Vehicle Routing and Scheduling with Time-Varying Travel Times

Richard Eglese
Lancaster University Management School
Lancaster, U.K.

From Interfaces 1980

- “While all the academic investigation of this problem class has increased knowledge and scope of understanding of the problem, is it of any direct use?
- “Based on my knowledge gained from theoretical study, detailed analysis of actual practice and attempted applications in a consulting environment, the answer is no!”

A recent email

- “My company recently purchased a vehicle routing system … the routes it planned …made no logical sense to me whatsoever.
- “This software was trialled for three days last month… we got a record amount of failed deliveries.
- “…the software seemed to be routing my vehicles in a spirograph…
- “Do you believe routing software is a viable option for the industry?”

Modelling the problem (1)

- Finding solutions to real-world problems involves understanding and taking account of issues that may be ignored in solving benchmark academic problems.
- Most real-world VRPs have additional constraints or considerations that are often not present in academic benchmark problems.

Modelling the problem (2)

- Temptation is to ignore inconvenient issues, but that can make results useless or even illegal.
- "Routing installations tend to require a large degree of customization, as reflected in software prices, which often runs in the tens of thousands of dollars." *OR/MS Today Survey February 2008*

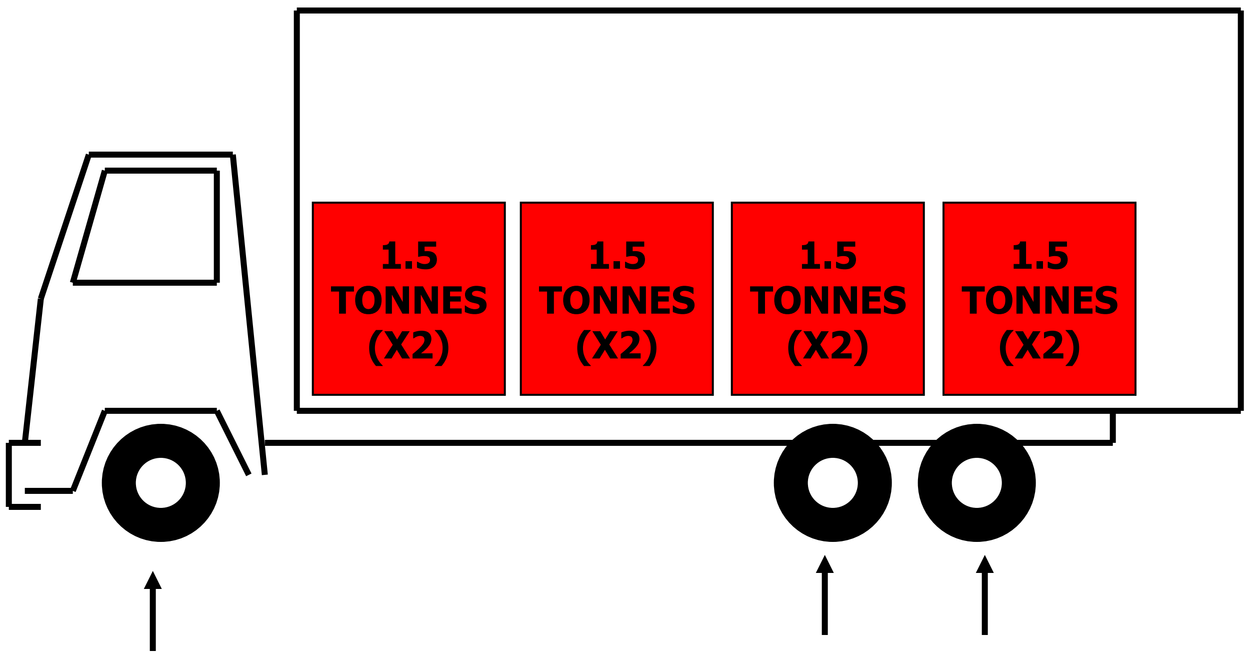
Examples of modelling issues

- Vehicle issues
- Product issues
- Delivery time issues
- Congestion issues

Problem of axle weight

- *"Unfortunately on more than one occasion our vehicles have been stopped either by the police or the vehicle inspector and found to be overweight either in total or on the front axle. We have asked our supplier of our vehicle routing and scheduling system whether they could modify their software to highlight a potential error. They have looked into this and been unable to offer a satisfactory solution."*
- Operations Director, Timber Merchants

