Cost effective Product Replenishment in the Oil & Gas Industry

NGB/LNMB Seminar on Operations Research and Energy

Janneke Meesters - 17 January 2008

Content

Introduction Inventory Routing Problem

Challenges and Solutions Fuels Industry

Challenges and Solutions Gas Industry

Optimization
& Decision Support Solutions

Traditional Inventory Management

Client
- Monitor of product level
- Place orders

Oil Company
- Take orders
- Stock of local terminals and depots
- Route vehicles
- Make deliveries to clients

→
- Large volatility in ordered volume
- Difficulty in workload balancing
- No use of geographical clustering possibilities

Inefficient Supply Chain and unnecessary transportation costs

Vendor Managed Inventory

Client
- Trust the Oil Company to supply product before stock-out

Oil Company
- Monitor Client stock level
- Decide when to deliver
- Decide how much to deliver
- Route vehicles
- Make deliveries

- Client requires less resources for inventory management
- More freedom in when & how to deliver, however also more complexity
- Better coordination of deliveries to decrease transportation costs

VMI transfers inventory management from the client to the supplier

IRP versus VRP

Three decisions instead of one:

1. When to deliver a customer?
2. How much to deliver a customer?
3. Which delivery routes to use?

Objective Vehicle Routing Problem (VRP):

minimize costs of planning period

Objective Inventory Routing Problem (IRP):

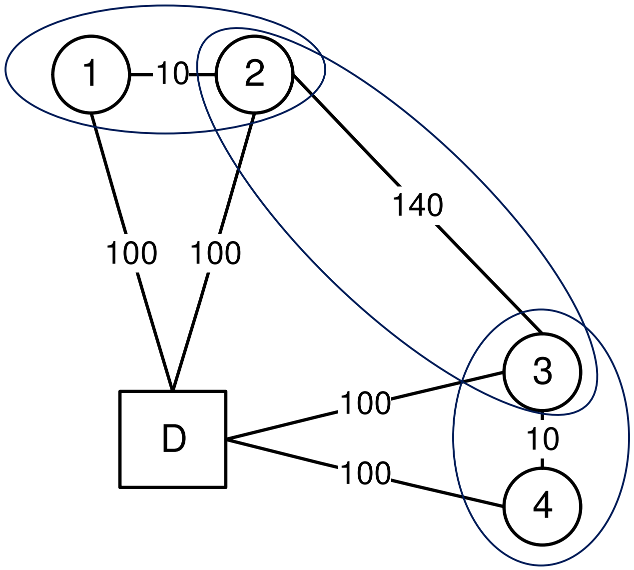
minimize the long-term cost while making sure no customer runs out of stock

Multi day Horizon

→ Decisions made today impact what has to be done beyond the planning period

Usage Instead of Orders

[BELL et all, 1983]



	Customer			
	1	2	3	4
Tank Capacity	5000	3000	2000	4000
Daily Usage	1000	3000	2000	1500

