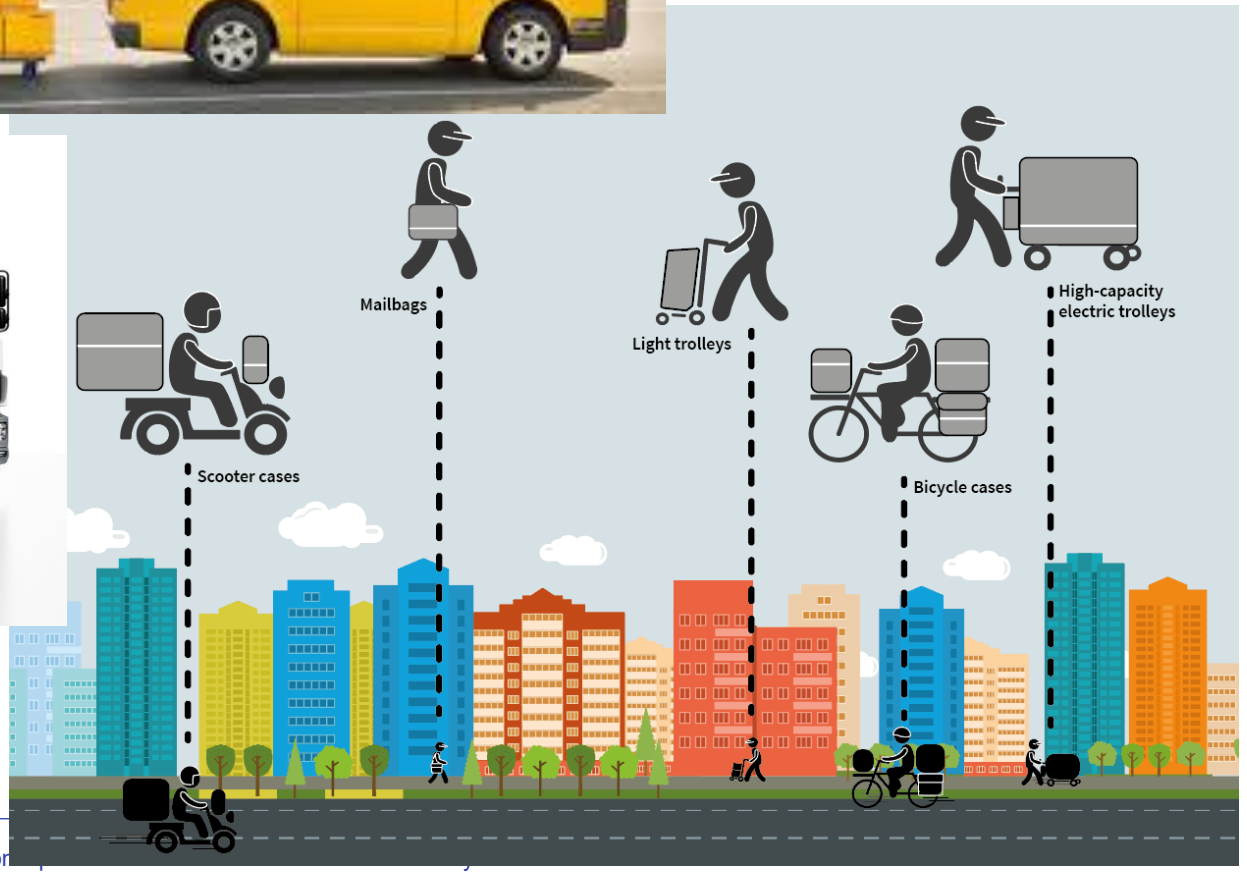


Transportation system Logistics

Transportation system Logistics

- Qingdao, China
- Seoul, South Korean
- Setar, Malaysia
- Dhaka, Bangladesh

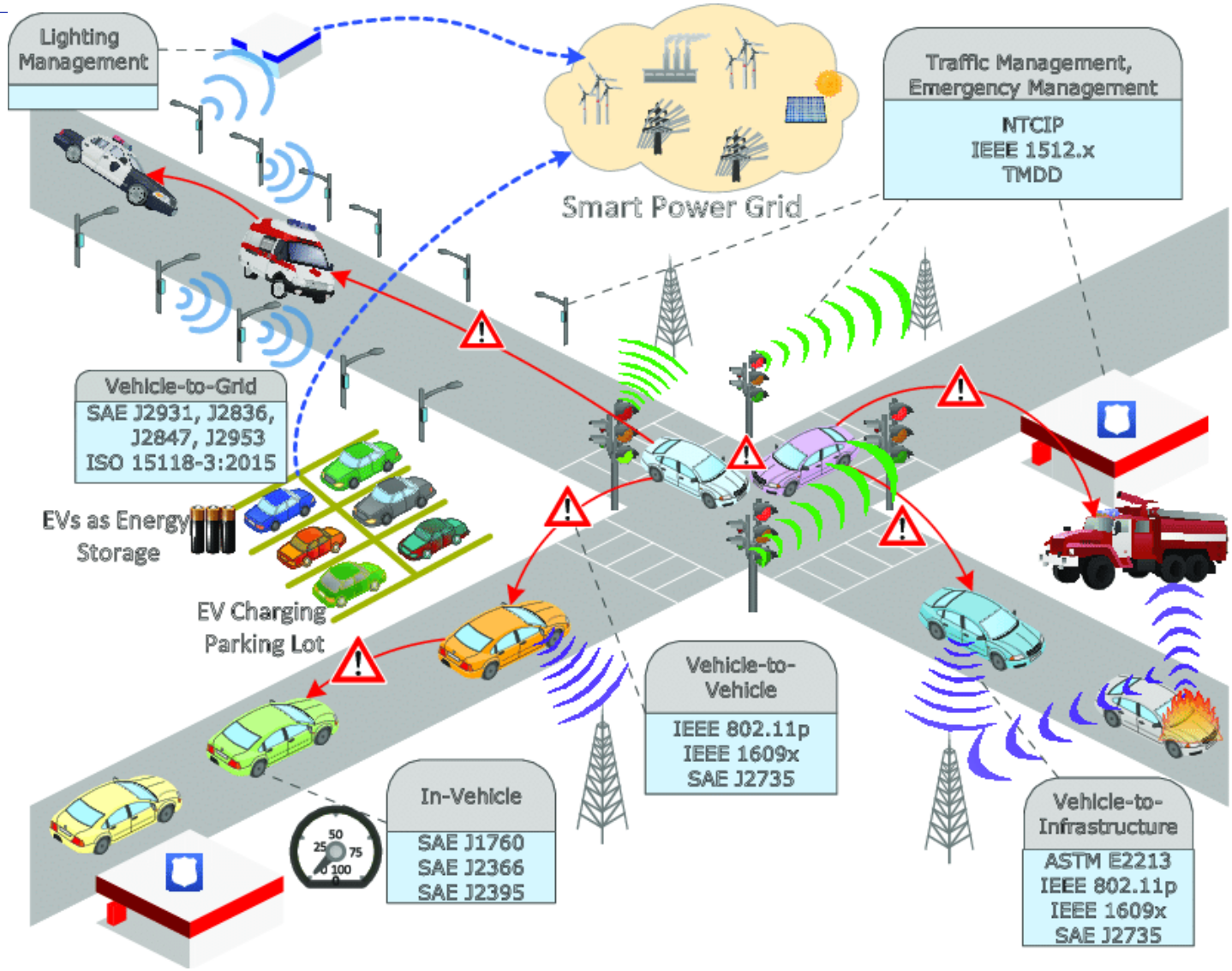
Transportation system Logistics



Intelligent Transportation System (ITS)

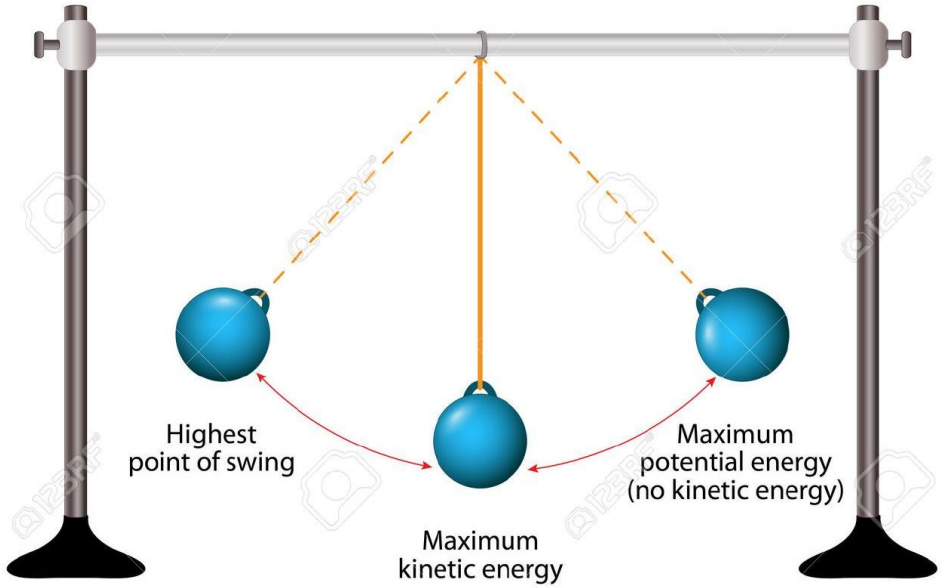
- … exhange information…..

ITS –Intelligent Transportation System



Commuting

- Repetitive movement between an origin A and destination B, on a daily basis (usually weekdays).



