Institute for Transport Studies
FACULTY OF EARTH AND ENVIRONMENT

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Developing Sustainable Urban Mobility Plans: the role of interactive land use - transport interaction models

Professor Anthony D May

Emeritus Professor of Transport Engineering

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European policy

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- Urban transport imposes serious problems
  - Urban congestion costs €80bn p.a.
  - 38% of all road fatalities
  - 23% of transport CO_2, 8% of total CO_2
- Urban areas account for 70% of people, 80% GDP
- Thus urban transport cannot be left solely to cities
- 2011 White Paper
  - Supports the development of Sustainable Urban Mobility Plans
  - Encourages incentives, expert assistance
- 2013 Urban Mobility Package
  - New SUMP guidelines

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Characteristics of a SUMP

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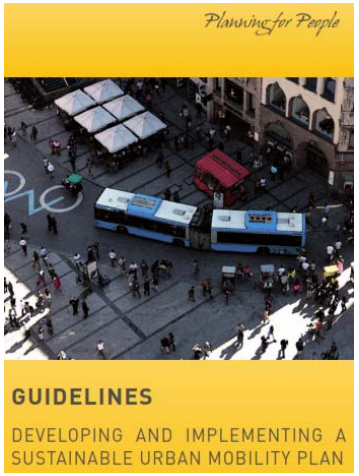
- Long term vision and strategy
- Participatory involving citizens and stakeholders
- Committed to sustainability in all its dimensions
  - Economic, environmental, social
- An integrated approach
  - Between modes of transport (and types of instrument)
  - Between policy sectors
  - Between neighbouring authorities
  - Between tiers of government
- Cost-effective, affordable, solutions to meet agreed targets



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The SUMP cycle (actually a spiral)

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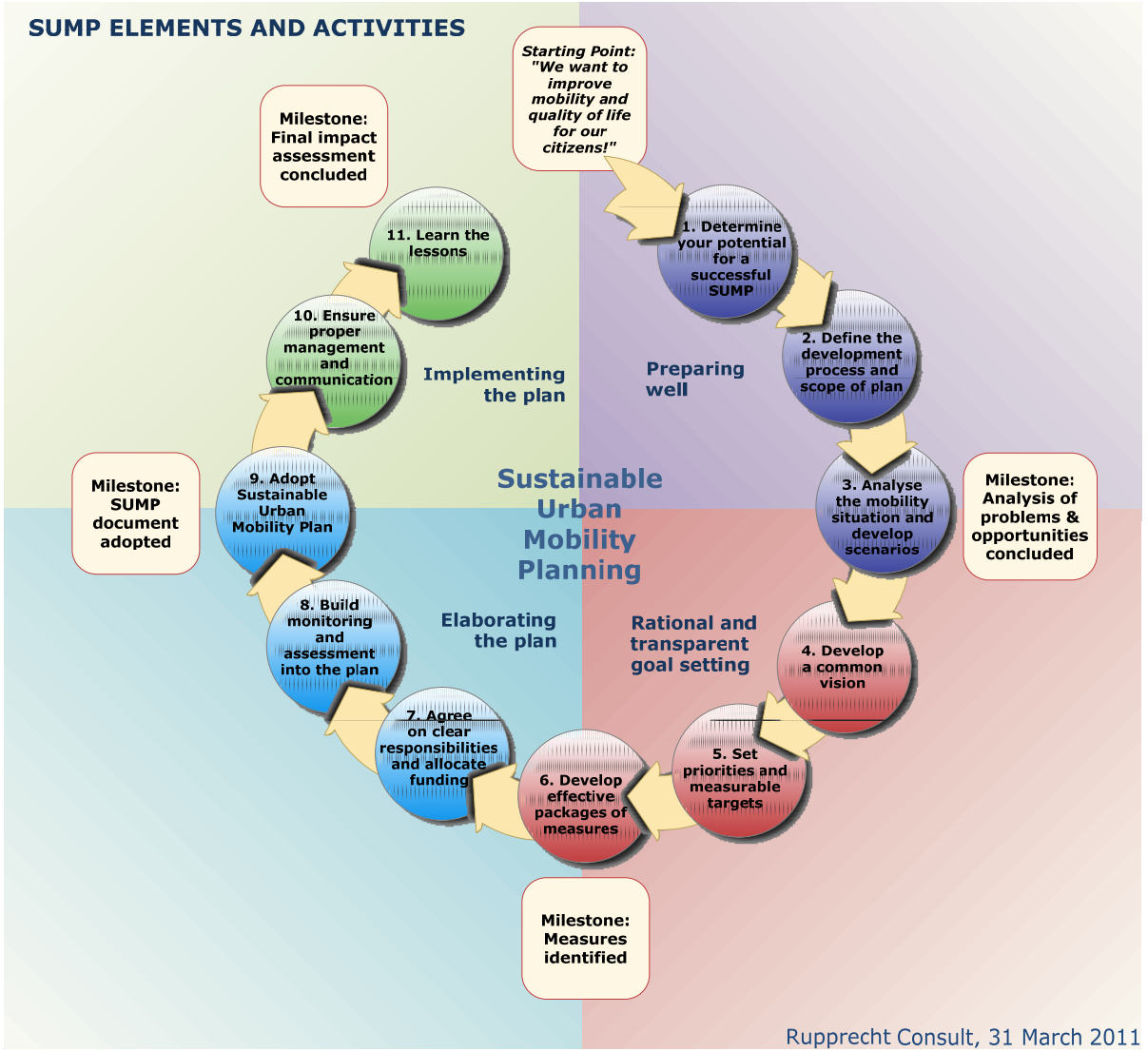

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Element 6: Develop effective packages of measures

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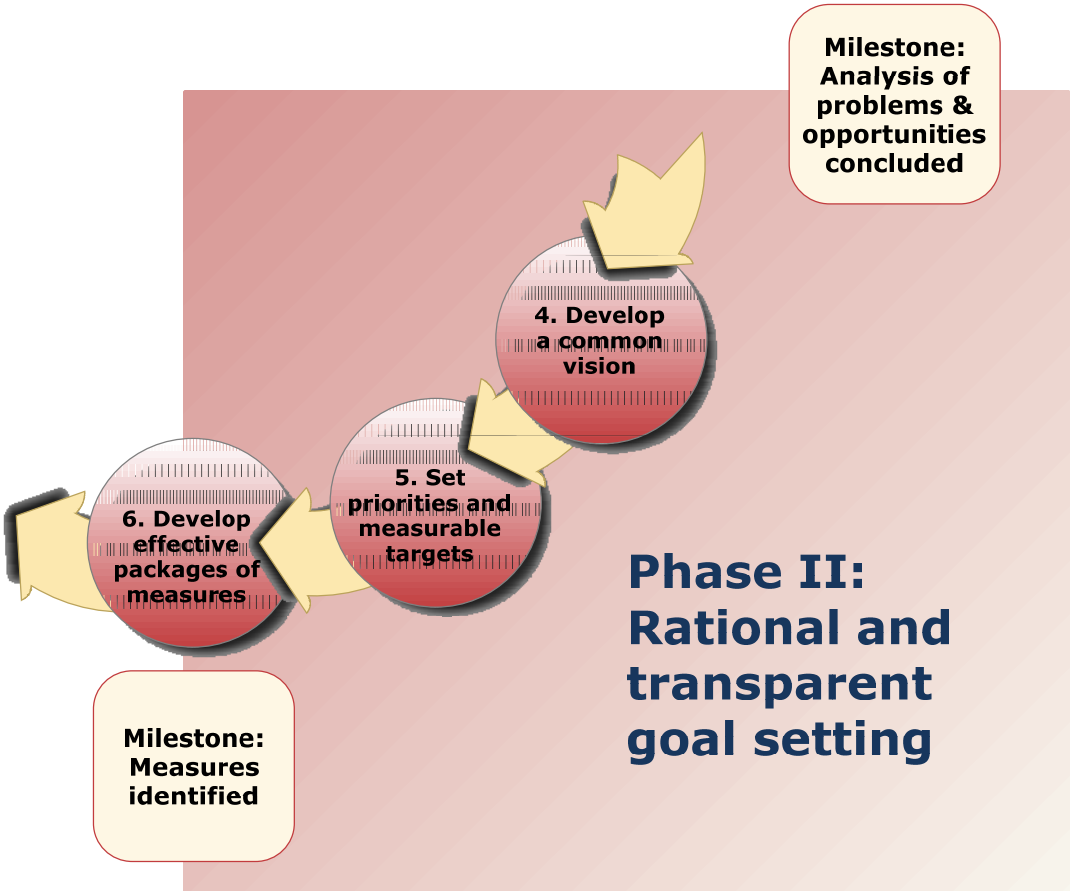

Element 6 Option Generation tasks

- 6.1: Identify the most effective measures
- 6.2: Learn from others' experience
- 6.3: Consider best value for money
- 6.4: Use synergies and create integrated packages of measures

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The Option Generation problem

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"Unless a wide range of appropriate options is considered, there is a risk that the best options are overlooked and money could be wasted.

A good option generation process is crucial to ensure that the transport interventions that offer the highest returns can be found.

The full range of options should look across all modes and include making better use of the existing transport system, including better pricing, investing in assets that increase capacity ... investing in fixed infrastructure, and combinations of these options".

[Eddington, 2006]

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The SUMP process in outline

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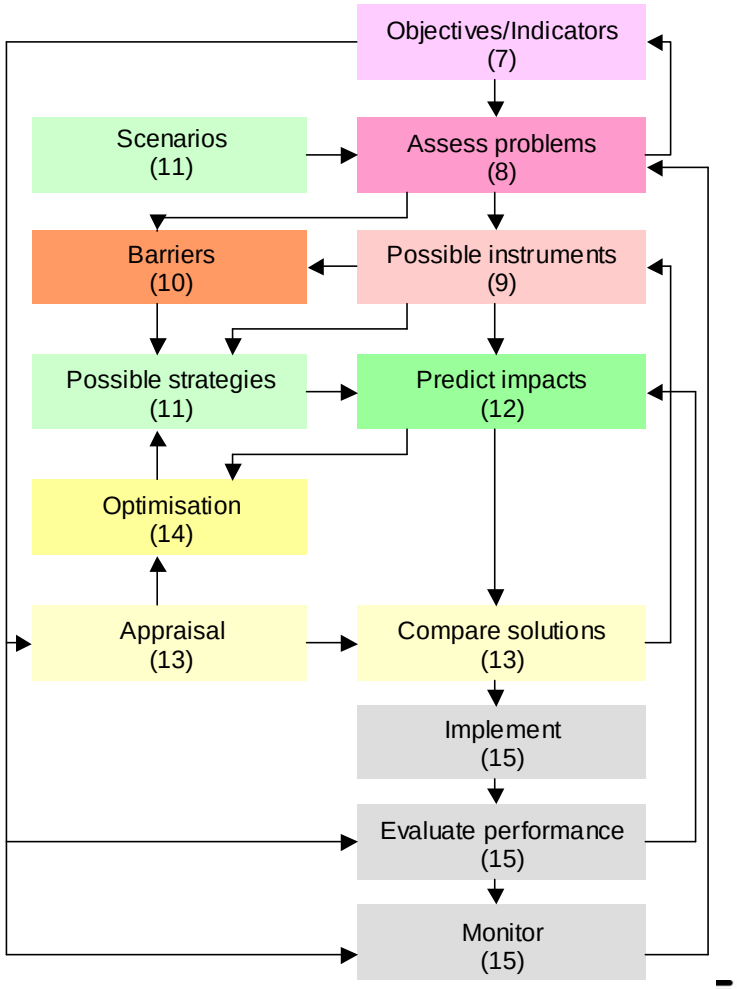
- A logical structure for transport policy formulation
- Included in the 2005 European Decision-Makers' Guidebook
  - In www.konsult.leeds.ac.uk
- Encouraging a logical sequence for problem solving
- While accepting that conventional decision-making is not necessarily so sequential
- A simpler version of the SUMP cycle



