# Introduction to LUTI modelling – What is it and why do we need it?

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## LUTI modelling

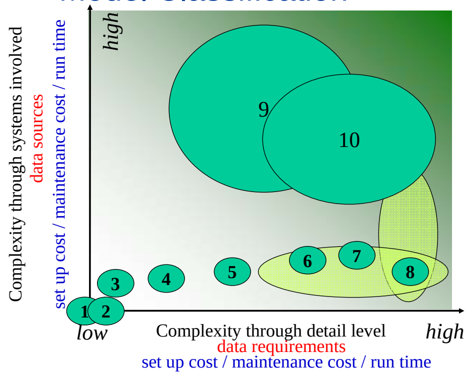
Structure of presentation

- Introduction
- What is a LUTI modelling?
- Why do we need LUTI models ?
- Conclusions





## Model Classification




1. No model
2. Simple cost based
3. Spreadsheet model
4. Sketch planning model
5. Network assignment model without elastic assignment
6. Network assignment model with elastic assignment
7. Network assignment model in conjunction with external demand / mode-choice model
8. Four stage model
9. Land-use Transportation Interaction (LUTI) model
10. Strategic Transport/ Environment Model





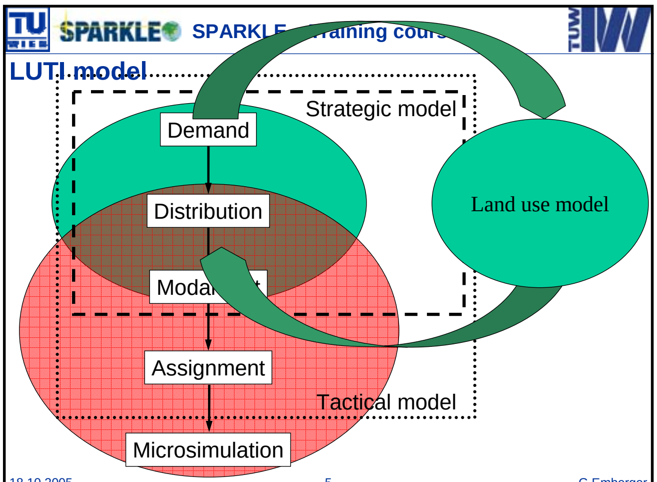
## What is a LUTI model?

- combination interaction of transport and land use (local, regional, national and global level)
- overall impacts of policies
- long term impacts of policies
- using simple supply characteristics
- focus on transport demand
- support tool for decision makers





## LUTI model








## Why do we need LUTI models?

- four stage modelling is complex through detail level
- mostly focused on assignment and not on demand
- mostly focused on private car and PT
- designed to adopt the supply to the demand
- four stage modelling is too slow
- no feedback between Land use and Transport
- tells the decision maker only the half of the truth

## Why do we need LUTI models?

- strategic modelling is complex through interaction between land use and transport
- is designed to estimate future demand
- includes all modes (and feedbacks between the modes)
- designed to find policies to influence future transport demand
- fast model runtimes
- designed to show decision makers a fuller picture of future developments





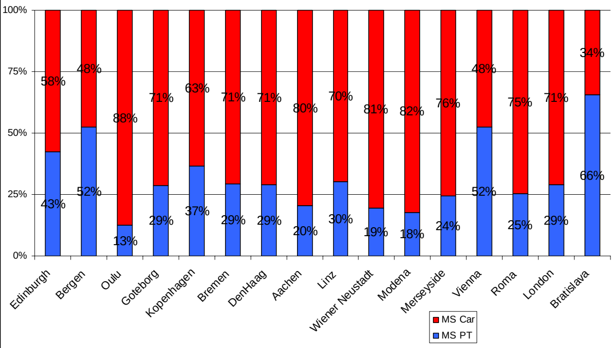
## Questions concerning modelling

- selection of system borders
  - spatial – what should be included and on what detail level?
  - temporal – what is the forecast horizon (daily traffic, peak/off peak 10 years 30 years)?
- which modes should be included?
- feedback of transport system and land use system and vice versa?
- consideration of time lags / reaction speeds
  short term transport system
  long term land use changes housing, employment