Commuting

Origin

Destination

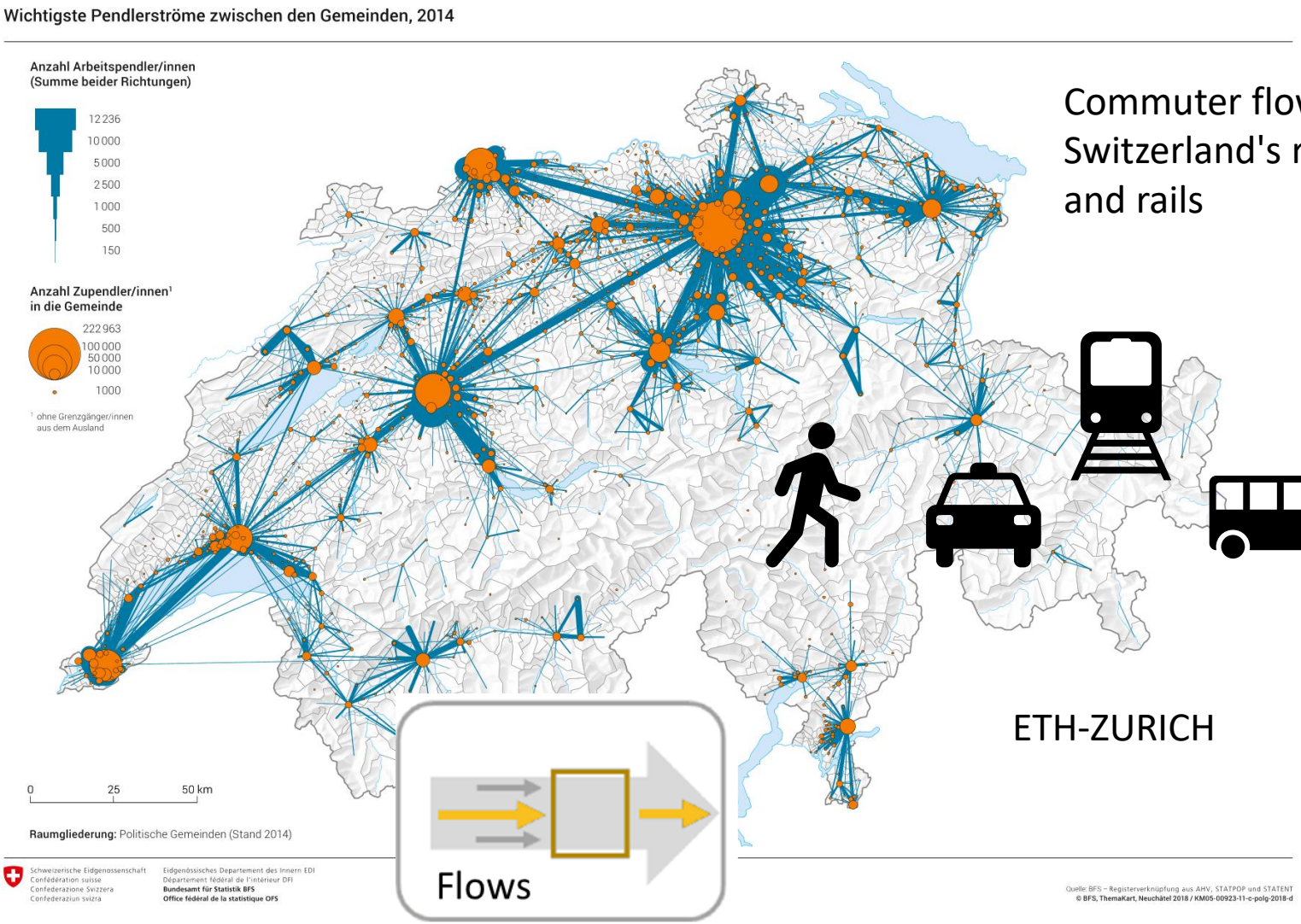
home

school

A

B

Intermodal transportation



Seamless transportation system

OBJECTIVE: MAXIMUM EFFICIENCY AND INTEGRATION

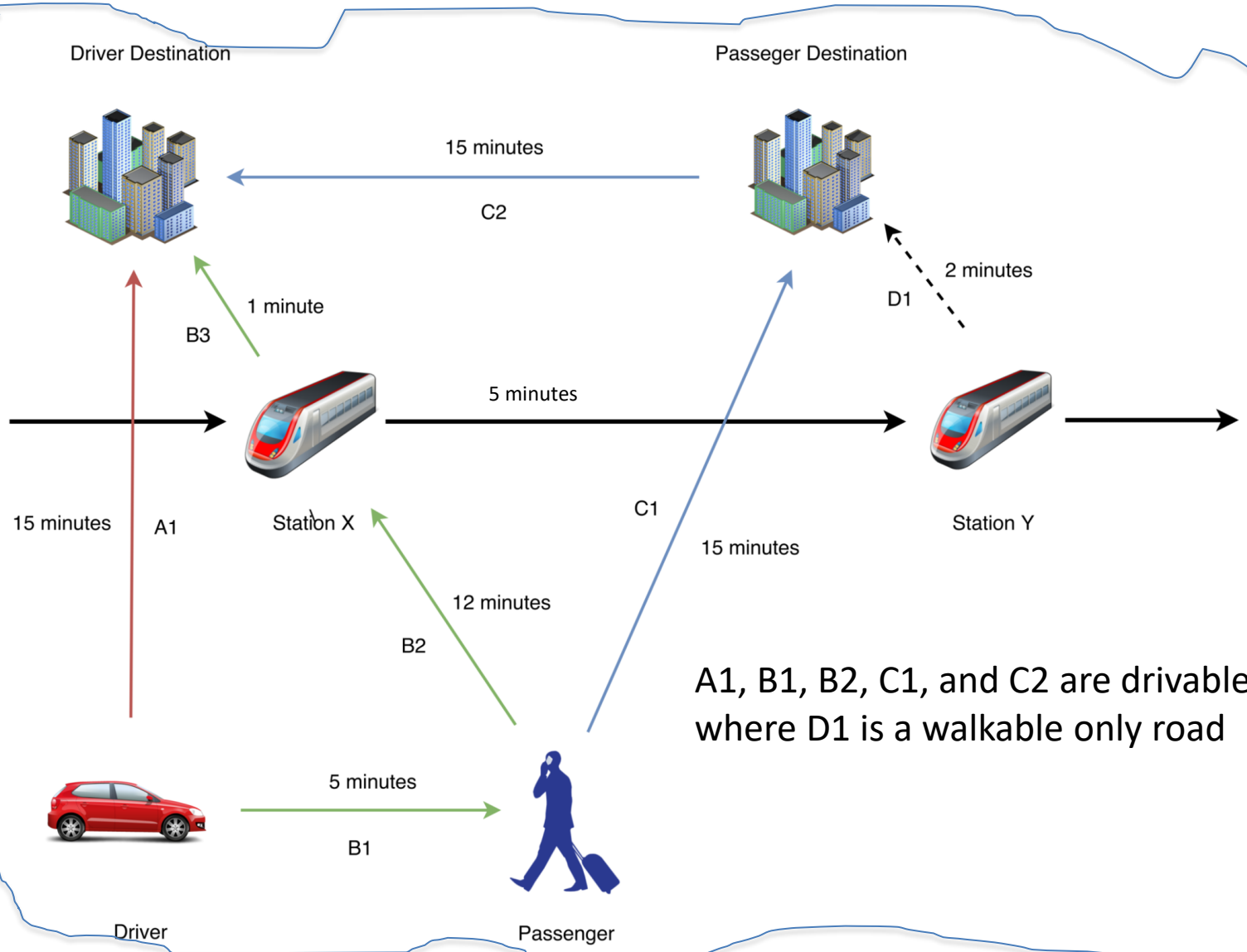
Mandatory:

- designed to minimize transfer time between modes;
- designed to minimize waiting times;
- tariff connection with a single ticket, even if operated by different carriers;
- a very good information technology connection

Seamless transportation system

- Intelligent Transport systems addressing first and last mile connectivity;
- Transparency and Accountability across all the stakeholders;
- Transport Safety;
- Cost effective on-demand services with maximum asset utilization.

Seamless transportation system



A1, B1, B2, C1, and C2 are drivable roads where D1 is a walkable only road

Transportation vehicles

- **Can be classified by:**

✓ Modes;

✓ Function;

✓ Geographical coverage;

✓ Ownership;

✓ Automation level;

✓ Tecnhology;

✓ Fuel/energy source;

✓ Eletric vehicles;

✓ Biofuels;

✓ Emission standard.

TRANSPORTATION BY MODES

- **air, road, rail, maritime** /passenger or goods carriers





TRANSPORTATION BY MODES

Soft modes (or active modes) /passenger or goods carriers

TRANSPORTATION BY FUNCTION/ SERVICE

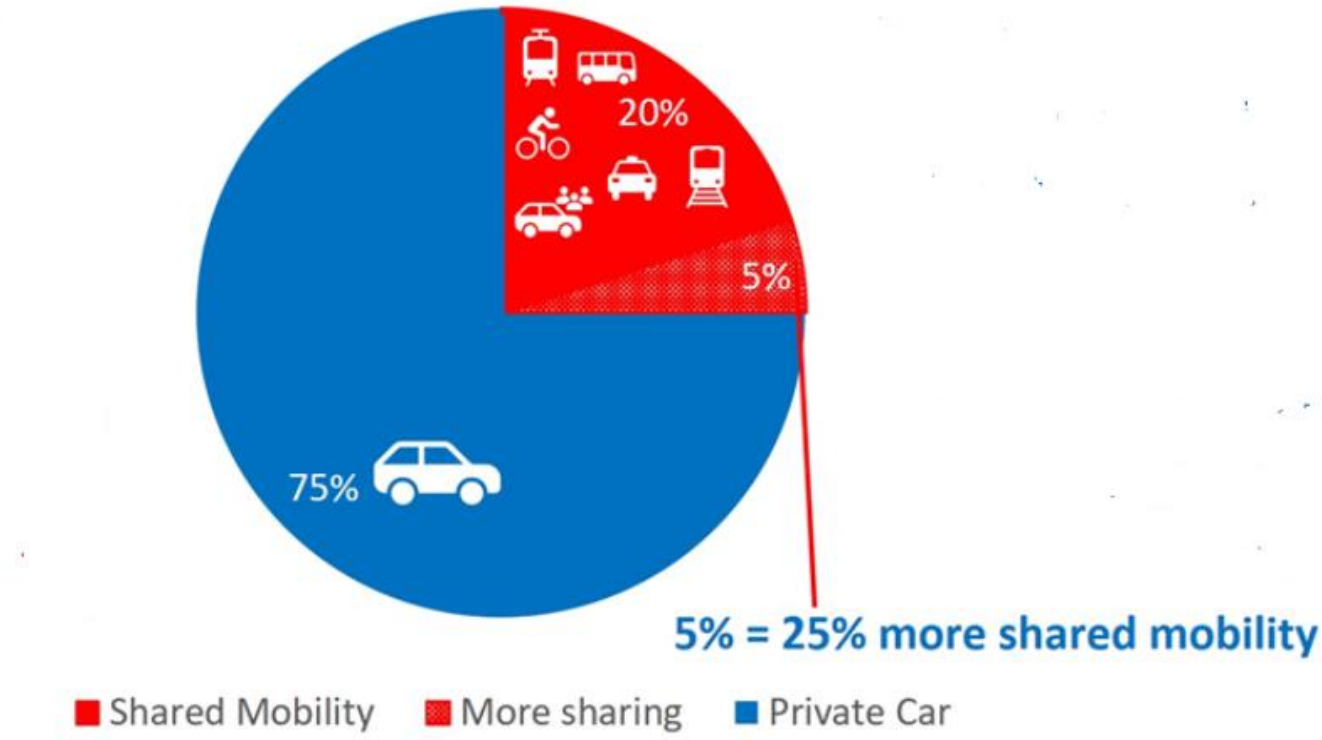
- Passengers and freight (goods)