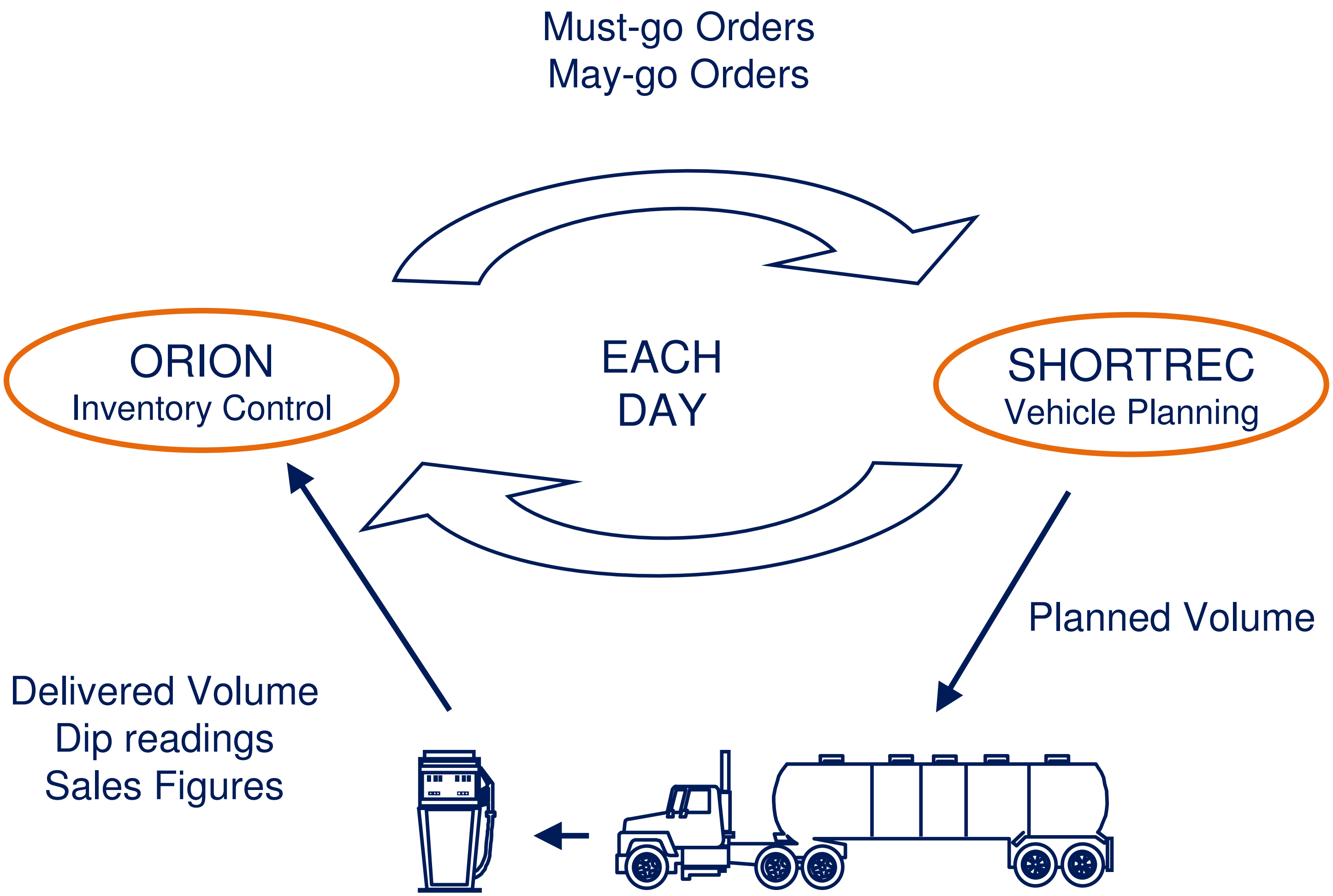
Suppose we have a truck with capacity 5000

Most obvious strategy each day two trips
Trip 1 (1,2) 210 Volume 4000
Trip 2 (3,4) 210 Volume 3500 Total distance **420** total volume 7500

A better strategy
Day1 Trip 1 (2,3) 340 Volume 5000
Day2 Trip 1 (1,2) 210 Volume 5000
Trip 2 (3,4) 210 Volume 5000
Total distance is 760, thus per day **380** and a volume of 7500.

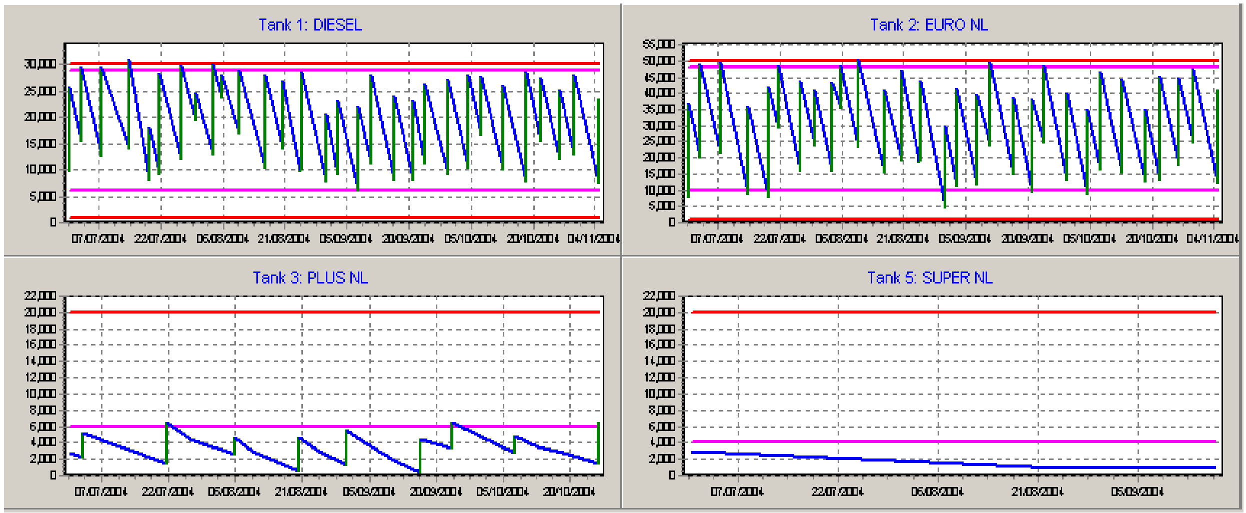
The second strategy is gives a reduction of 10% in distance compared to the first strategy

ORTEC Workflow



Order generation algorithms

Look at the last known inventory (DIP) and use the demand predictions to determine the point in time at which a tank reaches its safety stock.



