Green Logistics and Vehicle Routing

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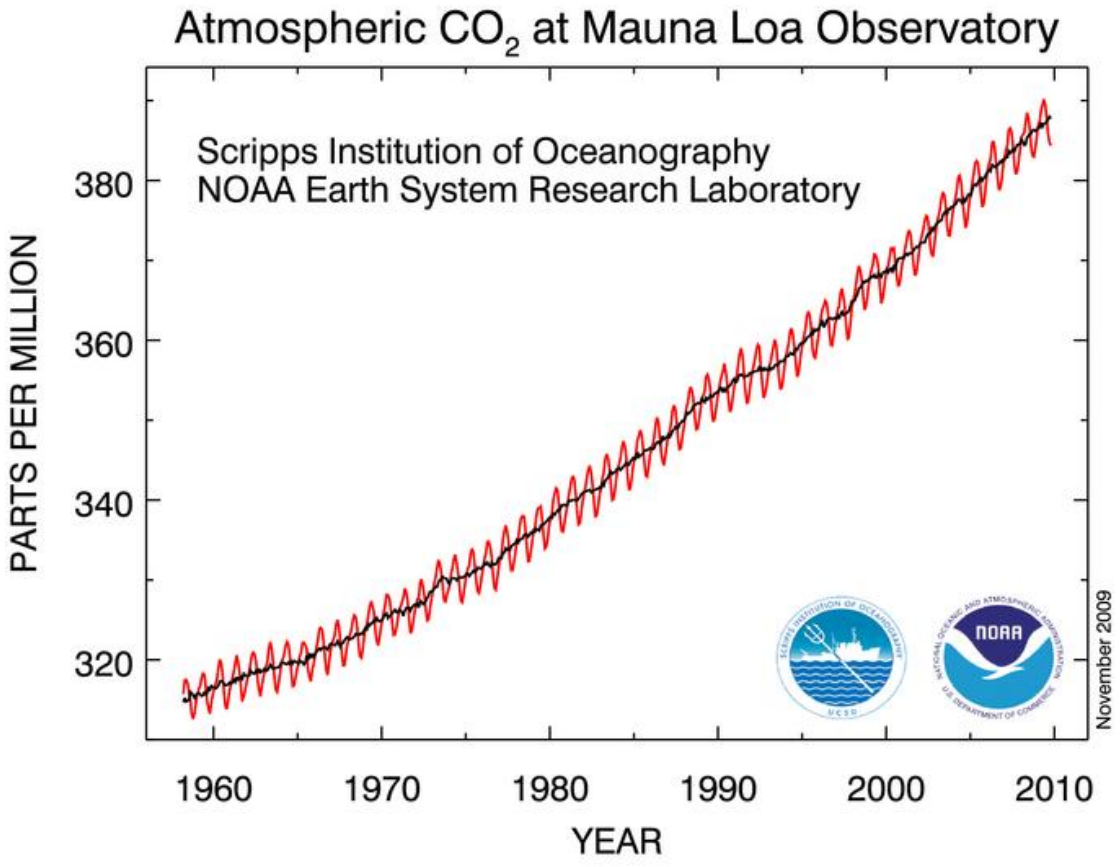
Change in atmospheric CO_2



Monthly mean atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii
Source: National Oceanic and Atmospheric Administration, accessed November 2009 at: http://www.esrl.noaa.gov/gmd/ccgg/trends/co2_data_mlo.html

The climate change debate

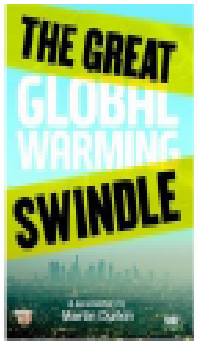
Gradual warming: sea level rise, increasing drought, declining agricultural yields, land becoming uninhabitable, more severe storm damage, loss of biodiversity / extinction of species

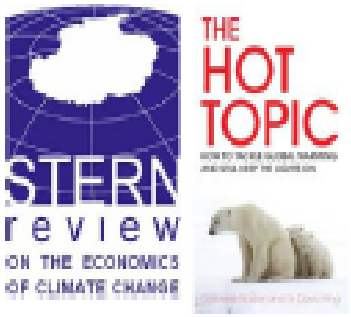
Crossing ecological tipping points:

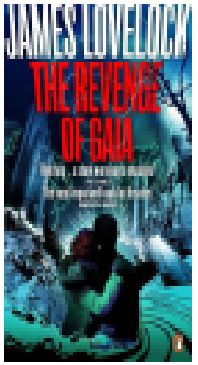
- Warming of tropical rain forest: *switch from CO_2 sink to source*
- Melting of Arctic / Antarctic / Greenland ice-sheets: *sea-level rises by several metres*
- Thawing of the Siberian tundra – *release of methane*

climate change denial → **apocalyptic vision**

We are not to blame / it has happened before / it will be self-correcting / it is a political - economic - scientific conspiracy..	There is a problem but we should concentrate on other priorities	Huge problem requiring urgent response. The necessary change is manageable within existing economic and political frameworks	Mankind's greatest challenge. There is still time, but it will require draconian changes to our way of life	It's too late. Try to preserve our civilisation in an era of runaway climate change







Source: McKinnon, 2008

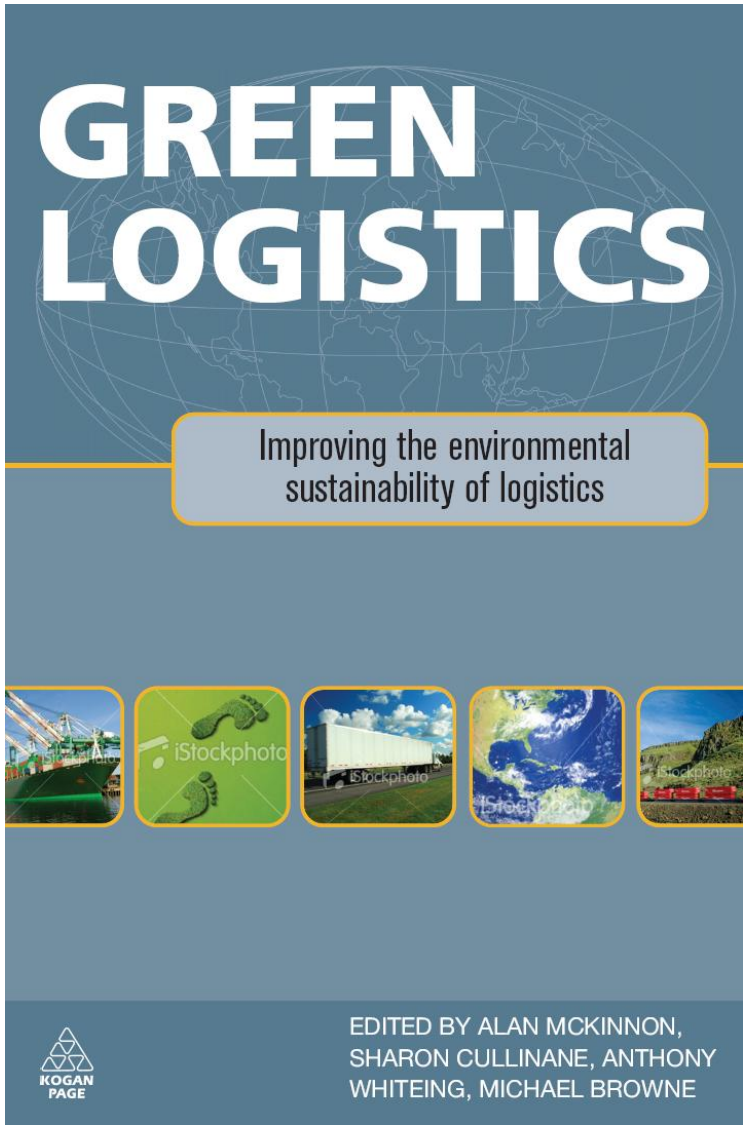
Green Agenda Issues

- To keep the increase in global temperature by 2100 within 1- 2°C it is estimated that CO_2 must be restricted to 450 ppm.
- Governments are introducing carbon reduction targets and policies.

