



Evaluation of telematics data with respect to EC-driver regulations for reporting purposes

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Overview

- Application context
 - Costs and constraints in long-haul freight transportation
 - Telematics technology and available information
- Exploration and analysis of telematics data
 - Technical vehicle data (driving behavior)
 - EU driver regulations
 - Keeping track of legal compliance using telematics data
 - Performance evaluation measures
- Enriching telematics data by other online data sources
 - Data types
 - Derived planning problems



Long-haul freight transportation

Classification of transportation services for standard goods

- Short distance carriage
 - Pickup and/or delivery of general cargo and parcels in a small region
⇒ Vehicle Routing Problem and its variants
- Long-haul freight transportation (national and international LTL and FTL)
 - Standard trips (point-to-point shuttle services, external milkruns)
 - ❖ E.g. headliners from Johnson Controls (Überherrn) to Daimler in Sindelfingen (3 times a day)
 - ❖ No recurrent planning situation
 - Individual trips for a dedicated customer („Gebietsspediteur“)
 - ❖ E.g. deliver goods for Bayer to its (changing) customers in Southern France
 - ❖ Find load for empty return trips (using freight from spot marketplaces)
 - ❖ Dynamic planning situation





Truck types and telematics technology



Capacity: 85 m³, 24.5 t



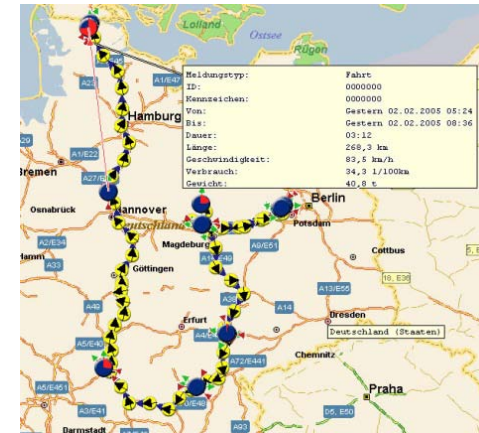
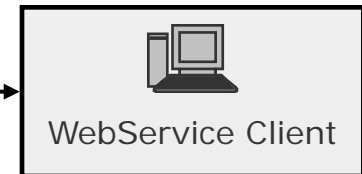
Capacity: 120 m³, 23.5 t



GSM



Internet



- Vehicle position
- Technical data (fuel consumption, break usage, mean speed, etc..)
- Driver activities (driving, resting, standby, working)
- Order status



Long-haul freight transportation: Cost breakdown

Sample cost breakdown

- Trip length dependent variable costs ~ 40%
 - Fuel, tires, repair, toll fees
- Driver(s) ~ 30%
- Other time dependent (fixed) step cost ~ 20%
 - Amortization/leasing fees, taxes
- Other fixed costs ~ 10%
 - General administrative costs

Fiedler (2007), S. 74

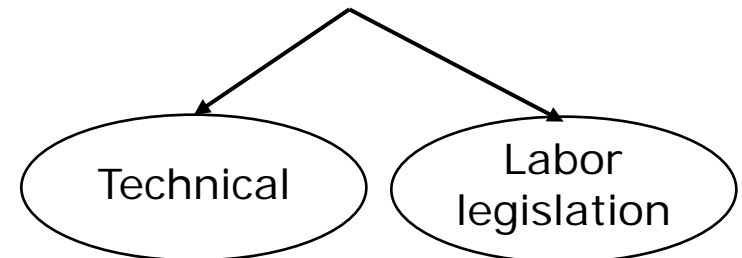
Impact factors on costs

Long term:

- Fleet age
- Employee qualification

Short term:

- Economic (not shortest) routes
- Economic fueling policy
- Driving behavior





Evaluation of driving behavior (technical)

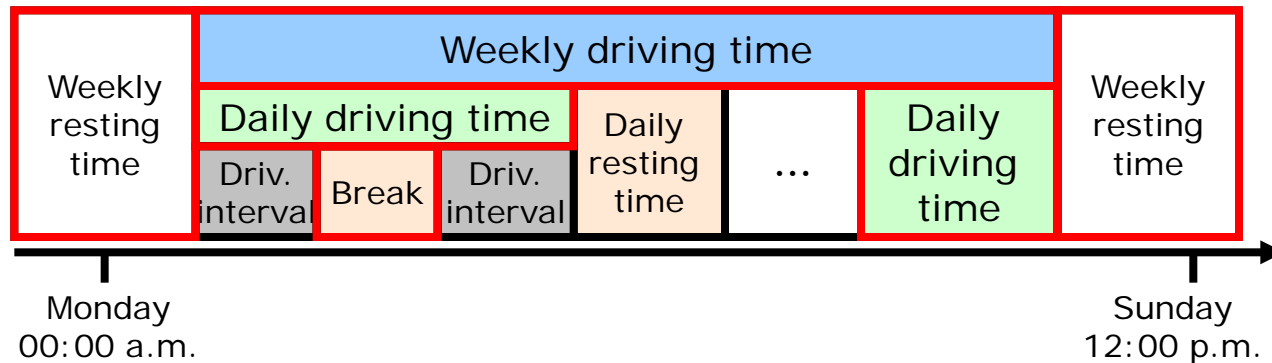
Fahrzeug	Zeitraum	Fahrzeug	Fzg. Gruppe	Telematik- gruppe	Fahrw. [Note]	Einsatz- schwere [Note]	Fahrstr. [km]	Ø-Gew. [t]	Ø-Geschw. [km/h]	Ø-Ges. Verbrauch [l/100km]
JS 112	Jahr 2009									
Fahrweise 9,2	Einsatzschwere 4.4									
Ø-Gesam. [l/100km] 33,3										70
										32,6
										72
										33,3
										72
										33,3
										71
										32,5
										74
										32,6
										72
										32,8
										70
										35,1
										73
										32,8
										73
										33,5
										73
										29,7
										70
										29,7
										72
										30,3
										72
										30,3
										73
										32,2
										73
										33,1