TRANSPORTATION BY geographical coverage

- National / International

TRANSPORTATION BY OWNERSHIP

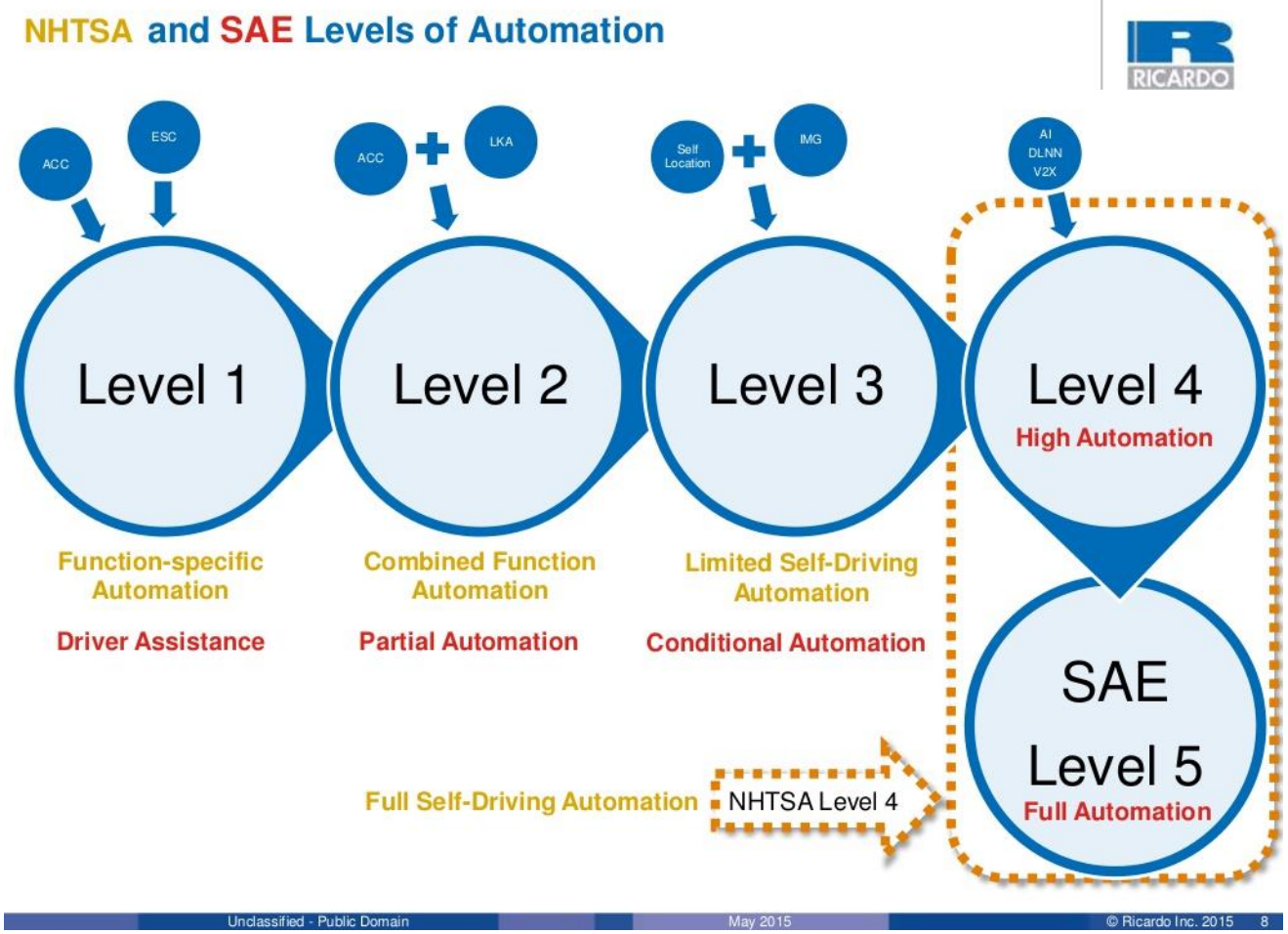
- Public or private
- Personal or shared



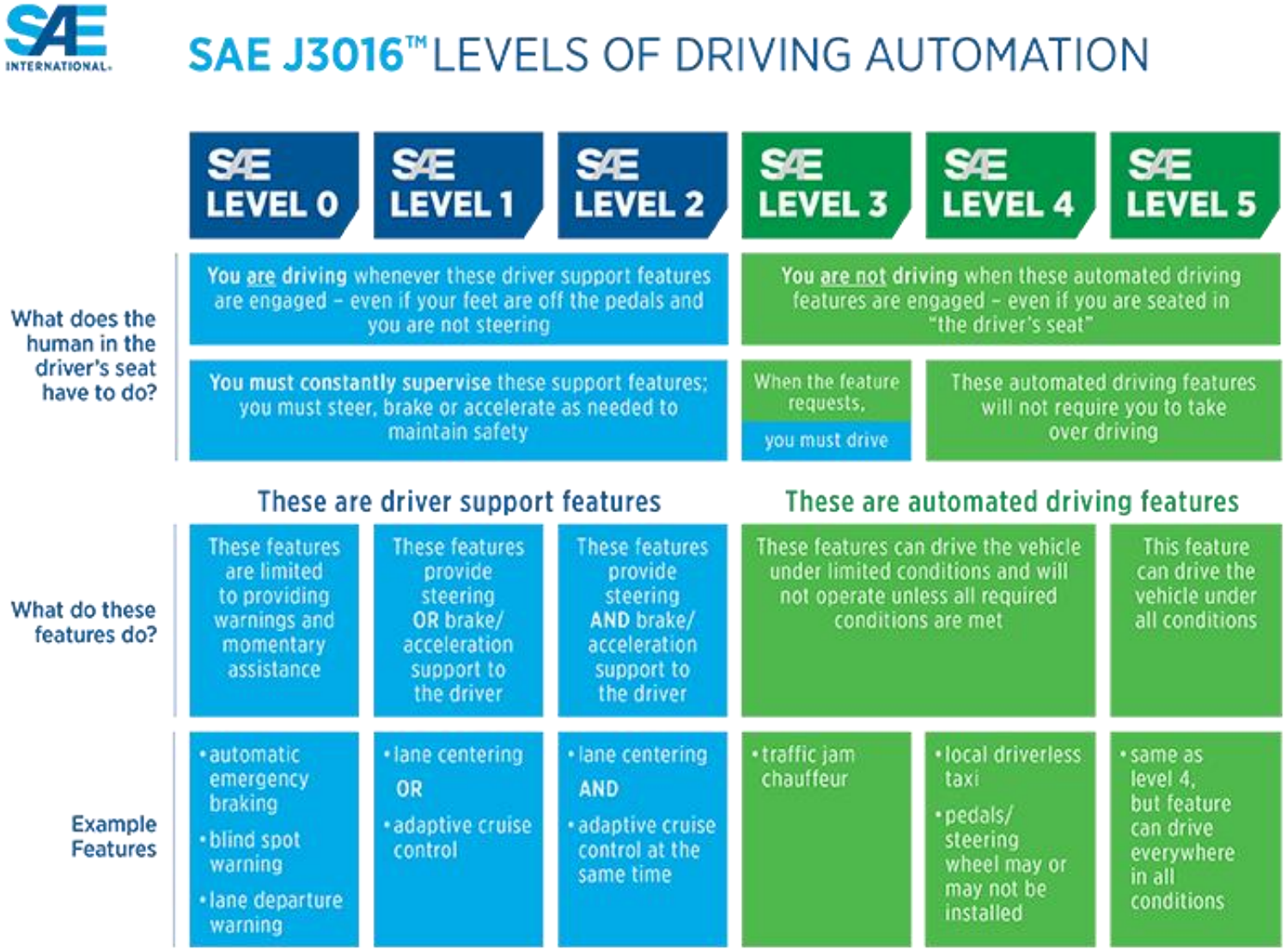
TRANSPORTATION BY AUTOMATION LEVEL

Levels of automation

- National Highway Traffic Safety administration (NHTSA);
- Society of Automotive Engineers (SAE).



TRANSPORTATION BY AUTOMATION LEVEL



TRANSPORTATION BY AUTOMATION LEVEL

forward collision avoidance - adaptive cruise control

https://www.youtube.com/watch?v=GInSPWZRFRM

SAE 1

SAE 2

TRANSPORTATION BY AUTOMATION LEVEL

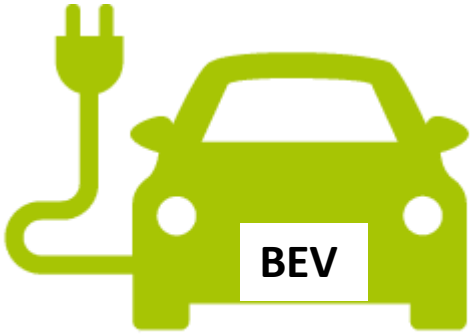
Example full automation non-road

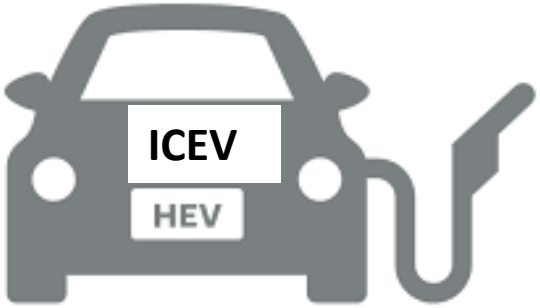
Heathrow Personal Rapid Transit system 2011

18 low-energy, driverless vehicles can each carry four passengers and their luggage. (Ultra PRT | www.ultraprt.com.)