Taking into account:

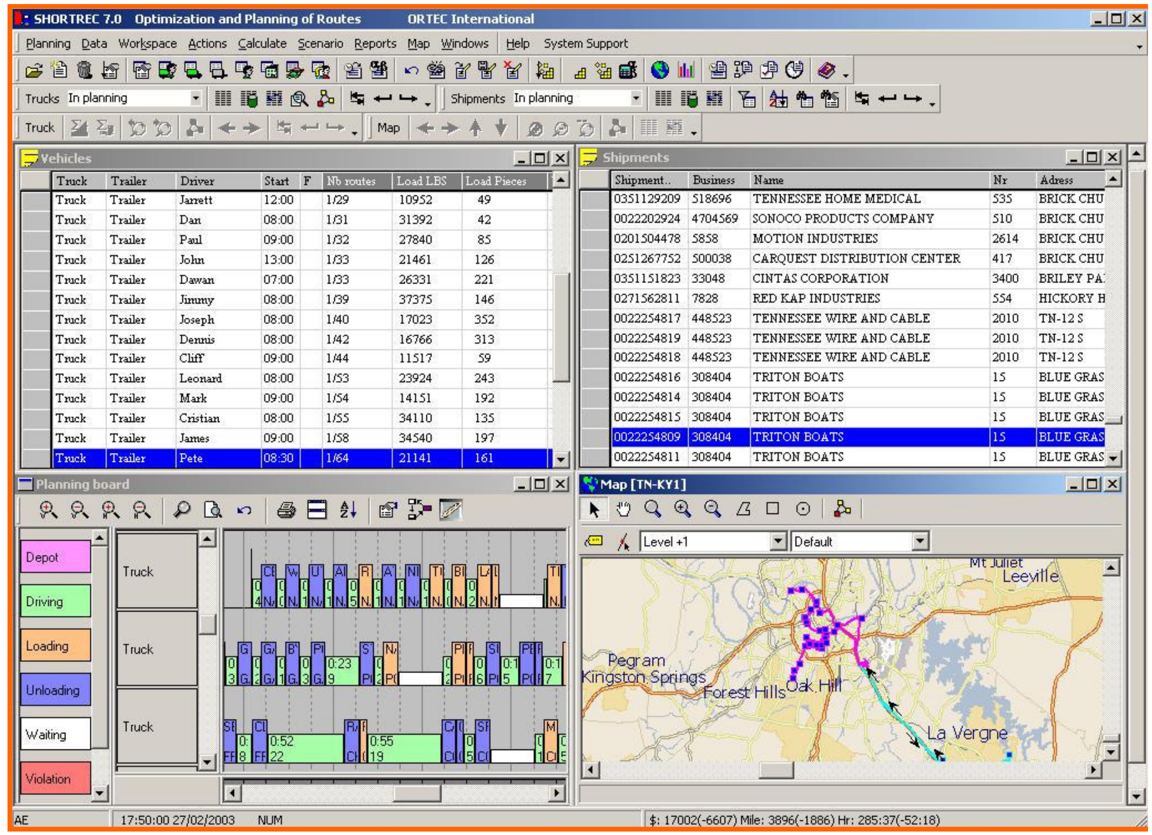
- Number of days left
- Critical date
- Compartments of trucks
- Round off quantity
- Opening time windows
- Minimum drop size

Looking at all products

Route scheduling algorithms

ORTEC

2-phase approach



Basic Solution

- Rule based strategy to build initial routes
- Only adds unassigned orders to existing or new routes
- Goal to assign as many orders as possible
- Focus on difficult orders; it is more important to assign orders than to build efficient routes

Different Optimization Routines

- Heuristics to minimize costs
- Is more time intensive especially when there are a large number of exchange alternatives