FLEETBOARD PRÄMIE FEBRUAR 2009							Prämiesysteme			
Rang- liste	LKW:	FAHRER:	NOTE:	PRÄMIE:	BENOTUNGSZEIT:					
1.	HOM-JS 153	Bungert	9,3	30,00 €	4 Wochen = 30,00 €	9 >	9,4 =	30,00 €		
		Ehrendt	9,2	30,00 €	4 Wochen = 30,00 €	9,4 >	9,5 =	60,00 €		
2.	HOM-JS 65	Kochler	9,5	90,00 €	4 Wochen = 90,00 €	9,5	=	90,00 €		
		Stabel	8,9	0,00 €	4 Wochen = 0,00 €					
3.	HOM-JS 112	Lamprecht	9,3	30,00 €	2 Wochen = 15,00 €					
4.	HOM-JS 114	Schilke	9,2	30,00 €	4 Wochen = 30,00 €					
5.	HOM-JS 24	Lemking	9,3	30,00 €	4 Wochen = 30,00 €					
6.	HOM-JS 240	Meier	9	30,00 €	4 Wochen = 30,00 €					
		Kowalsky	8,9	0,00 €	4 Wochen = 0,00 €					
7.	HOM-JS 198	Bergmann	9,4	60,00 €	3 Wochen = 45,00 €					
8.	HOM-JS 193	Quilisch	9,1	30,00 €	4 Wochen = 30,00 €					
9.	HOM-JS 68	Schmidt	9,1	30,00 €	3 Wochen = 22,50 €					
10.	HOM-JS 129	Weißner	9,1	30,00 €	4 Wochen = 30,00 €					
11.	HOM-JS 51	Frisch	9	30,00 €	4 Wochen = 30,00 €					
12.	HOM-JS 151	Bauer	9	30,00 €	2 Wochen = 15,00 €					
13.	JS-1012	Rein	9	30,00 €	4 Wochen = 30,00 €					
14.	HOM-JS 118	Schäfer	8,9	0,00 €	4 Wochen = 0,00 €					
15.	HOM-JS 124	Falkenberg	8,9	0,00 €	4 Wochen = 0,00 €					
16.	HOM-JS 116	Schäfer	8,9	0,00 €	4 Wochen = 0,00 €					
17.	HOM-JS 223	Schmitt	8,9	0,00 €	4 Wochen = 0,00 €					
18.	HOM-JS 184	Gill	9,2	30,00 €	4 Wochen = 30,00 €					
		Meier	8,2	0,00 €	2 Wochen = 0,00 €					
19.	HOM-JS 191	Wagner	8,8	0,00 €	3 Wochen = 0,00 €					
		Meyer	8,7	0,00 €	3 Wochen = 0,00 €					
20.	ohne LKW	Tipp	9	30,00 €	4 Wochen = 30,00 €					

Bonus for economic driving behaviour



Long-haul freight transportation: Driving and resting time regulations



- Break:
 - ≥ 45 min. after $4 \frac{1}{2}$ h driving
 - or 15 min. + 30 min.

- Weekly resting time: min. 45h
- Exception: Red. resting time 24h
- Compensation in the following weeks

- Daily driving time: max. 9h
- Exception: twice per week up to 10h
- Total driving time max. 56h/week
- Max. 90h in two succeeding weeks



Evaluation of driving behavior (legal compliance)

- Telematics data fine grained and not well structured

Lenkzeiten											
Fahrername	Aktivität	Beginn Aktivität	Dauer	Fahrzeug	Position	Restlenkzeit	Tağessumme	Tağessumme	Tağessumme	Tağessumme	Tağessumme
	⌘	03.01.2008 13:27	01:14	JS 68 (HOM-JS 68)	Airport Madrid Bar ...	09:59	00:00	00:00	01:13	00:00	00:00
	⌘	03.01.2008 13:27	00:00	JS 68 (HOM-JS 68)	Airport Madrid Bar ...	09:59	00:00	00:00	00:00	00:00	00:00
	⌘	03.01.2008 13:26	00:01	JS 68 (HOM-JS 68)		09:59	00:00	00:00	00:00	00:00	00:00
	⌘	02.01.2008 19:52	17:34	JS 68 (HOM-JS 68)		00:00	588:46	00:08	2564:33	17:33	00:00
	⌘	02.01.2008 19:52	00:00	JS 68 (HOM-JS 68)		00:00	588:46	00:08	2564:33	00:00	00:00
	⌘	02.01.2008 19:52	00:00	JS 68 (HOM-JS 68)	Burgos (E-09001)...	00:00	588:45	00:08	2564:33	00:00	00:00
	⌘	02.01.2008 19:51	00:01	JS 68 (HOM-JS 68)		00:00	588:45	00:08	2564:32	00:00	00:00
	⌘	02.01.2008 19:51	00:00	JS 68 (HOM-JS 68)	Burgos (E-09001)...	00:00	588:45	00:08	2564:32	00:00	00:00
	⌘	02.01.2008 19:51	00:00	JS 68 (HOM-JS 68)		00:00	588:45	00:08	2564:32	00:00	00:00
	⌘	02.01.2008 19:50	00:01	JS 68 (HOM-JS 68)	Burgos (E-09001)...	00:00	588:45	00:08	2564:32	00:00	00:00

