



## DESIGN IDEAS OF REMOVABLE VEHICLE RACKING CONTAINER IN LOGISTICS OF TRANSPORT OF PASSENGER CARS

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**ABSTRACT. Background:** There are many construction types of racks used for transport of passenger cars in standardized containers for sea and land transport. The producers of such solutions offer at present containers, which enable the transport of up to five passenger cars in one container but not always the loading space of the container is used in optimal way. Therefore researches are undertaken aiming to find solutions enabling even better use of free loading space of containers as well as to improve already existing solutions.

**Methods:** The analysis of already existing and used solutions of methods of fastening and transport of passenger cars in containers was conducted based on literature review.

**Results:** Based on obtained results, the desirable directions of further developing researches of innovative transport concepts were elaborated. They included two main requirements: utility for sea and land transport and in some conditions also for air transport, and the second postulate consisting in the possibility of the integration of specialized racks of changeable dimensions with the given container and their operational adaptation to the loading space of specific types of containers.

**Conclusions:** The concept of container system for sea transport of passenger cars was proposed. This idea is based on 40' container with ability to enlarge to the dimensions of 53' container and simultaneously to increase the number of transported passenger cars from four to five or even six ones in one container.

**Key words:** container transport, transport of passenger cars, module construction of container, car racks.

### INTRODUCTION

The trade within the international transport logistics creates the challenges, which concentrates i.e. on developing of concepts of containers for sea transport of passenger cars. A lot of operators declare the necessity to construct the specialized container, allowing the collision-free and efficient deep sea transport of various types of passenger cars in containers, having high coefficient of the usage of loading space of given container. At present, the providers of such solutions offer containers, enabling to transport up to five cars in one container. Such solutions are effective and reliable and lead to searching for even better use of loading space of containers as well as to the improvement of already existing

ones. The most active companies in this area are specialized innovative companies from Germany, US, England and China, which launch more and more technically advanced solutions to the area of the transport of passenger cars. The example of global transport company *DHL Global Forwarding GmbH* shows, that the essential innovation potential is in transport containers, offered by this company as well as functionalities expected by potential users and buyers of these devices.

The aim of this research is to show the directions of desired researches in the area of innovative solutions of container transport of passenger cars, with strongest focus put on the development of fastening methods in the interior of containers.

## REVIEW OF EXISTING SOLUTIONS

The basic postulate addressed to the containers is the requirement of the possibility to use them in the road and sea transport as well as (under some conditions) in the air transport. The second postulate consists in the possibility to integrate specialized racks of variable dimensions with a given container as well as their operational adaptation to cargo space of certain types of containers.

The representative example of such solution used for the transport of passenger cars, belonging to DHL company, is presented at the figure 1. The company has developed two basic transport systems in this area. The first one consists of two separate flat pallets, which could be raised by the use of a level to create spatial equipment to hold two passenger cars. When folded, they resemble the flat pallet, which can be put with no problem into the loading space of the container (see Fig 1). This pallet construction can exist also as an independent one, without the necessity to put it in the container.

To utilize 40' containers, there is a functional possibility to use also a flat pallet in them (fig 2), which is equipped in a rack tippable at any angle to position passenger cars in them. This solution (in combination with loading process) is presented at the figure 3.



Fig. 1. The variant of possible stacking based on construction of flat transport pallets



Fig. 2. Flat pallets with tippable rack for fastening of transported cars



Fig. 3. Flat pallet with the load of passenger cars

The above-mentioned types of transport constructions belonging to DHL company, provide the basic offer range of pallets for car transport, which adapted to dedicated types of containers, are used mainly in road and sea transport and optionally in air transport. The important requirement of such solutions is the possibility to transport such constructions (flat pallets with and without racks) in folded state in the loading space of containers.

This postulate is considered as an economically justified and rational transport of devices for cars transport, even in the absence of the use of car racks in return transport. Therefore the question can be raised about the direction of the development in this area as well as industrial requirements for sophisticated technical innovations in the area of system solutions. At present, the 40' containers are preferred in this area. It is justified by the widespread use of this type of containers for road and sea transport.

Table 1. Parameters of 40' General Purpose Container

Parameter	Value
dimensions (length x width x height)	12,02 x 2,35 x 2,39 m
outside dimension (length x width)	2,34 x 2,29 m
tare weight	3780 kg
maximal cargo	26700 kg
capacity	67,7 cbm



Fig. 4. 40' General Purpose Container

There are also variants with increased load space (high Cube) with dimensions as show in table 2.

Table 2. Parameters of 40' High Cube Container  
Tabela 2. Parametry kontenera 40-stopowego z podwyższoną przestrzenią ładunkową

Parameter	Value
dimensions (length x width x height)	12,02 x 2,35 x 2,69 m
outside dimension (length x width)	2,34 x 2,59 m
tare weight	4020 kg
maximal cargo	26460 kg
capacity	76,3 cbm

The 40' container variant, so called High Cube, is the most dominant type of globally used containers. Due to the height of loading space, they provide the solution preferred by many users. On the other hand, the Trans-Rack company from Warwick in England introduced very interesting 45' containers equipped in mobile levers with changeable inclination angle. It allows to transport simultaneously four passenger cars in the space of one container.



