DECISION MAKING TOOL FOR THE SELECTION OF URBAN MOBILITY PROJECT

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ABSTRACT

Even if Urban Freight Transport (UFT) represents only 20% of urban flows, it generates many forms of pollution such as emissions of pollutants, greenhouse gasses, noise, congestion, etc. In order to limit these significant problems; for instance 40% of CO_2 in cities is due to UFT, cities have to adapt their infrastructures, develop new components, and reorient user behaviour, etc. This means cities have to evolve.

Various UFT solutions have been designed and experimented for quite some time now. Different categories of actions including the best of practices relevant to UFT solutions have already been identified. Many of them have been recorded in the European BESTUFS programme (BESTUFS, 2007), in CIVITAS programme and Predit projects (PREDIT, 2008) or even ELTIS data base. Nevertheless the city evolution process cannot be considered through a simple succession of demonstration measures, or stand alone projects. Moreover, UFT does not represent the unique flow in the city and it is necessary to include Urban Passengers Transport (UPT) in the global reflexion. In 2007, European Commission encouraged local authorities to manage the transport network in order to ensure a smooth sharing for passengers and freights.

The proposed paper aims at merging different researches developed in the frame of systemic theory and manufacturing management in order to propose principles of a global approach for politicians who have to choose UTF solutions coherent with their city characteristics. This approach guides the evolution of the UFT and the UPT in an integrated way. We therefore will focus on a software tool developed to support the global approach. This research introduces works performed in the frame of CGOODS project (ANR-08-VTT-005-01)

Keywords: Urban Freight Transport, Urban Mobility System, Management of the evolution, Performance, Decision making tool

INTRODUCTION

Freight transport represents 20 % of the global traffic within urban areas but represents 40% of the pollution. Recent and convergent surveys (ex "Sustainable Urban Transport Plans" in 2007, French national surveys in 2004 or BESTUFS indicators) gave actual and future quantified situation for the Urban Freight Transport (UFT). They demonstrate that the growing importance of the associated flows will be more and more worrying.

On an economical point of view, the importance of UFT has been highlighted through its impacts on distribution process in term of costs. Considering economical context leading to stocks reduction and so deliveries size reduction, UFT costs are continuously growing (Study material, 2003).

According previous points, UFT challenges can be classified in four categories (Boudouin, 2002):

1. Economical ones, since UFT efficiency directly impacts the performances of supply chains and influences indirectly the commercial activities of the city;

2. Societal and environmental ones since UFT directly impacts citizen quality of life;

3. Functional ones, since the city is a system of systems, a collection of task-oriented or dedicated systems that pool their resources and capabilities together to offers more functionality and performance than simply the sum of the constituent systems;

4. Organizational ones, since space is not devoted to one specific flow but must be accessible both for the people and the goods.

Moreover freight is not the unique flow in the city. "Urban freight distribution could be better integrated within local policy-making and institutional settings. Public passenger transport is usually supervised by the competent administrative body while freight transport distribution is normally a task for the private sector. Local authorities need to consider all urban logistics related to passenger and freight transport together as a single logistics system" (European Commission, 2007). This introduces the concept of Urban Mobility defined by (Musso et Burlando, 1999) as all movements of persons and freight which are held in the city. It thus refers to two types of flows, passengers and goods, which interact in time and space, within the city.

Considering resulting complexity, it is quite difficult for politicians to improve UFT performance. In consequence, UFT is generally modified through a succession of had hoc projects:

- Impact of projects on global performance is not well known in advance,

- Projects are strongly constrained by actions implemented for Urban Passengers Transport.

This paper merges different research works developed in the frame of systemic theory and manufacturing management in order to formalize both UFT and UPT evolution process i.e. Urban Mobility evolution process focusing on performance management and organisational aspects. Then it presents a first prototype of a decision tool support to the approach. Considering the diversity in term of city profile (historical, geographical, economical, etc. aspects), we will restraint our propositions to small and medium sized cities.

MANAGEMENT OF THE EVOLUTION OF UFT SYSTEM

Reference frameworks associated to UFT evolution process

The considered framework should be global in order to include all stakeholders, resources, constraints associated to Urban Mobility and to point out relationships between these elements. This first reflexion fits with systemic approach which proposes a conceptual framework, a set of knowledge and tools to understand phenomena in a global way.

A system is defined as a group of processors of various natures structured, organised, connected and interconnected, in order to satisfy a specific relation defined as the finality of the system. This relation specifies that the environment of the system contains an entity which wants to consume one or several Objects that the entity can not produce itself. The identification of such relation brings to the foreground the system.

Urban City environment

According to the Federation of Mayors, mid-sized city corresponds to a city of 20,000 to 100,000. We shall therefore adopt this definition for this research. An interest in such city may appear to be unrepresentative, however, a special focus on mid-sized cities, can cover a wide panorama of European cities. In France, the member cities of the association of mid-sized cities alone cover one fifth of the French population and account for 200 cities.

Travel is mostly by direct traces; therefore, well knowledge of routes is possible (Delaitre, 2008). Moreover transported volumes are obviously less important than in large towns; this makes possible a nearly complete knowledge of the flow of goods and passengers. Mid-sized city allows us to considered the global problematic of Urban Mobility.