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Identifying possible measures

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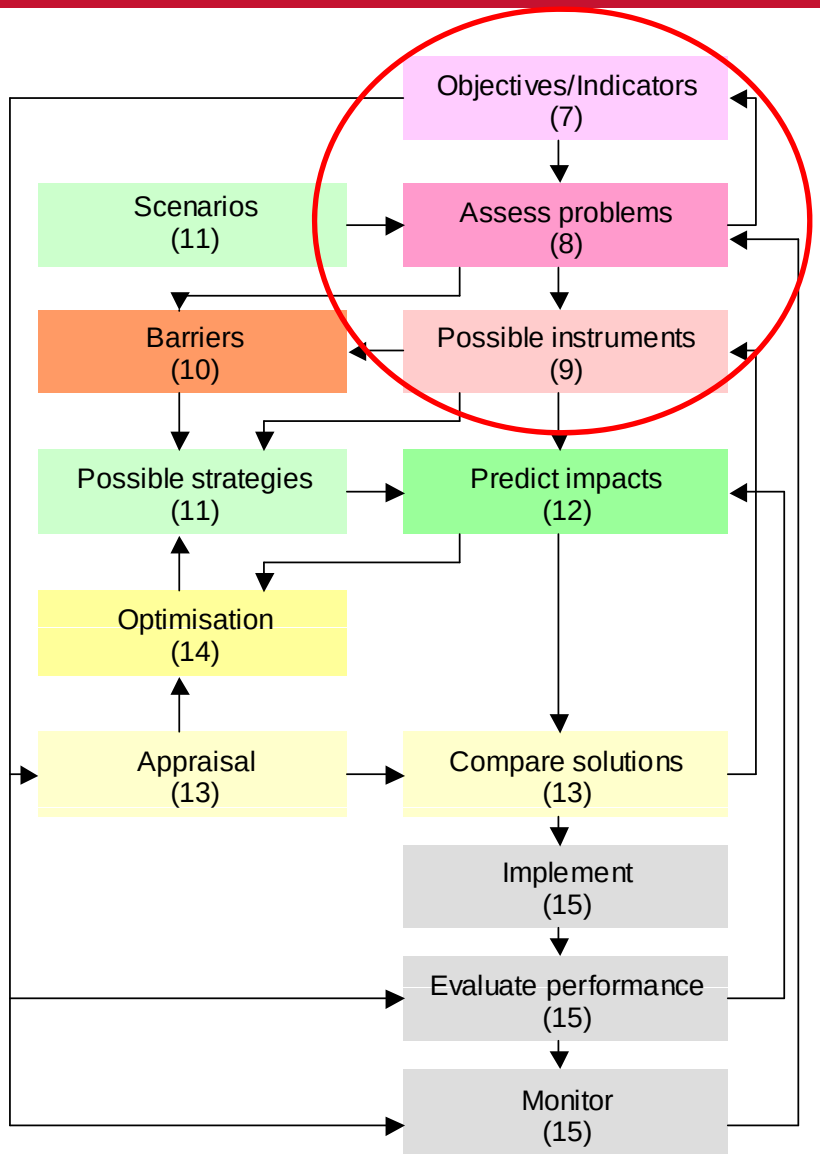

- The starting point
  - What are our objectives?
  - How can we measure them?
  - What are the problems which we face now and in the future?
- Answers to these will suggest possible measures
  - Provided that we know which measures are available
  - And what their impacts are

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A growing range of policy measures

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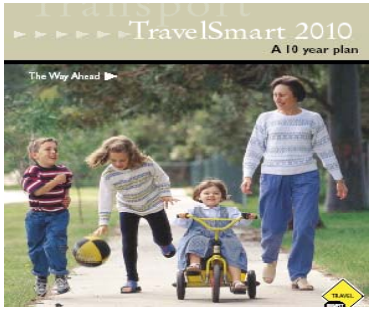
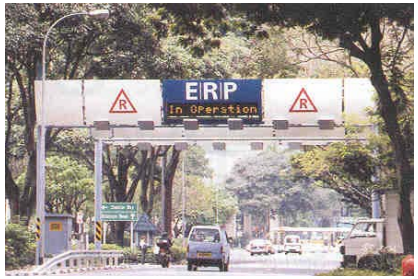
- Management
  - Bicycle sharing
  - Walking buses
- Information
  - Trip planning systems
  - In-vehicle real time guidance
- Awareness
  - Personalised travel advice
  - Company travel plans
- Pricing
  - Road user charging
  - Smart card fare systems
- Perhaps twice as many as in 1984
  - But how much do we know about them?
  - Are we making good use of them?





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Option appraisal

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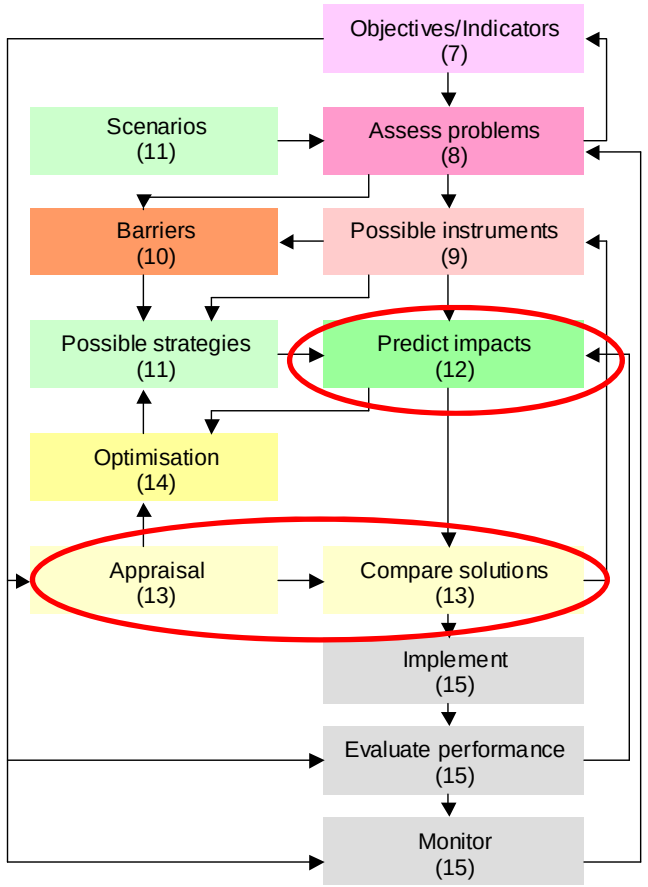
- Predict the impacts of each measure or package
  - Against the agreed objectives
  - Often using a predictive model
- Appraise and compare the options
  - Against agreed objectives
  - Using a formal appraisal process
  - Either approve the “best” option
  - Or go back to the search process



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Enhanced predictive models

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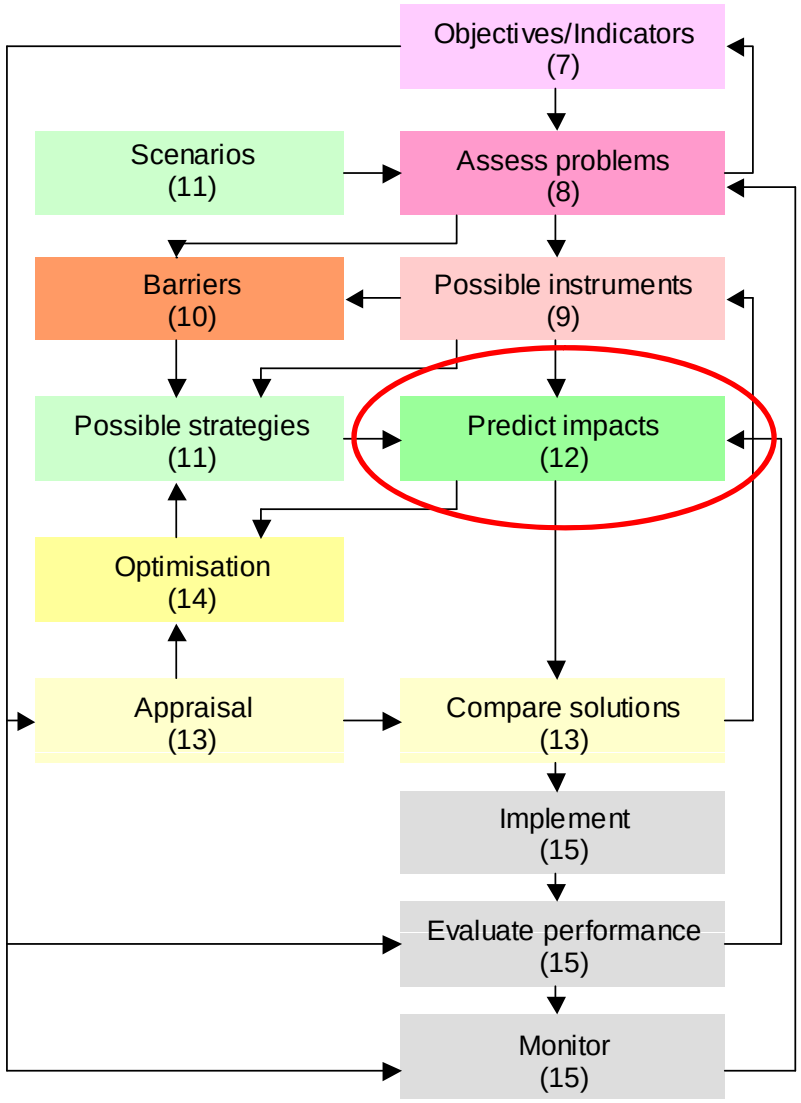

- One third of UK authorities used no model for their Local Transport Plan
- Particularly because of
  - Complexity of models
  - Lack of skills, trust and understanding
  - Inability to model many newer policy measures
  - Inability to reflect some objectives
- So a new approach is needed

