Structuring traffic integration: in search of innovative solutions

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Abstract

Here are summarized the results of eight months of labor as scientific advisers to a working group on sustainable transportation and climate change, created by the Government of Quebec. Our research method was a Delphi consultation designed for interviewing a selected range of public and private executives, in order to better define, and to supplement objectives and procedures.

Results. A better understanding of the strategy leading to the identification of an essential objective based on the concept of structuring traffic integration between an effective market demand and a balanced allocation of financial resources. A better insight on the methodological procedure necessary to address this objective, based on the development of a simplified mathematical model.

The conclusion aims to assemble all of the necessary elements, conceptual and practical, for accomplishing a successful traffic integration.

1. Introduction

As the Webster points out, we call traffic, the movement (as of vehicles and pedestrians) through an area, and integration the fact or process of unifying things to act in concert functionally and harmoniously.

Traffic is a form of spatial mobility performed in a transportation system, an essential component of a social and economic system. In order to avoid possible misunderstandings and to standardize our terminology we will speak henceforth of transportation (the system where traffic functions) Some authors [1] distinguish three forms: land, air and water transportation. Land transportation, by content, may be urban and interurban and carry goods and persons; by mode, it includes road and rail. Road and rail transportation are
mostly powered by petroleum or electricity and run at ground, above-ground and underground levels.

Integration is a normative orientation [2] that can be understood as a matter of degree and of dynamic progression or regression. In our case, we refer to a good transportation system whose integration can be more or less high, intermediate or poor and improve or deteriorate more or less rapidly. In order to standardize our terminology we will speak henceforth of sustainable transportation, a kind of transportation system that is good, well-integrated, functional, harmonious, affordable, rewarding, etc. This normative perspective is not an offspring of utopian expectations. Sustainable transportation is understood as the normal result of an efficient utilization of the technological, financial and managerial means that are available in present time.

Turning to real facts, specialists [3] generally contend that current land transportation is still far from satisfactory sustainability. We can just quote the “Call for papers” of this Conference: “One of the greatest challenges facing the new millennium is to effect a well-integrated and environmentally acceptable solution for urban transportation. In spite of many decades of studies, [...] success has often been elusive”. The last World conference on climate change (The Hague, November 2000) highlights dramatically the principal cause of this state of affairs: industrial society’s failure to propose new and useful ideas leading to both “safe climate and sound business” [4].

Innovative and useful ideas to resolve our difficult transportation problems (pollution and congestion) are indeed not unthinkable. For instance, some years ago, in the USA’s incongruous network of railways, goods and people crossing the nation had to change trains sixteen times. A few years later, new ideas have leaded to invest billions of dollars in better transportation. Why the reengineering [5] of the transportation system should be impossible today?

Of course, the real difficult question is not to determine if this new revolution is possible, but to find out the conditions under which innovative ideas will emerge (and the huge investments that must necessarily follow).

We have been recently hired as scientific advisers for the GTT (“Groupe de Travail sur les Transports”) [6], created by the Quebec Government. Our task was to shed some light on the difficult questions mentioned above in the search for new and convincing ideas. Our research method was a Delphi consultation conducted among a range of leaders from the private and the public sector [7].

Our results are summarized below. They concern namely the discussion of two essential matters: which objectives have to be pursued (what to do?) and which methodological procedures have to be applied (how to do?) to move towards a real progression of ideas on sustainable land transportation. A brief conclusion follows, suggesting further work and further analysis.

2. On objectives

GTT’s mission implies a large number of objectives, i.e., projects leading to concrete actions. Of course these objectives have to be defined and acted upon right away, although they can only be attained at best in the long term.
2.1. General and specific objectives

In transportation policy, objectives can be general (to accurately inform decision-makers, to improve sustainable transportation, etc.) or specific (to encourage car sharing, to promote walking or biking to work, etc.). Surely, objectives must be numerous, varied, general and specific, convincing and motivating. The presence of multiple obligatory interests (economic, institutional, scientific, professional, etc.) ensures this, and makes the exercise stimulating without any doubt.

Accustomed to analytical work within a theoretical framework [8], we asked a particular question. Could we conceive a central objective that is generally ignored by the specialists? We shall expand upon this point.

2.2. The idea of addressing a specific, hard-core objective

Inspired by the idea of the hard-core [9] of a research project, one can imagine a specific objective, decisive at environmental economic and social levels. GTT did not question the possible existence of this type of specific objective. Instead, the idea comes from the literature on environmental and economic indicators [10] which seeks to identify areas where data and analytical challenges/gaps exist.