Finality of Urban Mobility system

In order to transpose systematic paradigm to the urban mobility problematic, we can identify in the environment of our system entities which have to be moved from *A* point to *B* point in time *t* given.

In our proposition, *A* and *B* correspond to locations in the city and the entity is person or a good which can not operate this move from A to B by itself (Malhéné, 2009). The entity wishes to consume an Object (transportation service). Thus UFT system is depicted through Figure 1**Error! Reference source not found.**.

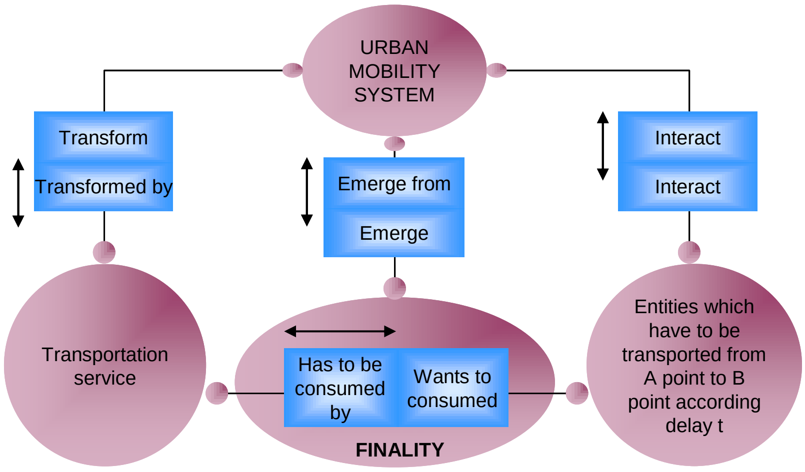

Figure 1 Emergence of the system dedicated to transport of entities

Urban mobility is shown as a system, exchanging material flow and information with its environment, the city, where passengers and goods moving in different modes of transport (Trentini, 2010). Considering the systemic paradigm is also possible to see the city as a more global system which propriety are relevant to a system of systems (Maier, 1996). It integrates mobility system and its own finality can define through the concept of sustainability. The following figure presents the decomposition of the concept into global objectives.

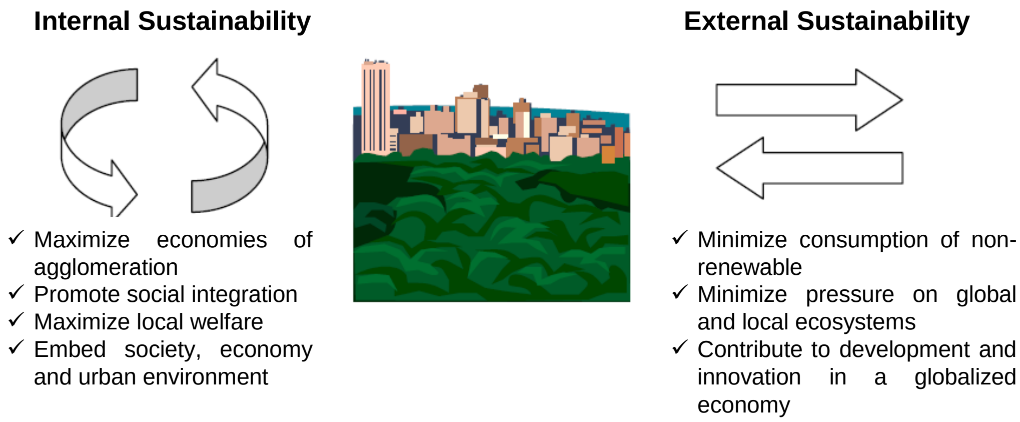

Figure 2 Concept of sustainability

CONCEPTUAL APPROACH OF THE EVOLUTION TRAJECTORY

According systemic approach, this mobility system can not be considered as static. Its environment is continuously modified. For this reason, the system has to change and to adapt its structure. These successive modifications draw the evolution trajectory of the system. As stressed by the systematic paradigm (Le Moigne, 1977) this evolution is a fact. However it can be undergone or anticipated in order to be controlled.

Our proposal is mainly based on techniques developed by the GRAI Laboratory on the coherence analysis and on the performance evaluation in manufacturing systems (Ducq, 1999). This research conduces to characterize the evolution of the system, as a continuous process based on a combination of "steps". Each step represents the evolution of the status of the system (Malhéné, 2000).

