# A transport modelling framework for Consensus

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# Preamble

- Consensus Transport Model was part of the work undertaken into the framework of Consensus EU project
  - Consensus project modeled real world policies (two scenarios: biofuel & road pricing) and delivered a multi-objective optimization tool that analysed and visualised the consequences of policy decisions and further provided policy makers with a structured approach for the comparative evaluation and - ultimately selection- of optimal policy options, based on a number of relevant criteria.

# Purpose

- Consensus Transport Model was tailor-made for the development and evaluation of the Consensus Road Pricing Policy scenario
  - "*comparative evaluation and identification of the most optimal road pricing schemes applicable on a "project basis", against a range of policy objectives that should cover the main pillars of sustainability; all that during the early stages of project and policy planning*"
    - resulted through stakeholders' consultation
    - also in line with one of the EU's primary considerations; to use road pricing as the basic funding mechanism for Trans-European road network development and maintenance.

# Challenges

- Development from scratch (due to lack of sophisticated software in the framework of Consensus) of a transport model is by default not an easy task. Adding to that
  - “project basis” implementation level; imposing tolls on any given road project (new or an upgrade of an existing roadway) in the area of EU countries.
    - the model should be able to parameterize such a generic case.
  - necessity of assessment at the early stages of project and policy development, where alternative options are still “just ideas”, thus base-case data are not always sufficient; nonetheless they should be quickly “scanned” and interpreted as either promising or not suitable for further development
    - the model should be able to work even with limited data at hand and provide approximate –yet reliable- estimates of the main impacts of different road pricing schemes

# Key considerations

- In general, when developing a (transport) model to support the ex-ante evaluation of transport policy options a key-consideration is that model's set-up should take place within the overall evaluation process
  - Establishment of a clear **policy context**; in terms of goals and the alternative policy options.
    - this also includes appreciation of the current circumstances as well as the available resources (data, time, cost etc.)
  - Development of a clear **assessment context**; in terms of the desired outcome and the evaluation objectives (criteria)
  - Review the **potential for different modelling techniques** to support the selected policy and assessment context requirement

# Policy Context (*1/2*)

- Road pricing policy options (or schemes) examined in Consensus are (different) combinations of the following policy components:
  - road pricing types: Road tolls (fixed rate), Distance-based charging, Congestion charging
  - toll collection technique: Pass, Toll booths, Electronic Toll Collection (ETC), Optical Vehicle Recognition System (OVR), GPS (or GNSS) based pricing – *and all their combinations*.
  - type of authority, responsible for operation: public or private entity
  - price level (how much is the base fee – concerning passenger cars) and structure (differentiations per vehicle –using as base passenger cars' fee-, per day period and discounts for frequent users).

# Policy Context (2/2)

- "Parameterization" of the generic case of a (road) project was based on:
  - project type; entirely new project or upgrade of an existing one.
  - project scale: corridor (usually a main axis), facility (a corridor part with specific operational of geographical characteristics) or spot (bridge/tunnel)
    - further differentiated by length (in kms) and typical cross-section (lanes number/ direction)
  - application area: urban or interurban.
    - urban area is further differentiated by population size (small when population < 2.000.000 or large when population > 2.000.000)

# Assessment Context

- Policy objectives (criteria) adopted were developed around four main sustainability pillars **Economy**, **Mobility**, **Environment** and **Society** and included:
  - economic feasibility, financial viability, reduction of traffic congestion, improvements on safety, improvements on the environment (air quality and noise) and users' convenience.
- More than half of the above criteria are traffic-oriented (reduction of traffic congestion) or traffic-related (improvement of safety level, improvement of air quality and reduction of noise annoyance).
  - The rest are not traffic-related; they are heavily depended on toll-collection technique and technology and/or on operational authority's structure and efficiency.

# Modelling Requirements

- Need of a simple –yet not simplistic- transport model, with manageable data requirements, for estimating the main effects of road pricing policy options for a typical road project. Main effects include the “immediate” (first-order) impacts of road pricing and more specifically impacts on travel costs and road network’s functionality (traffic volume, amount of travel, journey time, speed etc.)
  - Then the estimation of “chain” (second-order) impacts, such as reduction of the external costs of accidents, air pollution and noise, could be estimated relatively straightforward, since they are directly related with the amount of travel and traffic’s characteristics.
  - Estimation of the rest of the criteria was not based on the transport model but on analysis of readily available domain data and expert judgement.