- ⇒ Need for an aggregated report
- ⇒ Classification of violations
 - Types of infractions
 - Severity of the infraction (based on error type depending thresholds)



Classification of violations

Infraction types

Infraction severity

Fehlerschwellwerte			
Fehlertyp		Schwelle mittel	Schwelle schwer
Max. Anz. reduz. Ruhezeiten zw. zwei wöchentl. Ruhepausen überschritten	Anzahl	1	2
Max. Zeit zwischen wöchentlichen Ruhepausen überschritten	Sekunden	3600	14400
Max. Zeit zwischen täglichen Ruhepausen überschritten	Sekunden	900	7200
Max. Lenkzeit von 4 1/2 Stunden überschritten	Sekunden	600	1800
Max. Lenkzeit pro Woche überschritten	Sekunden	3600	14400
Max. Lenkzeit pro Doppelwoche überschritten	Sekunden	3600	14400
Max. Anzahl erweiterter tägl. Lenkzeiten pro Woche überschritten	Anzahl	1	2
Min. 1 reduz. und 1 regelm. wöchentl. LZU pro Doppelwoche unterschritten	Anzahl	2	1



Evaluation of driving behavior (legal compliance)

Lenk- und Ruhezeit Gesamtübersicht

von 25-11-2008 21:06
bis 10-12-2008 21:06

Anzeigen

Übersicht Verletzungen | **Übersicht Zeitwirtschaft** | Legende

Fahrer	Lenkzeit	Leicht	Mittel	Schwer	Σ
	104:14	2	2	14	18
	75:43	1	0	14	15
	60:13	0	3	11	14
	93:54	0	2	12	14
	104:32	1	2	10	13
	88:13	0	0	13	13
	92:43	3	2	8	13
	88:10	0	0	13	13
	73:20	0	0	13	13
	83:23	2	0	10	12
	63:27	1	1	9	11
	70:00	0	0	11	11
	60:43	0	0	11	11
	74:15	1	0	9	10
	98:48	0	1	9	10
	101:49	1	1	8	10
	101:56	0	2	7	9
	95:31	1	1	6	8
	114:48	0	1	7	8
	71:38	0	0	8	8
	00:21	0	0	8	8
	86:25	0	2	6	8
	32:55	0	0	7	7
	66:41	0	0	7	7
	23:13	0	0	7	7



Evaluation of driving behavior (legal compliance)

Lenk- und Ruhezeit Gesamtübersicht ✖

von
 bis

Übersicht Verletzungen Übersicht Zeitwirtschaft **Legende** **Details Verletzungen**

Intervall	Von	Bis	Regel	Fehler
Red. tägl. Ruhezeit	26.11.08 18:51	27.11.08 03:57	Max. Lenkzeit = 04:30	04:32
Pause	27.11.08 14:09	27.11.08 15:18	Max. Lenkzeit = 04:30	06:09
Tägl. Ruhezeit	28.11.08 19:23	29.11.08 06:29	Max. Zeit zw. tägl. Ruhepausen = 24:00	28:00
Red. tägl. Ruhezeit	01.12.08 16:39	02.12.08 03:44	Max. Lenkzeit = 04:30	05:47
Pause	02.12.08 09:43	02.12.08 10:27	Max. Lenkzeit = 04:30	05:13
Pause	03.12.08 16:50	03.12.08 17:26	Max. Lenkzeit = 04:30	06:59
Red. tägl. Ruhezeit	05.12.08 18:07	06.12.08 03:14	Max. Lenkzeit = 04:30	04:59
Red. wöchentl. Ruhezeit	06.12.08 14:33	07.12.08 21:00	Max. Anz. reduz. Ruhezeiten zw. zwei wöchentl. Ruhepaus...	5
Red. wöchentl. Ruhezeit	06.12.08 14:33	07.12.08 21:00	Max. Zeit zw. wöchentl. Ruhepausen = 144:00	258:12
Red. wöchentl. Ruhezeit	06.12.08 14:33	07.12.08 21:00	Max. Lenkzeit = 04:30	05:35
Red. wöchentl. Ruhezeit	08.12.08 05:15	09.12.08 05:29	Max. Anz. reduz. Ruhezeiten zw. zwei wöchentl. Ruhepaus...	5
Red. wöchentl. Ruhezeit	08.12.08 05:15	09.12.08 05:29	Max. Lenkzeit = 04:30	07:09
Wöchentl. Ruhezeit	11.12.08 04:59	13.12.08 01:59	Max. Anz. reduz. Ruhezeiten zw. zwei wöchentl. Ruhepaus...	5
Wöchentl. Ruhezeit	11.12.08 04:59	13.12.08 01:59	Max. Lenkzeit = 04:30	07:31
Woche	01.12.08 00:00	08.12.08 00:00	Max. Lenkzeit pro Woche = 56:00	56:48
Woche	01.12.08 00:00	08.12.08 00:00	Max. Lenkzeit pro Doppelwoche = 90:00	92:14
Woche	01.12.08 00:00	08.12.08 00:00	Min. 1 red. und 1 regelm. wöchentl. LZU pro Doppelwoche	Anz. Re...
Woche	08.12.08 00:00	15.12.08 00:00	Min. 1 red. und 1 regelm. wöchentl. LZU pro Doppelwoche	Anz. Re...