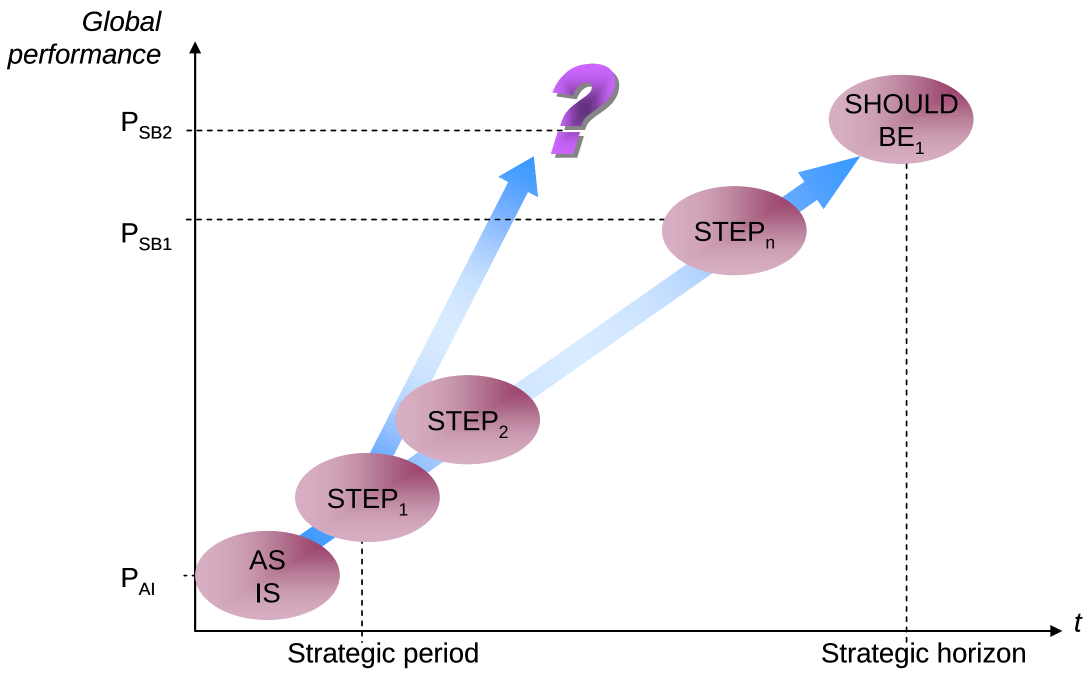

Figure 3 Evolution process

SHOULD-BE corresponds to the idealist vision of the UFT system at the end of the strategic horizon. This state is associated to a global level of performance expected by stakeholders. In fact, this state will not be reached; during the lead time corresponding to the strategic horizon, system environment will be modified. This requires the definition of a new level of performance relevant to environment requirements.

AS-IS corresponds to representation of the UFT system at time t=0. It gives the model of actual UFT system and the actual level of performance.

Successive $STEP_n$ draw the evolution trajectory of the UFT system. Lead time between two successive steps is the strategic period. It corresponds to the lead time at the end of which a new SHOULD BE is determined.

The evolution process depicted through these different conceptual states underlines two main levels of management.

The Strategic Definition level operates in the world of performances. Considering the fact that SHOULD BE will never be effectively reached, it is not necessary to build a detailed model for this state. On the other hand, it is necessary to determine the level of performance towards which we want to make tighten the UFT system and to compare this level with the actual one. This allows to determine gaps in term of performance between SHOULD BE and AS IS situations.

The Actions Planning level operates in a world of models. Scenarios are elaborated in order to reduce gaps in term of performance between SHOULD BE and AS IS situations. It consists in drawing the evolution trajectory and in defining the successive $STEP_n$ between AS IS and SHOULD BE.

STRATEGIC DEFINITION LEVEL

Proposal for a formalization of performance-based management of evolution

The Strategic Definition level targets the global level of performance associated to the SHOULD BE. In our proposition, it expresses the participation of Urban Mobility to the finality of the city and the associated global objectives. This level of performance results from a combination of local performances which can be represented within a referential.

CIVITAS II SUCCESS project provided European local authorities and decision makers with a consistent and ambitious panel of best practices for managing urban transport in medium sized cities considering:

- Respect of the environment,
- Citizen satisfaction,
- Traffic congestion,
- Safety and flexibility.

Measures impact has been evaluated through the definition of a set of performance criteria devoted to transport system (www.civitas.org). We propose to pick up these criteria to characterize UFT system performances referential.

Considering the number of criteria and so the complexity of the resulting referential, we will admit that evolution process management can focus on criteria extract. For instance, city authorities want to improve UFT system performance through three criteria:

- Operating costs,
- Service reliability,
- Congestion level.

In this case, the evolution process can be modeled inside a three-dimension space as presented in 0 where:

- P1 represents the Operating costs performance,

- P2 represents the Service reliability performance,
- P3 represents the Congestion level performance.

SHOULD BE is represented through a vector characterising a specific point in this referential. The value of its components ensures the coherence of the evolution process. This proposition supposes that politicians are able:

- To estimate the current situation of UFT,
- To filter information resulting from the environment,
- To transpose all these elements on strategic horizon.

During the evolution process, and while SHOULD BE global performance is of current events, it is supposed that performances' referential does not change. Only vector components values are modified. The fact that a new referential has to be defined means that SHOULD BE is modified and that a new process must be engaged.

Associated to the definition of this referential a set of concepts can be presented in order to characterize the dynamic of the evolution process.