TRANSPORTATION BY TECNHOLOGY

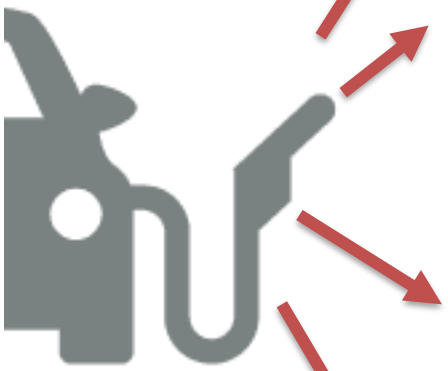
- Pure electric (battery EV)
- Plug-in Hybrid (PHEV)
- Hybrid (HEV)
- Conventional (ICEV)





TRANSPORTATION BY TECNHOLOGY

- Diesel
- Gasoline
- biodiesel
- bioethanol
- GPL
- Natural gas



Monofuel

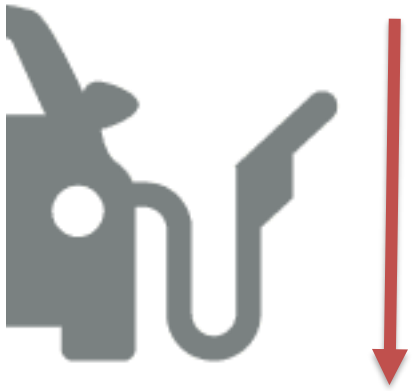
Bi-fuel (2 main tanks, e.g. LPG & gasoline)

Dual-fuel (main fuel tank & small tank start fuel)

Flex-fuel (1 main tank, both fuel mixed)

TRANSPORTATION BY EMISSION STANDARD

- Pre-Euro < 1992
- Euro I
- Euro II
- Euro III
- Euro IV
- Euro V
- Euro VI > 2014

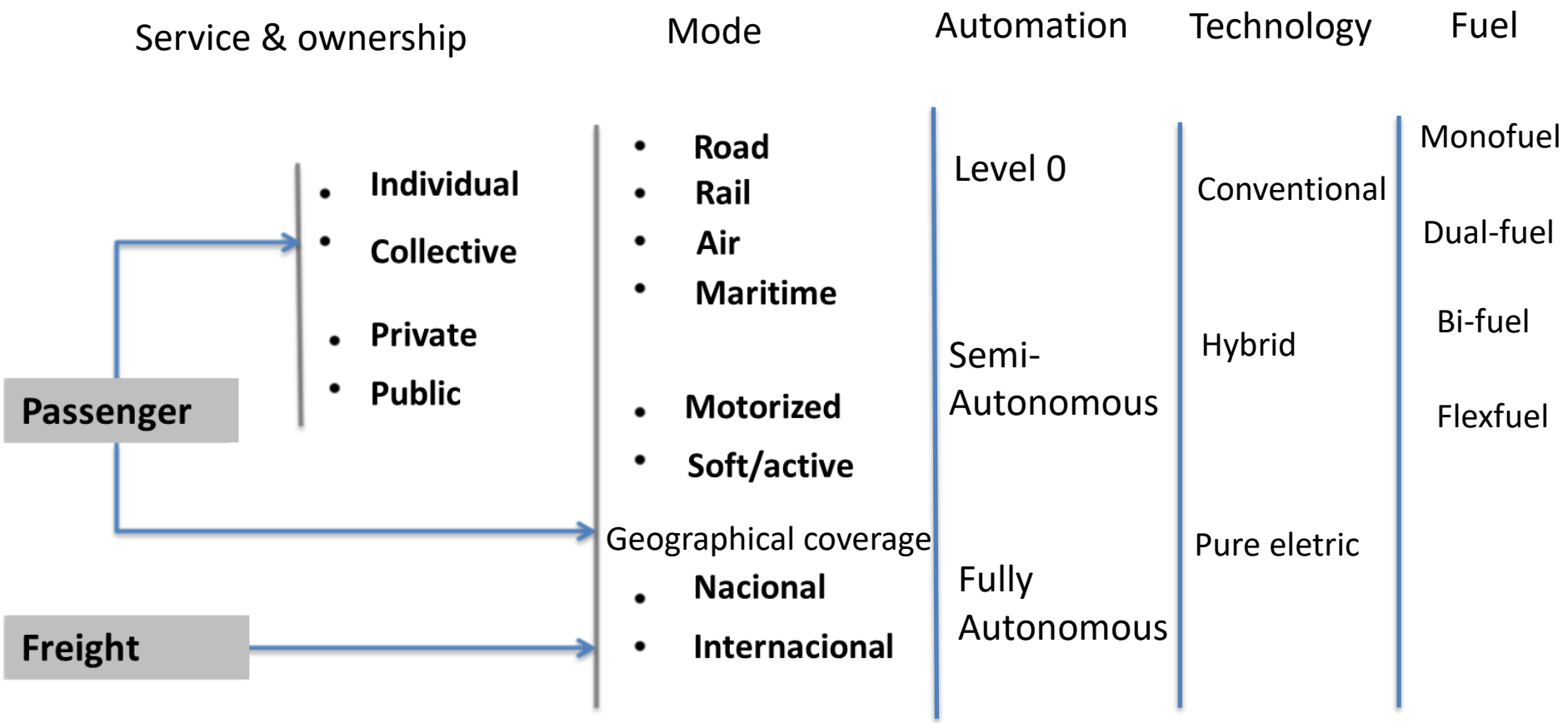


Less sulfur

Less NOx

Less PM

CLASSIFICATION OF TRANSPORTS



Classification….examples

e.g. *bike-sharing* individual passenger transportation, public, road (motorized in case of eletric bikes)

Classification….

e.g. táxi individual motorized

Uber individual motorized

Classification….

e.g. *car-sharing* individual, road motorized

Examples

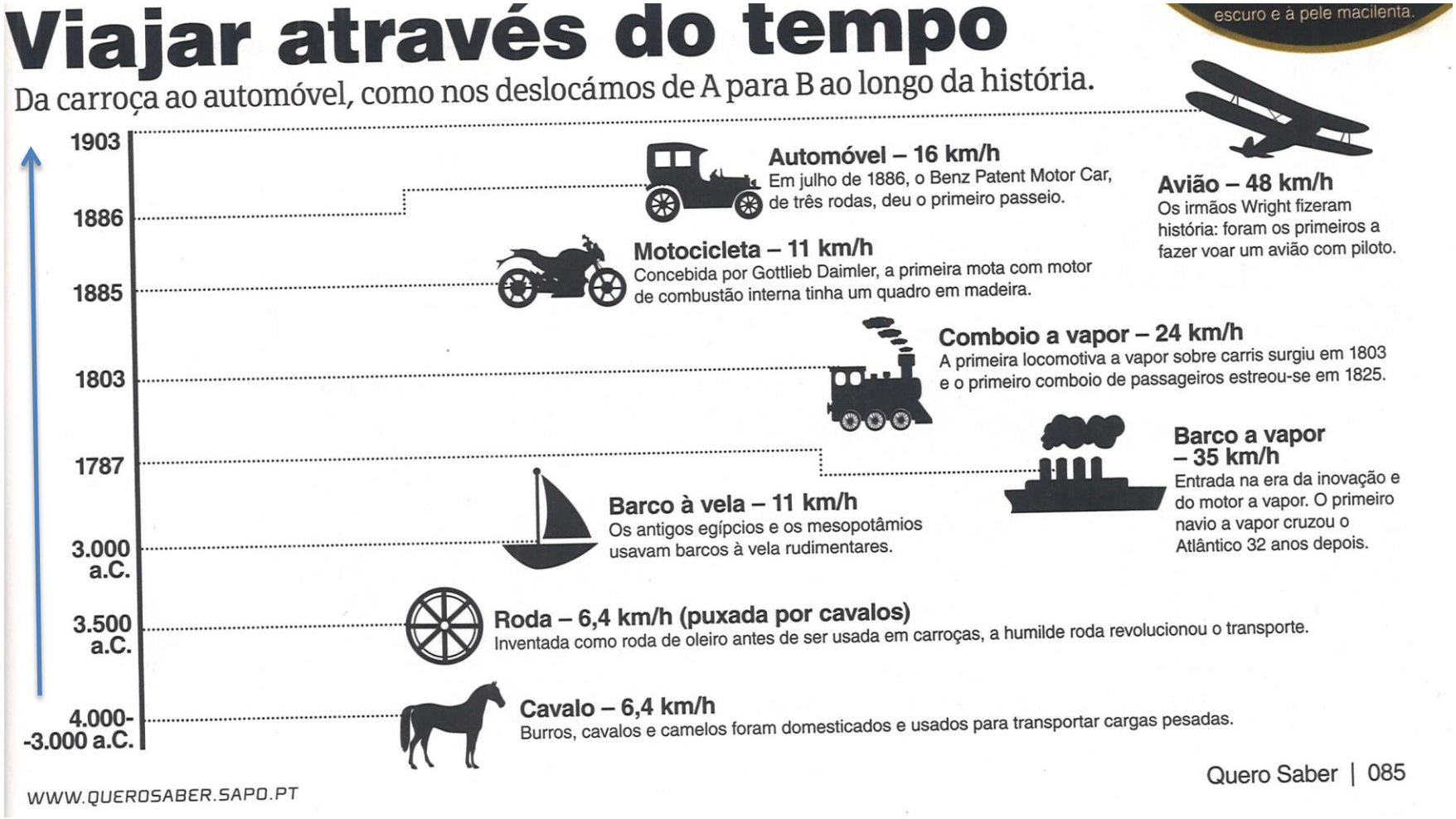
e.g. bike-sharing
individual, road
motorized/non-
motorized

Classification….