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The case for MARS

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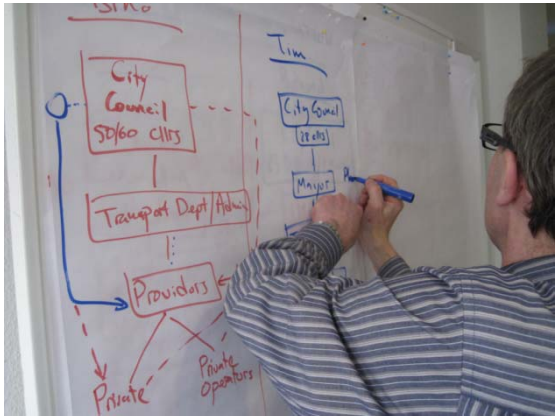
- Effective urban transport strategies require a combination of land use and transport policy measures
- Performance of strategies depends on the mix of measures and the levels of each
- Politicians, stakeholders, public need to be involved
- Hence a fast operating, sketch-planning LUTI model is needed
- Which is easy to use and understand



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The aims of MARS

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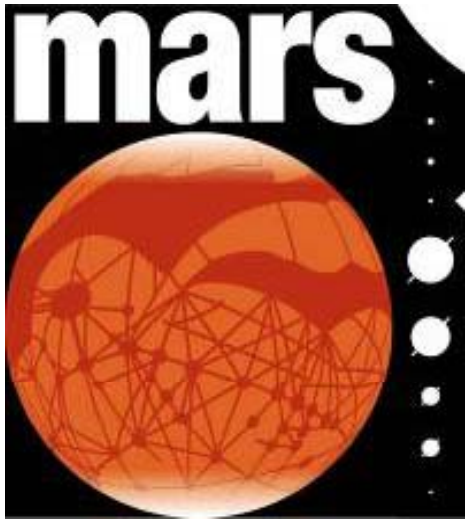
- Enable the user to test a wide range of policies
- Represent resulting interactions between land use and transport over a 30 year period
- Generate an appropriate set of performance indicators
- Operate quickly, producing results within a minute
- Be easy for the user to understand and interact with
- Facilitate stakeholder involvement
- Be used for (constrained) policy optimisation



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Characteristics of MARS

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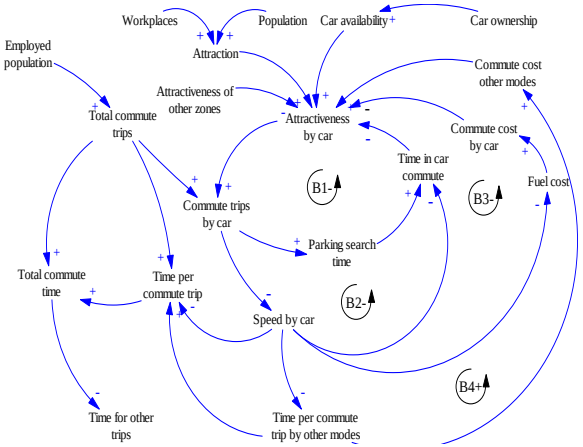
- A very fast land use and transport interaction model
  - Using VENSIM systems dynamics platform
- Works on a high spatial aggregation level
  - Typically one zone per 20k to 50k inhabitants
  - With a simplified area network
- Has a simplified categorisation of users
  - Two person types, purposes, time periods
- Represents up to five modes
- Is deterministic in each iteration
  - But each market is not necessarily in equilibrium
- Utilises the theory of constant travel time budgets
- Adaptation times
  - Transport < I year; land use >5 years



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Leeds model: 750k, 33 Wards

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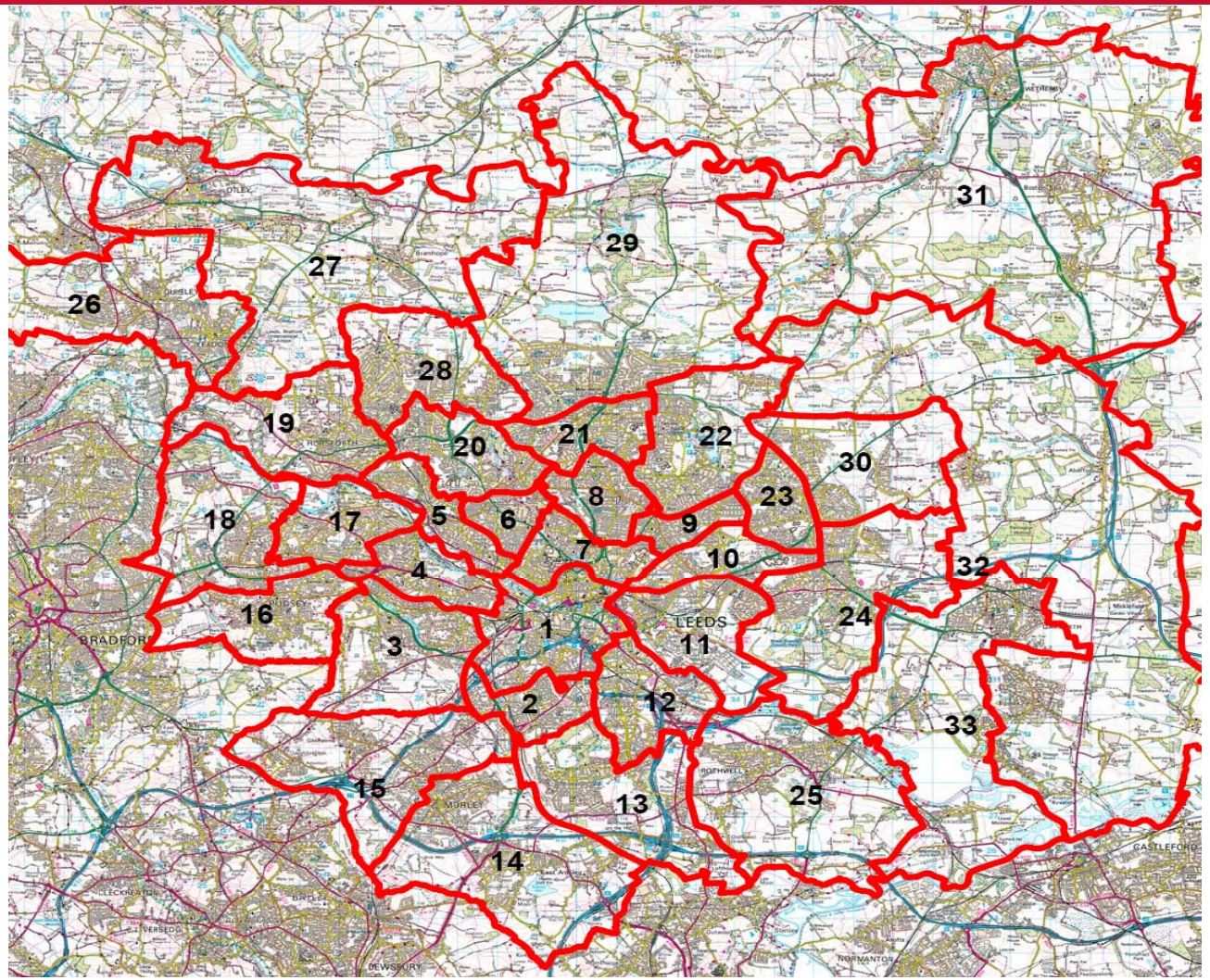

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The structure of MARS

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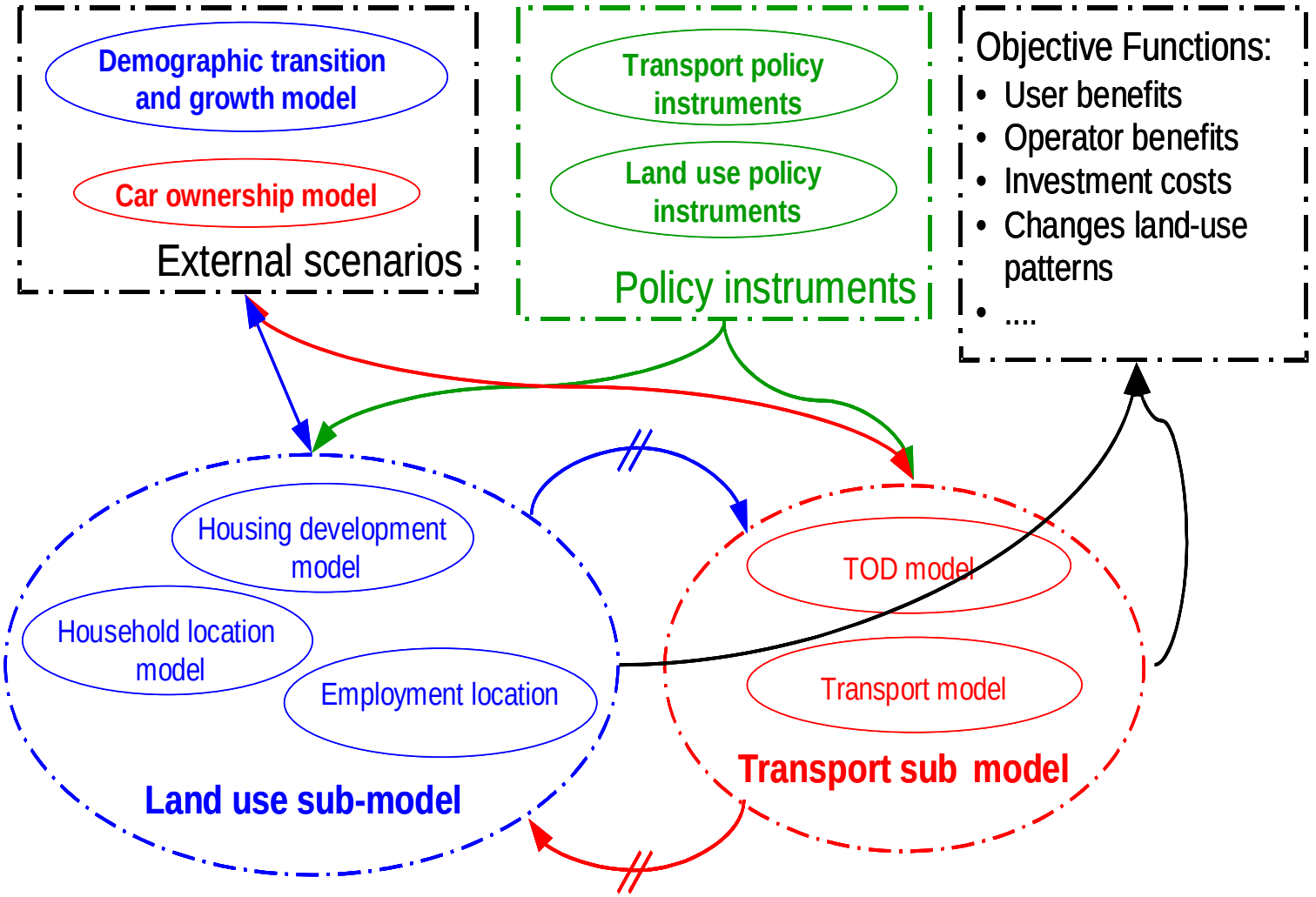