Fig. 5. 45' container for transport of cars

Due to the possibility to transport four cars, this solution is the most optimal one. The changeable configuration of lifting and anchoring blue construction elements is presented in the figure 6.



Fig. 6. Visible elements of rack construction with possibility of height regulation

The racks show at the figure 7, having the regulated height can be provided in quantities and configurations desired by the clients, depended on their requirements, i.e. the number of transported cars. This solution can be used specially in sea transport (see Fig. 8).



Fig. 7. Height regulated folding racks for various use (folded)



Fig. 8. Container ship used for transport of 45' containers

## DIRECTIONS OF NEW SOLUTIONS

Determinants describing the innovative potential of new solutions in the discussed field:

1. New transport concepts go in the direction to ensure the transport of at least four cars or to make the possibility of the transport of five cars by the implementation of innovative solutions in optimal configuration of loading racks or by the bigger height of containers.
2. The return transport of folded car racks in 40' containers should be ensured to provide the profitability of transport and maximal use of loading spaces of means of transport.

3. The conducted analyses covering the area of transport possibilities show that at present the most popular method is the transport of three or four cars in one container. The fifth cars is the optional variant and usually in combination with a car of small dimensions. The standard possibility of the transport of five normal-sized passenger cars would be a real innovation in this area.

The possibility to develop the concept of Removable Vehicle Racking System (RVRS) for three following container constructions is taken to be the general aim of project assumptions:

- to develop the RVRS rack for 40' container Cube type of dimensions: length 12,030 m, width 2,35 m, height 2,690 m and total weight 28 750 kg with retractable or built-in racks in loading space of the container for the transport of four cars.
- to develop the RVRS rack for 45' container Cube type of dimensions: length 13,55 m, width 2,35 m, height 2,695 m and total weight 27 910 kg for the transport of five cars, based on innovation system consisting of retractable or built-in racks of the changeable configuration.
- further development of the construction of 45' container by the implementation of changeable set of side walls, floors and roofs and increasing its dimension in the direction of 53' container, equipped in retractable racks as solid or moveable elements of inner equipment of discussed container.

The possibility of serial incorporating of racks system into the floor container, for positioning and stabilization of transported cars should be pondered as an innovative component. This idea was already used in the system Car Rack (see Fig 6). The innovation of this solution enables the possibility to develop two main technical variants:

1. The innovative solution in the form of retractable rack (into the container interior), which allows loading of cars on the rack standing outside the container and then as a whole to put it into the container interior. The difficulty of this solution consists in the necessity to secure the high stability of the rack with cars during the loading process

into the container. This problem can be solved by proper construction and static calculations. After fulfilling this condition, only the rack should be attached properly in the container interior.

2. The innovative solution in the form of the rack consisted of separate elements, which could be gradually incorporate into the loading space of container, based on the system of built-in rails, situated both on the floor as well as the ceiling of the container. It would provide higher flexibility in case of the transport of cars of various classes and brands. This type of solution would mean, that given container would be designed in its construction parameters to be able to take over the load of transported cars.

There are already construction solutions in the international space, protected by the patent law. However the new innovative components would be concentrated on essential and constructive issues, therefore there will be no objections to submit a patent request for solutions in the form of module concepts. This type of solutions, including the innovative components, could be patented in case of realization of following project concepts:

- to develop the RVRS rack for 40' container Cube type of dimensions: length 12,030 m, width 2,35 m, height 2,690 m and total weight 28 750 kg with retractable or built-in racks in loading space of container for the transport of four cars. This type of solution is already known but there is a necessity to design it in the form of the module construction.
  - to develop the RVRS rack for 45' container Cube type of dimensions: length 13,55 m, width 2,35 m, height 2,695 m and total weight 27 910 kg for the transport of five cars, based on innovation system consisting of retractable or built-in racks of changeable configuration (flexibility of exploitation of the rack inside the container would be provided by operators, who would be able to justify a given rack in module way according to needs). The core construction of the rack would enable to position cars on the other level of the incline plane by the use of moveable support elements, placed on both sides. Therefore, the changeable configuration of the support elements would allow to transport cars of different sizes.
- to develop 45' container with built-in permanent rails in the floor plane and above the floor to put in them the outer rack with transported cars located in optimized way on it (it would create a specific solution of core construction with the possibility of integration with 45' container). The advantage of this solution would be the possibility to load the rack outside the container and not in the limited space of the interior of the container.
  - racks system of core construction should be equipped in internal rails system to ensure the movement of racks with cars within the space of built-in permanent rails inside the container.
  - the rack should be so constructed that it would allow to put it immediately after unloading back into the container in the folded phase. It should be possible to load also other parts of the equipment in the same container.
  - the system of module constructions should be designed in the form of multimodular transportation system. The idea of allowing the possibility to change 40' container into 45' or 53' container by the implementation of moveable side walls as well as moveable floor and roof would be a very original solution. It would mean, that the 40' container would have the ability to elongate to 45' container (or even bigger one). These characteristics of the container would be an original feature of the construction uniqueness.
  - at present 53' container is used in US for the transport of truck tractors. So also in this case, it would be necessary to ponder the possibility to include it into the system of modular constructions as well as to enlarge the system so the 40' or 45' container in second variant could be enlarged to 53' container. It would mean to enlarge 40' container by 2,44 m. Such option would allow to transport even six passenger cars (in case of optimal configuration) in one container.