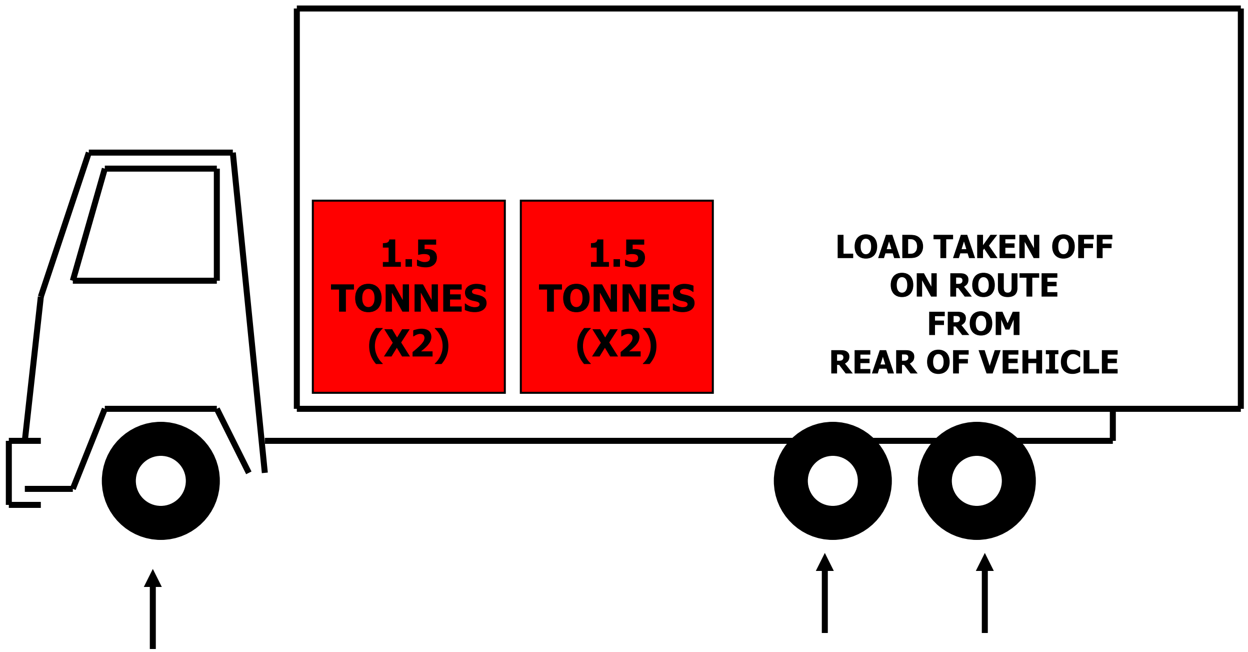
Vehicle leaving depot



PAYLOAD	**3.5 TONNES**	**15 TONNES**	**(TOTAL 17.5 TONNES)**
ACTUAL	**2.8 TONNES**	**9.2 TONNES**	**(TOTAL 12 TONNES)**

Lancaster University
Management School

Vehicle after first delivery



PAYLOAD	**3.5 TONNES**	**15 TONNES**	**(TOTAL 17.5 TONNES)**
ACTUAL	**4 TONNES**	**2 TONNES**	**(TOTAL 6 TONNES)**

Problem of volume

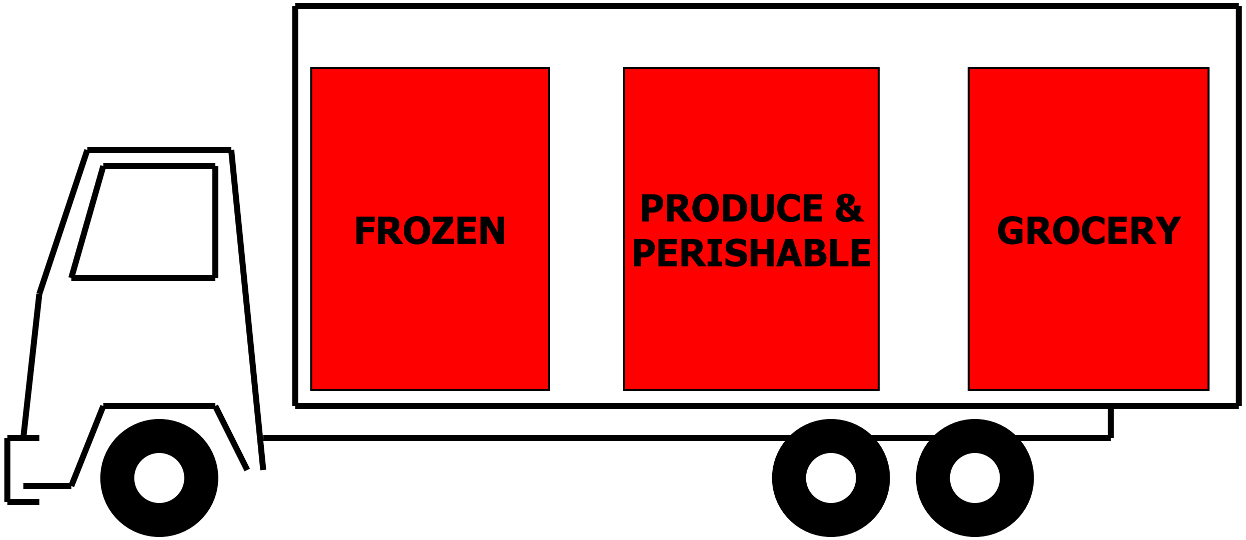
- *Our routing and scheduling system occasionally generates a trip with more product than our vehicles could carry – we need to manually check each trip for this error"*
- Transport Manager, White goods wholesaler UK


550

Product restrictions on loading

- Types of supermarket products:
  - Frozen
  - Produce and Perishable
  - Grocery