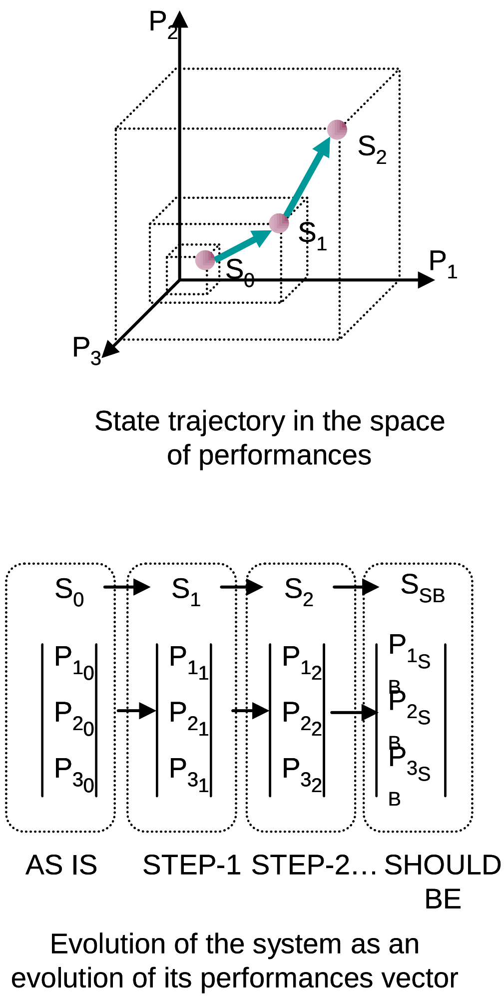

Figure 4 Modelling the system and its evolution trajectory inside a space of performances

Concept of transition

Each evolution state is associated to a vector of performances. Two following states are linked by a "transition". A transition is characterized by a cost value (regarding one or several criteria like money, environment or social impacts …) and a lead time.

Most often, cost value and time are strongly linked. Evolution process can be accelerated: this will generate over costs…

Concept of accessibility

A state is accessible if the state vector associated can exist, i.e. if the values of the vector respect external constraints. Two main kinds of situations explain this notion.

The first one is simple. It corresponds to a performance that cannot be associated with a certain value. It is the case if a maximum exists; for instance, CO_2 emission of a vehicle can not be negative.

The second situation is more complex: one performance limits the value of other ones (mutual exclusion). It is the case when two performances are linked by a trade-off illustrates. For instance, it is well known that operating costs and service reliability limit each other. Then, let us consider the two P_1 and P_2 performances which can be only positive:

$$P_1 \geq 0$$

$$P_2 \geq 0$$

Moreover, let us imagine that these two performances are linked by the following inequality:

$a.P_1 + b.P_2 \leq X$ *(Where a, b and X > 0)*

Then, the P_1P_2 plan is not fully accessible by the evolution of the system. 0 represents the part of the plan accessible, i.e. the part of the plan containing accessible states.

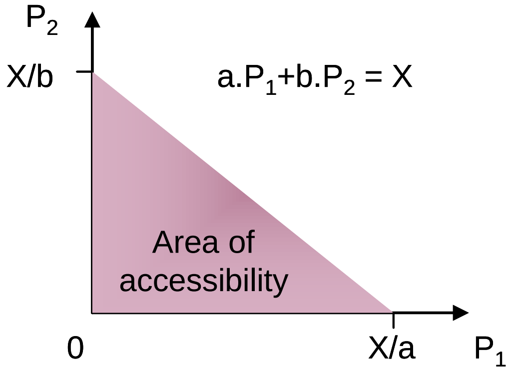

Figure 5 Concept of Accessibility

Concept of pertinence

A state is pertinent if each component of the associated vector participates effectively to the global performance of the system. The effective participation of a performance means that if this performance is reduced then the global performance is reduced as well. Two cases of non-pertinence can be defined.

The first case is the simplest. The expected value for a component of the vector is reached. However the overall performance of the system will derive no benefit. In this case, the evolution of the system is on the wrong track. The first case is due to poor decomposition of goals.

The second case is more complex. We consider that each component of the vector performance is involved in achieving the overall value. However, as they depend on each other, the overall performance does not increase.

For example, imagine a city wishing to implement a local storage facility. The idea is that a fleet of vehicles ensures deliveries from the warehouse to stores in the city center. Once construction of the warehouse is completed, the overall performance will not be influenced so that vehicles will not be purchased.

In this case, the system evolution can be understood through the evolution of two performances. The first is the performance of the warehouse itself ("P_1"). The second is the performance of the fleet of vehicles ("P_2"). Because every performance has an interest only in connection with the other, we consider that the overall performance ("G") associated with the couple <warehouse, fleet of vehicles> can be expressed as follows:

$$G = \text{Min}(P_1, P_2)$$

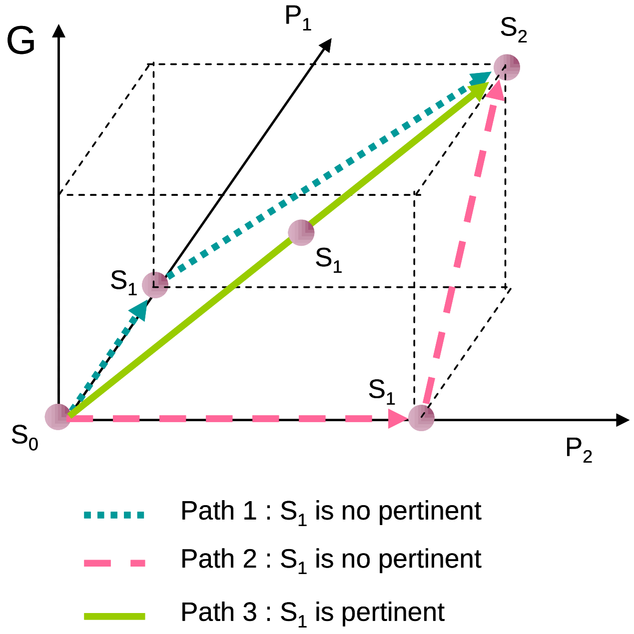

Figure 6 Concept of Pertinence

Several paths are illustrated in 0. Because of the relation existing between P_1 and P_2, path 3 is the best one because it enables a harmonious evolution of both performance criteria leading to the optimal evolution of G. Conversely, the two other paths pass through non pertinent states because one performance evolves without the second one getting no profit from the evolution until this targeted state is reached.

