Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria

Truck parking space creation through intelligent structuring of given capacity

Ilja Bäumler a*, Herbert Kotzab b

[a]*University of Bremen, Chair of Logistics Management, Wilhelm-Herbst-Str. 12, Bremen 28359, Germany*
[b]*University of Bremen, Chair of Logistics Management, Wilhelm-Herbst-Str. 12, Bremen 28359, Germany*

Abstract

This study shows how intelligent parking systems can extend the parking space capacity along German federal motorways by the use of satellite close-ups. Through this approach, the expansion potential of existing rest and service stations can be analyzed by means of intelligent parking facility management. We focused our analysis on German federal motorways with the highest lack for truck parking lots. Along these motorways, suitable rest and service stations were identified and we applied different telematics and non-telematics approaches in order to increase the capacity of parking areas without starting extensive constructional projects. Our findings show that parking space utilization can be significantly improved by simple structural extensions and a simultaneous use of intelligent parking facility management. Our study shows possibilities for a rapid and sustainable increase of truck parking spaces in a simple way.

Keywords: Intelligent Transportation Systems (ITS), Compact Parking, Telematics, Intelligent Truck Parking Systems

* Corresponding author. Tel.: +49 421 218 66986
E-mail address: ilja.baeumler@uni-bremen.de

1. Introduction

The issue of truck parking space is a hot topic in Germany. In 2008 as well as in 2013, the German Federal Ministry of Transport and Digital Infrastructure (FMTDI) has analysed the parking space situation at German motorways. The German federal motorway network includes a length of 13,000 km and offers a total of less than 60,000 parking lots at more than 2,000 different types of parking locations. Still there is a deficit of 11,000 parking lots which are required in order to keep pace with the growth of road freight transport as well as to cope with the legal requirements for driving and rest times (Kathmann et al., 2014).

This deficit means that every fourth driver is not able to find a legit parking lot at or near the motorway. Consequently drivers rest with their trucks at illegal places at exit or entry areas of service stations or use parking lots for passenger cars. This leads to additional noise pollution in city areas as well as to neglecting the resting time regulations. Furthermore wrongly parked trucks pose a safety risk towards other road users (Dierke et al., 2016).

Therefore, the FMTDI has invested a lot into new buildings, re-buildings and expansion of service stations in order to create new parking lots for trucks. So far, the relative share of lacking parking lots has decreased from 23 per cent to 15 per cent, but absolutely the number has not changed a lot due to the increasing freight volume on roads. Thus many trucks are still parking dangerously in entry and exit areas of service stations.

Due to financial as well as spatial restrictions innovative ways to solve this problem are required which aim at improving the given infrastructure with low costs. Intelligent parking facility management (IPFM) as part of intelligent transport systems are thereby seen as such a possibility as they are able to use their sensor and image recognition technology allowing an increasing of an absolute number of parking lots. Furthermore, dynamic and changing display panels are used for a more efficient use of parking lots as they are able to indicate the number of free parking lots for the following two to four service stations.

In this paper we want to discuss existing solutions and intelligent parking facility management systems that can be used to reduce the parking lot problem. In addition we are going to show how these systems can be used to increase the absolute number of possible parking lots at German federal motorway rest areas.

For our analysis we used Google Earth satellite close-ups for all German federal motorway sections, which lack five and more truck parking lot per kilometre. By this we show an easy way to identify and adapt rest and service areas in terms of our research goals.

2. Systems and technologies for intelligent parking facility management

2.1. Principal approaches for intelligent parking facility management

IPFM includes all technological advances, which ensure the automatic registration and differentiation of condition data. This includes sensor as well as radio-based transmission technologies. Faheem et al. (2014) recognise six principal approaches for IPFM that are shown in Table 1.