Loading restrictions



Lancaster University
Management School

Time Window Constraints

- Hard or soft
- Electrical wholesaler example

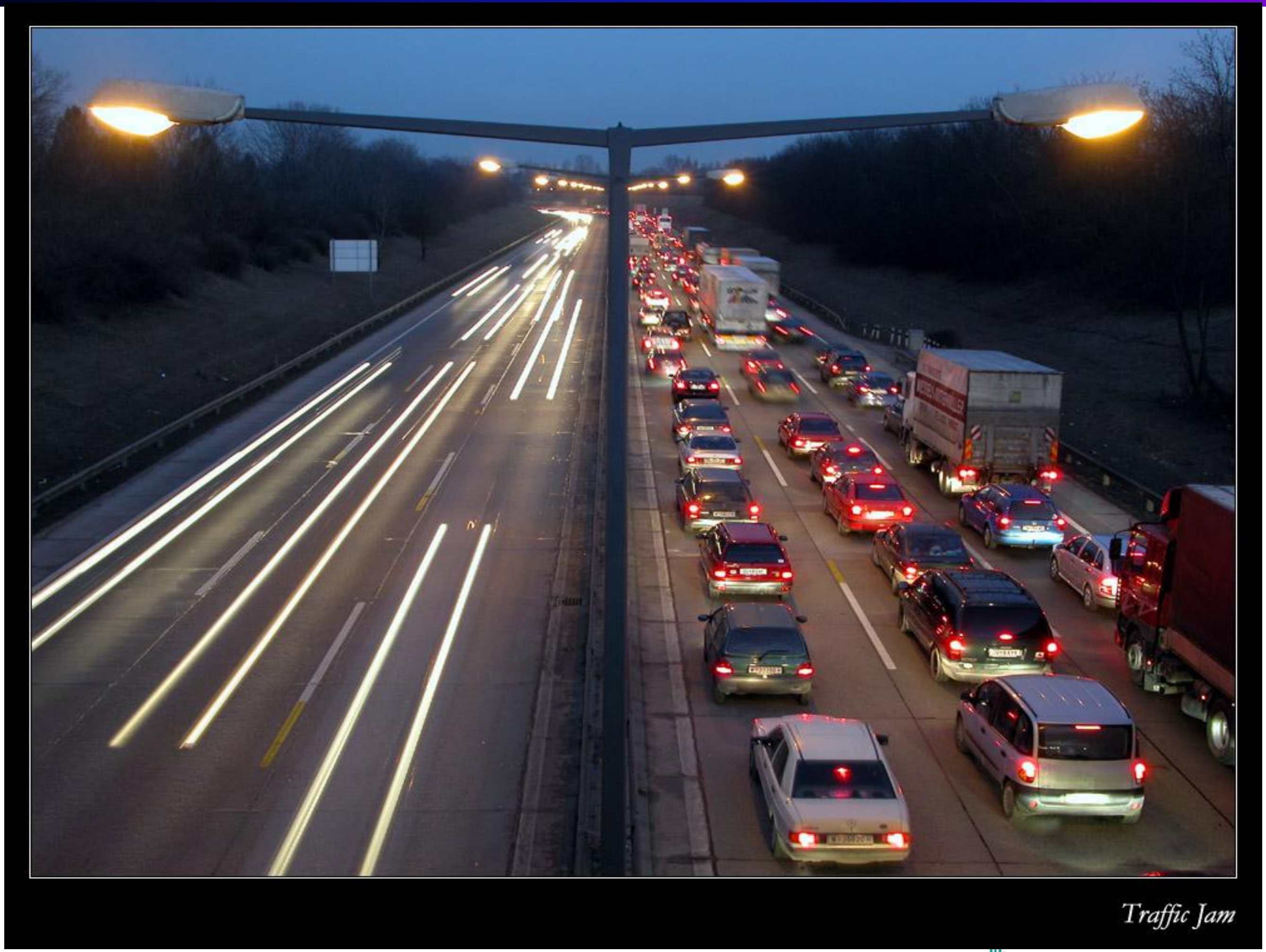
Recent research

- http://greenlogistics.org
- http://www.lancs-initiative.ac.uk/
- **ODYSSEUS 2009**

  4th International Workshop on Freight Transportation and Logistics
  Çeşme, İzmir, TURKEY
  May 26-29 2009
- http://www.odysseus2009.org/

Lancaster University
Management School

The problem



Data Source

A leading provider of traffic information and vehicle security services