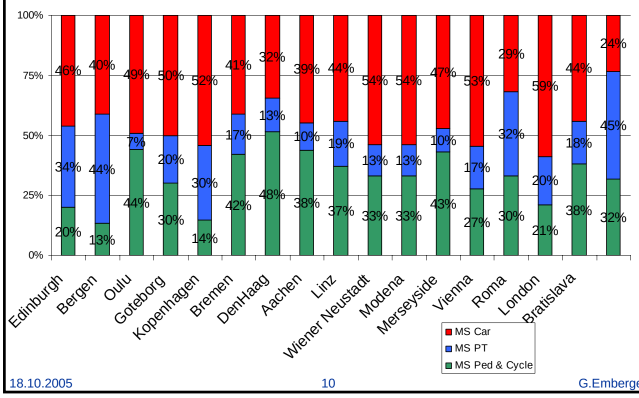
## Modal Split figures








## Modal Split figures








The mars - model

**Metropolitan Activity Relocation Simulator**

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Acknowledgement to Paul Pfaffenbichler





## What is the MARS-model?

- is a very fast land use and transport interaction model
- it works on a high spatial aggregation level (max 34 Zones! not any longer)
- it includes feedback loops between land use and transport system
- it includes all means of transport
- it is not an equilibrium model
- and it is designed to identify optimal land use and transport strategy packages

## MARS-model some further details

- Two person groups (person living in household with / without a car)
- Two trip purposes (commuting / other)
- Two time periods (peak and off-peak)
- Three means of transport (Slow, PT, PC)
- NEW - includes motorcycles as 4th means of transport
- Trip generation using the constant travel time budget theory
- Adaptation speed
  transport system – 1 year
  land use system – 5 years
- Use of gravity model approach for transport model and land use model





## MARS-model as it was: Software details

- MARS is implemented in VBA V6
  (~ 10.000 lines of code – V6y)
- Front-End is Excel
  1. Control file
  2. Inputfiles:
     - Transport System data file
     - Land Use System data file
     - Calibration data file
  3. Output
     - Evaluation file (transport indicators, LU indicators, etc)
     - Textfiles for every indicator for each simulation year
- Run time for a single run (30 year simulation) ~ 3 minutes





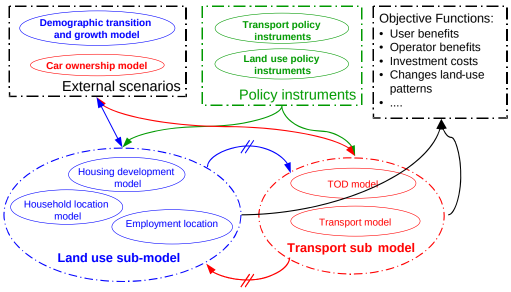
## MARS-model as it is: Software details

- MARS is implemented in Vensim (System Dynamics programming environment)
- (code is generated automatically – programming is done via a graphical editor)
- Data front-end is still Excel
  1. Data input file which contains information about
     - Transport System
     - Land Use System
     - Calibration data file
  2. Output
     - Automated graphs and table within VENSIM environment (transport indicators, LU indicators, etc)
     - Textfiles or Excels files for every indicator for each simulation year
- Run time for a single run (30 year simulation) ~ less than 1 minute
- Model can be distributed using Vensim Model Reader (runtime version)





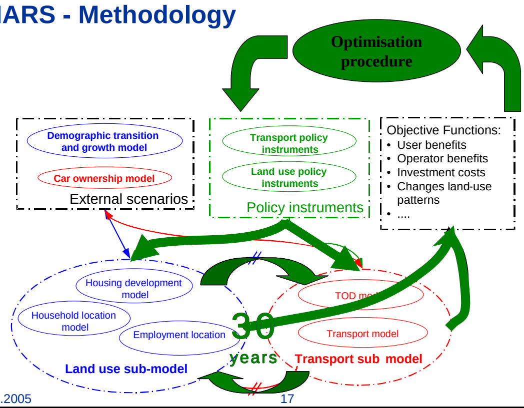
## MARS-Model description








## MARS - Methodology



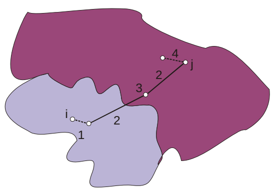





## Public transport

A journey with the mode transport consists of four different parts:

- Walking from the source to the public transport stop
- Driving from the public transport stop to the destination
- Changing time
- Walking from the public transport stop to the destination






3

## Friction factor PT

$$f(t_{ijPT}) = t_{W,to,i} * SV_{W,to} + t_{W,i} * SV_W + \sum t_{DR,ij} + \sum t_{Ch,ij} * SV_{Ch} + t_{W,from,j} * SV_{W,from} + R_{C,ij}$$

| | |
|---|---|
| $t_{W,to,i}$ | Walking time from source i to public transport stop (1) |
| $SV_{W,to}$ | Subjective valuation factor walking time from source to public transport stop |
| $t_{W,i}$ | Waiting time at public transport stop i |
| $SV_W$ | Subjective valuation factor waiting time at public transport stop |
| $t_{DR,ij}$ | Total driving time from source i to destination j (2) |
| $t_{Ch,ij}$ | Total changing time from source i to destination j (3) |
| $SV_{Ch}$ | Subjective valuation factor changing time |
| $t_{W,from,j}$ | Walking time from public transport stop to destination (4) |
| $SV_{W,from}$ | Subjective valuation factor walking time from public transport stop to destination |
| $R_{C,ij}$ | Impedance from costs travelling from i to j |

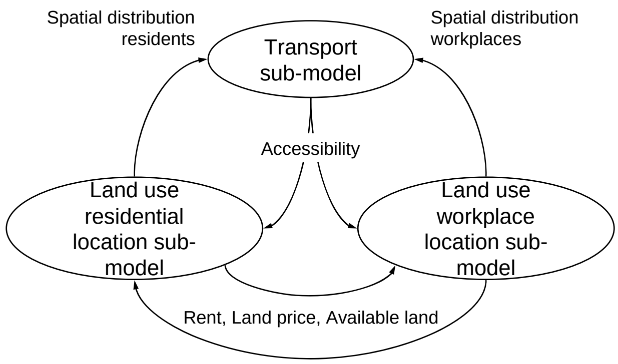
$$R_{Cij} = \frac{C_{PTij}}{\alpha * Inc_{HH}}$$

| | |
|---|---|
| $\alpha$ | Factor for willingness to pay (=0.17) |
| $Inc_{HH}$ | Household income per minute |





## Land Use Model








## Current capabilities

Within the MARS model we can evaluate the impacts of combinations of the following policy packages:

| Pedestrians | Pedestrianization | spatial(S) / temporal(T) |
|---|---|---|
| Public Transport | New PT-Infrastructure<br>Fares<br>Frequency | S<br>S/T<br>S/T |
| Private Car | New Roads<br>Road Pricing<br>Parking charges<br>Road capacity increase/decrease<br>Fuel price | S<br>S/T<br>S/T<br>S/T<br>S |
| Land use measures | Controls on development<br>Land use charges | S<br>S |





## Data requirements

### Transport model

- **Average trip distance between and within the zones**
- **Average travel speed for all modes (pedestrian, bike, bus, tramway, metro and private car)**
- **Average distance between a parking space and source/destination for each zone**
- **Average time to find a parking space for each zone**
- **Average distance between a public transport stop and source/destination for each zone**
- **Average public transport waiting and change time for each source – destination combination**
- **Fuel costs per vehicle kilometre private car**
- **Other costs per vehicle kilometre private car**
- **Average occupancy private car**
- **Parking costs private car**
- **Costs per trip public transport**