Evaluation of driving behavior (legal compliance)

Lenk- und Ruhezeit Gesamtübersicht

von
 bis

Übersicht Verletzungen | Übersicht Zeitwirtschaft | Legende | Details Verletzungen | **Details Zeitwirtschaft**

Aktivität	Beginn	Ende	Dauer
Ruhezeit	25.11.2008 22:51:00	25.11.2008 22:54:00	00:03
Lenkzeit	25.11.2008 22:54:00	25.11.2008 22:55:00	00:01
Ruhezeit	25.11.2008 22:55:00	26.11.2008 07:56:00	09:01
Lenkzeit	26.11.2008 07:56:00	26.11.2008 11:40:00	03:44
Arbeitszeit	26.11.2008 11:40:00	26.11.2008 11:42:00	00:02
Lenkzeit	26.11.2008 11:42:00	26.11.2008 12:08:00	00:26
Arbeitszeit	26.11.2008 12:08:00	26.11.2008 12:11:00	00:03
Lenkzeit	26.11.2008 12:11:00	26.11.2008 12:13:00	00:02
Ruhezeit	26.11.2008 12:13:00	26.11.2008 13:21:00	01:08
Lenkzeit	26.11.2008 13:21:00	26.11.2008 15:12:00	01:51
Ruhezeit	26.11.2008 15:12:00	26.11.2008 15:14:00	00:02
Lenkzeit	26.11.2008 15:14:00	26.11.2008 15:16:00	00:02
Ruhezeit	26.11.2008 15:16:00	26.11.2008 15:22:00	00:06
Lenkzeit	26.11.2008 15:22:00	26.11.2008 15:26:00	00:04
Ruhezeit	26.11.2008 15:26:00	26.11.2008 16:01:00	00:35
Lenkzeit	26.11.2008 16:01:00	26.11.2008 17:02:00	01:01
Ruhezeit	26.11.2008 17:02:00	26.11.2008 17:17:00	00:15
Lenkzeit	26.11.2008 17:17:00	26.11.2008 18:51:00	01:34
Ruhezeit	26.11.2008 18:51:00	27.11.2008 03:57:00	09:06
Lenkzeit	27.11.2008 03:57:00	27.11.2008 06:31:00	02:34
Ruhezeit	27.11.2008 06:31:00	27.11.2008 07:16:00	00:45
Lenkzeit	27.11.2008 07:16:00	27.11.2008 11:17:00	04:01
Ruhezeit	27.11.2008 11:17:00	27.11.2008 11:38:00	00:21
Lenkzeit	27.11.2008 11:38:00	27.11.2008 12:01:00	00:23
Ruhezeit	27.11.2008 12:01:00	27.11.2008 12:24:00	00:23