Within path 1 and path 2, a performance is overvalued, i.e. a performance grows without making the global performance growing at the same time.

$O(P_1)$ and $O(P_2)$, overvaluations of respectively P_1 and P_2, may be stated as:

$$O(P_1) = P_1 - G$$
$$O(P_2) = P_2 - G$$

0 represents the evolution of P_1, P_2 and G and the overvaluation of P_1 and P_2 in the case of non pertinent states.

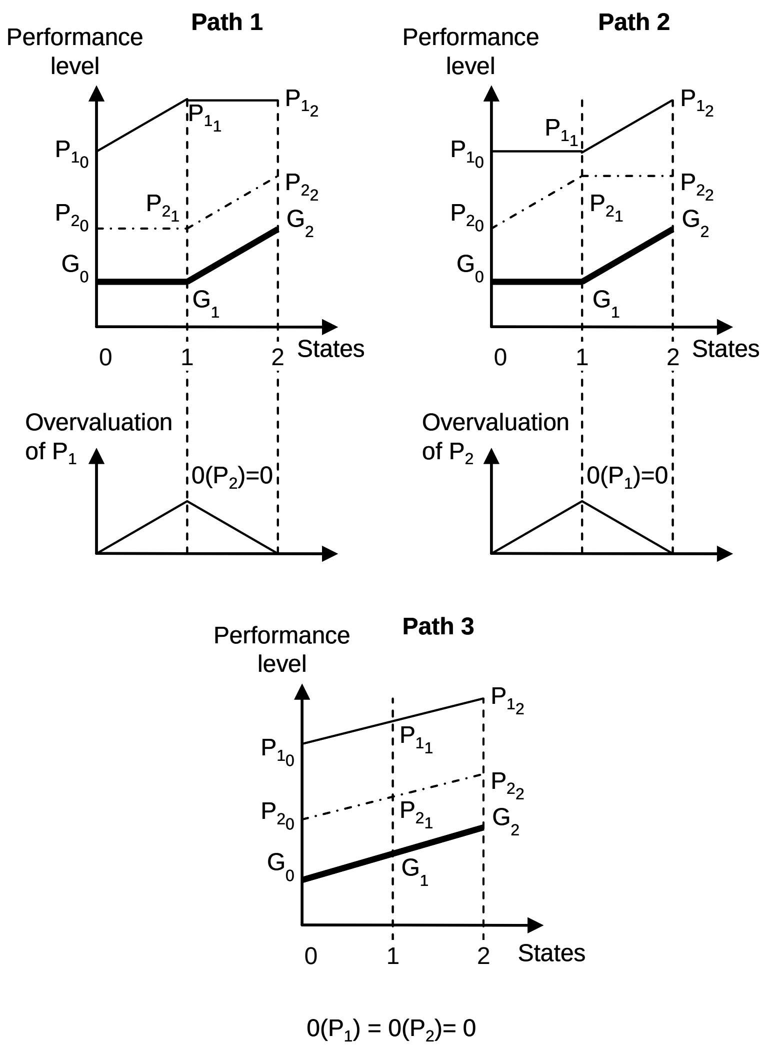

Figure 7 Pertinence: overvaluation

In our proposal SHOULD-BE and $STEP_n$ are accessible and pertinent states. That means that they correspond to situations where performances provided are really used i.e. that the effort consumption to reach new performances brings profit to the system.

ACTIONS PLANNING LEVEL

Introduction of new processors

The capability for a system to evolve is based on the variety of this system. It is function of the potential number of relations between system's elementary processors and depends directly on the number of processors of the system. One closed system can not import or exchange processors: its variety growths till a maximum $V_{max} = 2^{N^2}$ where N is the number of processors of the system. This is not the case for an open system: the variety of the system continues growing while the system is able to import new processors.

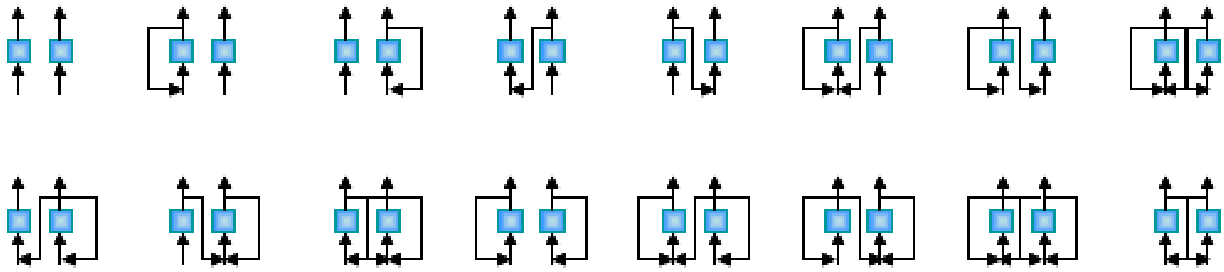

Figure 8 Variety of the system with 2 processors

On an etymologic point of view, the system should stay a coherent group in order to fulfill the finality of the system. The Action Planning level is a design phase which consists in modifying the existing model through integration of new processors or recombination of existing ones which impact performance level. This level aims at evaluating the different scenarios in order to select the most relevant evolution trajectory. It is composed of successive $STEP_n$. These states should respect the equilibrium of the system. For this reason the principles of accessibility and pertinence previously presented have to be considered.

