TRANSPORTATION PLANNING AND MANAGEMENT

Master of Eng. in Civil Engineering

Course 2016-2017 (Q2)

TRANSPORTATION SYSTEM ON THE TERRITORY

Course notes based on the Powerpoint and class taught by Prof. Francesc Robusté during the course 2016-2017, group 10 (Q1 quarter), elaborated by Natalia Barón.

1. INTRODUCTION AND OBJECTIVES

The number of people living in the cities is increasing: in the 21st Century, the number of inhabitants in cities is greater than 50% for the first time in history. We need better integration of territory planning and mobility planning and management thinking in the services and users. To better integrate the mobility plans with the environment, the *Sustainable Urban Mobility Plans (SUMP)*, are used for planning in a sustainable manner.

Smart Cities are equipped with new technologies that bring real time information that allows to improve the quality of mobility: sensors, real time info, smart phones with GPS, internet, apps, pricing, managed lanes/speed limits/VMS, autonomous (self-driving) vehicles, electric vehicles, etc. New trends in city and mobility planning put the people in the center, recuperates public space from vehicles to non-motorized modes or eco-mobility (walking, bicycling), and focuses in emissions and air quality rather than on functionality, speed and congestion.

In an "economic territory" the physical world is distorted in economic corridors and the distance is proportional to the cost. For example, in Europe or North America the distances are smaller than the physical territory because their transportation system is very efficient and the transportation costs are low; Asia or Africa have larger economic territories than the physical ones, because transportation costs (related to time) are still high.

OBJECTIVES: intuitive concepts about mobility as service to decision making customers, economic, physical and operational constraints, stakeholder behavior, concept of "trade-off" and win-win solutions, need to "project" the services, planning as a systematic procedure, transportation system management (supply and demand) as continuous improving process, some apparently successful concepts that hide planning/design/implementations/management mistakes, physical units of the key variables, "grounded" role for ICT, "innovation" and "smart" technology (sensors, real time info, etc.) and future trends.

2. TRANSPORTATION SYSTEM ON THE TERRITORY

2.1 MANAGEMENT AND PLANNING

The city mobility system could be similar to a "mobility factory" where the customers have their own behavior and perception. When we plan, we have to think about the possible users and try to satisfy their needs. Services must be "projected" (precisely defined in a way that if given to different people, the implementation would be the same) and their management should be quantified (dynamic processes), to ensure the accessibility (local and global) with a "permissible" social cost.

Out of the 6 stages of a transportation infrastructure or service (planning, design/project, construction/manufacturing, management, regulation, financing), we'll focus on Planning and Management.

Planning is a rational process that, starting from the system's analysis and understanding its behavior, allocates resources effectively in order to reach a target in a future scenario.

We need to make "systematic" planning (well defined procedure to be executed by third parties with a unique implementation), and both users and the operators need to be proactive in planning (not just the Administration regulating the services)..

2.2 MOBILITY'S "MUTATION"

Patterns are changing and the people's behavior is always variable. This factor and the improved technology, make that the strategy for planning the transport systems must be changed. Now, we have to design **dynamic services** as a process (a process is never finished and is always improvable). We need to design services for singular mobility patterns or needs (instead of the traditional home-based mobility, subject to recurrence of "pendular" mobility).