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Cause and effect in VENSIM

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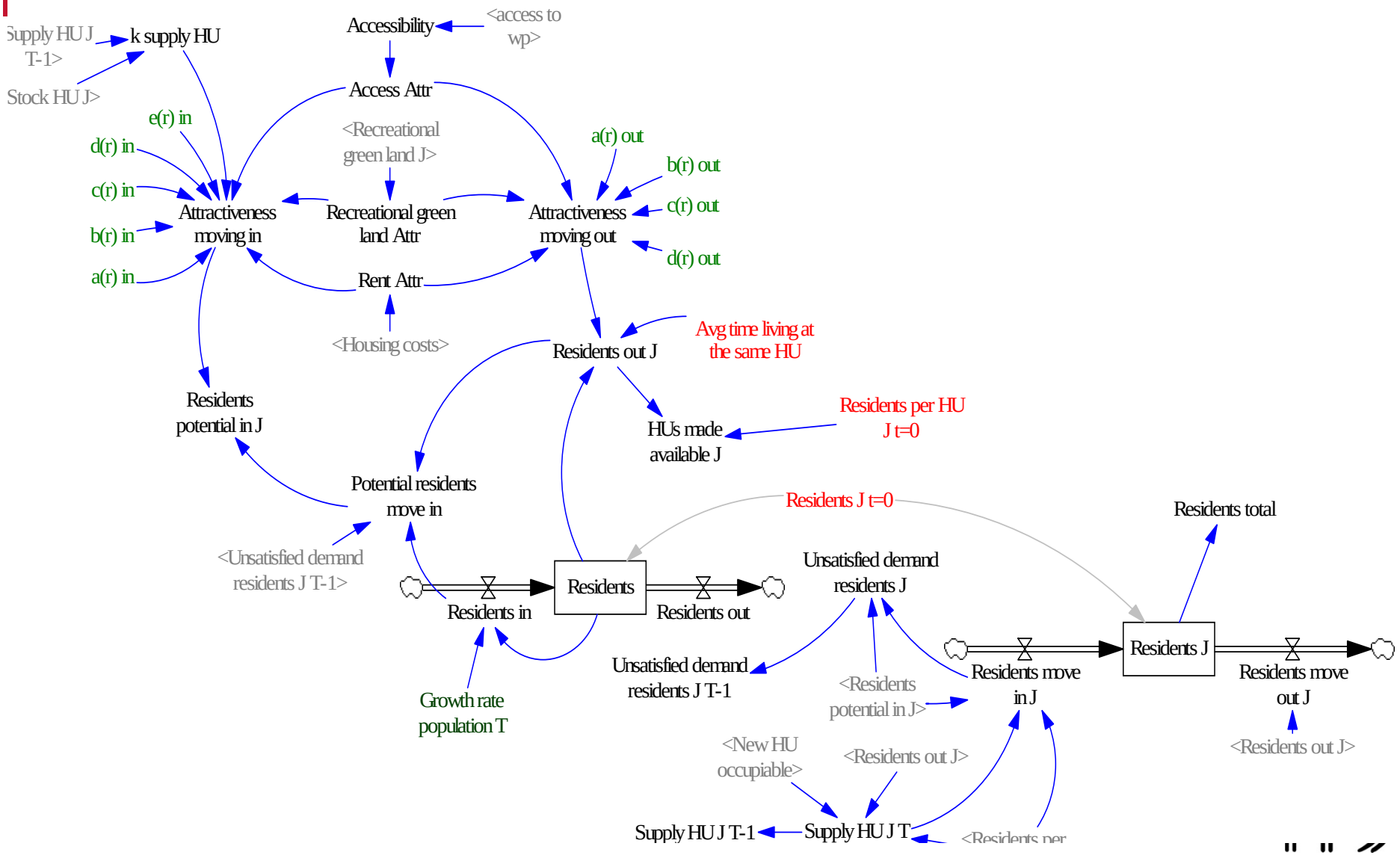

The “flight simulator” policy input screen

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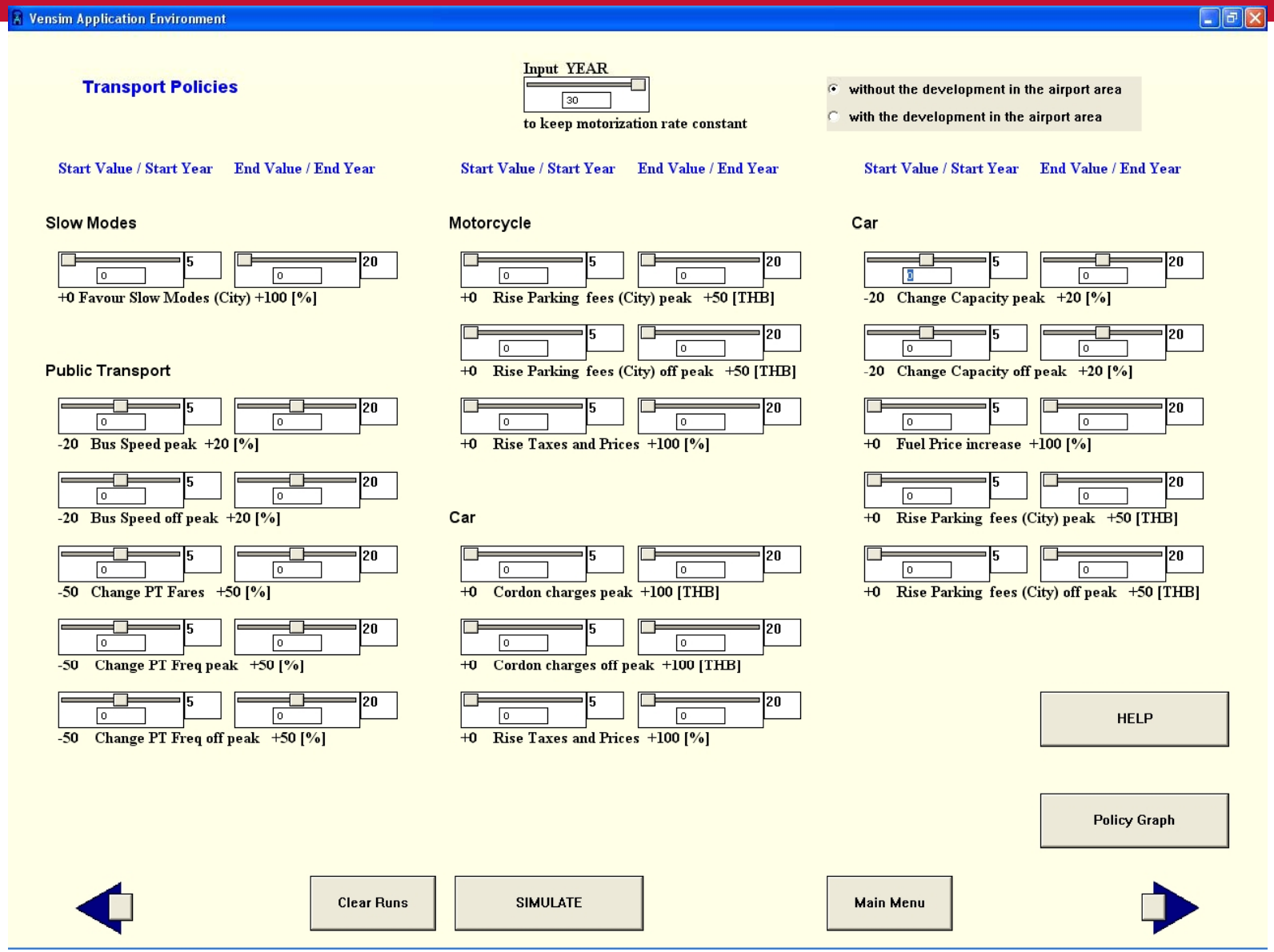

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Policies which can be modelled

S: spatial T: temporal

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Pedestrians	Pedestrianisation	S/T
	Pedestrian/cycling travel time	S/T
Public Transport	New PT-Infrastructure	S
	Fares	S/T
	Frequency	S/T
	Quality factors	S/T
	PRT, cyber cars, BRT	S
Private Car	New Roads	S
	Road Pricing	S/T
	Parking charges/capacity	S/T
	Road capacity increase/decrease	S/T
	Fuel price/tax	S
	Awareness campaigns/teleworking	S/T
Land use measures	Controls on development	S
	Land use charges	S

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Output indicators for UK goals

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Goal	Indicator
Climate change	Annual CO_2 emissions
Productivity	Person-h delay in the peak Economic vitality
Equality	Accessibility by all modes Non-car accessibility
Health and safety	Number of accidents
Quality of environment	NO_x and PM_{10} emissions Proportion of developed land

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Comparing outputs for different tests

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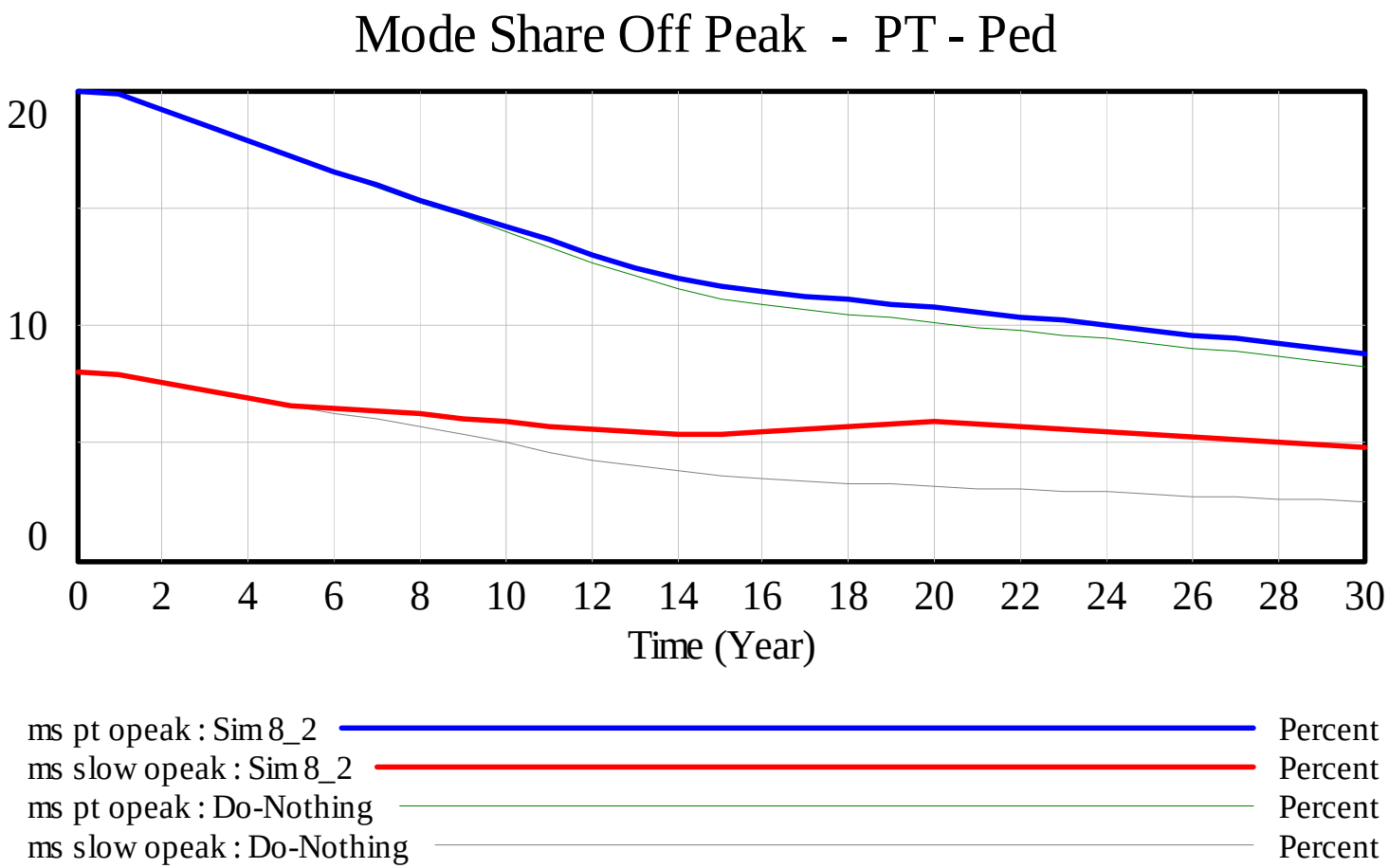