Characterisation of Urban Mobility System processors

The concepts of UFT fall on two dimensions: "operational" and "organizational". The operational dimension includes all concepts related to resources and infrastructures, and do not directly affect the flow organization. The only means of consolidation are to consolidate small shipments from shippers different in space and / or time to rationalize the exploitation of the resource.

The organizational dimension directly affects the organization of deliveries. Sender and logistics service provider designed to streamline workflows by optimizing the timing of deliveries, the organization of tours, packages, etc. The specificities of transport and storage are used as part of this planning.

Three distribution patterns can best be broken down:

- ⇨ *Composite warehousing*: deliveries of different origins are combined into a distribution center and from there they are transported to their final destination.
- ⇨ *Commodities and specialities*: different types of goods are loaded throughout the delivery route. The system requires resources for the transport compatible with different types of goods. The warehouses serve all destinations, and are specialized by type of goods.
- ⇨ *Split & combine distribution (pipelining)*: it allocates optimally the individual packaging logistics system (vehicles, handling systems, deposits) to optimize the available capacity. This means that transfers can be divided and the contents can be transported along different paths and at different times. At the end of the chain, deliveries are recombined and delivered the final address.

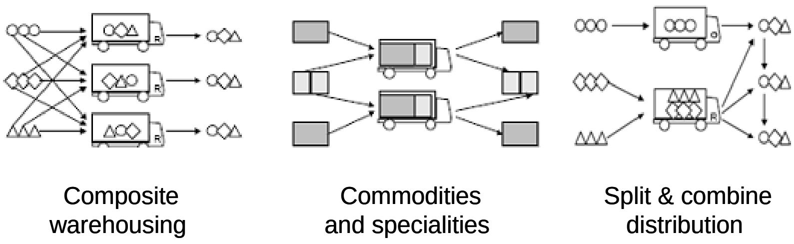

Figure 9 Distribution pattern

All these distribution pattern result from a combination of two activities: transport and stock. At the conceptual level, whether the carriage of passengers or goods, two kinds of processors compose the Urban Mobility System: processors dedicated to the transport and processors dedicated to the storage of entities.

Transport oriented processor

To transfer a part of passengers' transport and goods' transport towards more environmentally friendly practices, it is necessary to orient transport strategies towards public and shared transport.

The mutualisation is facilitated by the development of information technology allowing to implement tracking and tracing of goods and simplifying communication (data exchange) between the different partners of the supply chain. The model of the processor dedicated to the mutual transport is based on the implementation of a single vector transport across the city or across one area of the city. The capacity of the vector should be sufficient to transport passengers and goods.

All along the vector technical infrastructures ensure the widespread distribution of goods and of the passengers (Capillary Transportation System) to its final destination, through cleaner vehicles, replacing the traditional trade routes of the vehicles.

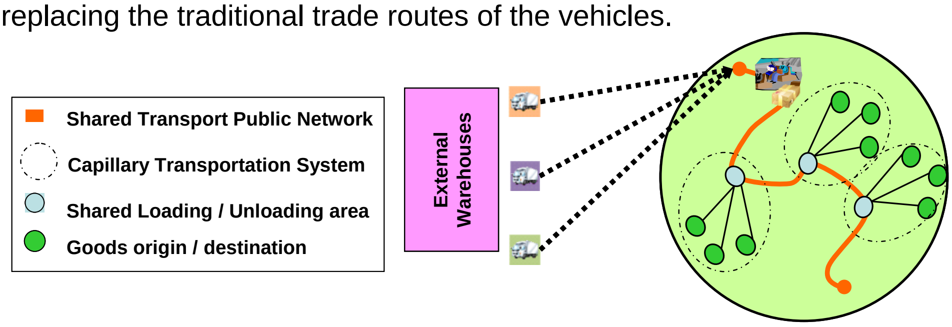

Figure 10 Transport oriented processor

Storage oriented processor

The second processor focuses on the storage and introduced infrastructure for passengers and goods, to transfer the associated flows towards clean urban transport modes and environmentally friendly. With these structures, an alternative urban transport could be provided, capable of reducing the total number of kilometres travelled and emissions of CO_2 per kilometre in the city.

From a perspective of urban development, it should be necessary to define strategic plans for the construction of a network node interface between the transport of long distance and short distance distribution to final destination, both for passengers and freight.

Concerning the “storage” of persons, “park & ride” solution is more and more developed. It consists in a parking with public transport links that allow those who need access to the downtown park their personal vehicles in the parking and continue their journey by bus, rapid rail system, light rail, etc.

Regarding the distribution of goods, politics should plan to introduce into the city infrastructures to ensure a more flexible transfer of cargo from various origins and with different destinations.