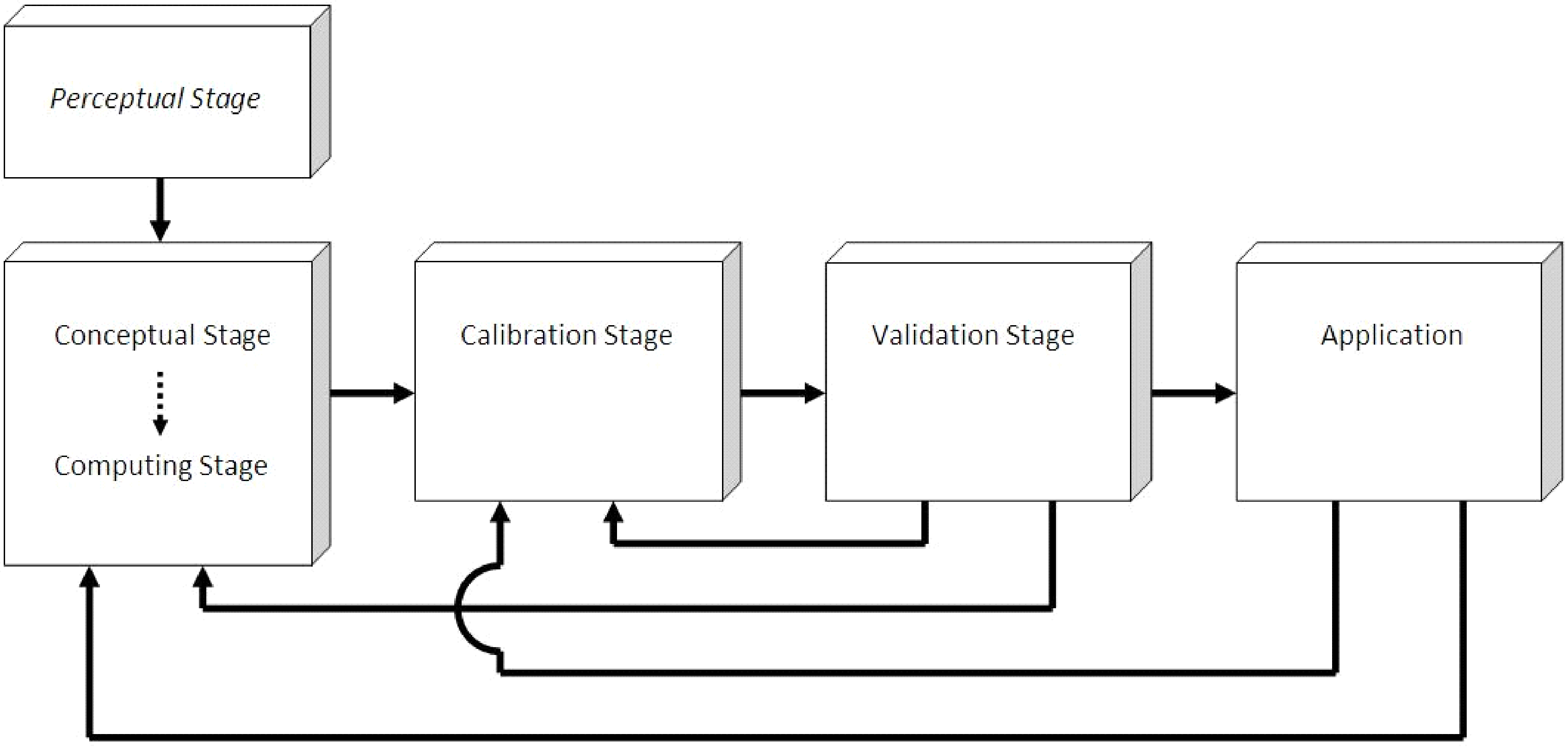
# Potential for different Modelling Techniques

- Conventional (four-step) vs. Simplified models (?)
  - inherent structure of conventional models tends to make them complex to use, data and time consuming and often unresponsive to such policy options testing (at least not without substantial modification)
  - simplified models and especially diversion (post processor) models or sketch planning methods they are considered more flexible, quick-response, easy to understand and use; they still apply similar to conventional model concepts but to aggregated or generalized data and usually for a specific project
- Regardless of the modelling procedure used, two common underlying assumptions exist; travellers make economically rational choices (based on generalized cost of travel) and there is an inverse relationship between travel demand and generalized cost of travel.