http://www.itisholdings.com

- Largest commercial application of FVD ™
  - Real road speeds time matched and day matched
  - 96 (15 minute) time bins

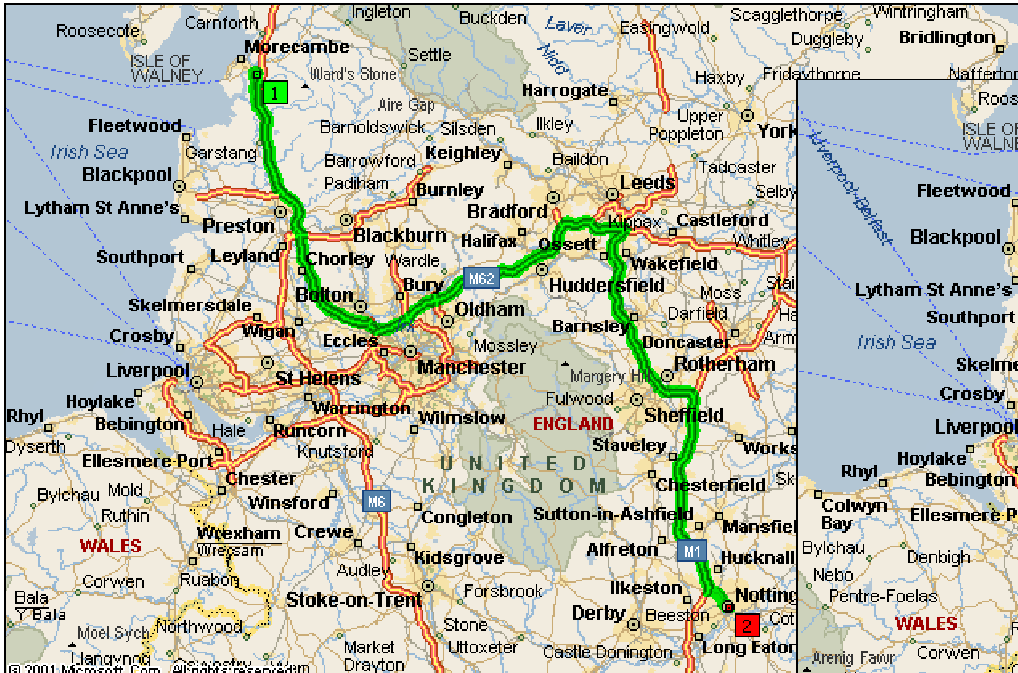
Rationale for a Road Timetable

- On one section of motorway in the North of England the same commercial vehicle speeds varied in one week from 5 mph (at 08.45 on the Monday) to 55 mph (at 20.15 on the Wednesday).
- When the recorded speeds were compared over a ten week period the variation in speed recorded for the same time of day and day of the week was less than 5%.