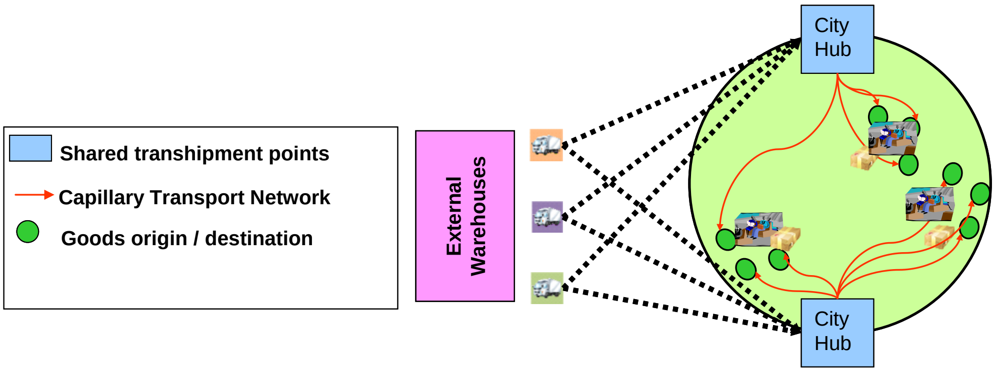

Figure 11 Storage oriented processor

DECISION TOOL FOR THE IMPORTATION OF UFT PROCESSOR

Our objective is to develop a tool which can support the concepts exposed in the frame of the evolution of Urban Mobility System. The tool should assist decision makers in the optimization of the processors associated to the Urban Mobility System. It should also assist in the choice of technical resources which should support the processors.

The first version does not aim at integrating all our theoretical proposals. This prototype named POLYCOLIS focuses on UFT. It considers two consecutive steps of the evolution process and the associated transition. It assesses a priori the impact of Urban Mobility solutions and their cross influence. This tool takes into account the specific context of a city (topology, transport network, flows…) and evaluates the impact of possible actions once they have been determined and dimensioned by the decision maker.

Respecting principles of accessibility and pertinence, POLYCOLIS aims at directing politicians to several projects, so that they become aware of the largest number of potential solutions. The tool is based on a data base and a qualitative matrix. The data base integrates different results of CIVITAS initiative European program in particular:

- Global characteristics of different middle size cities involved in the program,
- Global description of several demonstration measures launched by cities involved in the program.

Based on these elements, the use of the tool is quite easy. The global characteristics of middle size cities that we have integrated in POLYCOLIS give a reference model of the city. By quantifying these characteristics the decision maker build the vector of performances of the existing situation.

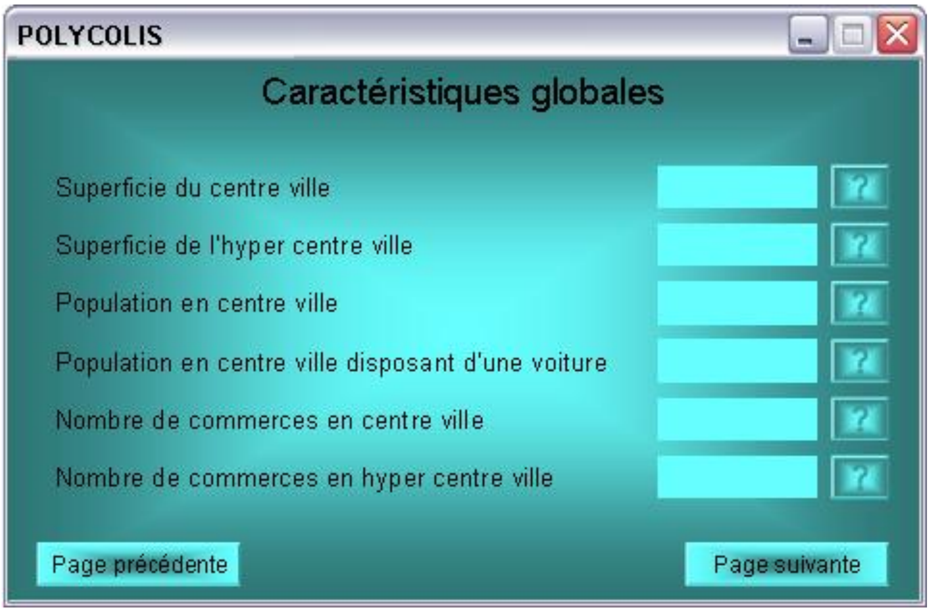

Figure 12 Basic characteristics of the city (Screen shot)

The characteristics are compared to average CIVITAS data. A score results from this comparison and allows going through the qualitative matrix which is already fulfilled.

This matrix is the kernel of the tool. To highlight the most sensible solution to be set up in a city, we opted for a homemade binary notation. This system of notation allows increasing the note associated to a solution if its contribution is considered as positive regarding specific city characteristic. If its contribution is negative or neutral the note is not influenced. By the way the biggest note corresponds to the most pertinent solution in this sense that it positively influences a majority of the city characteristics.

So, the tool informs the decision maker on the opportunity to choose a UFT action among others through a hierarchical presentation. Finally, the decision making tool presents the results of the implementation of similar action in a similar context. It also gives information related to characteristics, advantage and inconvenient of such actions as well as the cost aspects considering the fact that such factor is quite important for this kind of decision.