Oil&Gas requirements / functionality

- Compartments (single product per compartment)
- Equipments (truck/customer/order/depot)
- Vehicle access restrictions
- Stock restrictions (product availability per depot)
- Loading/unloading speed and requirements (gravity/pump/hose)
- Min/Max volume (allow optimizer to modify ordered volume)

Oil vs. Gas

	Oil	Gas
Number of customers	Few	Many (home deliveries)
Number of products and Compartments	Multiple up to 6	One
Number of drops per trip	Few (1-3)	Many (8 -10)
Dominant demand profile	Weekly	Seasonal
Delivery frequency	Daily - Weekly	Weekly - Yearly

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Daily Process Fuels

Pre scheduling

Planners change VMI calculated orders
- Create complements that fit on a compartmentalized truck
- Balance the amount of orders/volume transported

Vehicle Planning

Predefined combinations are assigned to vehicles
- Planners modify push orders to solve violations on compartment constraints and reach 100 % utilization of trailers

ORION
Inventory Control

•Tank Levels in the Time
•Throughput Information
•Demand Profiles

Planners use all information making a plan

Orders →

SHORTREC
Vehicle Planning

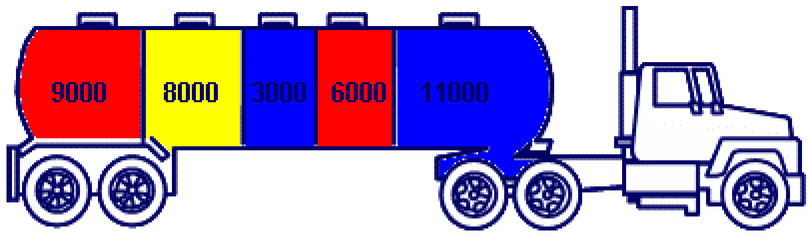
•Locations
•Driving Times
•Trailer Characteristics
•Driver Availability

Approach IRP for Fuels

1. Two sets of orders

Must-Go → Pull orders and urgent Push orders (fast movers)
May-Go → Not urgent Push orders (slow movers)

2. Volume Ranges



Fuel type	Tank capacity	Daily Usage	Equal days delivery Volume	Equal days delivery Days	Full truck delivery Volume	Full truck delivery Days	Volume Difference Equal days Full truck
Diesel	15000	5000	15000	3	15000	3	0
Euro	15000	3000	9000	3	15000	5	6000
Plus	15000	1000	3000	3	15000	15	12000
		Totals	27000		45000		18000

Min ≤ volume delivered ≤ Max

Results

Principles work

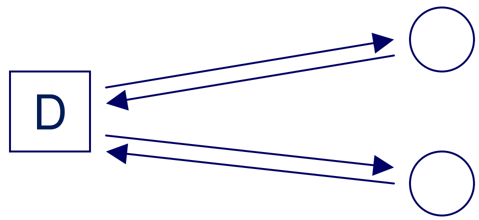
- Good multi-stops are made (few long inter-customer driving times)
- Trailers reach a high utilization (97%)
- Planned volume is balanced

Is ORTEC better?

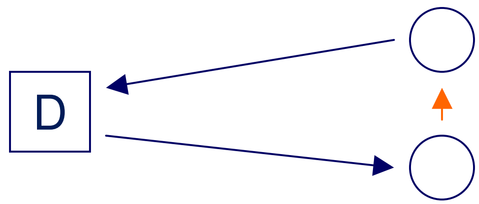
- **Yes,** on total cost, if we include fixed costs of trucks & drivers
- **No,** not on volume per kilometer

Lower bound for the Fuel IRP problem:

- 'Deliver all stations a full truck' (Liters / KM)



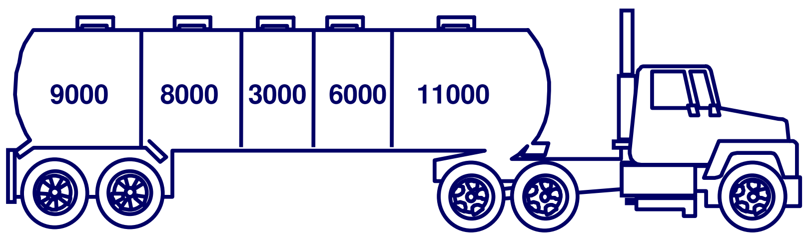
The planner is quite close to the lower bound!