Table 1. Classification of major approaches of IPFM (adapted from Faheem et al., 2014; Longfei et al., 2009; Lu et al., 2010; Pullola et al., 2007)

System classification	**Characterisation**
Expert system (also known as agent sytems)	Experts or agents represent the elements of the observed systems and take over their characteristics such as intelligent or autonomous behaviour. In certain circumstances, agents are also able to negotiate. These systems are able to reduce the amount of transferred data but also identify an optimal parking lot solution by considering a lot of restrictions such as parking fees or distances to the parking lot. Expert systems are used in dynamic environments with a lot of interactions.
Fuzzy logic based system	These systems are able to learn from experts and these systems are also able to adapt their decisions and directions. This is an advantage in recurrent situations as the system

	can intervene. In combination with additional sensors and image recognition, such systems can identify parking spaces in very short time as well as execute the parking process.
Wireless sensor based system (WSN)	WSN are capable to control an area via video detection or sensor technology with low effort. Sensors transmit the current conditions via their receivers which are condensing the data in order to identify parking possibilities for the users.
GPS based systems	GPS-based systems are a very simple but rather unreliable tool for searching parking lots. Depending on the coordinates, the driver receives the next parking lots, however not having the guarantee of their availability. Some systems are capable to show free parking lots based on the analysis of past and current parking occupancy based on probability distributions.
Vehicular communications systems (VCS)	VCS is a system that is able to control a large parking area and communicates free lots to drivers and also provides navigation to the free areas in short time. This allows real-time navigation to the parking lot, ease of use of information as well as anti-theft protection.
Vision based systems (VBS)	VBS work with installed cameras where software recognises the type of vehicle based on the edge pattern. Based on this, VBS is capable to check free parking lots. Route navigation as well as real-time data can assist VBS. There are two disadvantages to be considered: VBS are expensive systems and they require a continuous transmission of a lot of data which leads to high load of radio transmission for the receivers.

It is important to note here that these systems are more or less valid for passenger car IPFM.

2.2. Telematics Parking Facility Management for truck parking lots

In this paper we discuss telematics systems that can be used for solving the current truck parking lot problems at German federal motorways. This includes telematics controlled parking, intelligent controlled compact parking and dynamic parking position displays. In addition we present two non-telematics solutions, which are mixed use of parking lots for trucks and passenger cars and provision of parking space by companies which are located in the vicinity of the German federal motorway. Thereby we consider the legal requirements for driving and resting times for drivers who have depending on the length of their tour different needs for parking lots. Furthermore we focus on such solutions with low economic efforts.

2.2.1. Telematics Controlled Parking and Intelligent Controlled Compact Parking

Telematics controlled parking as well as intelligent controlled compact parking are systems allowing additional parking space for trucks without requiring far-reaching constructional measures. Following Fig. 1 shows the principle of both systems which are working identically in principal as parking space is created by using the middle lane between two truck parking rows as additional parking lot.

Fig. 1 Additional truck parking lots by telematics controlled parking

In 2005, the first telematics controlled parking was installed at the service station Montabaur on the A3. There it was shown that trucks can park in convoys depending on their planned exit times (Follmann und Menge, 2009).

Before 2012, drivers were required to fill in their exit times and the length of their vehicle at a terminal when entering the service area. Based on this information, they were allotted to a parking lot. Since 2012, the length of the vehicle is automatically detected at the terminal.

In the case of intelligent controlled compact parking it is the driver who decides in which row the vehicle is going to be parked. For this, departure displays are installed above every row so that a driver can identify the parking lot with a departure time that suits the driver. In addition, park area sensors are installed at every parking row and a laser scanner recognises the utilisation of the parking area. By this, free parking spaces can be released automatically in the parallel parking row with similar departure time if there is no parking space in a row of at least 20 m. The system adapts the precise time in accordance to the parking lot situation. (Dierke et al., 2016)

Any existing service area can be easily adapted to such a system by installing a tubular steel grid above the parking rows with variable traffic sign units and laser detectors. As such, these systems allow an efficient short-term solution for increasing the capacity at many rest and service areas.