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Normalised performance indicators

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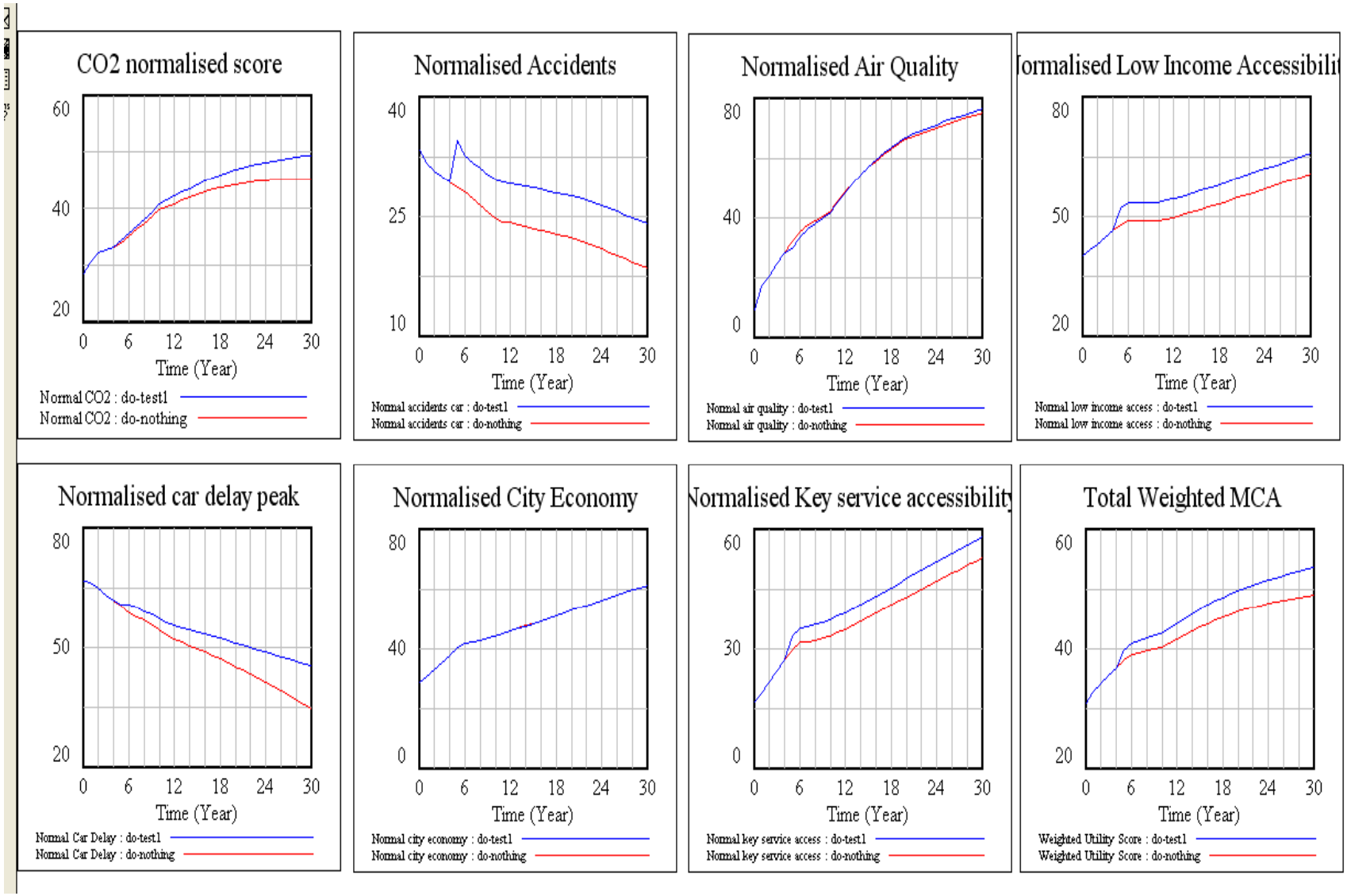

Spatial impacts using ANIMAP

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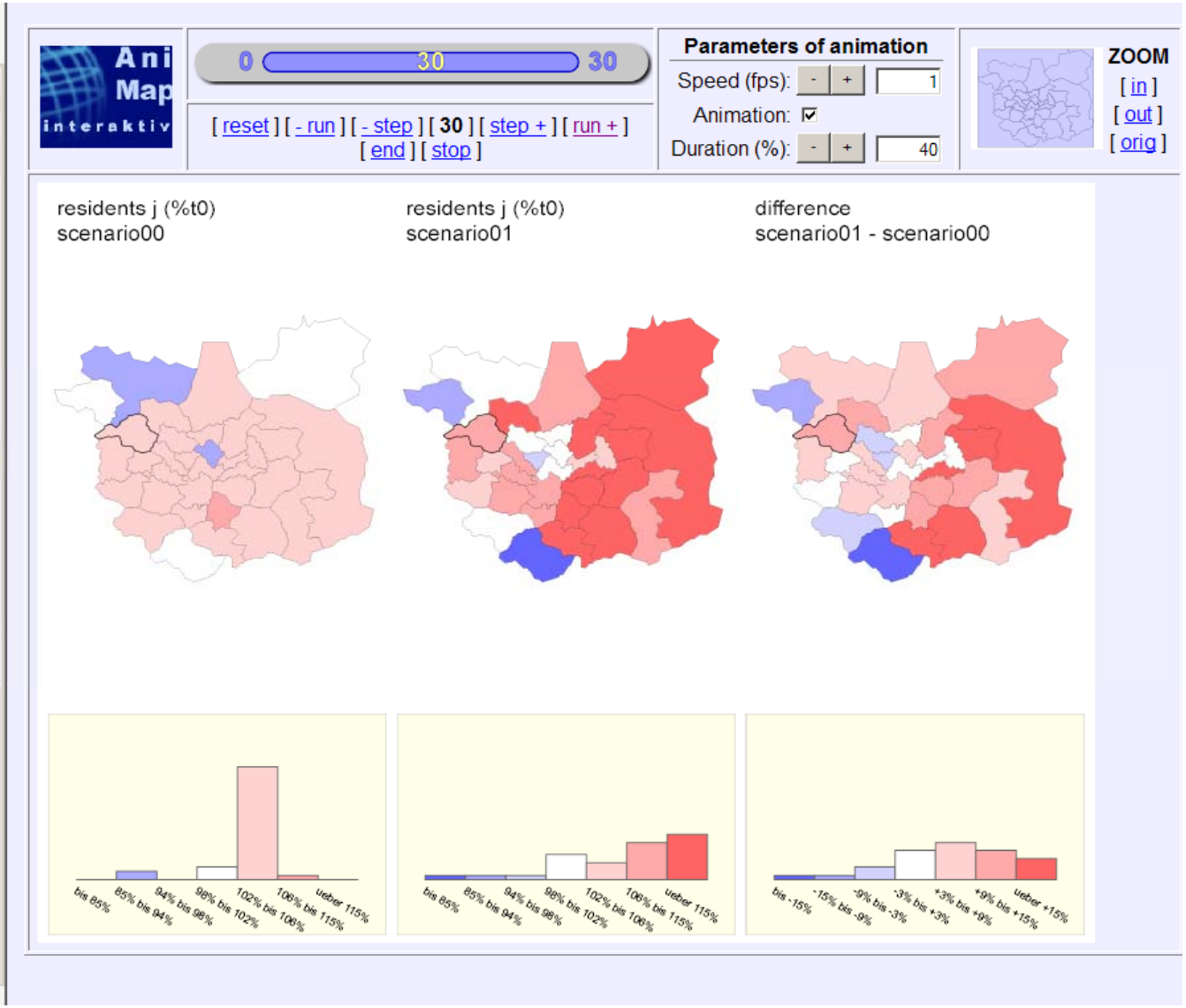

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Integrated assessment of policy scenarios for reducing CO_2 emissions