e.g. bus colective, public, road, motorized

History…..and…future

Speed/motorization



History…..and…future

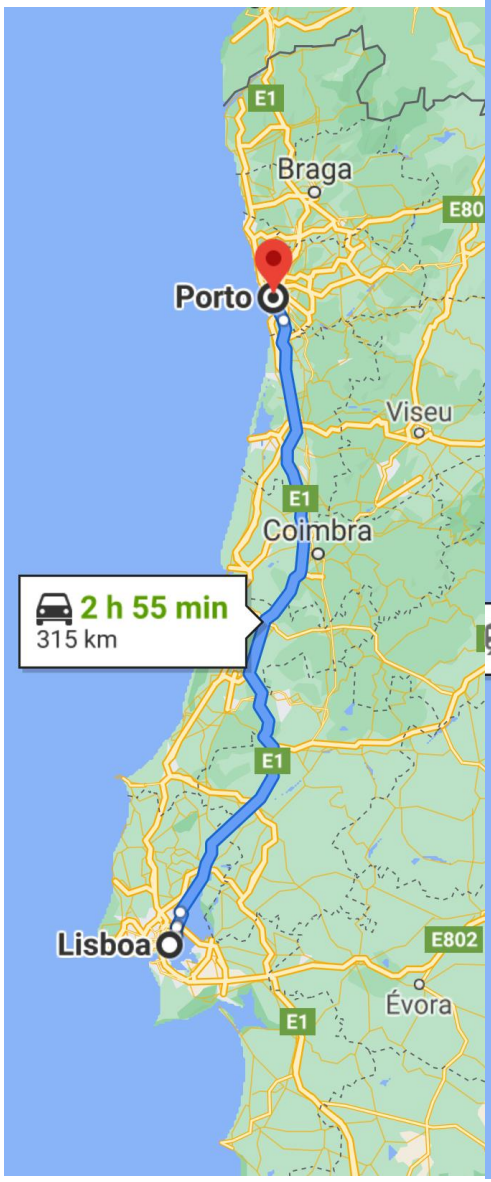
Lisbon - Porto

History…..and…future

~ Year 1859	~ Year 1864	~ Year 2000	~ Year 2016
	1st train 		
7 days	14h	2h35 Alfa Pendular	<1h Airplane

3h  

History…..and…future



History…..and…future

New York on the 1800's

History…..and…future

Lisbon on the 1800's, CARRIS carriage

History…..and…future

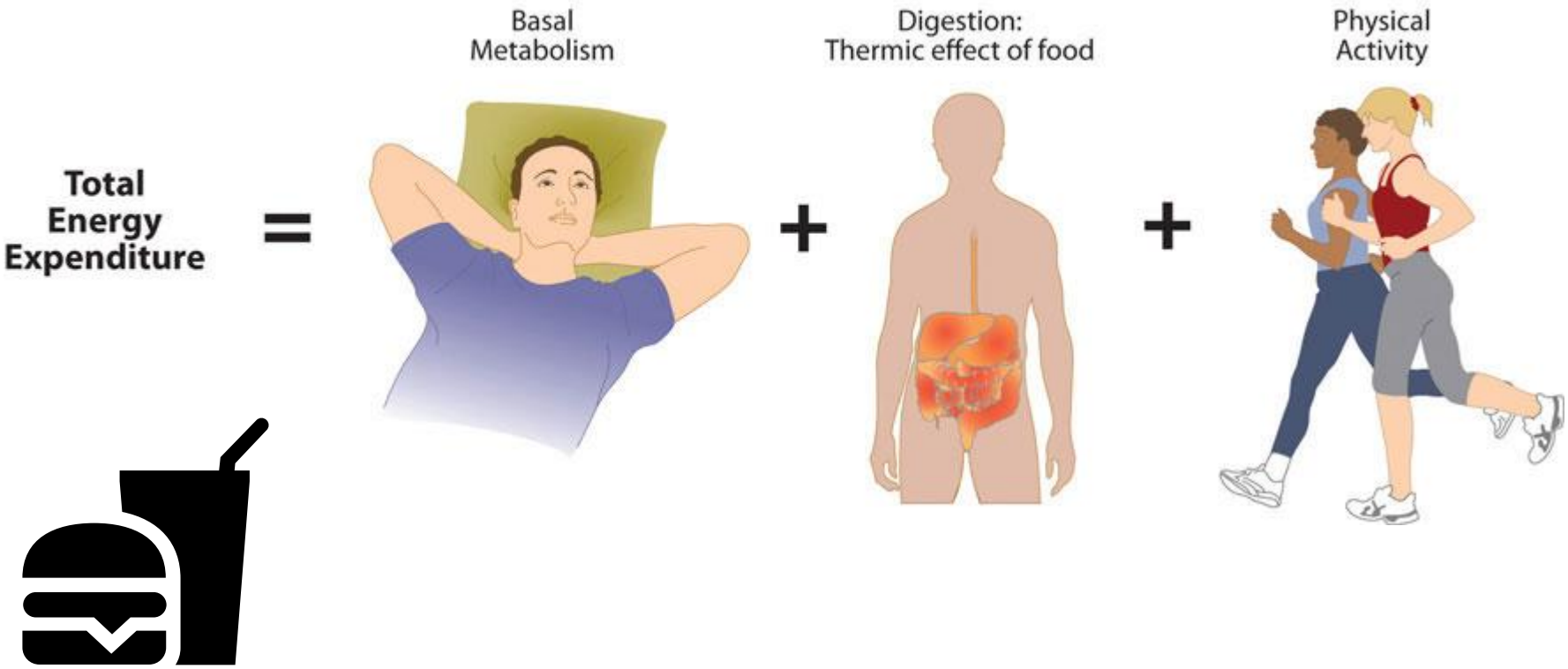
Lisbon Av. 24 Julho 1912, CARRIS electric tram

History…..and…future

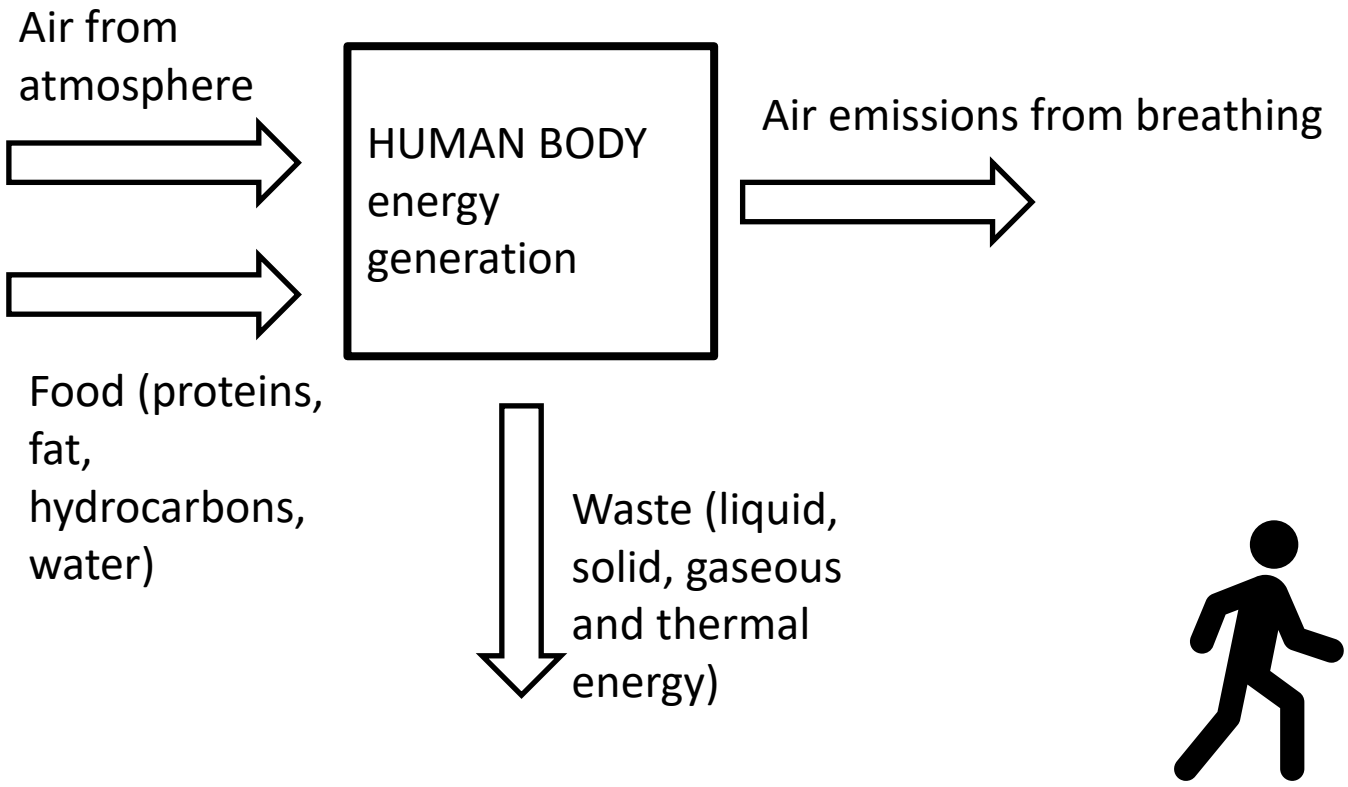
Walk….always….Energy????