Theory vs. Practice

Research does not combine IRP with Fuel characteristics

- Few customers large orders
- Heterogeneous fleet
- Multi-product and a compartmentalized fleet
- Multi-depot and price differences per depot
- Weekly profiles and a high delivery frequency



	Order 1 fit	Order 2 does not fit
Diesel	15000	21000
Euro	11000	9000
Plus	11000	7000
Total	37000	37000

Further Research at ORTEC

Computation time makes integration VMI-VRP impossible

Alternative approach:

1. Generate orders (VMI software)
2. Assign orders to vehicles (VRP software)
3. Delivery volume optimization (VMI software)

Optimize the orders assigned to vehicles

- Increase volume to reach 100% utilization
- Create complements if 100% utilization can not be reached

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Planning challenges Gas Industry

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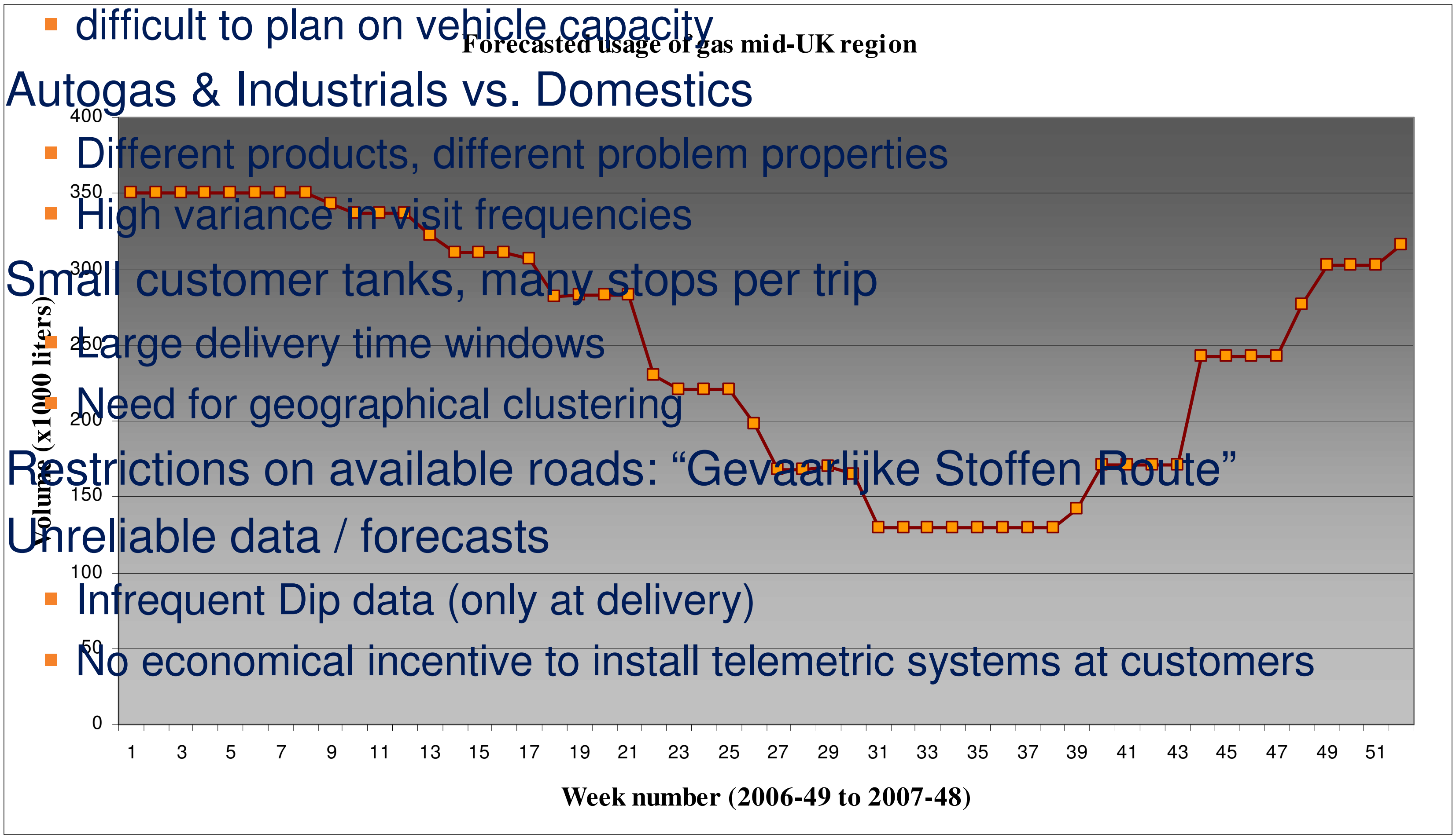
- Huge seasonal profile in product usage
- Top-up policy
  - difficult to plan on vehicle capacity
- Autogas & Industrials vs. Domestics
  - Different products, different problem properties
  - High variance in visit frequencies
- Small customer tanks, many stops per trip
  - Large delivery time windows
  - Need for geographical clustering
- Restrictions on available roads: “Gevaarlijke Stoffen Route”
- Unreliable data / forecasts
  - Infrequent Dip data (only at delivery)
  - No economical incentive to install telemetric systems at customers