2.2.2. Dynamic parking position displays of multiple successively positioned service areas

The problem of driving and resting times regulations is pressing drivers a lot as they are required to immediately use the next exit in order to keep their resting times. However, what needs to be done if the service area is fully occupied? Dynamic parking position displays can help here to ease the situation for drivers who will receive information on the parking lot situation of the coming service areas. This reduces the information deficit. These systems consist mainly of two modules, one including a system for parking lot control via sensors and system architectures and the other is for displaying the availability of parking lots along the motorways (Kleine et al., 2014).

All information are put together by an external service provider or by a traffic control centre and shown to the drivers on variable displays on the motorway. The displays inform not only on the parking availability on the next but also on the following two to three service areas which allows a driver to make a better decision on when to stop for keeping the resting times (Kleine et al., 2014).

2.3. Other non-telematics solutions

Besides sensor-driven and telematics generated parking areas, there are other possibilities, which increase the capacity of given service areas. A mixed use of parking lots for trucks and passenger cars depending on day and night times could be one option. However there it is important to check that entry and exit areas are easy to be accessed by trucks as well as safety requirements are kept and sufficient parking space for passenger cars are available (BMVBS, 2011).

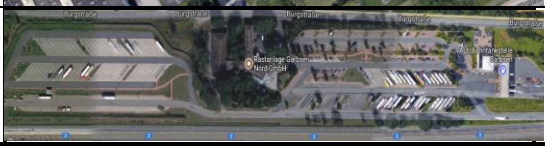
Another solution is currently provided by Bosch and Gebrüder Weiss which focuses on sharing parking space following the principle of car sharing. Forwarding companies as well as other companies that are located near motorways can offer parking space on their premises via a web-portal (operated by Bosch). Drivers can make reservation on this online platform. Also here additional capacity is generated without taking any constructional measure (DVZ Logistik & Verlader, 2017).

3. Method

We followed the notions of Malarvizhi et al. (2016) who used Google Earth satellite imagery for preparation of landuse maps in India. We adapted their approach by analysing those sections on German federal motorways which show a parking lot deficit of more than five lacking truck parking lots per kilometre (red sections in BMVBS (2008)). We photographed every rest and service area on these sections with Google Earth by sighting the German federal motorways. By doing this, we generated easy access for information on rest and service station along the German federal motorways even for the rest areas which are not operated and thus do not hold clear information. Afterwards we divided all identified rest areas into seven different categories (as listed in Table 2).

After having allocated all areas, we have examined all parking lots in regards to their principle extension. There we checked the possibilities for compact parking, mixed usability or useful sequencing of parking lot information. When checking for dynamic parking lot information displays for multiple areas, we carefully took into consideration that the respected areas are located on the same motorway section and not being separated by a junction. When examining mixed use of parking lots, we regarded enough space for manoeuvring the trucks and for compact parking we checked a minimum length of 60 metres per parking space so that three trucks are able to park in a sequential manner. All installations are considered to be easy implemented without complex constructional measures. In addition, we tried to assess the exact number of parking lots for both, trucks and passenger cars based on official numbers by the service area operators. In case these information were not available, we manually counted the parking lots.

Table 2. Classification of rest and service areas in the relevant motorway sections in dependence of their service offering.

Cate-gory	Example	Toilet facility	Gastro-nomy	Filling station	Truck parking lots
1					<15
2		x			<30
3		x			>30
4		x	x		<30
5		x	x	x	<50
6		x	x	x	50-100
7		x	x	x	>100

4. Results and discussion

Overall we identified a total of 154 different rest and service areas on the relevant sectors. Fig. 2 shows the differentiation of these areas based on the classification as outlined in Table 2 and the distribution of serviced and not serviced rest areas. Overall we were able to allocate 151 rest areas to our classification scheme. The remaining areas were either under construction currently or represent a customs parking lot.