History…..and…future

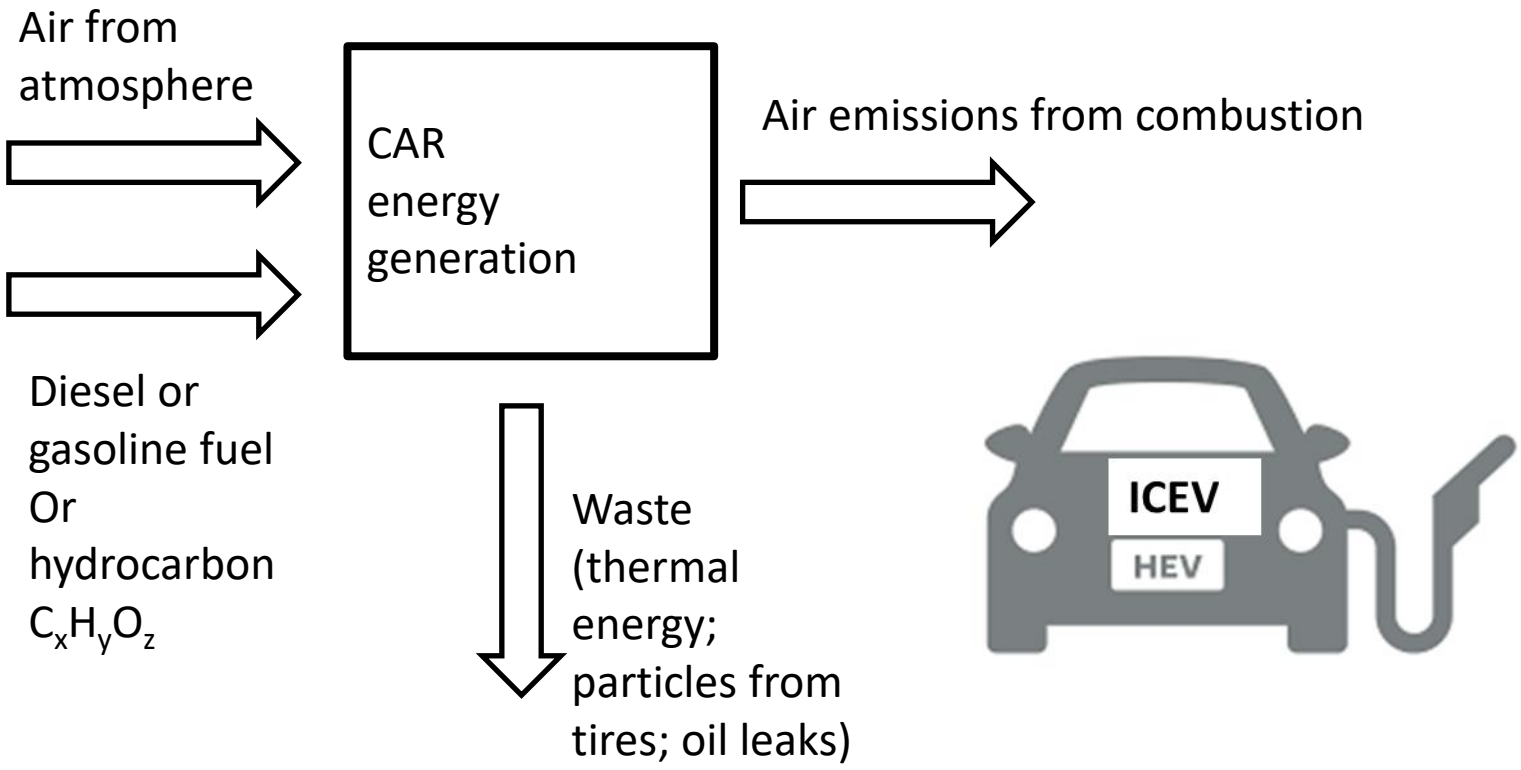
Walk….always….Energy????



History…..and…future - Energy



History…..and…future - Energy

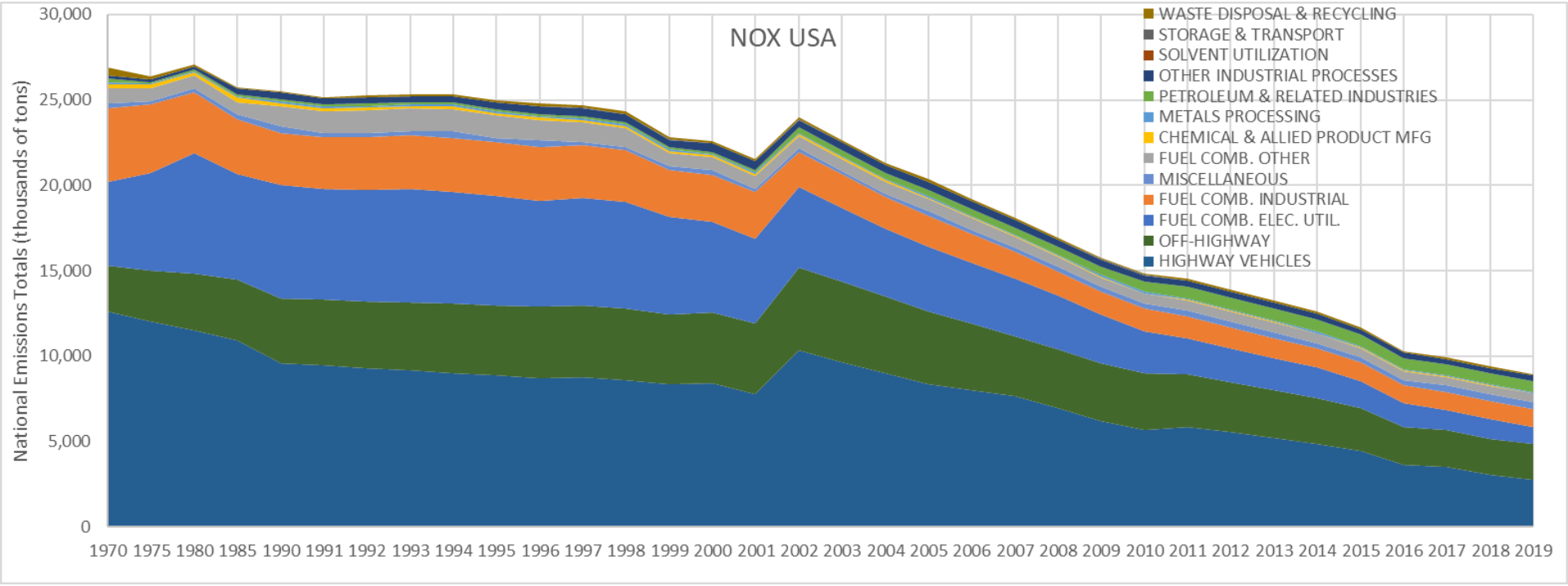


History…..and…future - Energy

Air emissions from combustion

Stricker emission standards

History…..and…future - Emissions



Previously…e.g. 1800….1970????

History…..and…future - Emissions

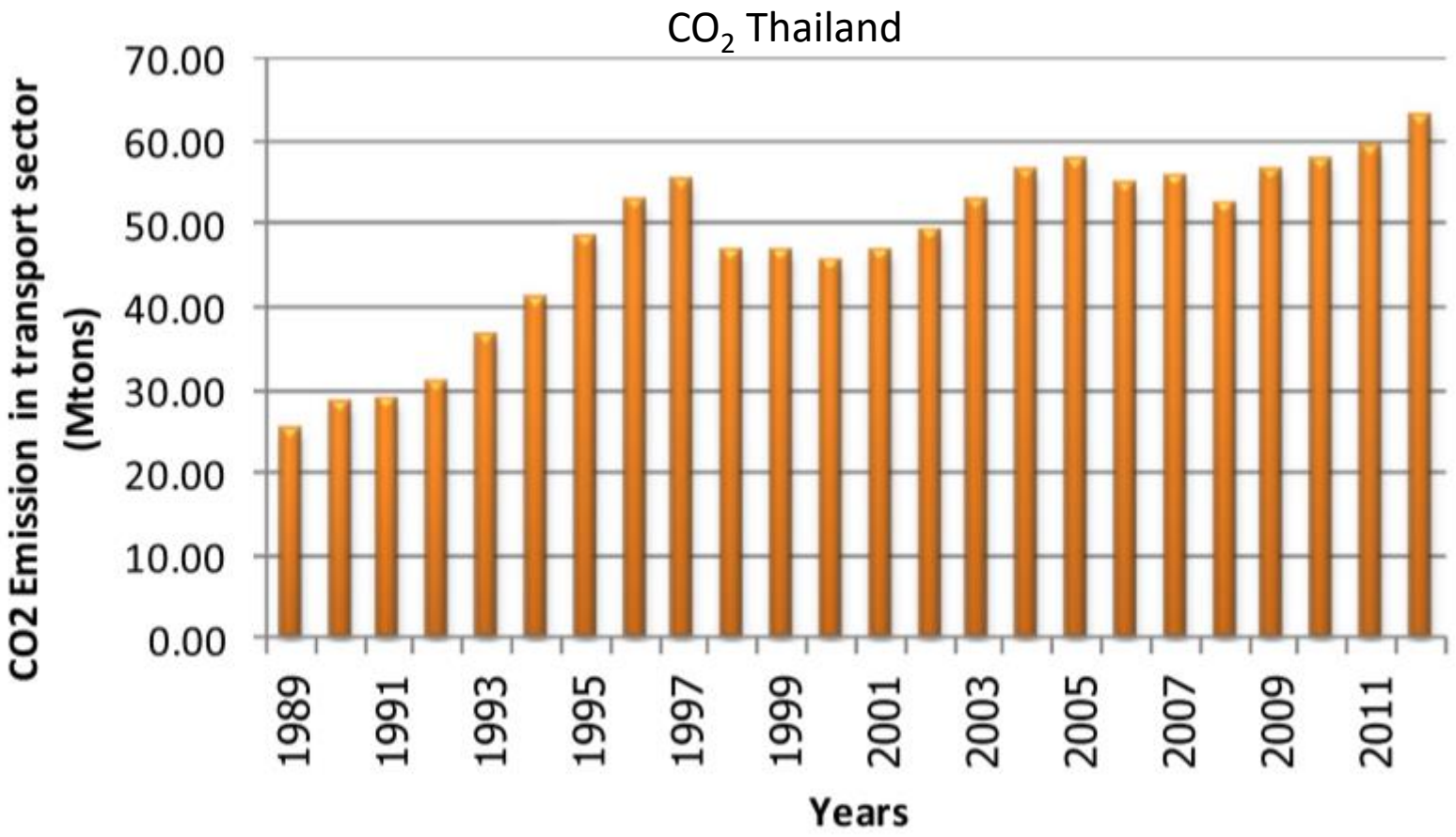
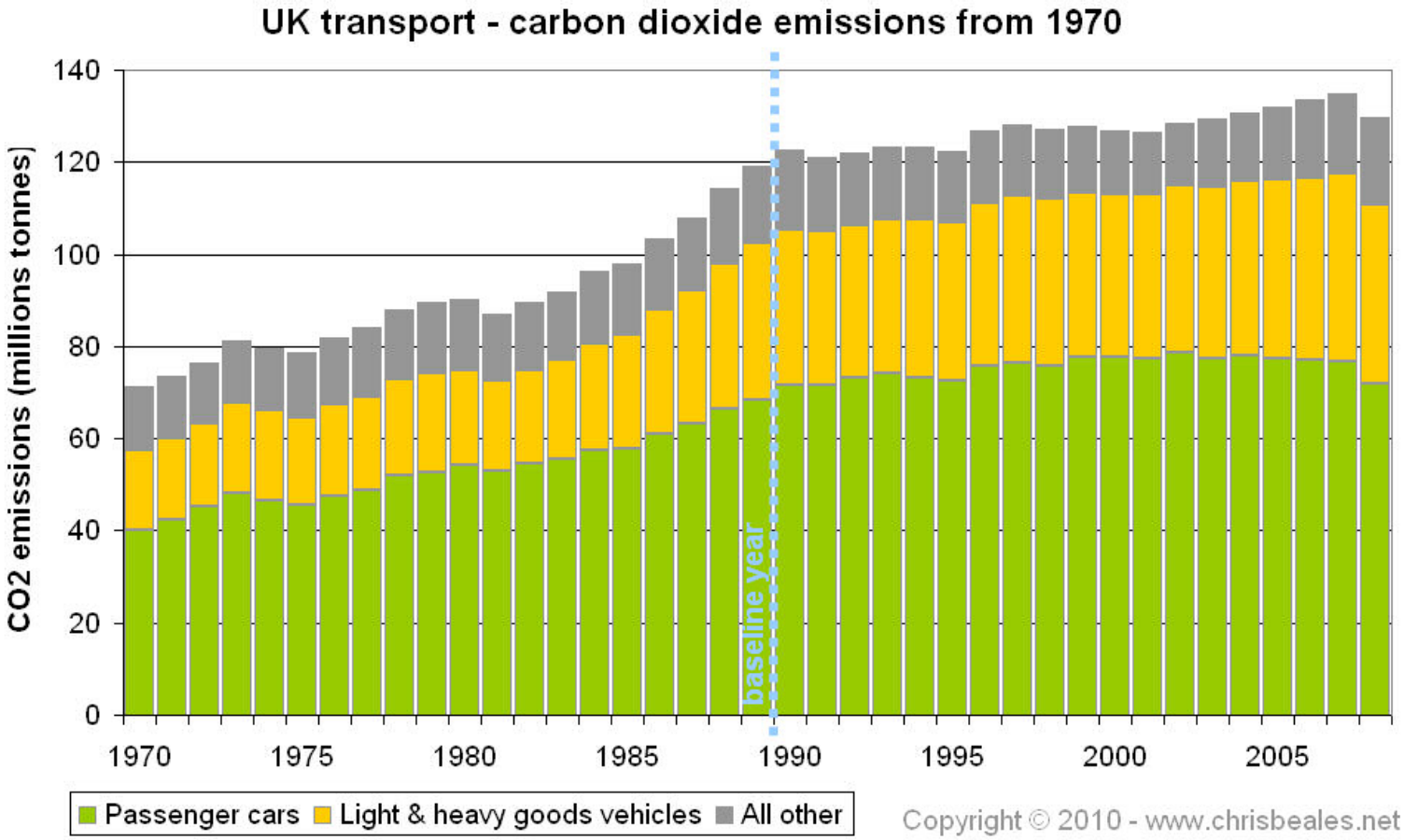