Concept Period Scheduler (PVRP)

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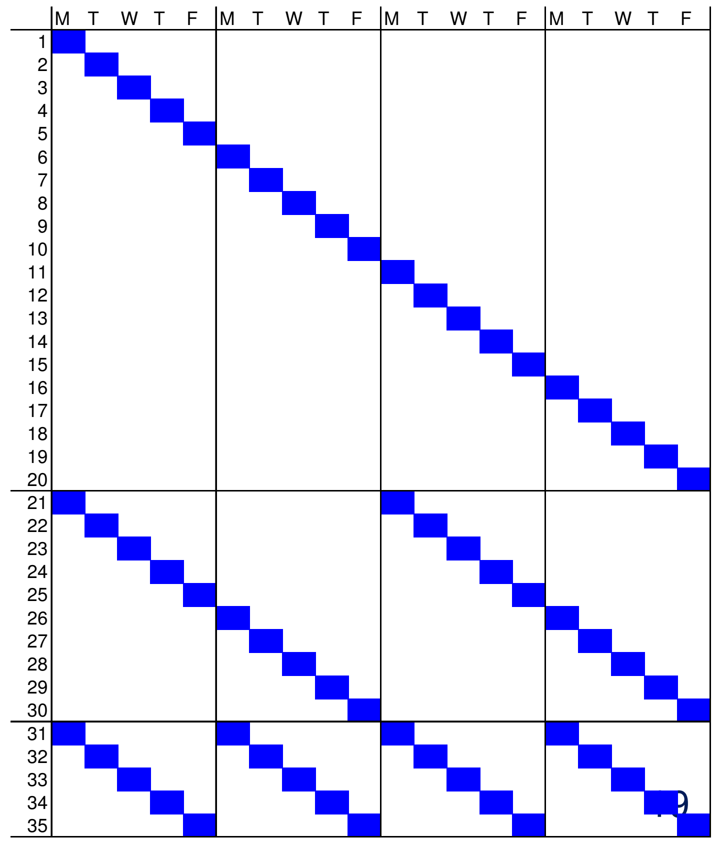
The period scheduler is a strategic tool which assigns customer visits to optimal days, creating optimal routes afterwards

- Representative planning horizon, e.g., one week, one month, etc.
- Visit frequency for each customer
- Set of possible visits