Road Timetable Description

- Using FVD data we can calculate routes between two locations.
  - Firstly we need to create a digital network based on real road junctions and connecting roads.
  - Using a shortest path algorithm to find the quickest route
  - FVD travelling times are dependent on starting times
- Times calculated this way are more accurate than methods based on constant speeds.

Time dependent routes



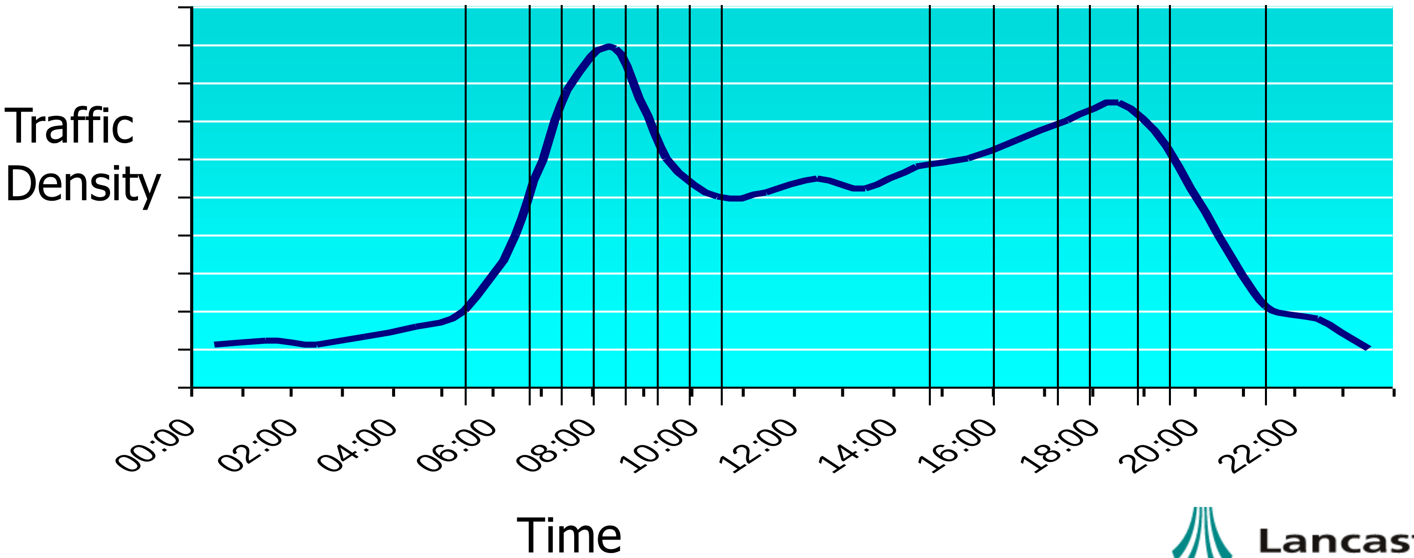
Lancaster to Nottingham
153miles 2h 21 m

Lancaster to Nottingham
142miles 2h 42 m

Lancaster University
Management School

Time bins for different speeds

- The 96 time bins can in practice be reduced to about 15 different periods of time with different speeds
  - These 15 represent distinct changes in the day and are narrower around the two peak times and the build up to them