Following this intellectual path, the results of our Delphi consultation, as well as our own understanding, the idea of considering a hard-core objective in transportation policy has resulted in a complex itinerary.

- To point out an area where data and analytical challenges or gaps exist.
- To determine in which sense this gap is particularly central to the issue.
- To transform this gap into a research project.
- To prepare a work plan to fill this gap substantially.

Let us follow these steps rapidly. In order to conform to the structure of this essay, the first and second steps are included in this chapter on objectives. The other steps will be addressed in the next chapter, on methodology.

2.2.1. Pointing out an area, and the data to collect

According to our results, we point out an important area or “niche” [11] where data and analytical gaps exist. It is the area of questioning, in a sound business perspective, how can accept the transportation market the actual gigantic unbalance between the investments allocated to the conventional technologies (automobile and trucking, roads and petroleum) and to innovative anti-congestion and anti-pollution technologies which are today available in very different forms (advanced light and heavy rail, etc.) [12].

To begin this questioning, and to identify and to calculate the basic data that it involves, constitutes indeed the hard-core objective we are suggesting. In order to clarify in which sense the gap that it fulfils is absolutely central, we examine briefly the basic robustness of this objective, i.e. its strength and capacity to lead to sustainable transportation.

2.2.2. The robustness of our hard-core objective

Contrasting with punctual objectives, the robustness of our objective is attested by its features: strategic, structuring, integrative, explanatory and manageable.
A strategic objective
It is a strategic objective in originally military sense: "the science and art of using the political, economic, psychological and military forces of a nation to afford the maximum support to adopted policies." (Webster).

It is strategic, according to management science, because it applies the most rational methods in order to go beyond conventional ones that were proving unsuccessful and to act with realism, originality, and an irrepressible involvement in being substantively efficient [13].

It relates with Strategic Environmental Assessment' perspective for its commitment in taking account of environmental concerns of all public issues, from the earliest stages of planning and decision-making [14].

A structuring objective
It is structuring because it seeks to bring into play all the necessary elements for creating a complex and self-reliant system that includes economic, social and environmental conditions and circumstances. [15].

It is structuring because it addresses transportation not as a sum of vehicles, ways and fuels, but as an interdependent system that functions under the control of an overall organizing principle: the market, i.e. the dynamic encounter of effective demand and of effective supply (appropriate investments) [16].

More concretely, it is structuring because it contains essential components of the transportation system. Local and global levels, in the short and in the long term. Decisive problems of pollution and congestion. Search for the source of these problems and of their and solutions. Changes at the technological and at the energy levels. A dynamic leading to substantive sustainable development.

An integrative objective
It is an integrative objective because it develops the process of unifying transportation system, in order to function in concert, harmoniously.

It is integrative because considers the conjunction of all parts of the system (rail and road, goods and people, urban and interurban, supply and demand, etc.) and the collaboration of public and private decision-makers. A renewed form of this partnership is today necessary for two reasons: the decrease of governmental financing capacity [17] and the demand for explicit evaluation of programs and policies affecting public concern [18].

It is integrative because it aims to calculate the efficient allocation of the gigantic resources needed for safe environmental protection, effective demand and sound capital rewards. In order to attain this target, that counts in billions of dollars, industry, financial backers and civil society must collaborate much more closely and intensively [19].

A causal explanatory and leading objective
It is a causal explanatory objective because it addresses the cause-effect relation between the billions of dollars invested in roads, petroleum, cars and trucking, and their poorly integrated proliferation, responsible for unwarranted pollution and congestion.

It is a leading objective, because its focus on this cause-effect relation provides guidance to act according to the logic of investments, which are
normally made in response to growing effective demand and financial profitability. Following this logic is indeed a most effective way to rethink the necessary conditions for changing distortions in the transportation market and therefore to lead to substantive sustainable solutions.

• **A manageable and operational objective**

  The study of market needs and sound investments allocation is not a pure speculative objective. Surely, analysts could say that “it seems interesting theoretically, but not operational, because it implies decisions of enormous transcendence which are then practically impossible to manage”. We would respond that this difficulty is indeed absolutely real. But it doesn’t pull down our point. We don’t suggest to intervene in investment practices, but to contribute to the advancement of knowledge concerning the conditions which can promote new technologies and new forms of investment New forms that can be better adapted to market needs, more productive at social and economic levels and finally, environmentally sustainable.