## Data requirements

### Housing development model:

- **Development of businesses in the FUR (Functional Urban Region)**
- **Average rent per modelled zone i (and time)**
- **Building costs per modelled zone i (and time)**
- **Potential floor space per land in each zone i**
- **Development area available in each zone i (and year)**

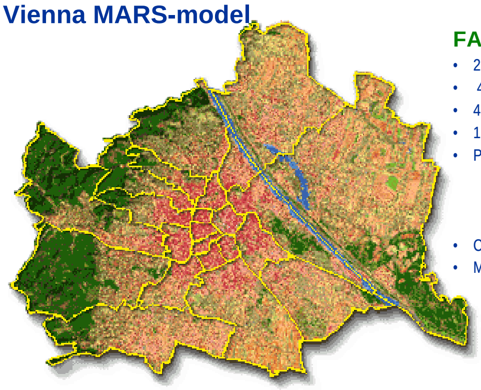
### Household location and employment model

- **Number of residents in the FUR**
- **Number of new- and relocating households in the FUR**
- **Number of dwellings per zone i in year 0**
- **Density of living per zone i**
- **Indicator for quality of living (percentage green areas,...?)**
- **Number of workplaces per zone i in year 0**
- **Available premises per zone**





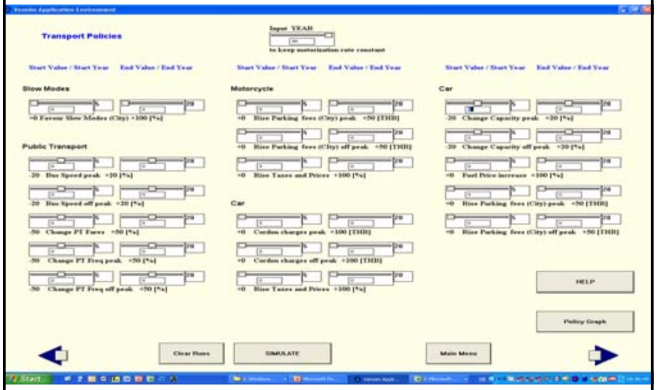
## Vienna MARS-model



### FACTS

- 23 Zones
- 4 external Regions
- 415 sqkm
- 1.6 Mio. Inhabitants
- PT System:
  - Tram (233 km)
  - Underground (62km)
  - Busnetwork (623 km)
- Cars per 1000 inh.: 354
- Modal Split:
  - 27.6% Slow modes
  - 27.2% PT
  - 45.3% car