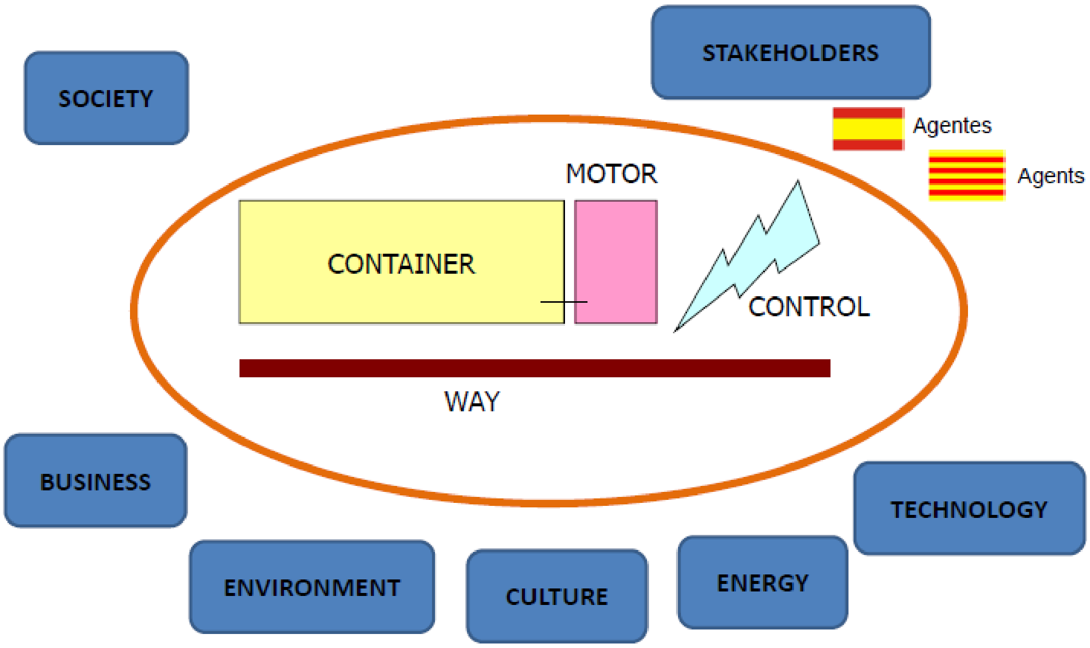
We have to incorporate factors like concentration, density, self-restraint, anisotropy, flow and urban services, networks, pedestrian zones, etc., to incorporate functionality in urban planning.

2.3 TRANSPORTATION SYSTEM

Any transportation system is composed by four basic elements:

- **Container**: where freight or passengers are transported (it could be virtual).
- **Motor:** transforms energy into movement (usually with wheels).
- **Way**: medium whereby the vehicle (container + motor) moves.
- **Control**: a system or rules to ensure safety (manual, automatic).

The transportation system interacts with different **stakeholders** (users, operators, administration) and others factors like society, business, environment, culture, energy or technology.



2.4 MOBILITY PHYSICS

To study the transport systems, we can quantify the mobility with the following mobility physics:

- Mobility (veh-km, pax-km, ton-km, TEU-km)
- Vehicle flow (veh/h)
- Vehicle density (veh/km)
- Space occupied (m2/veh)
- Occupation (pax/veh)
- Cost (average, marginal) (€/pax-km)
- Speed (↔ Time) (km/h)
- Acceleration / deceleration (& jerk)

Also we can qualify the mobility and knowing its quality through different factors:

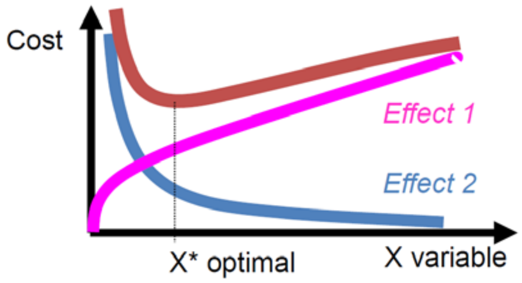
- Maneuverability / turns / change of direction speed
- Resistance against vehicle (aerodynamics, rolling, gravity) + tractor effort
- Safety / (security)
- Energy and type of energy
- Emissions and noise, etc.

Sometimes we forget some mobility factors that are not functional but they are important, regarding the aesthetics or creative and customized designs. For example, the heads of the tramways have an "aerodynamic shape" although it is not necessary because they don't achieve high speeds.

Other times we use some "transport icons" that aren't "good designs" but define our cities or our history, like the two-dockr bus of London, the yellow taxis of New York, the yellow "School buses" in USA that look very similar to a truck, etc. Although these aspects may attract users, they aren't effective solutions of transportation planning.