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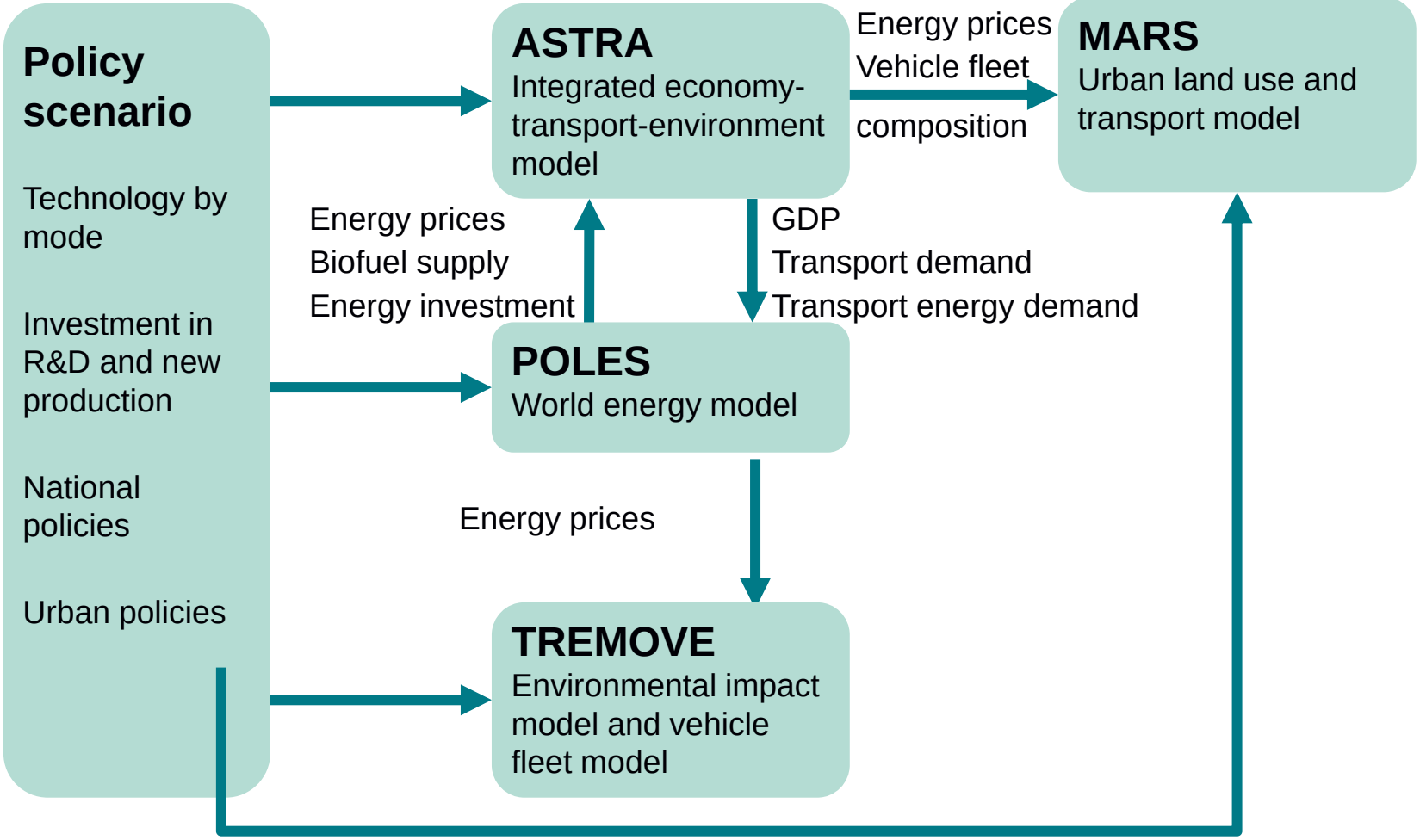

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Trend data for Leeds

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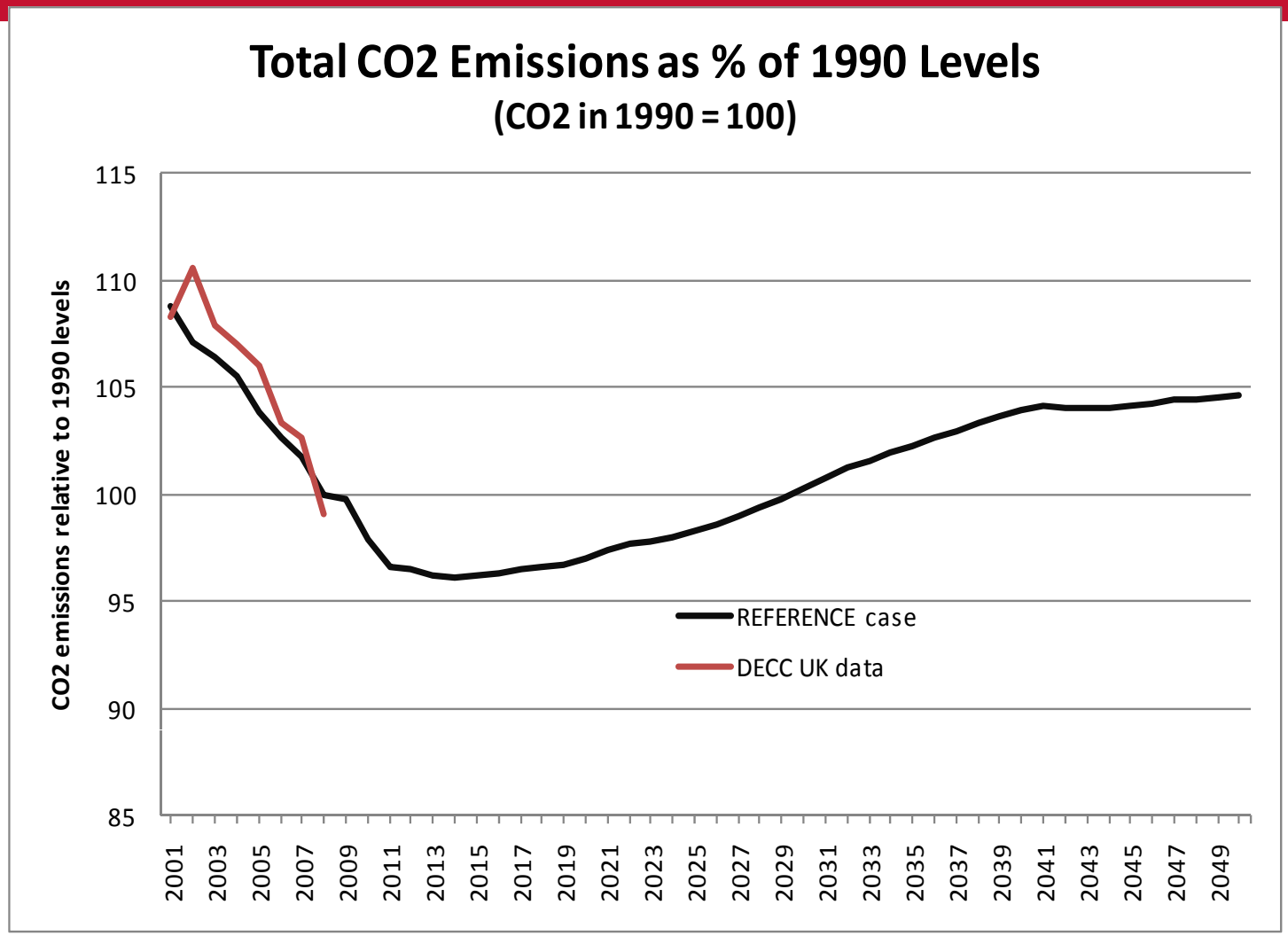

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Emission factors and growth in veh-kms

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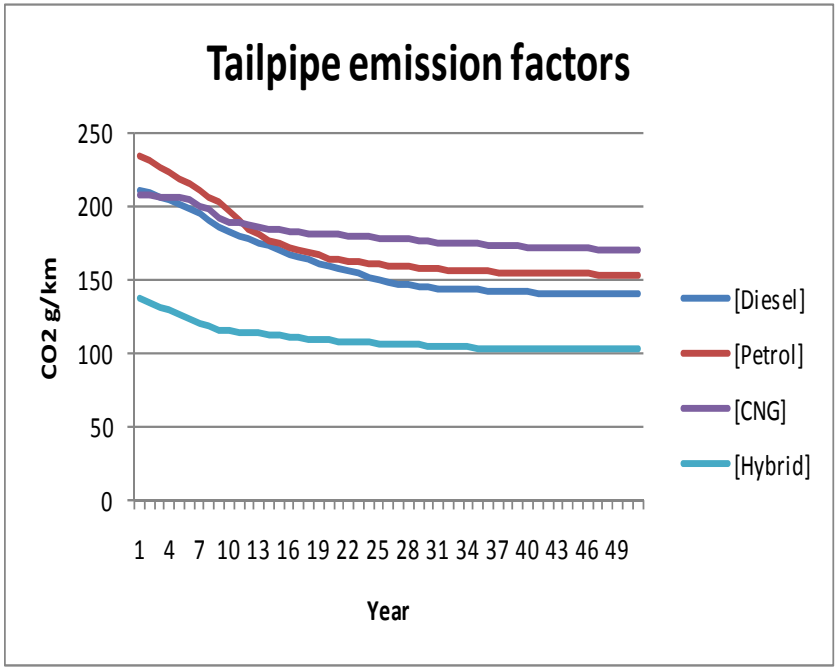

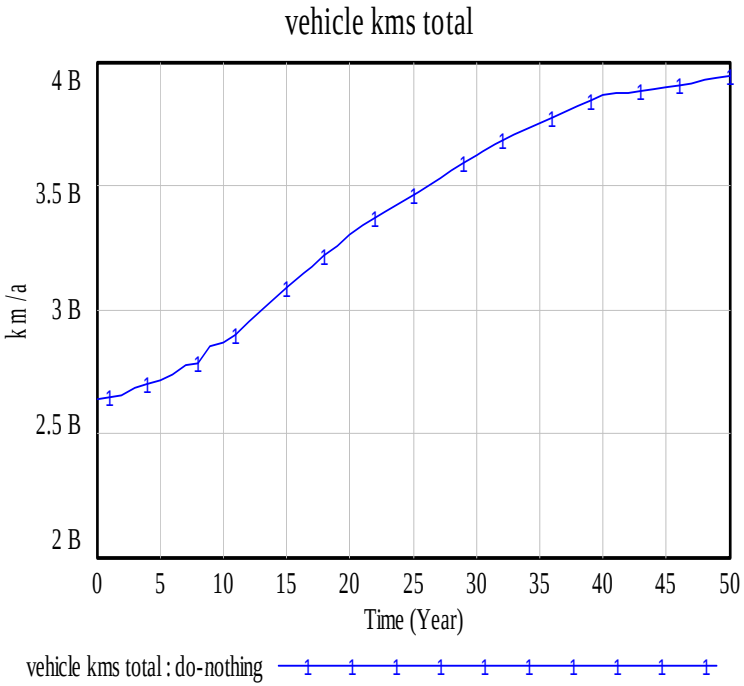

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Urban measures ranked by expected impact in 2050

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1. Walking & cycling visionary (with behaviour change)
2. Walking & cycling visionary (without behaviour change)
3. Smarter choices
4. Walking and cycling basic
5. Urban distance-based charging (7 cents/km)
6. Land use policy
7. Public transport fare reduction (-50%)
8. Public parking spaces (halved)
9. Urban cordon charges (4€ peak, 2€ off-peak)
10. Public parking charges (doubled)
11. Public transport: Trolley bus scheme for Leeds

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CO_2 index 1990 values

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	2020	2030	2040	2050
Reference	97	100	104	104
Walking & cycling visionary (with behaviour change)	89	78	61	54
Walking & cycling visionary (without behaviour change)	90	91	95	96
Smarter choices	94	95	99	100
Walking and cycling basic	96	100	104	105
Urban distance-based charging (7 cents/km)	92	96	100	101
Land use policy	96	99	103	103
Public transport fare reduction (-50%)	95	99	102	103
Public parking spaces (halved)	95	96	98	97
Urban cordon charges (4 euro peak, 2 euro off-peak)	97	100	104	104
Public parking charges (doubled)	97	100	104	104
Public transport: Trolley bus	97	100	104	104