Fig. 2. The statistics of CO_2 concentrations in the transportation sector from 1989 to 2012.

Previously…e.g. 1800….1989????

History…..and…future - Emissions

CO_2 UK

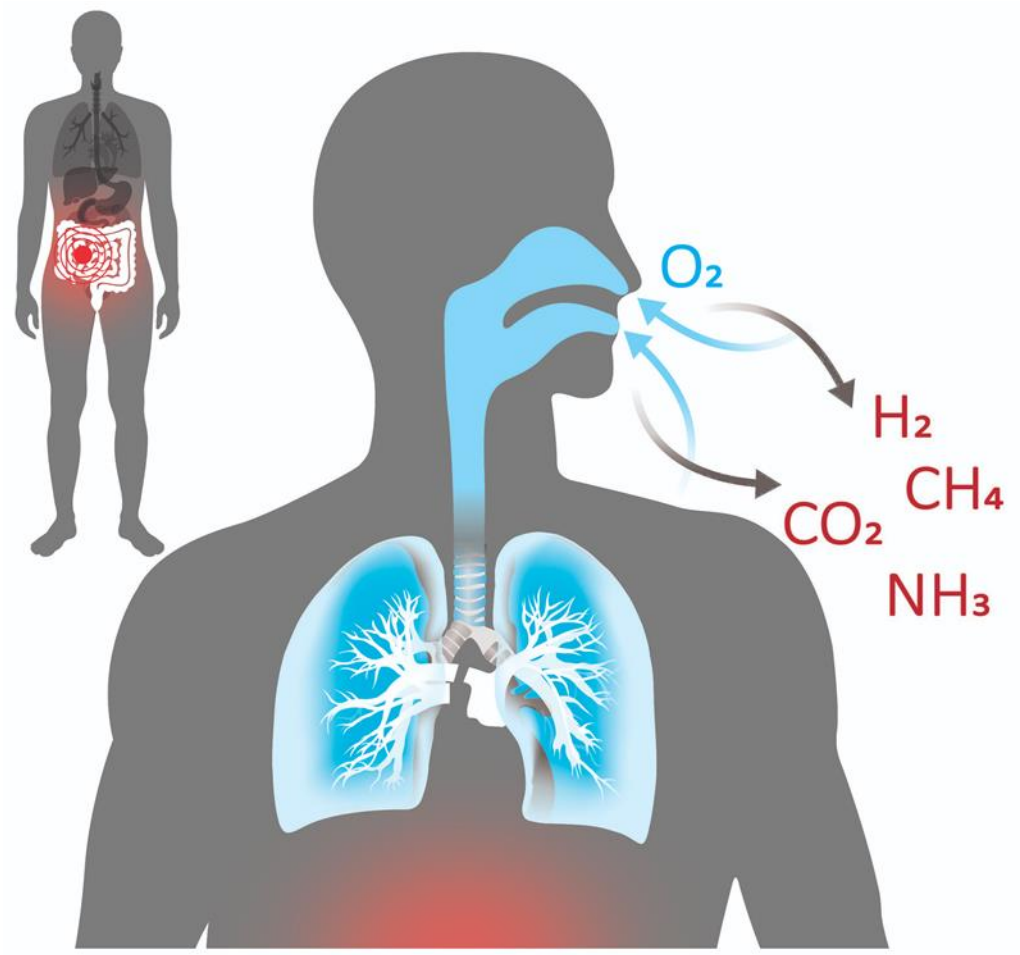


Previously…e.g. 1800….1970????

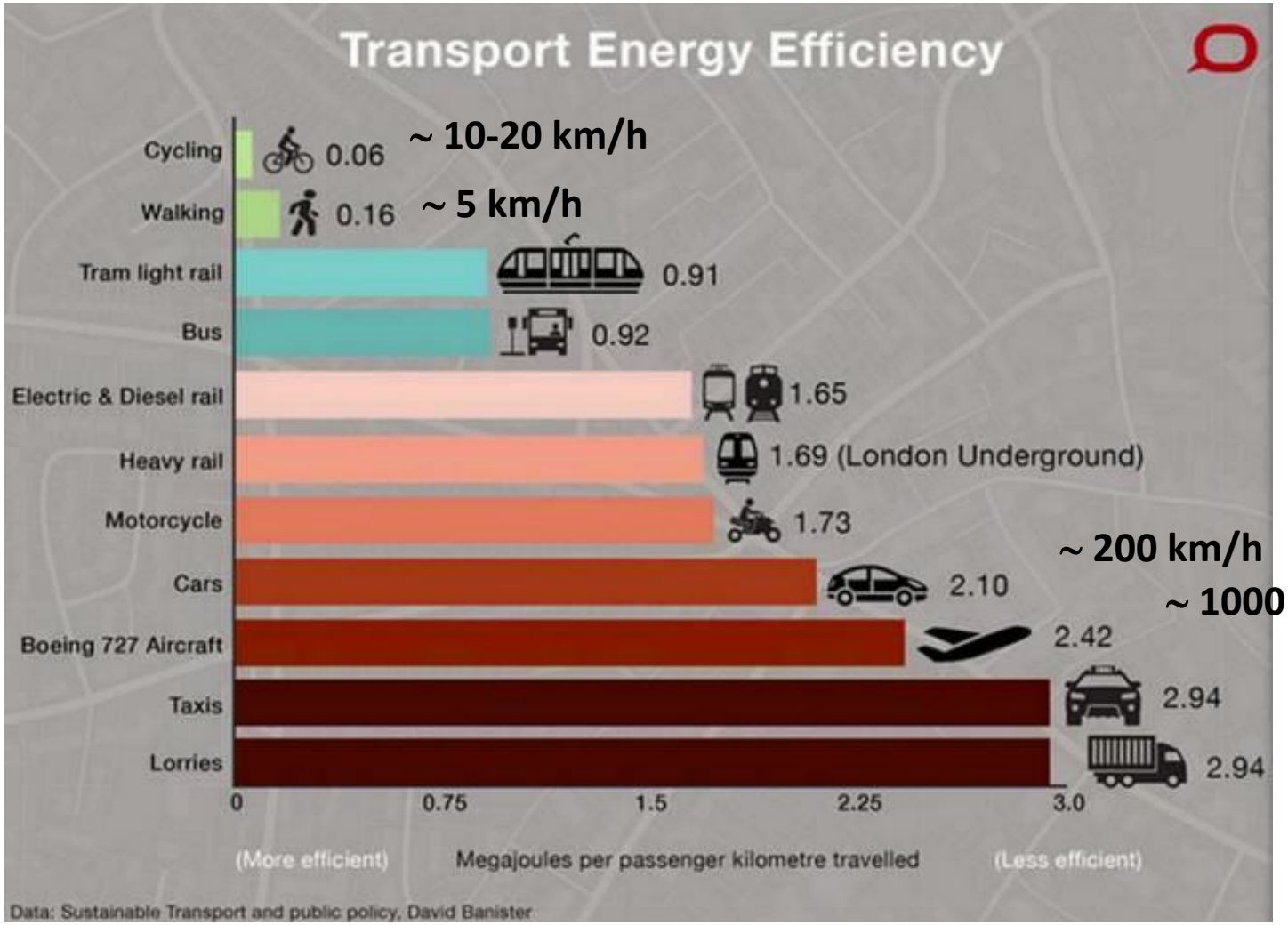
History…..and…future - Emissions

Substance	Inhaled air (%)	Exhaled air (%)	Explanation
Nitrogen (N_2)	78	75	Not used
Oxygen (O_2)	21	16	Used in respiration
Carbon dioxide (CO_2)	0.04	4	Produced in respiration
Inert (e.g. argon)	0.9	0.9	Not used
Volatile organic compounds (VOC, H and C and O)	Variable, depend outside air quality	Variable depends on outside air quality	Not used
Water (variable)	variable	Typical 4	Produced in respiration