2.5 FROM "TRADE-OFF" TO "WIN-WIN"

In some cases, we have two different effects for the same variable. Normally, we have to choose the option which is the global optimum, that is, making a "**trade-off**" of the two contradictory effects. If the effects can be translated into costs, one effect will usually have growing costs with the variable and the other effect the other way around: decreasing costs with larger values of the variable. The equilibrium is the value of the variable that minimizes the total costs.



In other cases, exists an option which improve the effects of the two variables, that is named **"win-win"** solution. Technology may take leaps (non-continuous improvement of quality) which favors this type of solution.

Ex. “trade-off”: To reduce the economic costs or to improve the quality of a service.
Ex. “win-win”: A new material that reduces the cost and improves the quality of the service.

A real case might be a *“trade-off”* between the sustainability goal and the trade facilitation. Trade facilitation needs competitive infrastructures and services, and that is usually contrary to sustainable mobility.

2.6 SUSTAINABILITY

The sustainable development is a compromise between **Economy and Ecology**. This concept arises to ensure present needs without compromising those of future generations.

The principal objectives of the sustainability are:

- Diffuse emissions and health problems
- Energy consumption, energy type and emissions
- Energy policy
- Energy pricing
- Fleet renewal (“RENOVE” plan): from pre-Euro to Euro-VI
- Eco-mobility **(*)**
- Electric and hybrid vehicles
- Sustainable Urban Mobility Plans (PMUS - IDAE)

(*) The **Eco-Mobility** is a sustainable mobility as a manner to improve the quality of life. Some of the measures to implement this idea are: to reduce noise, visual and environmental pollution, to promote public transport and bicycle, inter-modality and to give more importance to pedestrians in the city.

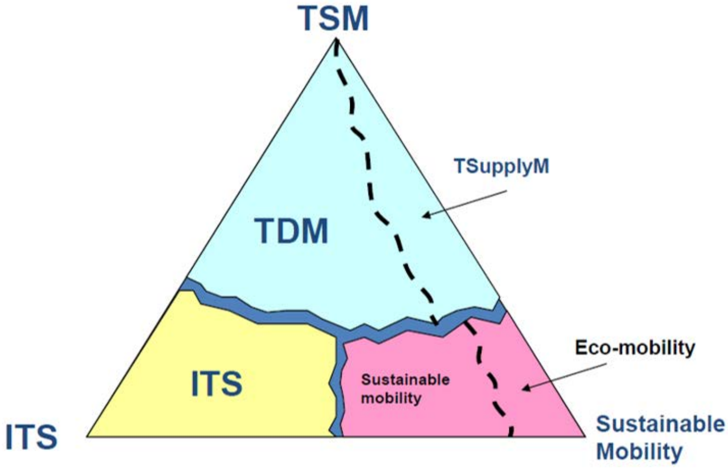
To deal with all these points, the **Sustainable Urban Mobility Plans (SUMP)** have been defined, which try to planning sustainable and efficiently the city. This SUMP takes into account different issues: public transport interchanges, parking regulation and pricing, road pricing, traffic restricted areas, boosting bicycles and walking, more quality in public transport, flexible supply to fit demand, logistic platforms for loading and unloading, tele-working, car-sharing centres, etc.

Some complementary publications above this topic are: “(2013), *Planning and design for sustainable urban mobility*. UNHABITAT”, “(2011), *Roadmap to a Single European Transport Area*. European Parliament” and “Robusté, (2010), *The Future of Urban Transport.* European Parliament”.

2.7 TSM AND “MOBILITY DEAL”

Three principal factors dealing with mobility management are: **Transportation System Management (TSM), Intelligent Transport Systems (ITS)** and the **Sustainable Mobility.**