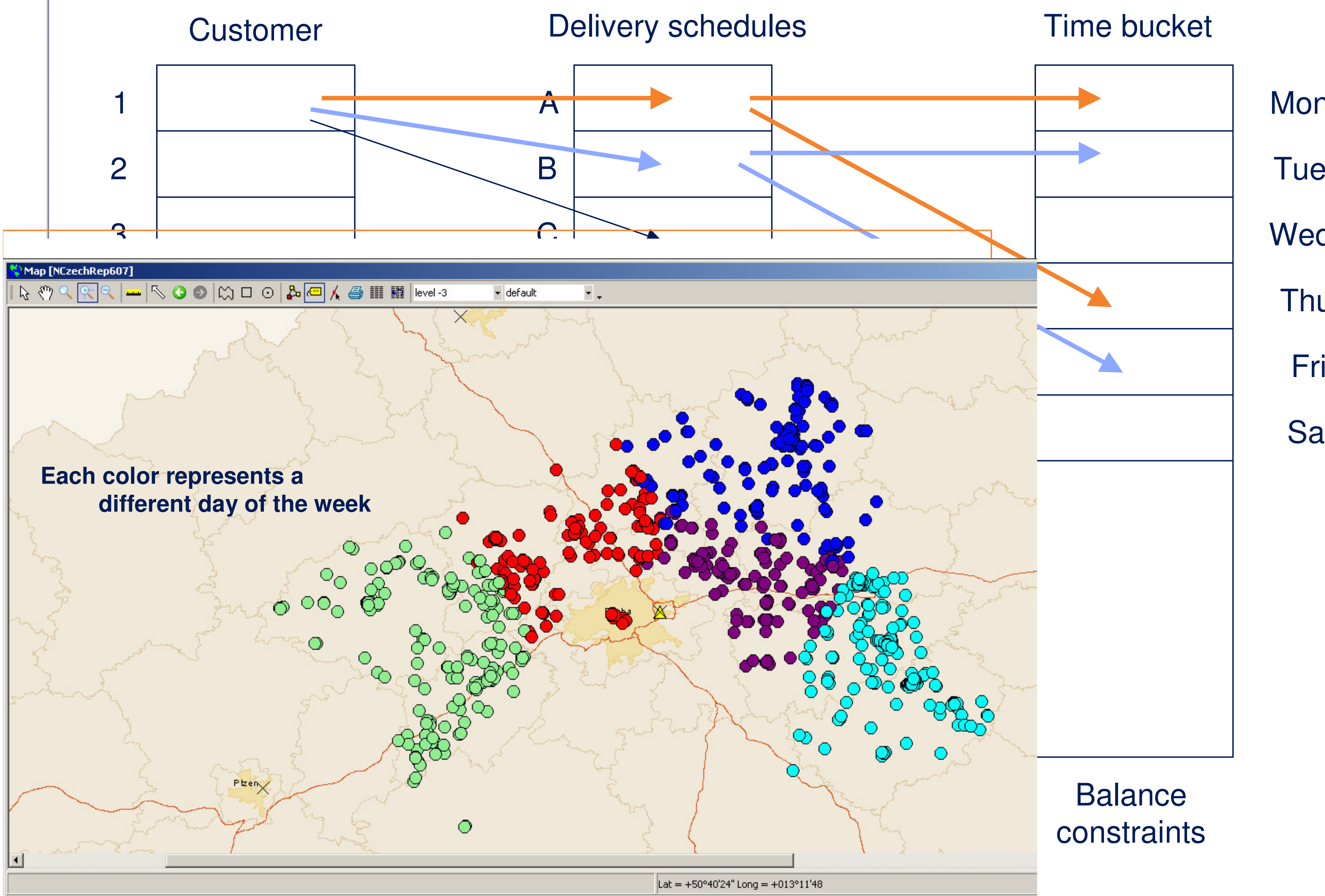
Period Scheduler is implemented for scheduling of sales reps at CCHBC (Coca-Cola distribution)

- Define 'centre points' (point per day)
- Define balance criteria
- Customer-visit schedule assignment

→ (integer) linear programming model



Assignment algorithm



Adapted Period Scheduler in Gas Industry

ORTEC

- Forecast is transformed to possible delivery schedules:
  - Customer has to be delivered before stock-out (or safety stock)
  - Customer can have may-go order when safety stock is reached within the next xx weeks, but where order is more that the minimum delivery amount
- 6th schedule of period generated for every may-go order including the volume that could be delivered in the next week

F033	1	1	%	26	0	0	0	0	0
F033	2	1	%	0	34	0	0	0	0
F033	3	1	%	0	0	41	0	0	0
F033	4	1	%	0	0	0	49	0	0
F033	5	1	%	0	0	0	0	57	0
F033	6	1	%	0	0	0	0	0	84