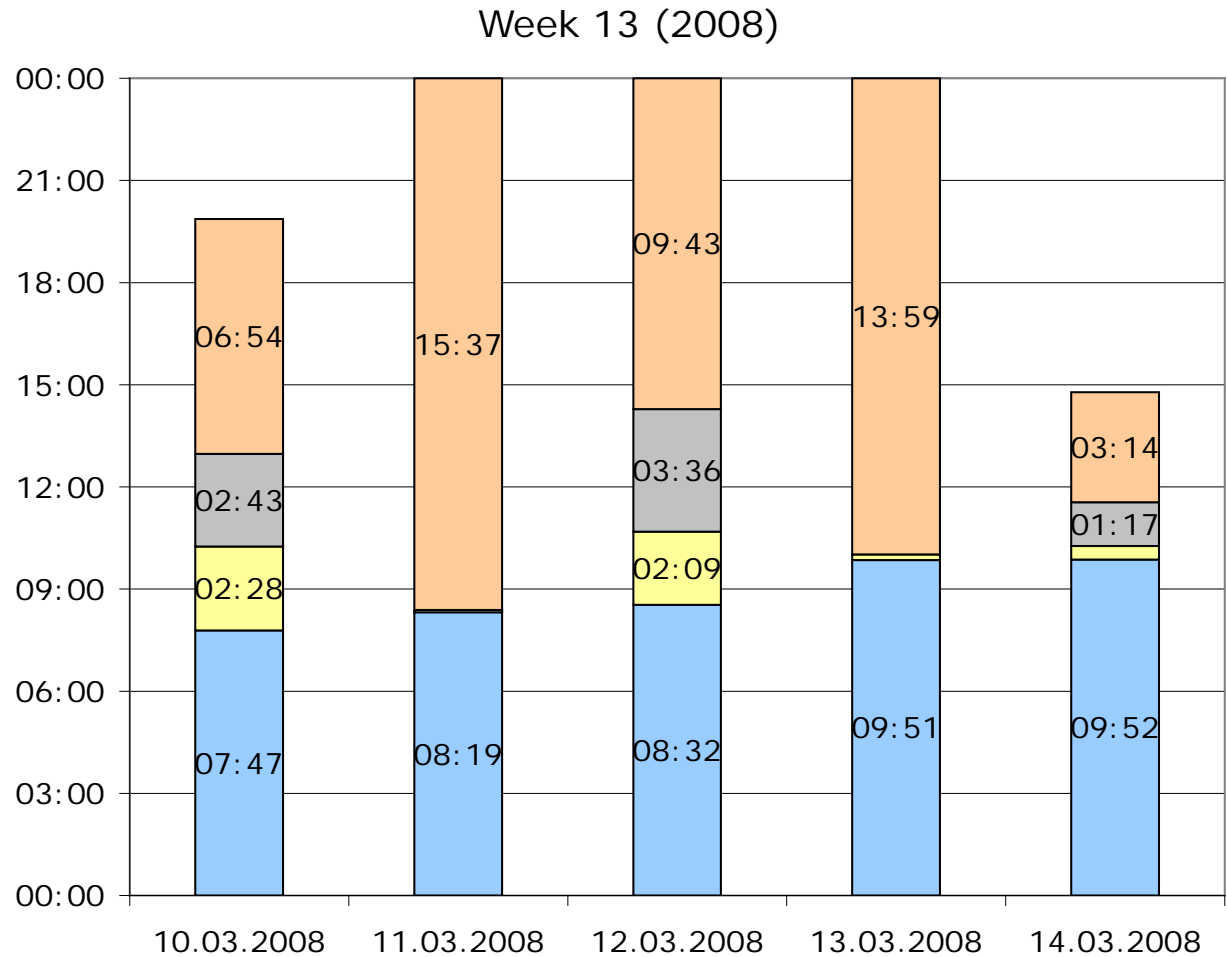


Performance indicators: drivers

Driver workload

- Individual workload over short time period (e.g. week)

- Resting time
- Standby time
- Working time
- Driving time

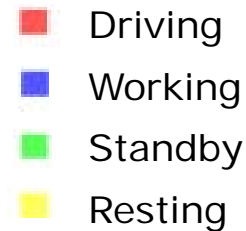




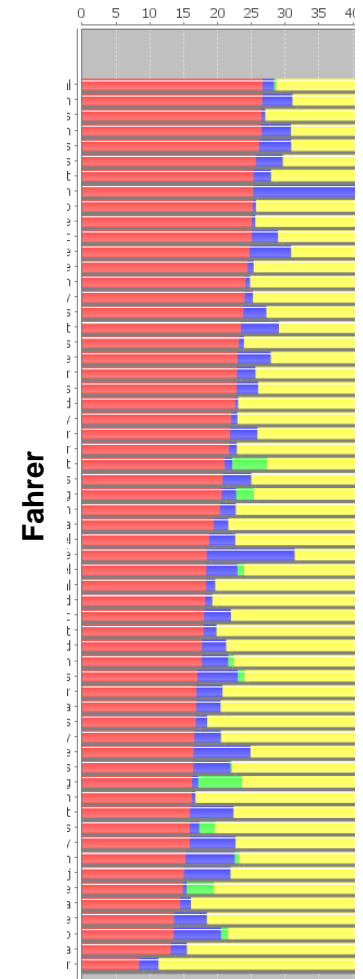
Performance indicators: drivers

Driver workload

- **Workload comparison** over extended time period (e.g. quarter)
- **Relatives numbers:** share of every activity type
- **Counting only working (active) days**
- **Reference values (mid-term max):**
 - Driving (EC): 45h / 120h ~ 37,5%
 - Driving + Working (D): ~ 40%
- **Sample data**
 - Driving time varies from 10% - 26%
 - Median ~ 20%



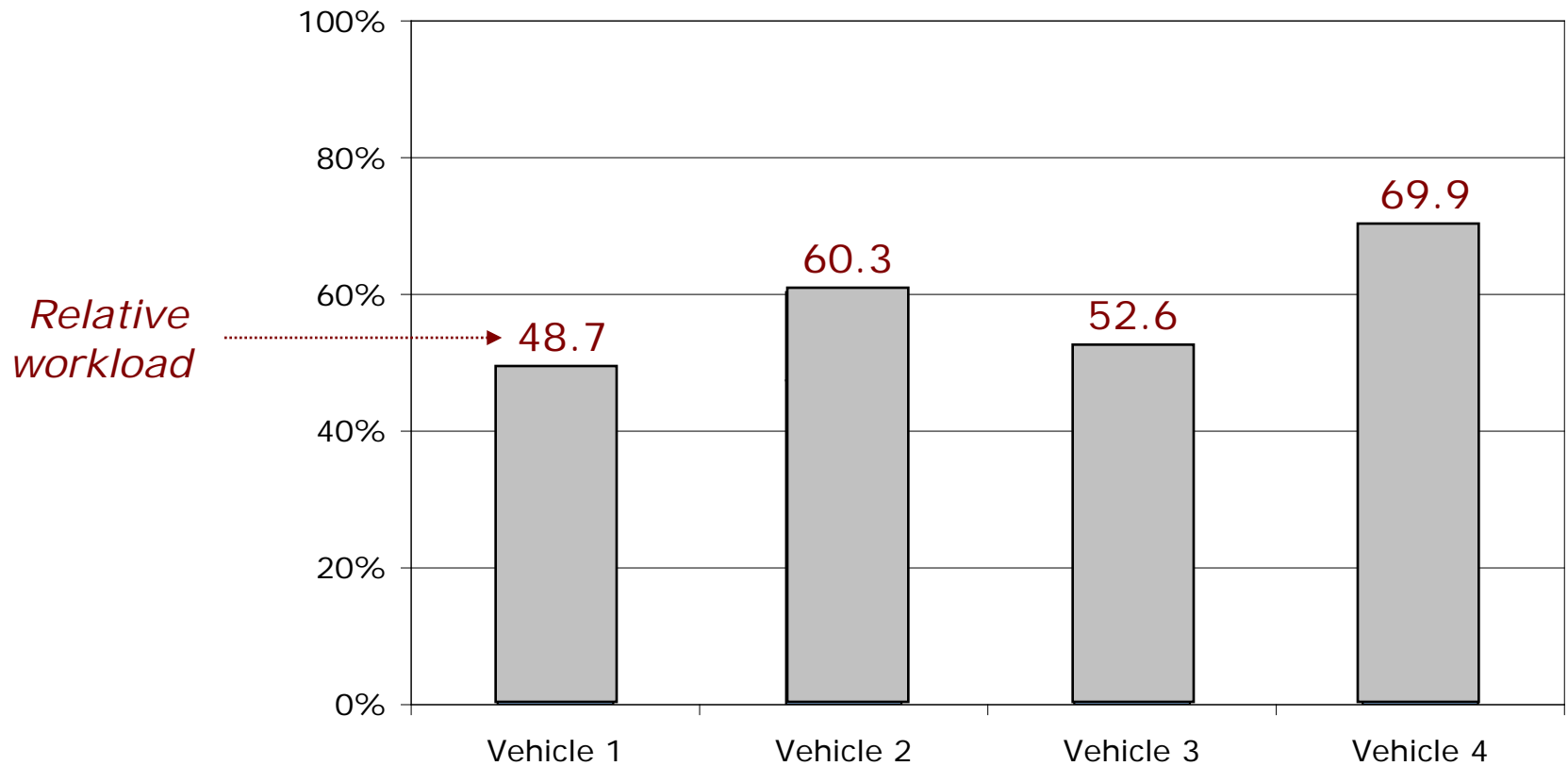
2rd Quarter 2009 =>
Source: J.S. Logistik