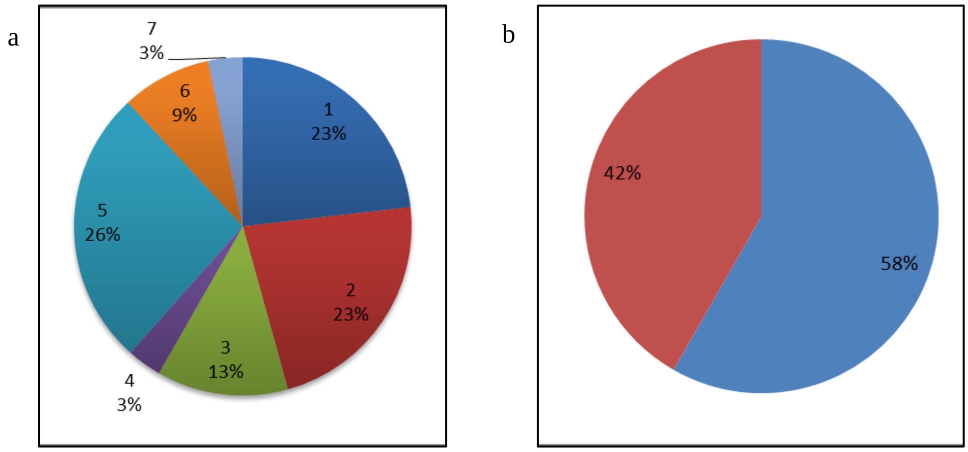


Fig. 2 (a) Distribution of rest and service areas on analysed motorway (see Table 2 for specification); (b) Distribution of serviced (red) and not-serviced (blue) rest areas

The majority of the areas were not serviced (n= 88) and the remaining areas were run by an operator (n=63). Fig. 3 summarizes the results of our analysis and shows the average possibilities of expanding the given parking lot capacity by compact parking and mixed use.