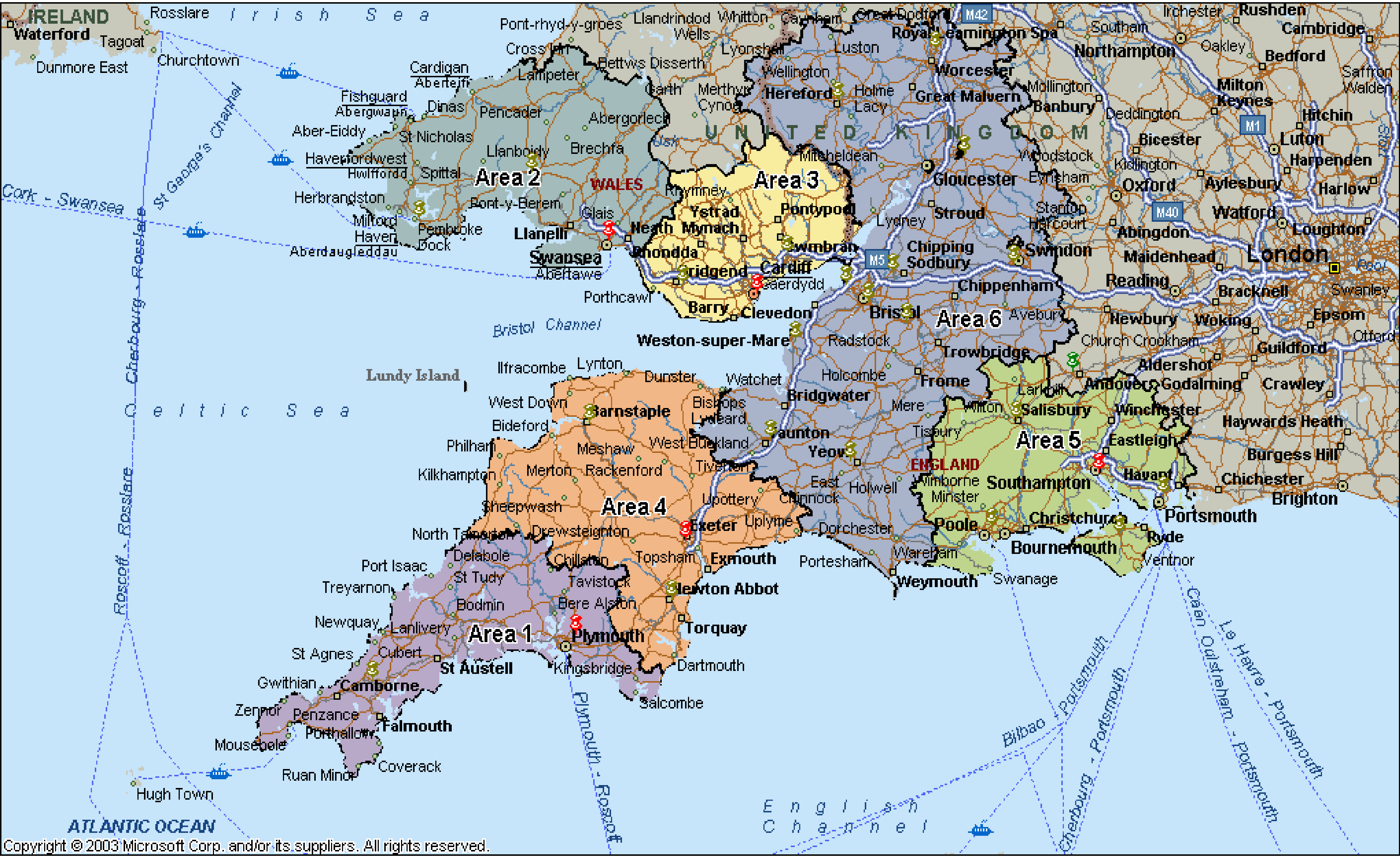
The LANTIME scheduler

- 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
- Using time-dependent data requires significant changes to the vehicle routing algorithms

Case Study

- Electrical Wholesale Distribution in the South West of England
- Type of vehicle - all 3.5 tonne GVW box vans. No restrictions on any roads.
- Weight/Cube - No restrictions
- Time Windows - none
- Time constraint – one shift per day