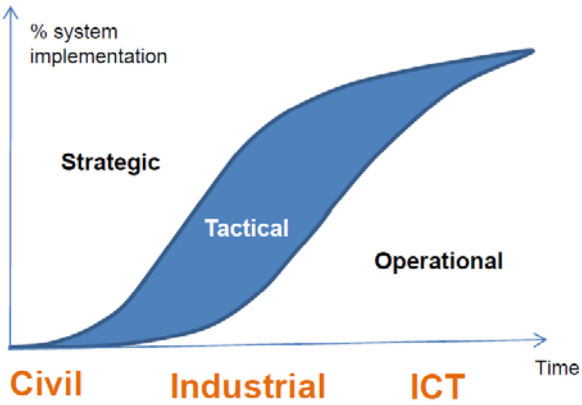
The 3 concepts are not quite the same, although many people use them interchangeably. The transportation system is composed of supply and demand. In the last two decades the acronym TDM (Transportation Demand Management) has been very popular… but the supply side can also be management (e.g.: a traffic light plan, multipurpose lanes, etc.). Eco-Mobility is a part of the mobility that does not use motorized means (although the electric bicycles are at the border of motorized/active mobility).



We need to improve the collaboration among administrations, universities and research centres, business and operators and the users, of course. All of these entities can work together in aspects such as energy, territory, society, environment to improve the quality of the mobility systems for the users.

An example might be the "Barcelona Mobility Agreement or Deal", where all the stakeholders are treated into a dialogue to achieve an agreement and social consensus. The "Barcelona Model" of mobility integrates this Agreement with safe, sustainable, efficient, social equity and a metropolitan perspective.

The **development of a transport system** begins with the strategic phase, continuing with the tactical process and ends with the operational stage which corresponds to civil, industrial and telecommunications/computer engineering respectively.



During the last decades the influence of technology (ICT) has increased, and it can be a useful tool to improve the transport system through the management of network, incidences, dynamic lane, speed and signals, the interaction vehicle-infrastructure, automatic vehicles, pricing, forecasting and reliability, road safety and general information.

But these resources might be a problem if we don't use them in the right way. Tracking obsession, information saturation or trial-and-error guidelines are some examples of that. Big data using available real-time information may be useful for marketing purposes (shops, etc.), but mobility still needs a lot of basic research that derive causal models of behavior.

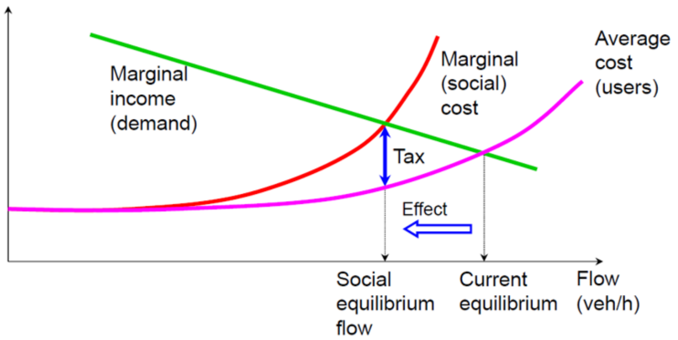
2.8 MANAGING FLUCTUATION

Controlling the **Supply Chain Management (SCM)** is really important in terms of demand. In physical media, fluctuations are absorbed because energy is dissipated with time. In SCM, is the other way around: a small fluctuation may be amplified upstream. The correct management helps to absorb fluctuations, returning stability avoiding the bullwhip effect. A good way to improve the supply chain is to give updated information in real time to users (tracking).

- **BULLWHIP EFFECT:** Small variations in end-user demand, produce large variations upstream of the supply chain.
  The idea of this concept is that, if for example I am the distributor of a product to the user, I have my inventory and my production optimized for a certain demand. If suddenly demand varies, increasing by 10%, I will anticipate that this tendency will continue to grow, and I will ask my supplier of raw materials more products, for example 20%. In turn, the producer of raw materials will think the same as me, and increase production an even higher percentage, 30%. And so it could happen in every "link" in the chain. Finally, this small variation in demand has become a major variation of stock upstream. If for some reason the user returns to its initial use or becomes it smaller, all this extra stock will be wasted. The bull-whip effect is created because the SCM “thinks” and the production and transportation of items is not instantaneous.

2.9 TRANSPORTATION MICROECONOMICS

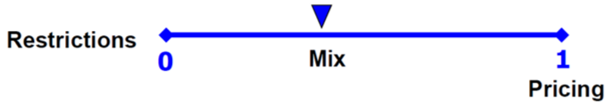
Economy is an important factor to take into account on the transport systems. The study of the average, marginal and total cost is crucial to improve the service and become it optimum. One of the examples where these costs are studied is the congestion tax defined by Arthur C. Pigou in 1912. We’ll learn to calculate this Pigouvian tax.