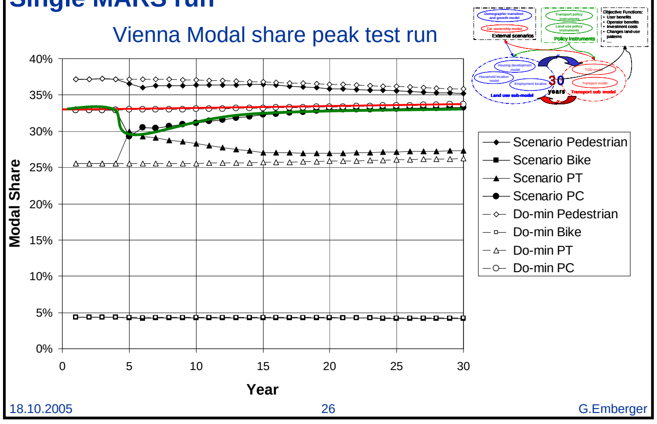
## MARS VENSIM user interface







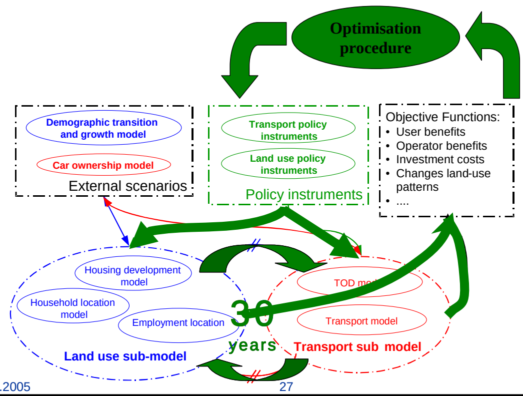

## Single MARS run







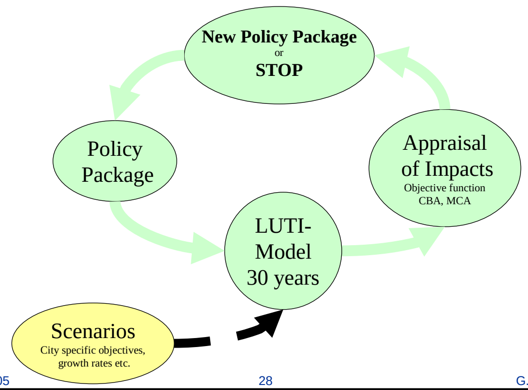

## Optimisation Process








## Optimisation Process








## Objective function

Objective Function
consists of a weighted sum of

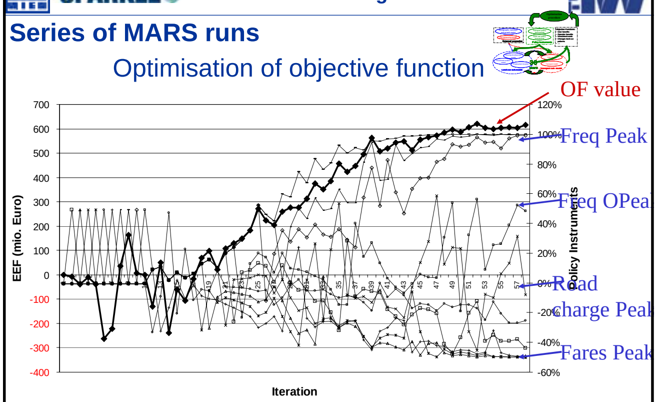
- User benefits
- Operator benefits
- Investment costs
- Changes in Land-use
- Environmental costs

over a period of 30 years
discounted to net present value





## Series of MARS runs



## Appraisal framework

Objectives for sustainability

- Protection of the environment
- Accident reduction Safety
- Economic efficiency
- Equity and social inclusion
- Economic growth
- Liveable streets and neighbourhoods

CBA - Objective Function weighted sum of

•User benefits
•Operator benefits
•Investment costs
•Changes in Land-use
•Environmental costs

over a period of 30 years discounted to net present value

We are looking for the **maximum** OF value !





## Appraisal framework

Objectives for sustainability

- Protection of the environment
- Accident reduction Safety
- Economic efficiency
- Equity and social inclusion
- Economic growth
- Liveable streets and neighbourhoods

Indicator/Target (I/T) approach weighted sum of target fulfilment

•Nox [tons/day], CO [tons/day],VOC tons/day]Noise [Euro/year] -5%
•Accident costs [Euro/year] -5%
•Journey times per mode (per mode in min) -1%;-5%,-1%
•Accessibility for those with/ without car
•not calculated 1%;5%,1%
•CO2 [tons/day] -3,5%

We are looking for the **highest** target fulfilment





## Summary

- strategic modelling was proved to be useful
- system borders are crucial (temporal and spatial)
- be aware that models always cover just a part of realty
- don't interpret sth. into model results what is not in the model
- try to see the forest and the trees at the same time





## For what we have used MARS so far

- Identification of optimal policy combinations (mostly Cordon charge, PT-frequency and PT fare level)
- Identification of elasticities of individual instruments
- Comparison of same set of instruments on different cities
  - using the same model
  - using different models
- Identification of impacts of used appraisal framework onto optimal strategies (CBA vs Indicator based approach)
- Identification of feasible targets (eg. a 20% CO2 reduction cannot achieved within the tested instrument ranges)
- Identification of barriers (technically, politically)
- Training purposes





mars Model

Thank you for
Your attention!

Acknowledgement to
Paul Pfaffenbichler

Guenter Emberger
TUW-IVV





- Show the input data file
- Show the application
- Show if time the development environment