# Consensus Transport Model

- Consensus transport model was decided to be:
  - a “simplified” sketch model, tailor-made for (the generic case of) a new road project or for the upgrade of an existing roadway
    - as such there is no specific location and/or network simulated
  - adopting diversion models’ technique and assuming that main demand drivers are roadway capacity and generalized cost of travel
    - as such produce/ forecast changes in demand using the selected drivers changes as well as respective elasticities
      - all parameters and equations are based on extended literature and practice review

# Model Development Stages

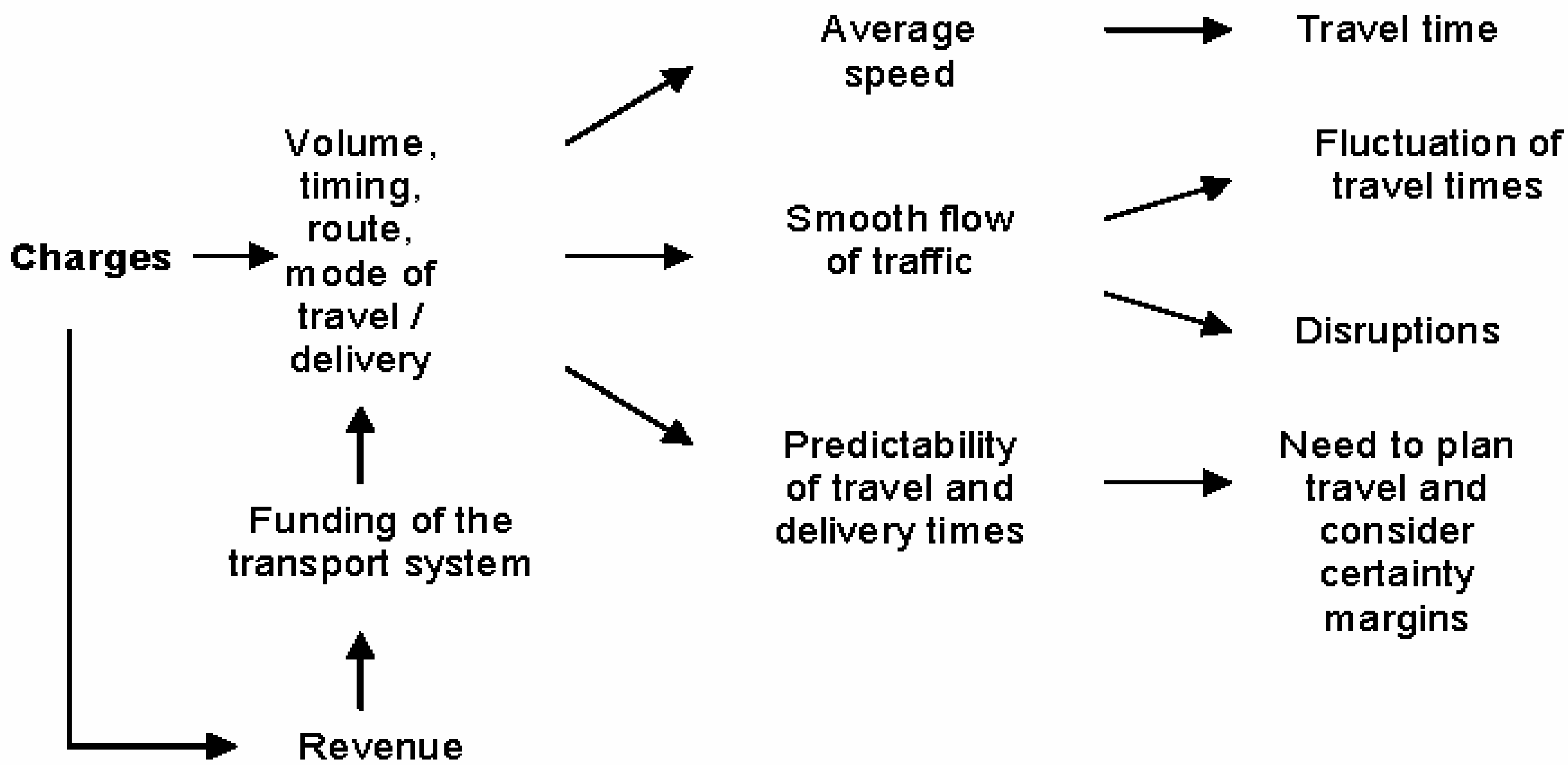


# Perceptual Stage

- Develop a general understanding of road pricing policy alternatives' possible impacts on each criterion
  - i.e. on traffic congestion, by qualitatively describing how demand for road travel can be affected from a road pricing policy alternative and in turn what that means for future congestion levels.
- Perceptions were developed/formed based on
  - transport theory –and practice
  - modeller's experience,