  Within its limits, our hard-core objective is the quite operational and manageable. In regard of real transformations, however, a general remark can be instructive. The well known history of scientific discovery as well as the analysis of the recent evolution of world business, concerning new market needs and new huge investments in computerized telecommunications easily confirm that human systems are eventually doomed to become outdated, and must therefore be readapted and transformed.

  In summary, a large amount of general and of specific objectives must necessarily be pursued. This being clearly stated, we insist on the opportunity of testing the robustness of our hard-core objective in a concrete situation. The components of the idea and its founding reasons have been given We will now outline some considerations on methodological procedure.

3. On methodological procedure

The methodological procedure necessary to test the robustness of our hard-core objective in a concrete situation involves two main issues: the preparation of a preliminary research project and the design of a work plan.

3.1. Preparing a research project

  The above-suggested conceptual ideas are now transformed into a preliminary research project with several different essential themes.

  • A previous and truly justified specification, of concrete conditions of time and space were shall be tested the robustness of our hard-core objective.

  • A detailed specification of most advanced speed light transportation mode actually available.

  • A simulation of this mode’s capacity to respond to market needs on the basis of the necessary investments required for its successful introduction.
A quantitative and comparative analysis of the resources needed by each part of both conglomerate industries (conventional car and trucking and advanced speed light vehicles).

- The measurement of the consequences of each of these conglomerate industries on market needs and on environmental degradation.
- The study of the optimal allocation of resources that should, from now on, be devoted to each one of these conglomerate industries in order to obtain the most substantive returns on terms of capital and of market needs, at the mid and long run.

To address these themes concretely, two approaches are indispensable: a detailed analysis of indicators and the construction of a model.

3.1.1. The analysis of indicators
Borrowed from economic analysis, indicators are statistical values (for instance employment level) that give an "indication" of the health of the economy. Based on a detailed literature review, the research project has to analyze conceptually and quantitatively the necessary indicators needed to measure and compare the two suggested conglomerate industries. Three types of indicators have to be specified, those that measure environmental impacts and those that measure economic and social causes and consequences. All indicators have to be selected and tested according to a framework of linkages and policies. They need to be selected in a critical perspective in order to assess their strengths and their limits to contribute to a substantive mitigation of adverse environmental effects of transportation in a sound business perspective.

The analysis of indicators bring to the fore an important question. Transportation technologies and advanced managerial organization imply an enormous differentiation of possibilities. To avoid an endless data collection, it is then imperative to select [22] a very restricted scenario, well justified and able to prove its capacity to be applied in different case studies [23].

The mapping out of indicators should not be limited to wishful and nebulous recommendations. It should always be submitted to a systematic Delphi consultation, in order to prove very concretely the efficiency of a specific action program related to a specific and real situation.

3.1.2. The construction of the Model
The necessary manipulation of a great number of quantitative data, requires the development of a mathematical Model (see fig.1 on the next page).

This mathematical Model shall focus on strategic indicators guided by the most crucial components of contemporary industrial civilization, i.e. market needs and the amount of huge investments allocated to a particular sector. The principal goal of the Model is then to calculate to what extent the switching and balancing of investments, from conventional to advanced transportation modes can produce substantive benefits, in terms of mitigation of adverse environmental effects and, above all, in terms of real economic and social benefits.

Based on systems' theory [24] where the sum of the parts is always inferior to the whole, the Model does not address the environmental indicators independently of the economic and social ones. On the contrary, it focuses on their interactions, under the primacy, to be sure, of economic profitability.
Fig. 1- Diagram of the mathematical model.
An important remark must be made. There actually exists major macro-energetic [25] and macro-economic models [26] combining the main features of transportation system. However, we think that besides overall performance models, it is useful (and complementary) to test a restricted model focusing on a simplified scenario destined to test the robustness of our hard-core objective. This is why, following the terms of ITEM (Integrated Transport Economy Modeling System), we attach great importance to Computable Particular Equilibrium besides the framework of Computable General Equilibrium [27].

The Model indicates the effect of retroactive actions in an iterative process destined to find solutions, according to the constraints of input parameters. Given the complexity and multiplicity of data and of particular situations (pricing, taxation, land use, demand expectations, political issues etc.), the Model is constructed in a preliminary form. It focuses on a simplified scenario that nevertheless has the full capacity of adopting numerous developments in order to refine and to increase in complexity each one of its main input and output constituents.