Website

- www.greenlogistics.org
- Information on all work modules
- Latest working papers

New book



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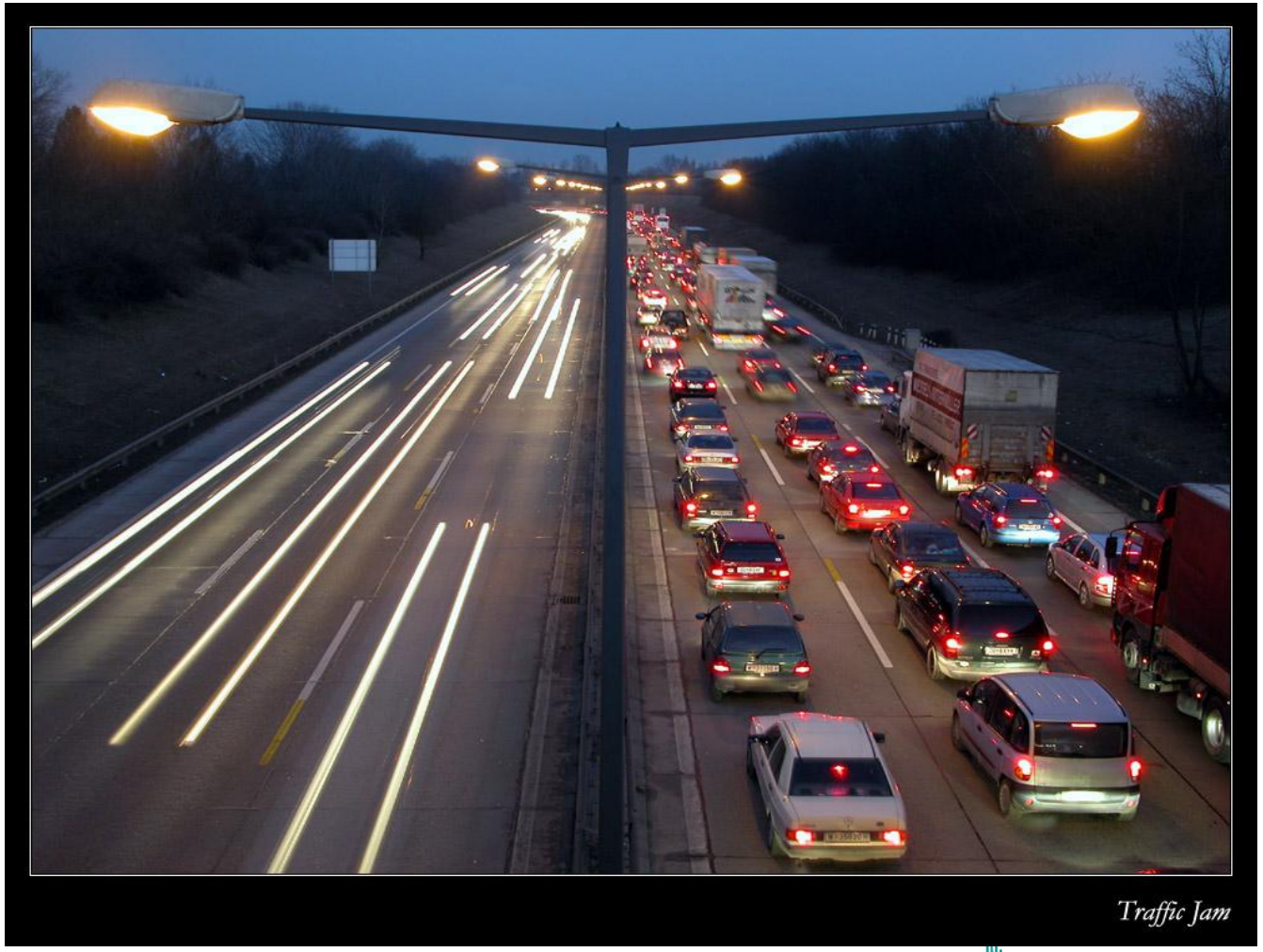
Vehicle routing & scheduling

Can planning vehicle routes and schedules make a contribution?