SOUTH WEST PROPOSED DELIVERY AREAS



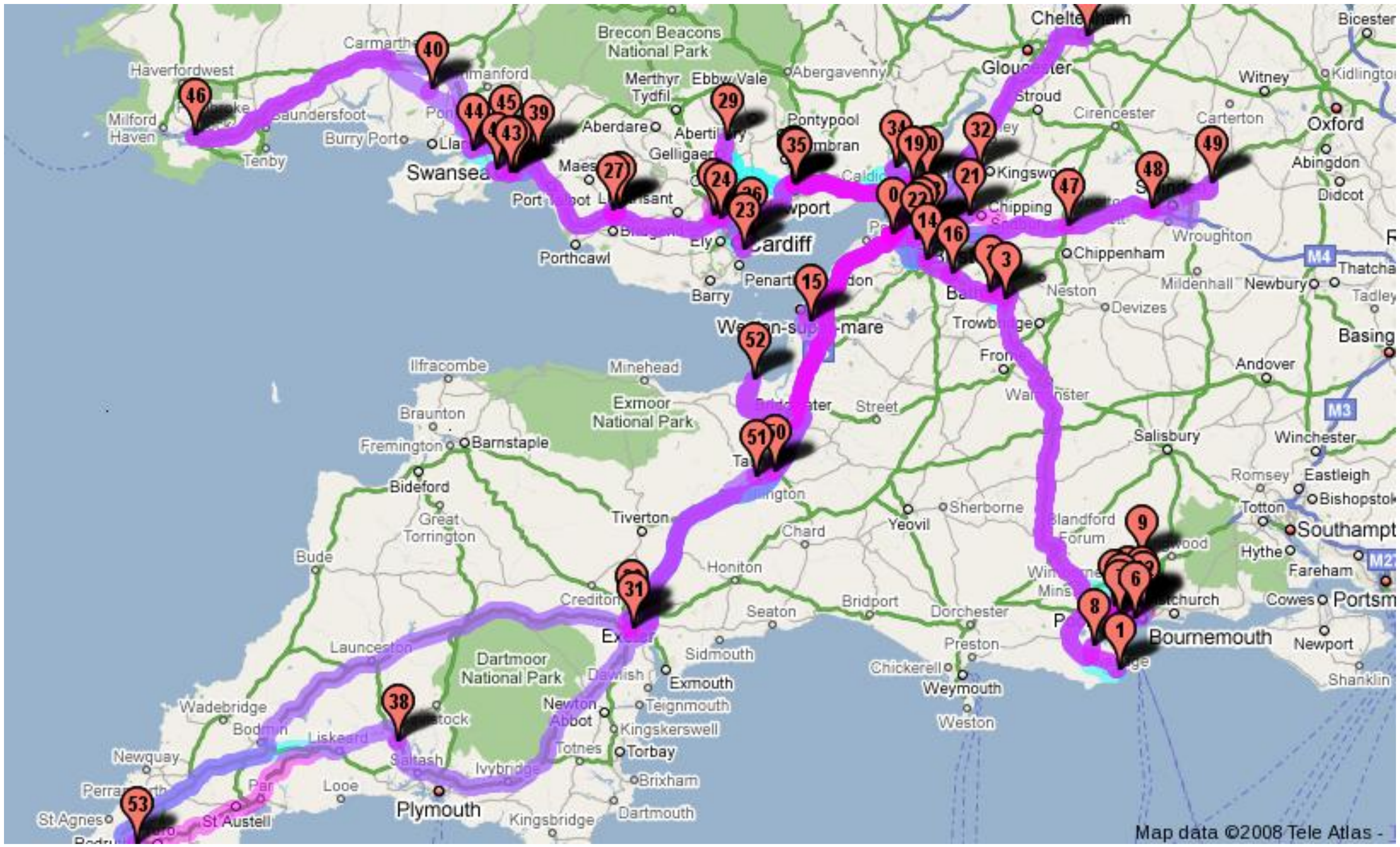
ITIS Data information

- Data based on information aggregated into 15-minute time bins for a 3-month period covering February to April 2007.
- An average speed per time bin is used to construct the relevant Road Timetables.

Sample Comparisons

- For ten-hour shifts including legal breaks for drive time and work time.
- Depot based at Avonmouth
- Up to 7 vehicle routes required
- No. customers varies between 40 and 67 per day over 13 days.

Vehicle Routes on one day



Uncongested routes

LANTIME routes

Lancaster University
Management School

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	Total time
A	597	586	596	563	597	598	0	3536
B	631	600	653	572	600	608	0	3665

A – using uncongested speeds, reduced by 10% 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