# *i.e impacts of road pricing on road network functionality*

*(Source: CEDR, 2009)*



# Conceptual Stage

- Perceptual processes are described and simplified by equations, based on transport literature and practice
- This stage includes:
  - Demand drivers' estimation; mainly generalised cost (incl. travel time cost and vehicle operating costs)
  - Demand changes estimation;
    - Key assumption: demand change estimated based on changes of demand drivers (generalized cost and section capacity)
    - Key piece of information: elasticities of demand w.r.t to respective drivers ($El._{c}$ , $El._{CP}$)

# Demand drivers

$$Y = F\left(c, CP\right)$$

Y : traffic volume on roadway section
CP : section capacity, measured through project's technical/geometrical standards
**c : generalized cost of travel**

$$c_{ij}^{m,tp,ut} = \alpha_1 * T_{ij} + \alpha_2 * D_{ij} + \theta$$

| | | |
|---|---|---|
| $c_{ij}^{m,tp,ut}$ | : | generalised cost of travelling from zone (i) to zone (j), by vehicle type (m) for trip purpose (tp) and for user type (ut) |
| **$\alpha_1$** | : | **value of time (VoT), for vehicle type (m) and trip purpose (tp)** |
| $T_{ij}$ | : | travel time from zone (i) to zone (j) |
| **$\alpha_2$** | : | **vehicle operating cost (VOC) for vehicle type (m)** |
| $D_{ij}$ | : | distance from zone (i) to zone (j) |
| $\theta$ | : | any toll encountered by a trip from zone (i) to zone (j), for vehicle type (m) and for the specific user type (ut) |
| m | : | vehicle type, m= passenger car, truck |
| tp | : | trip purpose, tp = commuting, other |
| ut | : | user type, ut= frequent (discount), random |

# *VoT and VOC calculations*

- VoT ($\alpha_1$ coefficient): HEATCO study provides unit values for time in (€/passenger/hour), for each EU country, for different trip purposes
- VOC ($\alpha_2$ coefficient):

$$VOC = a * V^2 + b * V + c$$

VOC : vehicle operating cost

V : vehicle's speed (in km/hour)

a,b,c : parameters dependent on vehicle's type (passenger, truck)

# Demand changes

- Based on PDFH approach

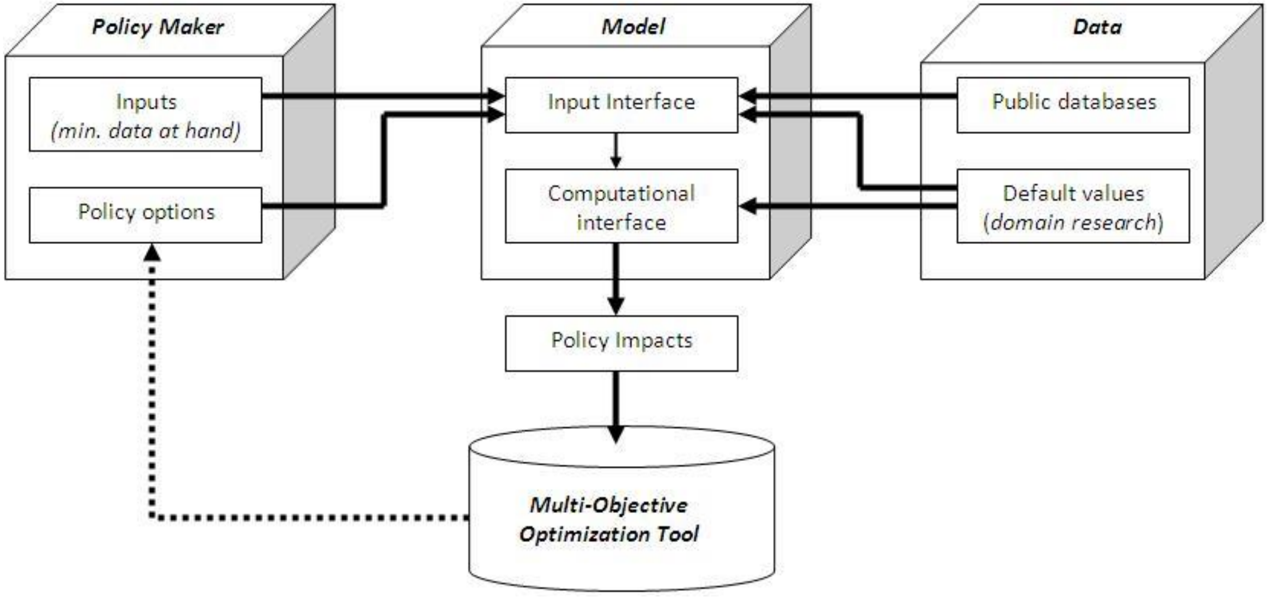
# Growth Index (I)