The problem



The LANTIME scheduler (1)

- Given a set of customers and associated demands, central depot, vehicle fleet
- Objective: Min total time
- Constraints:
  - Vehicle capacity (weight and space)
  - Delivery time windows
  - Driving time for each route

The LANTIME scheduler (2)

- Using time-dependent data requires significant changes to the vehicle routing algorithms
- Maden W., Eglese R. and Black D. (2010) *Vehicle routing and scheduling with time-varying data: A case study.* Journal of the Operational Research Society, Vol. 61(3), pp 515-522.

Case Study

- Electrical Wholesale Distribution in the South West of England from Avonmouth
- Up to 8 vehicles - 3.5 tonne GVW box vans. No restrictions on any roads.
- Weight/Cube - No restrictions
- Time Windows - none
- Time constraint – one 10-hour shift per day including legal breaks
- 40 to 67 customers per day

SOUTH WEST PROPOSED DELIVERY AREAS

Sample solution for one day

Vehicle	1	2	3	4	5	6	7	Total time
A	538	571	573	598	152	501	0	2933

A – using uncongested speeds

Sample solution for one day

Vehicle	1	2	3	4	5	6	7	Total time
A	538	571	573	598	152	501	0	2933
B	605	628	637	716	168	587	0	3341

A – using uncongested speeds

B – using routes from A with actual speeds

Sample solution for one day

Vehicle	1	2	3	4	5	6	7	8	Total time
A	556	568	589	595	580	599	564	588	4639
B	542	577	548	551	539	551	533	532	4373

A – using uncongested speeds, reduced by 20% everywhere

B – using routes from A with actual speeds

Sample solution for one day

Vehicle	1	2	3	4	5	6	7	8	Total time
A	556	568	589	595	580	599	564	588	4639
B	542	577	548	551	539	551	533	532	4373
C	596	198	597	566	501	595	578		3632

A – using uncongested speeds, reduced by 20% everywhere

B – using routes from A with actual speeds

C – using LANTIME with actual speeds

Vehicle Routes for that day

Uncongested routes

LANTIME routes

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Summary Statistics

Run	Total dist. (km)	Total time (min)	Total CO2 (kg)
P-20%	21796	28232	4694
C	20236	26431	4363

In this case, a reduction in CO_2 emissions of about 7%

Conclusions from case studies

- Routing and scheduling taking traffic information into account can lead to worthwhile reductions in carbon emissions
- Scope and size of reductions is dependent on factors such as
  - Whether computerised VRP systems have been used before
  - vehicle capacity and time window constraints