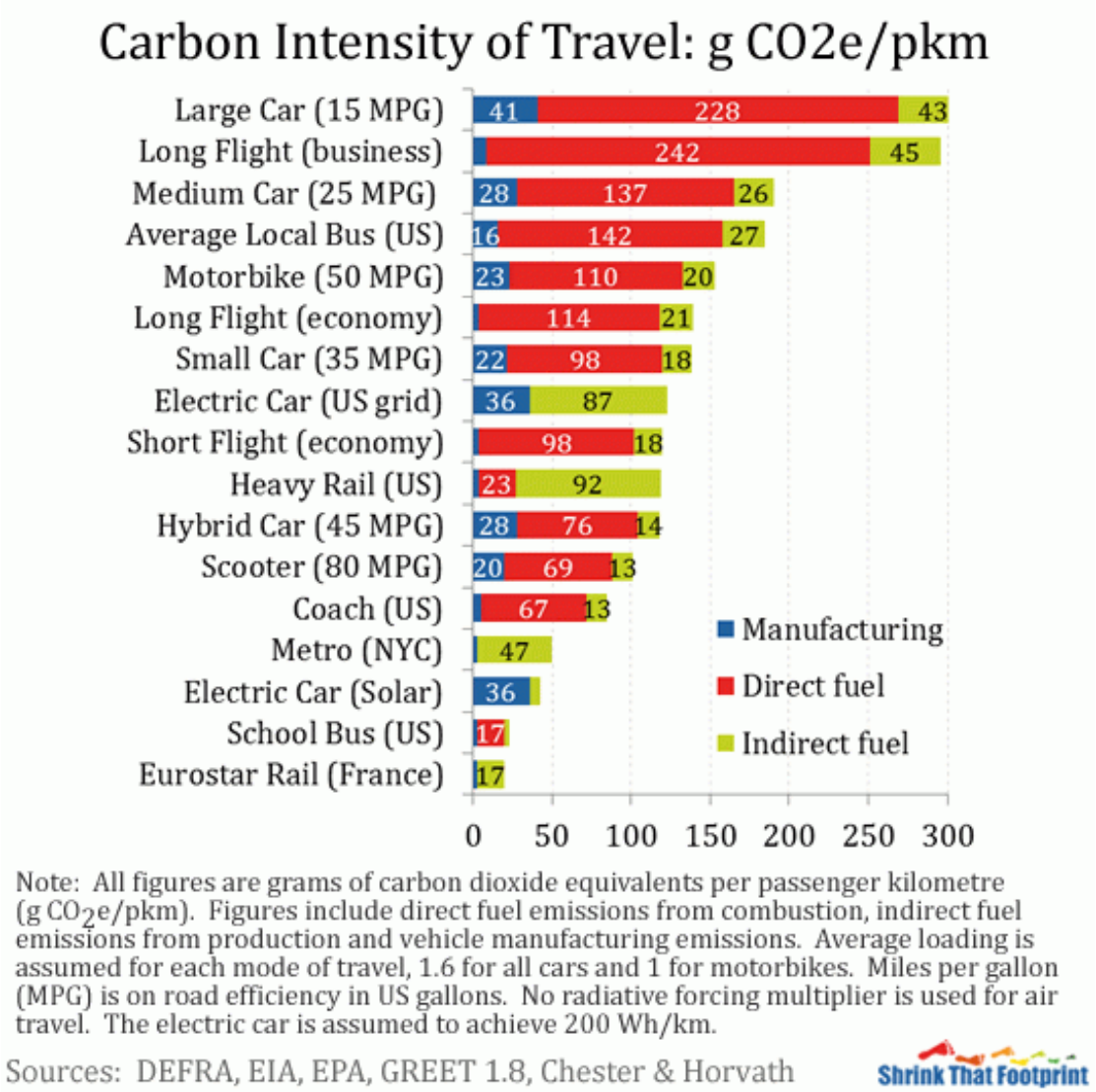
History…..and…future - Emissions



History…..and…future - Energy

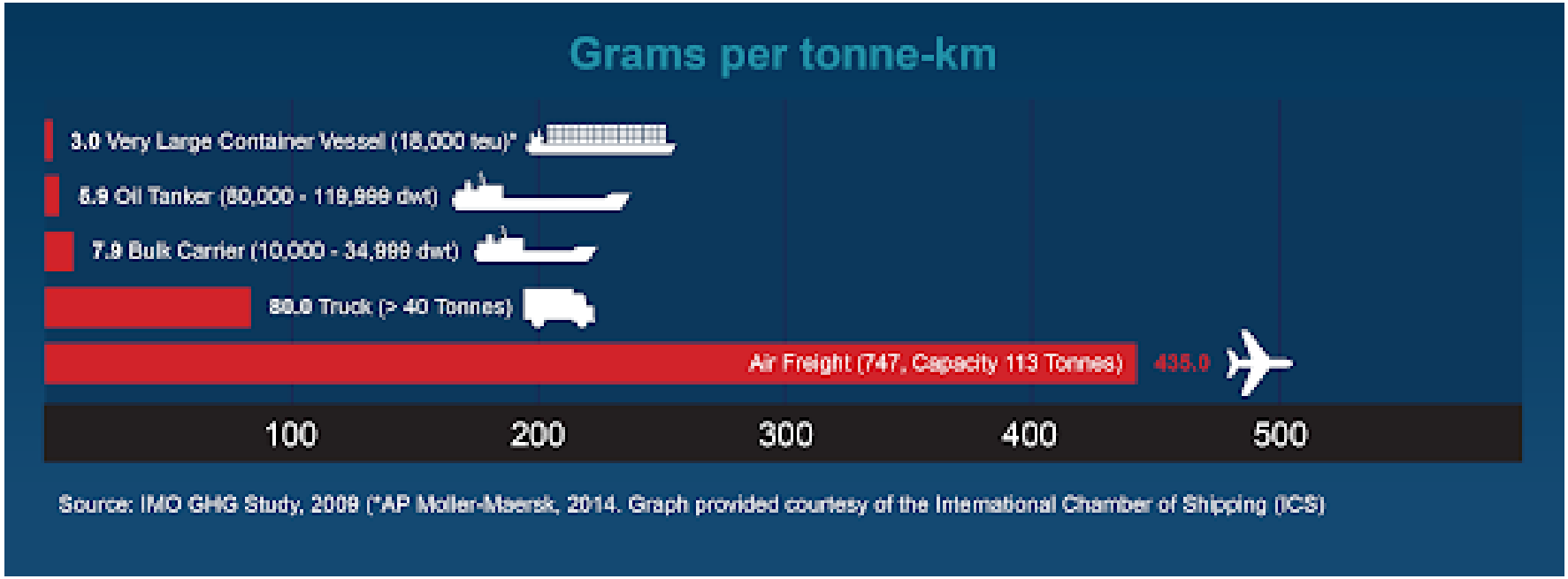


History…..and…future - Emissions



Slow
Efficient (food-energy)
Low CO2 (~0.01 g/pkm)

History…..and…future - Emissions

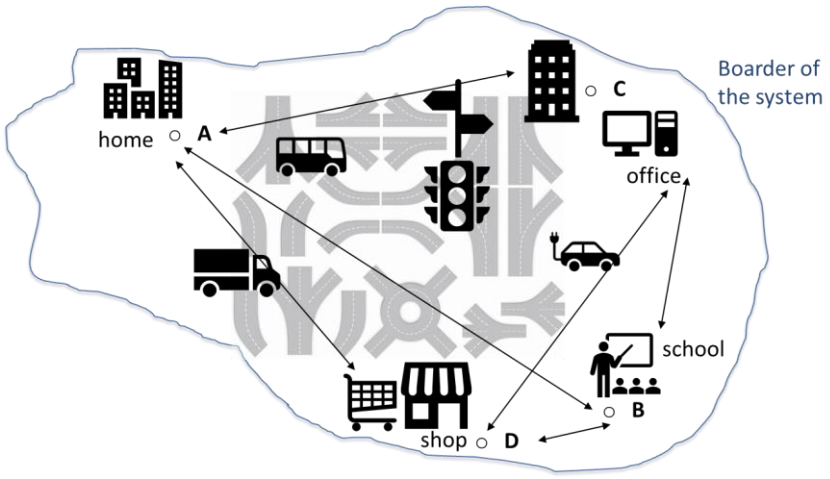


OPEN QUESTION

Consider the transportation system in the figure next slide. With the OD matrices regarding n^{er} of trips and n^{er} trips per day (flows) and regarding road distances, estimate, for the System:

- Number of links, nodes and carriers;
- Number of total trips per week;
- **Energy** consumption; in **MJ/week**;
- **CO_2** emissions; in **g/week**.

OPEN QUESTION



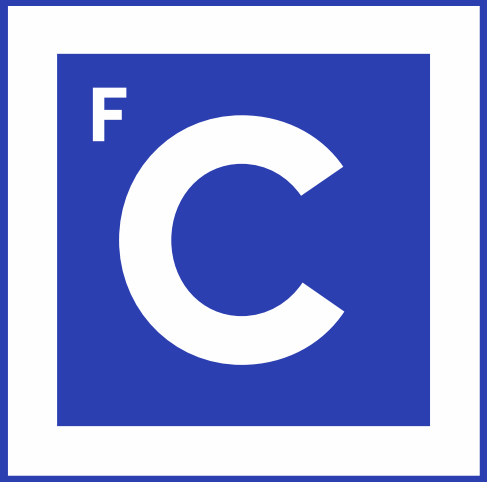
n^{er} km per link (distance between nodes)

		DESTINATION				SUM
		A	B	C	D	
ORIGIN	A		15	10	10	35
	B	15		5	2	22
	C	10	5		10	25
	D	10	2	10		22
SUM						

n^{er} trips per day (flows)

		DESTINATION				SUM
		A	B	C	D	
ORIGIN	A		65	28	28	121
	B	69		12	83	164
	C	100	60		217	377
	D	86	127	63		276
SUM		255	252	103	328	**938**

Thanks



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