A – using uncongested speeds, reduced by 20% everywhere

B – using routes from A with actual speeds

Sample solution for one day

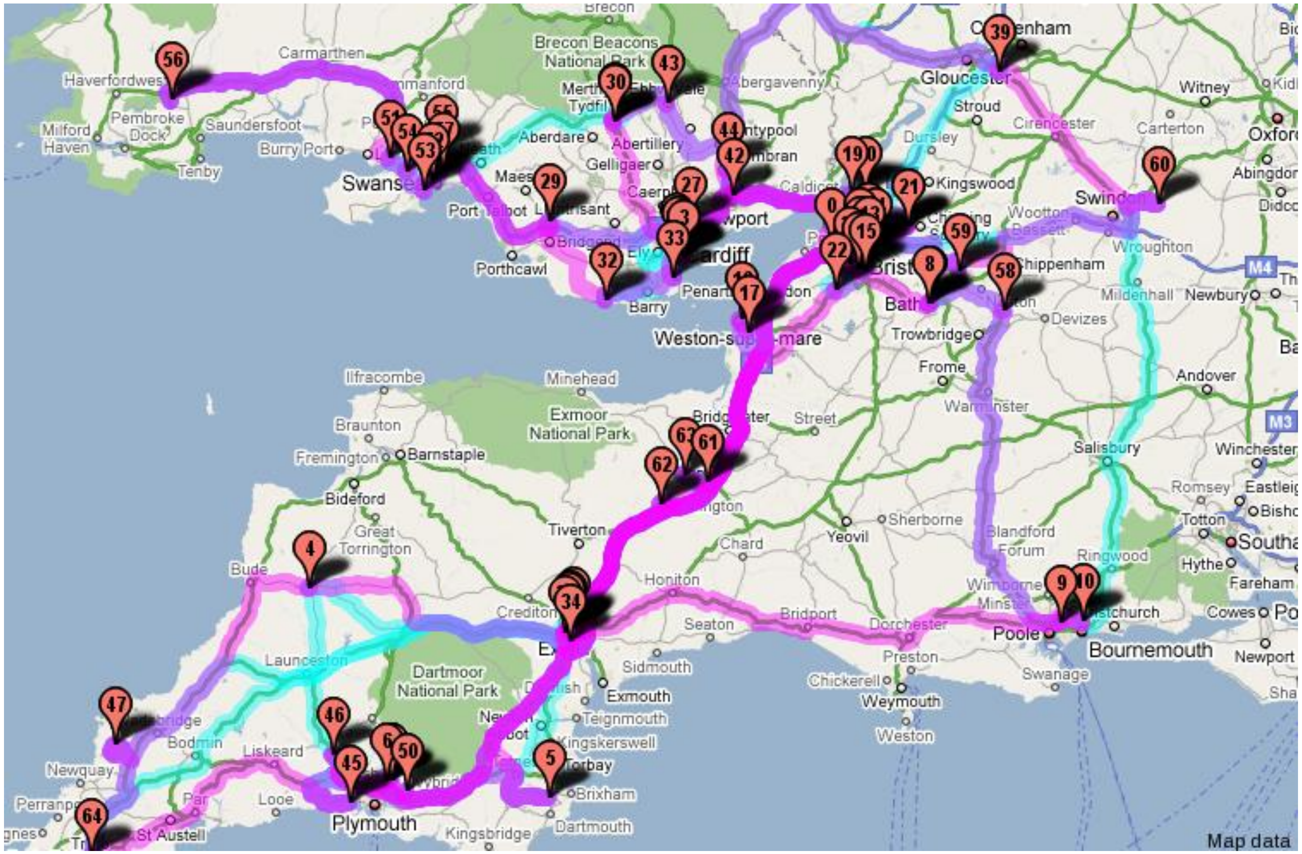
Vehicle	1	2	3	4	5	6	7	8	Total time
A	556	568	589	595	580	599	564	588	4639
B	542	577	548	551	539	551	533	532	4373
C	596	198	597	566	501	595	578		3632

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

Lancaster University
Management School

Future Work

- Modifying for least polluting rather than least time
- Further testing of LANTIME for other cases
- Measuring how much difference this can make in practice

Reference

- Eglese R.W., Maden W. and Slater A. (2006) A Road Timetable™ to aid vehicle routing and scheduling. Computers & OR. Vol. 33, pp 3508-3519.

References

- C L Doll (1980) Quick and Dirty Vehicle Routing Procedure. Interfaces. 10, No. 1, 84-85.
- R Hall and J Partyka (2008) Vehicle Routing Software Survey: On the Road to Mobility. OR/MS Today February 2008.
- Alan Slater (2005) Monograph on Vehicle Routing and Scheduling, Added Value Logistics Consulting.
- RW Eglese, A Mercer, and B Sohrabi (2005) The grocery superstore vehicle scheduling problem. J Opl Res. Soc. 56, 902-911.