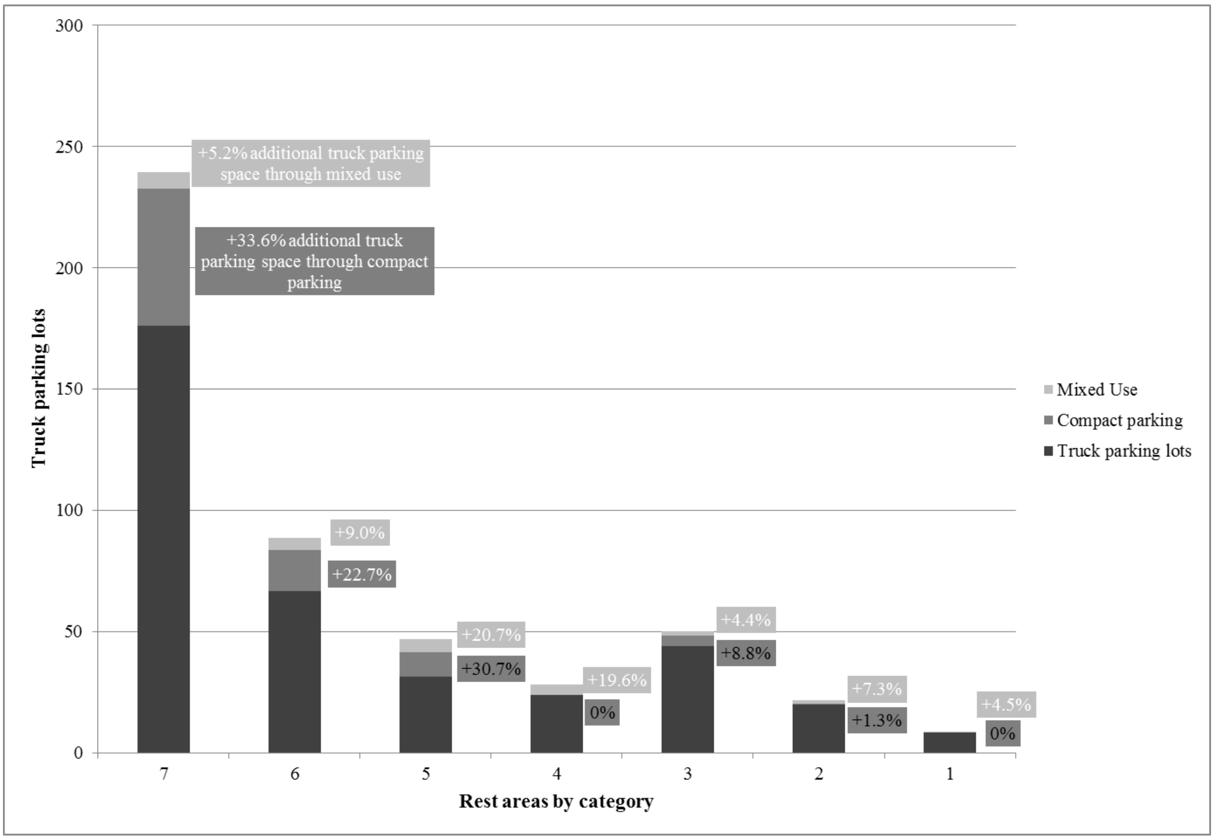


Fig. 3 Average truck parking space by rest area category and average increase of truck parking space by mixed use and compact parking

Fig. 4 exemplifies how we counted additional parking lots through compact parking or mixed use of parking lots. Whenever two truck parking lots could be merged to one parking row to a length of 60 m, we continued placing black bars to indicate the amount of parking rows. Consequently every parking row represents one additional truck parking lot. In case of mixed use of parking lots we checked for easy access for trucks at entry and exit areas as well as for assurance of safety requirements. Furthermore we assumed the minimum length of a truck parking lot to be 20 m or seven adjacent passenger car parking lots. As it can be seen in Fig. 3 we determined eight additional parking lots with the method of mixed use.

Fig. 4 Example of compact parking and mixed parking analysis (rest area Lichtendorf Süd)

Out of the 88 non-serviced areas, we consider seven areas to be expanded by compact parking. There we see a potential of additional 98 parking lots representing 5 per cent of the existing parking lots of all unserviced parking areas. Looking at the operator-driven service areas, we see 31 service areas having a potential of additional 883 parking lots, which represent 28 per cent of the existing parking lots.

Looking at the potential of mixed use of parking lots for evening and night hours we consider an increase of 422 additional parking lots for trucks at 90 service areas. However, only 29 of those are capable to create at least five additional parking lots.

Overall we see that many service areas have the necessary size to allow compact parking. The costs for implementing a compact parking systems for 35 additional parking lots are according to Kleine and Lehmann (2014) a little more than € 22,000 per parking lot. Caris (2017) assesses the costs for building a new motorway parking space with toilet facilities for 30 passenger cars and 50 trucks at 6 million € (on the Motorway A3 at Lohmar). When taking away the costs for the toilet facility and considering the costs for trucks and passenger car parking lots to be equal a rate of less than € 70,000 per parking lot.

5. Conclusion

In this paper we discussed the possibilities to increase the capacity of given parking lot areas on German motorways by using intelligent parking facility management systems.

With the use of satellite close-up we were able to easily identify 1,000 additional truck parking lots at specific sections of German federal motorways representing an increase by nearly 30 per cent. Our suggestion for adaptation would cost approx. € 21.5 million which would be 1/3 of the costs for new buildings.

We understand our result as 'food for thoughts' as we are only focussing our analysis on the most critical sections of the German federal motorway network. We are also aware of the fact that not all service areas are satisfactory for adaptations and we consider only operator-driven service areas to be adequate for our adaptations. When looking at our mixed-use suggestion, it is necessary to take into account that our calculations are maximum-calculations in terms of all available passenger-car parking lots will be made available. Our display solution also requires additional automatic detection systems in order to provide current parking lot availability.