Other remarkable concept is the **PARETO OPTIMUM** or Pareto efficiency, which is a state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off. Pareto efficiency is a minimal notion of efficiency and does not necessarily result in a socially desirable distribution of resources: it makes no statement about equality, or the overall well-being of a society.

So, when we managed a system transport the Pareto optimum will be a mix between the interests of users and the companies or the Administration. A real example of the implementation of this principle is the congestion pricing of regulation: in Latin America they do not have technology and they do not have money to pay, therefore a restriction process called “pico y placa” (literally, “rush hour and license plate”) was implemented in Sao Paulo and later in Colombia and

Ecuador, etc. In Europe, we had technology and people accept better paying rather than restrictions: after several Norway cities (Trondheim, Bergen, Oslo) in the early 1990's, London adopted the "congestion charge" scheme in 2003. Daganzo proved that the Pareto optimal policy is a mix of restriction and pricing that nowadays is being implemented in Santiago (Chile).



3. CONCLUSIONS AND RECOMMENDATIONS

We could say that transport systems and its logistics have evolved considerably in recent decades due to technology and studies on the subject. We head towards a Smart City where the managing of public transport, with improved and adaptive services are essential. This is a field full of future potential for engineers, especially considering the Mobility as a Service (MaaS) that is a "business" an order of magnitude larger than mobile telephones (around 20 Euros/person and month on the average) and also larger than car manufacturing business (car manufacturers are worried twofold: Millennials will not buy many cars, and everyone can build an electric motor…. Unlike what happened with the internal combustion motors).

The principal characteristics and advantages of improving the public transportation ("transit") system in a city are: good network design, bus lanes properly used, traffic signal coordination for buses (TSP), tandem bus stop, contactless payment, bus bunching operative control, demand and supply adapted, concentrated management of resources, flexible shifts and schedules, integrated fares, legibility and mnemonics, information in real time, etc.

Recommendations: Trying to get an overview of the topics that will be taught during the course and to understand the important concepts: SUMP, planning, elements of a transportation system, *"trade-off"*, *"win-win"*, mobility deal, bullwhip effect, Pareto optimum, Smart City, etc.

Some key concepts and acronyms in mobility:

Bicing:	**HOT**=High Occupancy Tolled lane:	**Speed:**
BLIP:	**HOV**=High Occupancy Vehicle:	**Stakeholders:**
Bottleneck:	**IBL**=Intermittent Bus Lane:	**Sustainable mobility:**
BRT=Bus Rapid Transit:	**ITS**:	**TDM**:
BSS=Bicycle Sharing System:	**LRT**=Light Rail Transit:	**Tracking:**
Bull-whip effect in SCM:	**MaaS**=Mobility as a Service:	**TSM**:
Bunching:	**MFD**:	**TSP**=Traveling Salesman Problem:
Carsharing:	**Multipurpose lane:**	**TSP**=Transit Signal Priority:
Carpooling:	**Pigouvian tax:**	**Value pricing**:
Density:	**PRT**=Personal Rapid Transit:	**VAO**=*Vehículo de Alta Ocupación*
Ecopass:	**Ridesharing:**	**VMS**=Variable Message Sign:
FAIR lane:	**SCM**=Supply Chain Management:	**VRP**=Vehicle Routing Problem:
Flow:	**Smart City:**	**WISE city:**
Gridlock:	**Social equity:**	

4. REFERENCES

- European Parliament (2011) *Roadmap to a Single European Transport Area*".
- Robusté, F. (2016) TRANSPORTATION SYSTEM, class taught in the Master of Civil Engineering during the Q1 quarter of the course 2016-17. BarcelonaTech.
- Robusté, (2010), *The Future of Urban Transport*. European Parliament.
- UNHABITAT (2013) *Planning and design for sustainable urban mobility*.
- https://en.wikipedia.org/wiki/Pareto_efficiency.