$$I = \left( \frac{CP_P}{CP_{BC}} \right)^{El._{CP}} \times \left( \frac{c_P^{m,tp,ut}}{c_{BC}^{m,tp,ut}} \right)^{El._c}$$

| | | |
|---|---|---|
| $CP_P$ | : | roadway section capacity, for proposed project |
| $CP_{BC}$ | : | roadway section capacity, for base case situation |
| $c_P^{m,tp,ut}$ | : | generalised cost of travelling by vehicle type (m), for trip purpose (tp), for user type (ut), for proposed project |
| $c_{BC}^{m,tp,ut}$ | : | generalised cost of travelling by vehicle type (m), for trip purpose (tp), for user type (ut), for base case situation |
| $El._{CP}$ | : | elasticity of demand (in vehicle-kilometres travelled) with respect to roadway capacity |
| $El._c$ | : | elasticity of demand (in vehicle-kilometres travelled) with respect to generalized cost of travel |
| m | : | vehicle type, m= passenger car, truck |
| tp | : | trip purpose, tp = commuting, other |
| ut | : | user type, ut= frequent (discount), random |

# Computing Stage

- Transferring the conceptual process to computer code.
- A spreadsheet-based (Excel) model with two main interfaces:
  - Input Data interface
  - Computational interface; for traffic and traffic related factors (speed, travel time, costs) estimation



# Input Data Interface

- Enter readily available data concerning
  - current situation (“base-case” scenario) that generates the need of a specific road project
  - proposed road project on which the various road pricing policy alternative scenarios will be tested
- *In case of limited data availability model provides user with a set of default data*
  - *all data points/cells are highlighted with a specific colour in order to guide users which data to enter, alter or not, choose from a list etc.*
- Examine the available set of alternative road pricing policy options under consideration (and comparison), as produced by model

# Computational Interface

- Main results - *for the proposed road project and for all alternative road pricing policy options*
  - LOS (Speed and Flow)
  - Travel costs per vehicle type (passenger, truck)
    - further analyzed by trip purpose (commuting, other) and user type (paying full toll, discount for frequent users)
  - Total Vehicle-kilometres travelled
    - further analyzed per vehicle type (passenger, truck) and trip purpose (commuting, other)

# Calibration/ Validation Stage

- Models can be calibrated by using default values derived from other studies;
  - model was developed based on extended literature and practice review as such is by default calibrated
- Model is generally represented by one cordon link so it should be validated against AADT counts and observed average travel speed of a real road project (either a sole road corridor or at least a very simple network) using Geoff Havers (GEH) statistic

$$GEH = \sqrt{\frac{2*(M-C)^2}{M+C}}$$ (ideally should be < 5)

  - M: the average hourly traffic volume from the traffic model
  - C: the observed average hourly traffic count

# Application Stage

- Applied during Consensus Transport Pilot; produced a (defensible) simulation of “immediate” (first-order) impacts of road pricing policies (traffic volume/ amount of travel, journey time, speed, costs etc.) on specific road projects selected by pilot users
  - Model results used for estimation of traffic-oriented/-related policy objectives of Consensus transport policy scenario: reduction of traffic congestion, improvement of safety level, improvement of air quality and reduction of noise annoyance

# Consensus Transport Pilot

- http://platform.consensus-project.eu/consensus/Account/LoginExpert
  - model’s Input Interface used as basis for Consensus platform user interface (in the transport pilot scenario)
  - model’s Computational Interface in the back-end of Consensus platform (in the transport pilot scenario)

# Conclusions

- Analytical feedback, collected (through questionnaires and interviews) during Transport Pilot, indicated both pros and cons of the developed model.
  - \+ does not produce misleading results, order of magnitude type errors or incorrect relationships
  - \+ might not produce accurate results but it provides "approximate, yet comparatively reliable, estimates"
  - \+ easy/not complex, not time consuming, not data demanding and as such not expensive to use
  - \+ it is structured for the "generic case" of a road project so can be adapted to any simple road project (a sole road corridor or at least a very simple network)
  - – cannot represent a detailed network or spatial areas
  - – it relies on transfer of assumed relationships from one context to another
  - – it can only ever provide indicative, comparative and approximate answers
  - – it is not suitable for detailed project appraisal

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