Performance indicators: vehicles

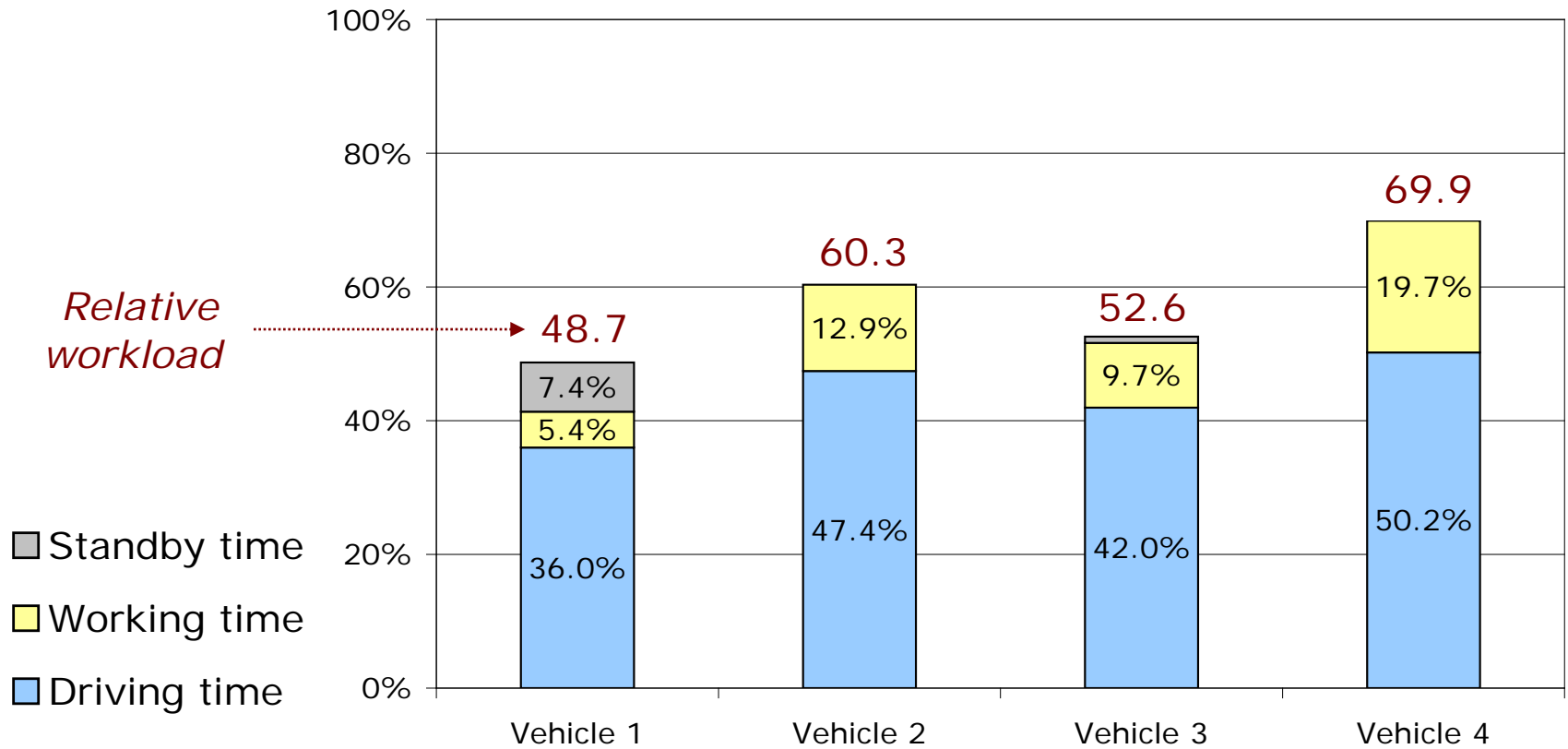
3rd Quarter 2008





Performance indicators: vehicles

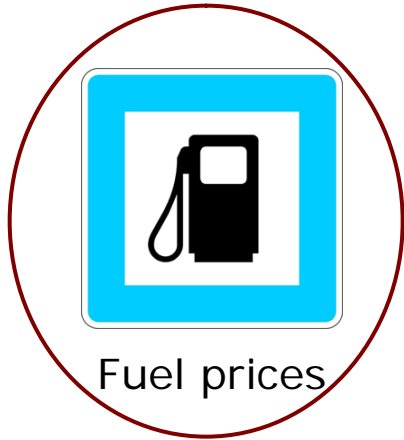
3rd Quarter 2008





Online data and decision support

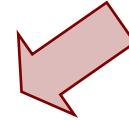
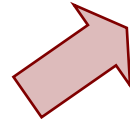
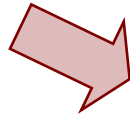
Additional online data



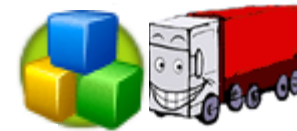