In terms of the method applied, some limitations refer to the topicality of the images as well as the resolution quality. Not all images, especially for those service areas that are not operated by providers, were at an acceptable quality.

References

BMVBS, 2011. Güterverkehr und Logistik-Lkw-Parken in einem modernen, bedarfsgerechten Rastanlagensystem. Bundesministerium für Verkehr, Bau und Stadtentwicklung, Bonn.

BMVBS, 2008. Parksituation für Lkw auf BAB in Deutschland in den Nachtstunden.

Caris, M., 2017. Für Lkw: Kahlschlag an der A3 bei Lohmar – neuer Parkplatz kostet sechs Millionen Euro [WWW Document]. Köln. Rundsch. URL http://www.rundschau-online.de/region/rhein-sieg/lohmar/fuer-lkw-kahlschlag-an-der-a3-bei-lohmar---neuer-parkplatz-kostet-sechs-millionen-euro-25946228 (accessed 9.7.17).

Dierke, J., Kleine, J., Lehmann, R., 2016. Intelligent Controlled Compact Parking for Modern Parking Management on German Motorways. Transp. Res. Procedia, International Symposium on Enhancing Highway Performance (ISEHP), June 14-16, 2016, Berlin 15, 620–627. doi:10.1016/j.trpro.2016.06.052

DVZ Logistik & Verlader, 2017. Parkplatz-Sharing: Bosch und Gebrüder Weiss starten Projekt [WWW Document]. DVZ. URL http://www.dvz.de/rubriken/logistik-verlader/single-view/nachricht/sicheres-parken-bosch-und-gebrueder-weiss-starten-projekt.html (accessed 9.4.17).

Faheem, F., Mahmud, S.A., Khan, G.M., Rahman, M., Zafar, H., 2014. A Survey of Intelligent Car Parking System. J. Appl. Res. Technol. 11.

Follmann, J., Menge, J., 2009. Verbesserung der Parkmöglichkeiten für Lkw an Autobahnen. Straßenverkehrstechnik 1/2009, 25–31.

Kathmann, T., Schröder, S., Bär, A., 2014. LKW-Parken auf BAB (Schlussbericht). DTV-Verkehrsconsult GmbH, Aachen.

Kleine, J., Lehmann, R., 2014. Intelligent controlled compact parking for modern parking management on German motorways. Presented at the Transport Research Arena (TRA) 5th Conference: Transport Solutions from Research to Deployment.

Kleine, J., Lehmann, R., Lohoff, J., Rittershaus, L., 2014. Rastanlagen an BAB –Verbesserung der Auslastung und Erhöhung der Kapazität durch Telematiksysteme [WWW Document]. URL http://bast.opus.hbz-nrw.de/volltexte/2014/827/ (accessed 9.10.17).

Longfei, W., Hong, C., Yang, L., 2009. Integrating mobile agent with multi-agent system for intelligent parking negotiation and guidance, in: Industrial Electronics and Applications, 2009. ICIEA 2009. 4th IEEE Conference on. IEEE, pp. 1704–1707.

Lu, R., Lin, X., Zhu, H., Shen, X., 2010. An Intelligent Secure and Privacy-Preserving Parking Scheme Through Vehicular Communications. IEEE Trans. Veh. Technol. 59, 2772–2785. doi:10.1109/TVT.2010.2049390

Malarvizhi, K., Kumar, S.V., Porchelvan, P., 2016. Use of High Resolution Google Earth Satellite Imagery in Landuse Map Preparation for Urban Related Applications. Procedia Technol., International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST - 2015) 24, 1835–1842. doi:10.1016/j.protcy.2016.05.231

Pullola, S., Atrey, P.K., El Saddik, A., 2007. Towards an intelligent GPS-based vehicle navigation system for finding street parking lots, in: Signal Processing and Communications, 2007. ICSPC 2007. IEEE International Conference on. IEEE, pp. 1251–1254.