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Walking and cycling visionary package

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- Walking and cycling network uses 20% reduction in distance to reflect ease of access
- Awareness campaign adopted
- Road capacity reduced by 5%
- Bus lanes added to some corridors
- Parking spaces reduced by 10%
- Parking charges in central area doubled
- **Plus behavioural change**

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Emissions with Walking and Cycling visionary

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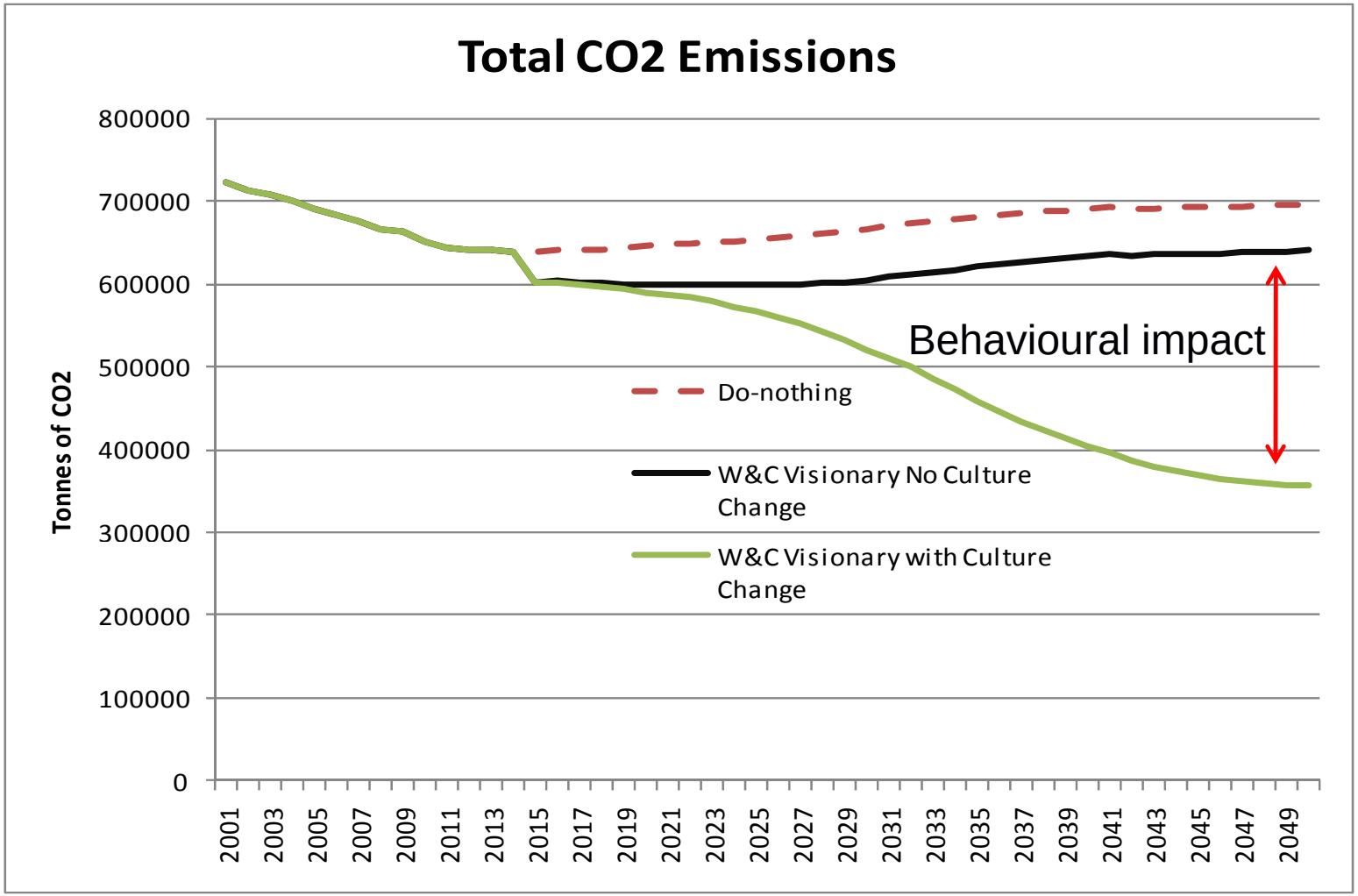

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Scenario packages

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- SC1 – Awareness+ Urban Distance-based Charging

- SC2 – Parking charges double, supply halved, 50% fare reduction, W&C Basic

- SC3 – W&C Visionary + Urban Distance-based Charging

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Packages: CO_2 index 1990 and abatement costs

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	2020	2030	2040	2050
Reference	97	100	104	105
SC1 – Smarter choices + Urban Distance based charging	89	91	95	97
SC2 – Parking charges double, supply halved, 50% fare reduction, W&C Basic	91	92	95	93
SC3 – W&C Visionary + Urban Distance based Charging	83	73	55	48

Abatement costs	User	Authority	Social
SC1	2036	-1708	+328
SC2	-1283	1174	-109
SC3	152	-154	-2

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Some conclusions

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- EC White Paper target -67% CO_2 by 2050
  - IPCC target -80%
- Traditional urban transport measures only contribute 1-5%
- Urban Packages can achieve around 10-11%
- Technology alone can achieve 50%
- We need behavioural change as well to achieve the targets
  - Which involves halving car share in urban areas

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Prioritising transport investments

- The challenge
  - New Combined Authority
  - Involving five local authorities, 2m population
  - Proposed £1 billion West Yorkshire Transport Fund

- New Approach to planning transport investments
  - Target spend set at outset
  - Multi Authority approach
  - Shared strategic objectives

- Successful outcomes dependent on agreements at outset:
  - Objectives
  - Evidence led/needs based
  - Methodology and appraisal

The agreed objectives and indicators

- Primary objective of the Fund is to maximise the increase in employment and productivity

- Two employment accessibility targets are proposed at the package level:
  - A better than average improvement in employment accessibility for residents in the most deprived 25% of WY communities
  - Every WY district to gain an average improvement in employment accessibility no less than half the average across WY

- A neutral carbon impact at the package level

Impact of rising transport ‘costs’ on the objectives

Increasing transport costs will impact on economic growth:

- Efficiency of business markets – rising costs, unreliability and journey times for business/freight reduce accessible markets which will affect productivity
- Shrinking labour pool – harder for employers to recruit as commuters face rising costs/journey times
- Contracting access to jobs – reduced number of jobs within accessible commuting time and distance for workers – worse for deprived communities

Modelled in a dynamic transport, land use and econometric model (the Urban Dynamic Model)

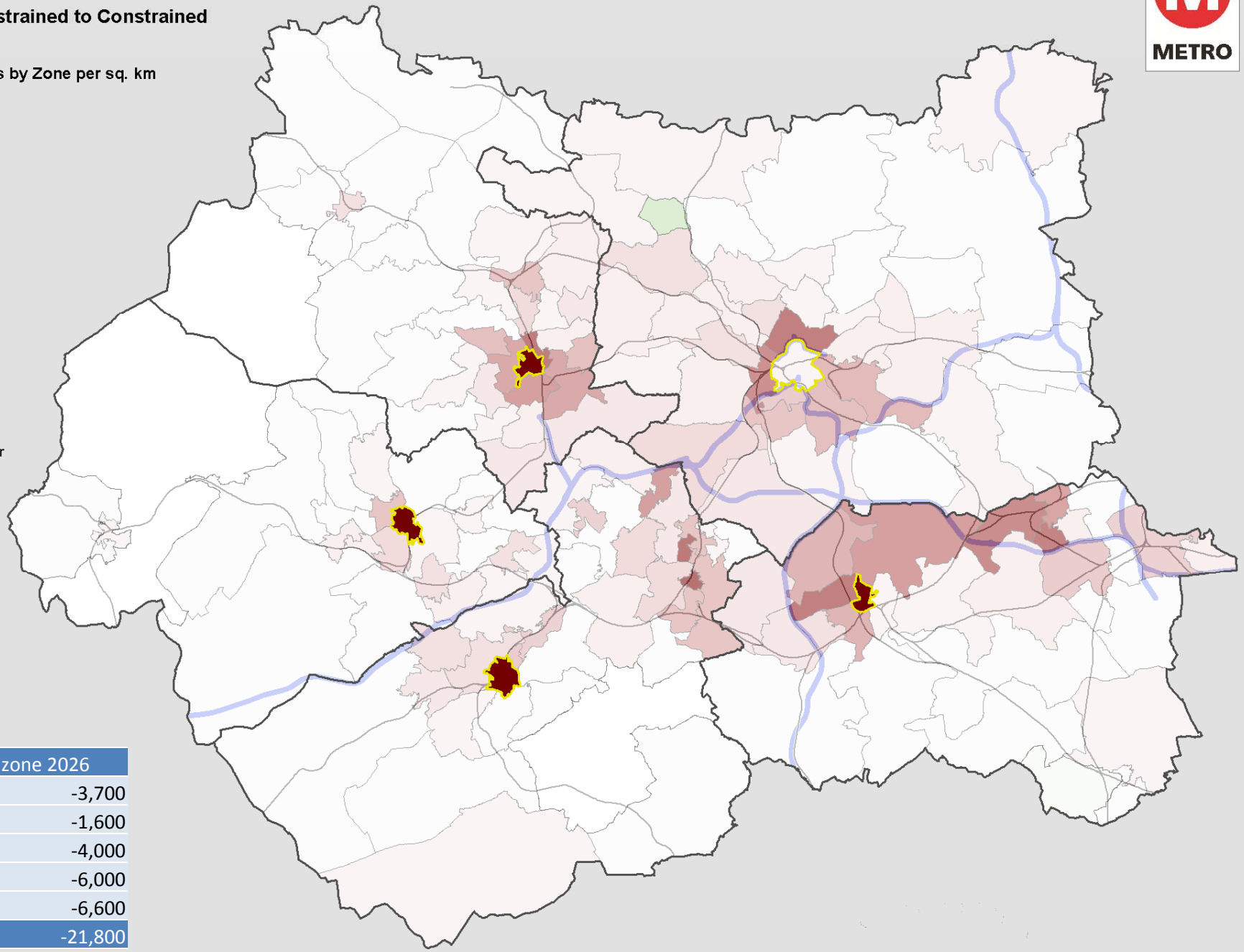
- MARS being developed as an alternative (200 zones: 10min)