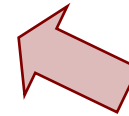
Fuel prices



Parking areas



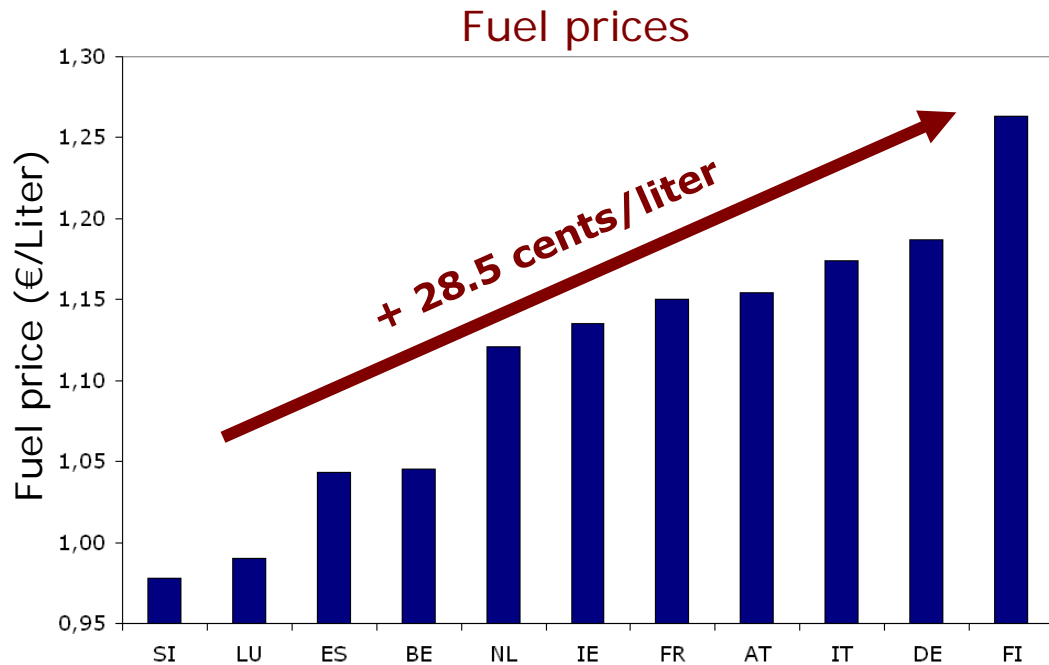
Traffic information



Freight marketplace



Online data and decision support



Online Data:

- Current fuel level
- Network of gas stations
- Up-to-date prices

J.S. Logistik:

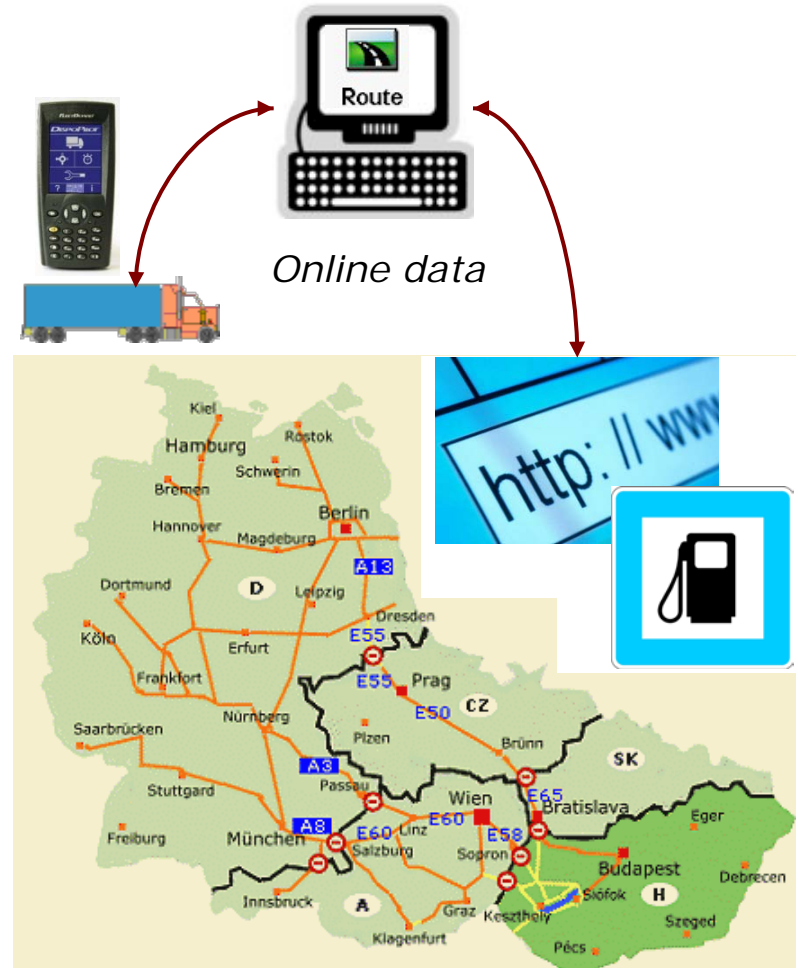
- ~50 vehicles, daily 20 000 liters fuel
- If 2 ct./l less \Rightarrow 100 000 € annual savings