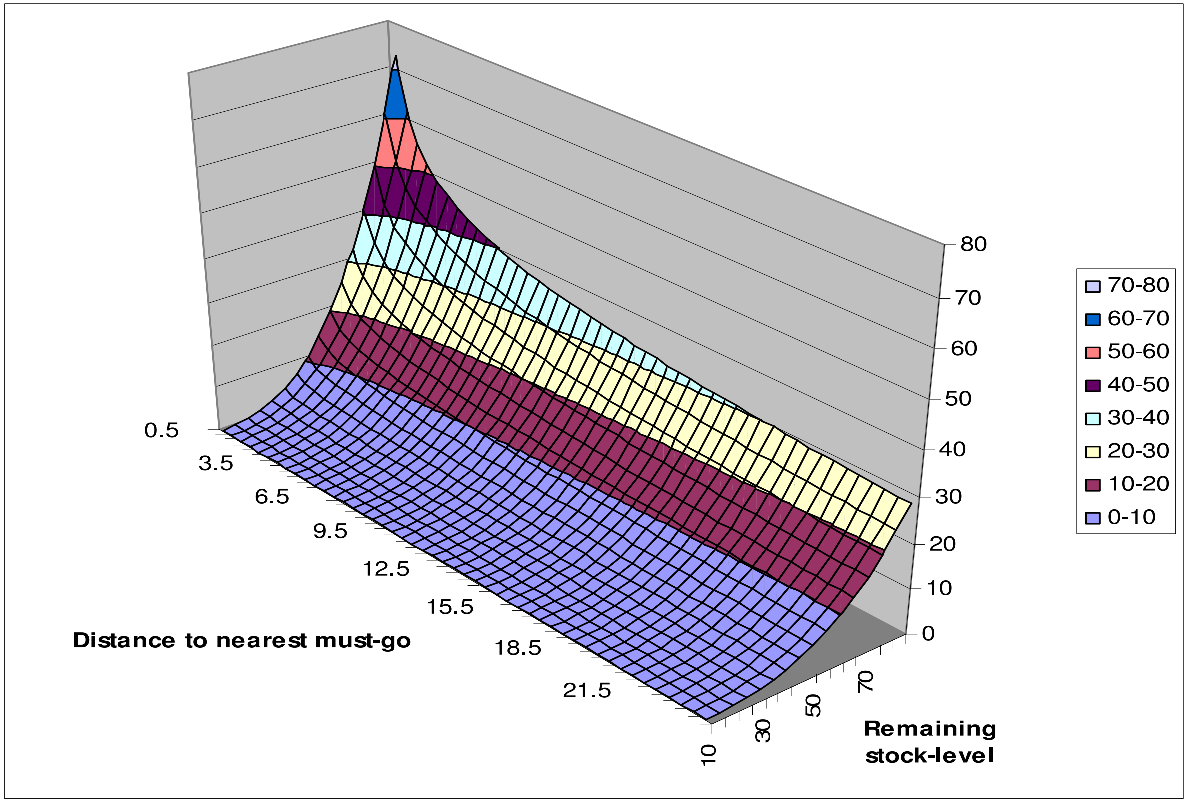
- Example above leads to 6 different possible delivery schedules:
  - 26% of maximum stock can be delivered if you go on Monday
  - …
  - 57% of maximum stock can be delivered if you go on Friday
  - 84% of maximum stock can be delivered if you go next week

- Period Scheduler computes the best delivery scheme, given the clustering, the balance criteria and the cost

Details Costs Balancing

- Costs for assigning this customer to any day of the week is based on the distance to the centre point for that day

- Costs for choosing to leave this customer until after planning horizon based on remaining stock-level and distance to nearest must-go order



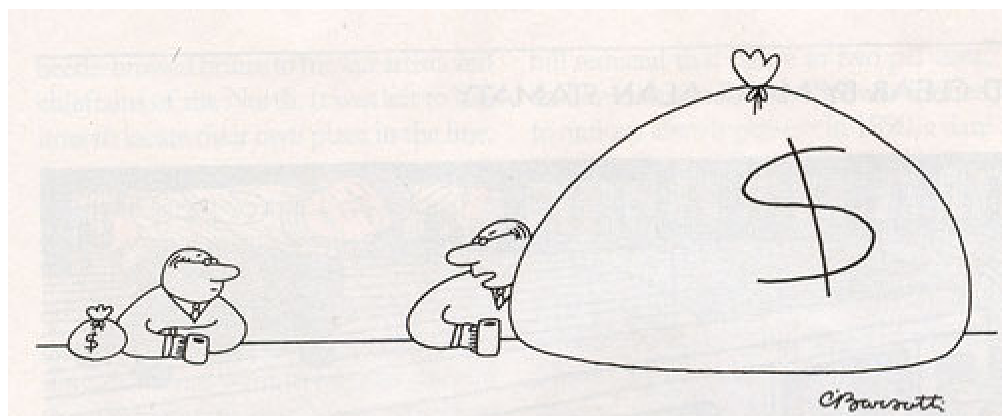
Using Period Scheduler in the Gas Industry

Fixed frequency vs. variable frequency including balancing

Fall 2007: PoC in France

- west-region, 13 depots, 44 vehicles
- 4 weeks, 13.000 customers, 13.000 deliveries

Nr Orders	- 7 %
Nr Trips	- 7 %
Volume	+ 6 %
Hours	- 10 %
KM	- 26 %
Volume / KM	+ 43 %



"Where'd you get that?"

Further Research

Practice vs. the literature

- Large instances (up to 100.000 customers, multiple depots, many restrictions)
- Heterogeneous fleet properties
- Vehicle access restrictions
- Restrictions on computation times

Further Research to improve Period Scheduler-approach

- Improve long-term cost perspective
- multi-depot approach
- ‘intelligent’ clustering for improved computation time

Finally….

Savings through VMI are great and many Oil companies have moved to VMI, but OR challenges remain

Thank you for your time and attention !!

Any questions?