• Inputs
   (i) The amount of investment necessary to a balanced integration of conventional and advanced transportation modes (concrete types of infrastructures, vehicle production and maintenance, energy sources, management orientations, financial partnerships, marketing, logistics, intelligent systems, etc., shall be entered in the Model progressively). (ii) The market needs and the capacity to pay for transportation of goods and people in a determined place and time.

Initial investments are distributed into four principal modules of input:

• Electricity. It is mostly an energy source for clean and rapid transportation and a sink of money for the investment.
• Petroleum. It is mostly an energy source for transportation, a money sink for investment and a most important source of pollution.
• Transportation modes. The Model shall define well-appropriated units of measurement. For instance, in freight, the ton/km or the semi-trailer (and its equivalent, either travelling on the road, or on rail platforms). For the transportation of people, the unity of measurement can be the person/km (and its equivalent). Rail, trucking, buses and cars are sources of pollution and sinks of money. In order to facilitate calculation procedures, the Model shall work according to preliminary premises about corridors, distances, etc.
• Persons and goods are source of money. The Model shall distinguish sets of pre-established parameters (price for unity of weight, etc.)

Calculations are of course based on available statistics and databases. The Model shall use well-known statistical methods (multiple regression, robustness and validity testing, etc.) to formulate the equations that it needs to run.

The Model aims to optimize the whole set of parameters. It will respond, for example, to questions such as these: what are the expected benefits of switching 1 billion dollars from conventional car production to advanced electric railways? What are the expected costs and benefits [28] of the one and another of these actions, in terms of market needs and/or GHG substantive mitigation?
• Outputs

The Model contains three output modules: environmental, economic and social.

The environmental module calculates the impact of different investment policies on substantive mitigation of pollution. The economic module calculates the costs and benefits of each of these policies, according to their relative weight on substantive and profitable investments. The social module calculates the needs and resources of transportation consumers, in order to improve their affordability and their mobility, and to mitigate substantively the drawbacks of congestion. Of course, the Model does not treat each of these three modules separately. It treats them jointly in a perspective of balanced optimization.

Should our calculations proof positive, each output module becomes an input module in the elaboration of a resumption of the Model. The goal of this resumption is to allow new calculations concerning pertinent complementary considerations (management of investments, reconversion of petroleum use, problems of taxes and fees, land use considerations, etc.).

The Model’s calculations should be informative. They shall indeed clarify the positive, neutral or negative influences on pollution, on economic and social developments, of different ways of allocating the global amount of investments. If the results were not convincing, the Model shall help either in reviewing the hypotheses and the calculation procedures, or to end the whole operation.

3.2. Designing a work plan

Our understanding of the Project leads to give top priority to substantive pollution mitigation coupled with substantive sustainable social and economic development. Four overall steps/actions seem determinant.

• To specify, *in order-of-magnitude*, the ratio of investment/impact related to each indicator, and thus verify the robustness of our hard-core objective.

• If the robustness of our hard-core objective is verified, to submit the conclusions of the study to decision makers from government, industrial, and financial sectors in order to improve its inputs and outputs.

• To discover the conditions needed to gather together a group of real decision-makers interested in drawing practical inferences, in order to begin a program of concrete feasibility studies, and to bring progressively into play a pertinent and balanced action program.

• To follow up each step of the operation. By their complexity, it is impossible to permanently settle all issues. A consistent follow-up is therefore absolutely necessary, from its earliest to its most advanced stages.

4. Conclusion

We will conclude briefly. Altogether, our consultation and our thoughts on traffic integration, and on sustainable transportation have simply resulted in a preliminary accomplishment. We have defined a central specific objective and a methodological procedure. It was a long way and an exciting experience. However, we are well aware of being just at the starting point. It is only in the
years to come that this pretended central objective will be tested, if the circumstances allow.

In this context, an intriguing question arises. How high will be the cost of the research project we are suggesting? Certainly, the cost of the complete achievement of our objective is immense. Montreal newspapers report that the cost of a feasibility study of a light rail system over ten kilometers is 14 millions Canadian dollars ... The study of the robustness of our hard-core objective is nowhere near this incredible amount. We would suggest that approximately two years of work, by a team of three or four analysts, would suffice. This is very far from costing millions of dollars!

However that may be, to come to an end, we hope that the intellectual orientations we have suggested will prove to be fully rewarding.

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