Change in Employment Density: 2026

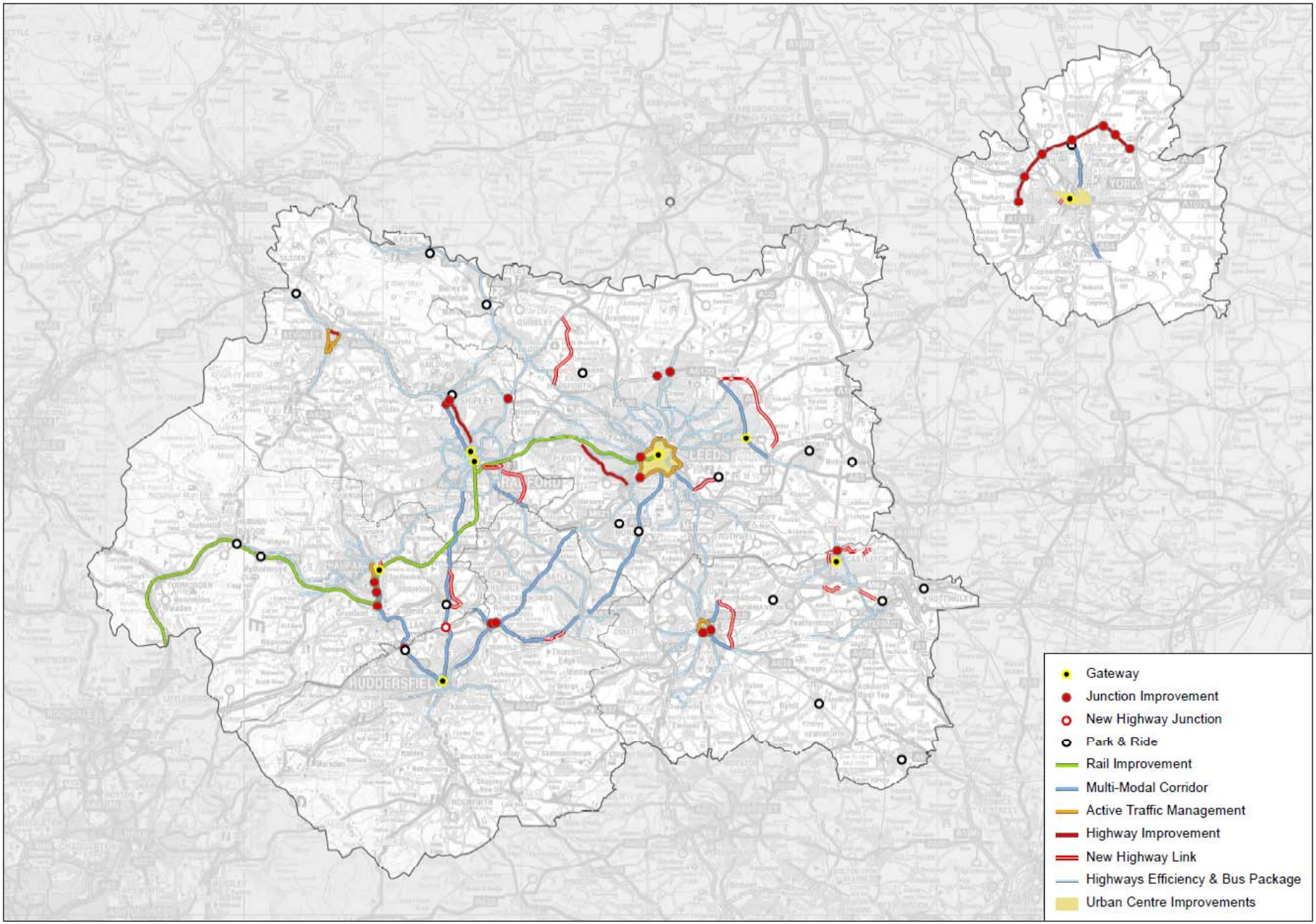
From Unconstrained to Constrained

Change in Jobs by Zone per sq. km

- +200 and over
- +140 to +160
- +120 to +140
- +100 to +120
- +80 to +100
- +60 to +80
- +40 to +60
- +20 to +40
- +0 to +20
- -0 to -20
- -20 to -40
- -40 to -60
- -60 to -80
- -80 to -100
- -100 to -120
- -120 to -140
- -140 to -160
- -200 and under



Jobs filled by zone 2026	
Bradford	-3,700
Calderdale	-1,600
Kirklees	-4,000
Leeds	-6,000
Wakefield	-6,600
West Yorks	-21,800

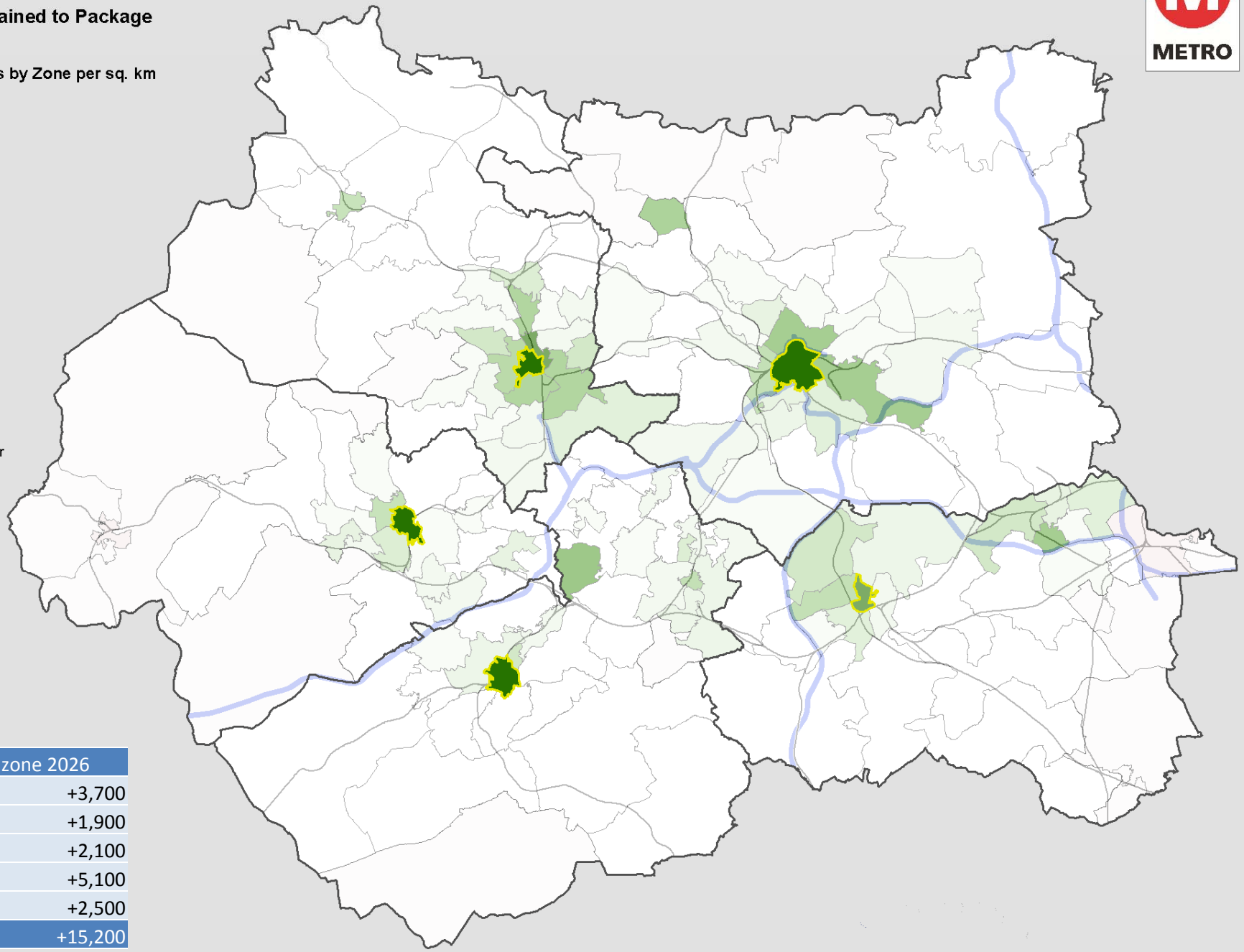

Gateway
Junction Improvement
New Highway Junction
Park & Ride
Rail Improvement
Multi-Modal Corridor
Active Traffic Management
Highway Improvement
New Highway Link
Highways Efficiency & Bus Package
Urban Centre Improvements

Change in Employment Density: 2026

From Constrained to Package

Change in Jobs by Zone per sq. km

- +200 and over
- +140 to +160
- +120 to +140
- +100 to +120
- +80 to +100
- +60 to +80
- +40 to +60
- +20 to +40
- +0 to +20
- -0 to -20
- -20 to -40
- -40 to -60
- -60 to -80
- -80 to -100
- -100 to -120
- -120 to -140
- -140 to -160
- -200 and under



Jobs filled by zone 2026	
Bradford	+3,700
Calderdale	+1,900
Kirklees	+2,100
Leeds	+5,100
Wakefield	+2,500
West Yorks	+15,200

Package effects

- Whole greater than the sum of the parts
  - Travel costs fall
  - Network effects of interaction between schemes
- 18,000 new jobs
- £1.2 billion of Gross Value Added
- 10,000 new homes
- Carbon neutral
- 3% reduction in car commuting
- 28% increase in accessibility

Some strengths and weaknesses

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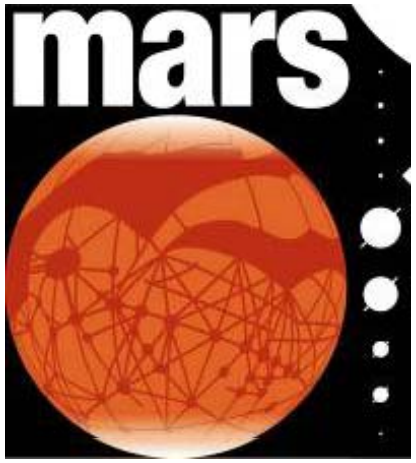
- Land Use Transport Interaction models generally
  - Able to model land use policies and land use impacts of transport
  - But complex, demanding of data and time consuming
  - So more difficult to interpret, and less often used
- MARS
  - Also able to model land use policies and impacts
  - Very rapid to operate, so can be used interactively
  - But only identifies strategic impacts
  - Dependent on assumed fixed travel time budget
  - And still does not include all types of measure



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Future developments

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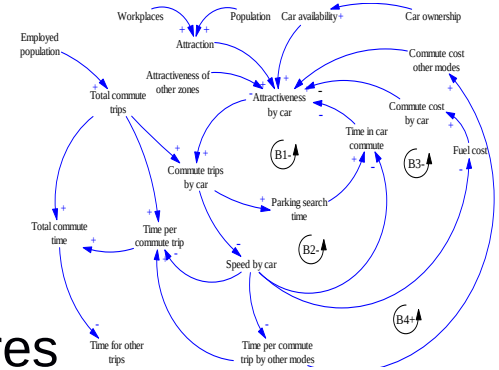
- Systems dynamics to simplify the modelling approach
  - And increase understanding
- Enhanced computing capacity
  - To incorporate more elements
  - Zoning and networks, freight, more policy measures
- Interactive decision-making, with the model used
  - To support conceptual thinking
  - To answer what if? questions
  - To conduct sensitivity tests
  - And answer why? questions



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