Online data and decision support

Decision support

- Develop refueling policies
 - Which gas stations?
 - How often?
 - Which quantity to refuel?
- Take advantage of low-priced gas stations
- Comply with drivers' working & resting regulations
- Account for time windows
- (Consider driver's preferences)





Online data and decision support

Vehicle refueling problem - State-of-the-art

- 1990s: “Commercial fuel optimizers” by software vendors in North America
- 2000s: Research
 - Greedy algorithm for fixed-route vehicle refueling, Lin et al. (2007)
 - Joint path and fueling optimization, Lin (2008)
 - ❖ Optimal solution in $O(\Delta n^2 \log n)$
 - Polynomial time approximation algorithms for TSP, Khuller et al. (2008)



Major limitations:

- No consideration of dynamic fluctuations of fuel prices (use of latest price data available at time of dispatch)
- No integration with drivers' working regulations, customer time windows, traffic information, ...

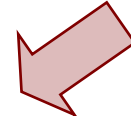
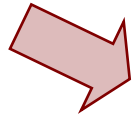


Online data and decision support

Additional online data



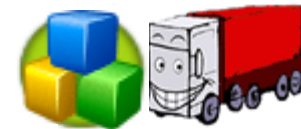
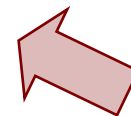
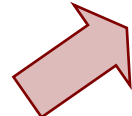
Fuel prices



Traffic information



Parking areas



Freight marketplace




Online data and decision support

Parking areas

- Congested parking areas in German highways (additional 14 000 parking spaces needed)
- Non-availability of parking space leads to violation of drivers' regulations
- Pilot projects:
 1. Highway A3: Availability and reservation via internet / cell phone

Tank- und Rastanlage Montabaur	
Angaben gelten für Lkw-Parken - keine Pkw Infos	
Adresse:	A3 Frankfurt Richtung Köln 56410 Montabaur
Bauart:	Offene Fläche
Anzahl Parkplätze:	84
am 27.03.09 um 14:28	frei Tendenz* →
Öffnungszeiten:	Montag-Sonntag 00:00-24:00 Uhr
Preis:**	kostenlos
Sicherheit:	Personalüberwacht





Online data and decision support

Pilot projects:

2. Highway A8: LCD-display for parking space availability



3. "Secure European Truck Parking Operational Services" (2007-2009)

- ❖ Development of new telematics systems for trucks
- ❖ Online database with availability of parking areas
- ❖ Reservation system via call center, cell phone, internet



www.setpos.eu

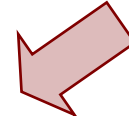
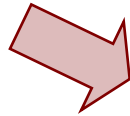


Online data and decision support

Additional online data



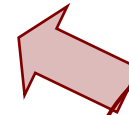
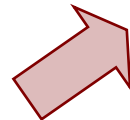
Fuel prices



Traffic information



Parking areas



Freight marketplace



Online data and decision support

Freight spot market

- Over 100 electronic marketplaces in Europe
- Benefits for dispatchers:
 - Increase capacity utilization of vehicles
 - Reduce empty return trips
 - Find suitable orders quickly

Major limitations:

- Time-consuming search for freight orders
- Limited automatic filtering of “suitable orders” and information display (e-mail, SMS, fax)
- No integration into dispatching software tools



www.timocom.de



Online data and decision support

e-Marketplaces - State-of-the-art



- Yield management problem
 - Choice of e-marketplace, setting of bid prices, Nandiraju and Regan (2003)
- Combinatorial auctions: Winner determination problem, Carrier's bidding problem
 - Mostly heuristic procedures, Song et al. (2004), Song and Regan (2005) Figliozzi (2004), Agrali et al. (2008)
- Collaboration strategies between shippers and carriers:
 - Auction strategies based on game theory, Song and Regan (2004)



Summary - Outlook

Summary

- Telematics data
 - to keep track of legal compliance with EU drivers' working regulations
 - to generate driver and vehicle performance evaluation measures
- Additional online data for decision support
 - Fuel prices, parking availability, freight transportation marketplaces, ...

Work in progress

- Research project "DynaServ" (06/2009 – 05/2012) funded by Federal Ministry of Education and Research; Project partners: J.S. Logistik and software company UKS
- Checking available online information (on European level)
- Developing formal model and decision support



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