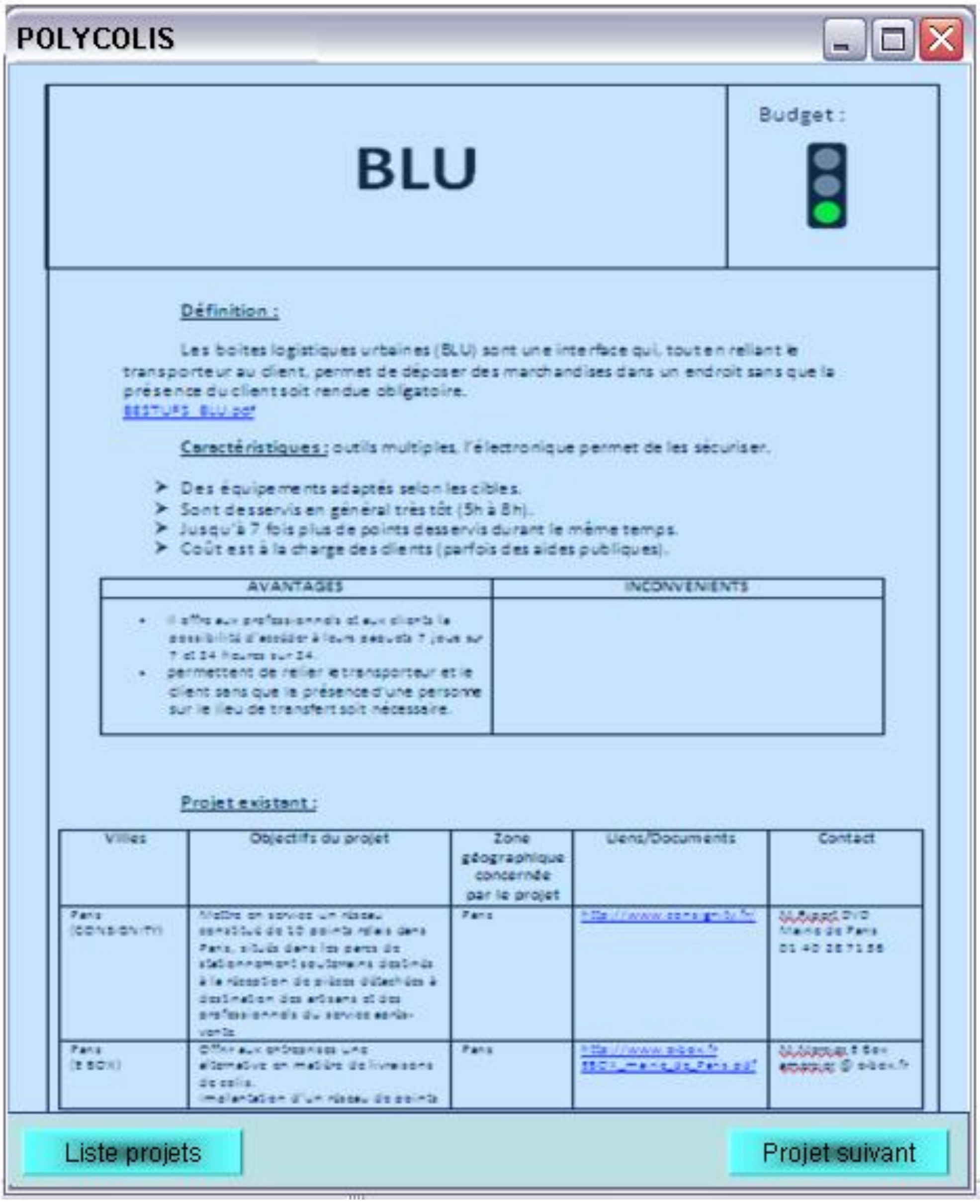

Figure 13 Example of result (Screen shot)

CONCLUSION

The software tool has been validated by politicians of the Urban Community of La Rochelle. It is a very first version of a global set of tools which will integrate the overall conceptual approach and relevant theoretical proposals. The actual development of the tool is done in the frame of CGOODS project (ANR-08-VTT-005-01). The overall approach itself and in particular the formalization of the evolution process will be widely developed in the frame of CGOODS project. Three main tracks have been identified:

The actual prototype deals with the overall city when it appears more coherent to take into consideration characteristics of different local areas of the city in order to optimise the organisation of Urban Mobility System. Thus we have to take into account interactions between areas and associated transport resources. Dynamic of the system should allows to analyse these interactions.

Recent work related to management of the evolution process of industrial enterprise gives some perspectives. (Ben Zaïda, 2008) conceptualizes change projects to evaluate associated cost, duration and impacts. The generic framework developed in this work allows evaluating the interest of change projects in order to build a relevant trajectory. This approach could be transposed to our problematic.

PRODIGE Project (ANR VTT Program) proposes optimizing freight transportation and in particular UFT, through the development of an efficient real-time control and monitoring centred on products routing. Combination of passive and active tags allows defining the concept of “communicating” product which can dialog with computing servers. This point of view argues in favour of our proposals. It points out interoperability problematic and introduces new one paradigm in term of logistics

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