Other objectives

- Shortest time
- Minimum emissions
- Minimum cost

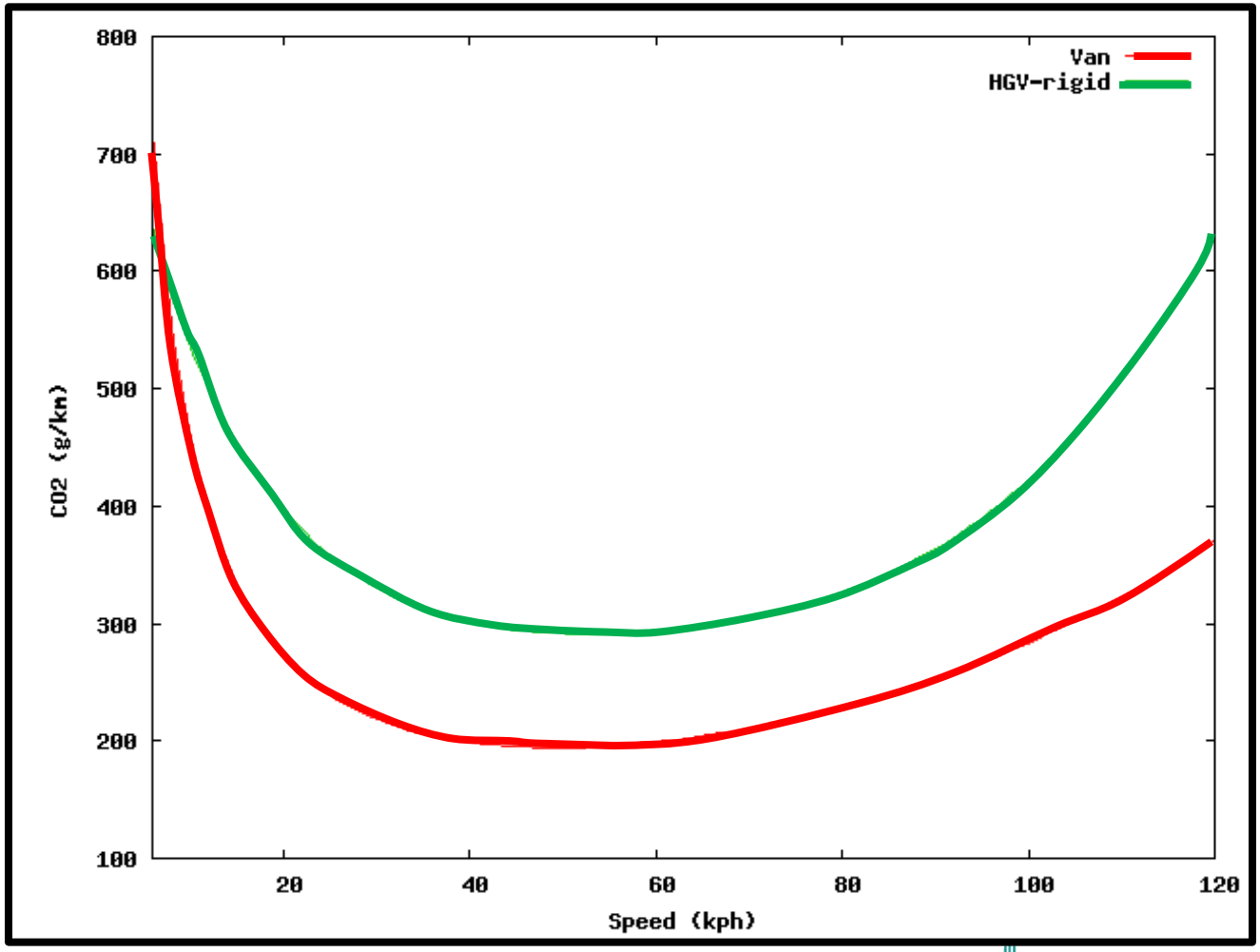
Using fuel more efficiently

- Those elements that influence fuel consumption are:
  - Travel related factors such as speed and acceleration rates
  - Road conditions such as congestion, inclines, bends, roundabouts and traffic lights
  - Vehicle characteristics such as engine size, fuel type, payload and age

For example…

The size, weight and shape of the load will affect the fuel consumption.

CO2 Emissions



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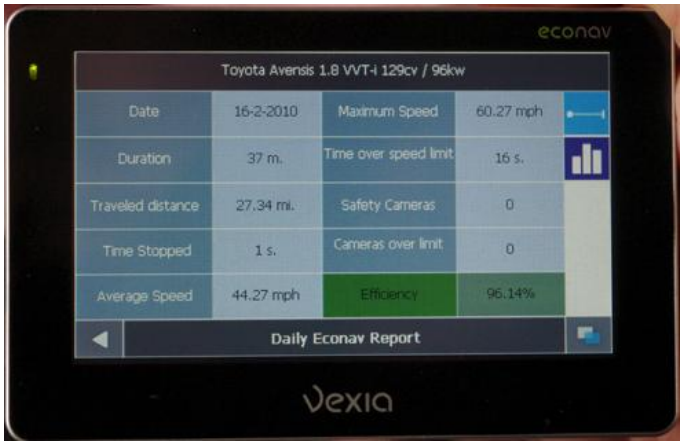
Current Work

- Modifying for least polluting rather than least time
- Modifying to take account of congestion charging

Minimising pollution or fuel

- Fuel use and hence carbon footprint depends on speed.
- Treat speed as a decision variable in the network.
- Model using approximate dynamic programming and a column generation style heuristic.
- Implement using in-cab navigation systems



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Congestion charge

- General case is technically challenging
- Heuristics are being developed
- Future work to look at the design of a congestion charge scheme

Concluding remarks

- New technologies provide new tools and sources of data
- New objectives provide new problems that are technically challenging
- What should be the priorities?

Questions ?