The realization of above-mentioned solutions would efficiently increase existing wide range of patents, mainly by the own unique constructions of transport means, which could be submitted to patent protection and then used in serial production.

## POSTULATED PARAMETERS AND TECHNICAL FUNCTIONS

Concluded from above-mentioned analytic contemplations, the following design works should be initiated:

- to develop the system of module elements as Removable Vehicle Racking Container in case of standard 40' and 53' containers as well as 40' container with function of enlarging to 53' container (in such case, the basic construction would cover three types of containers). The indispensable part of such containers would be a system of floor and over-floor rails, incorporated in their construction, which would enable to move moveable outer racks for transport of passenger cars into the loading space of containers.

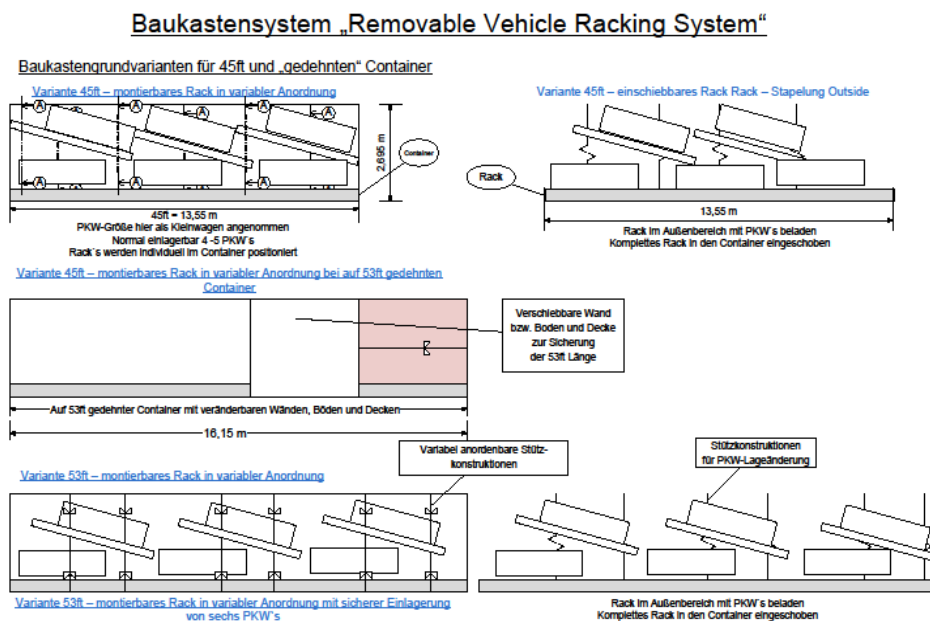


Fig. 9. Basic schema of the module construction system for containers used in logistics of transport of passenger cars

- to develop the construction of individual racks, enabling the mechanical loading process of passenger cars outside the container (during loading and unloading) into and from the loading space of the container.
- to develop the system of reliable fastening of car racks to be used in sea transport, even in situation of extremely high waves.
- to develop the construction of 40' container having the possibility to enlarge it to the dimensions of 53' container and to equip it in racks of changeable sizes,

enabling to load up to six cars on it. This possibility to change the dimensions is especially important in case of the transport of empty containers by sea roads, taking into consideration saving of area and loading space on cargo ships.

The schemas of module constructions of containers representing the individual solutions are shown at figure 9.

## CONCLUSIONS

The concepts of container systems for logistics implementation of sea transport of passenger cars, based on 40' container with possibility to enlarge it up to 53' container, were proposed. The container variants used at present, limit the number of transported cars only to four. Therefore the postulate was raised to increase this number to five or even six cars, transported in one container, mainly through creating the construction elements of containers to be more flexible and allowing to enlarge the range of innovative solutions in this area. It would create a significant innovation turning point in the area of logistics of sea transport of passenger cars.

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## KONCEPCJE PROJEKTOWE KONTENERÓW Z MOBILNYMI STOJAKAMI W LOGISTYCE TRANSPORTU SAMOCHODÓW OSOBOWYCH

**STRESZCZENIE. Wstęp:** W praktyce transportowej stosuje się obecnie różnego rodzaju rozwiązania konstrukcyjne stelaży i pojemników służących do przewozu w znormalizowanych kontenerach samochodów osobowych w transporcie morskim i lądowym. Producenci tego typu rozwiązań oferują obecnie kontenery, przy pomocy których można przewozić do 5 sztuk samochodów osobowych w jednym pojemniku kontenerowym, nie zawsze jednak wykorzystujących optymalnie wolną przestrzeń ładunkową. Dlatego trwają szukania koncepcji jeszcze lepszego wykorzystania przestrzeni ładunkowej kontenerów, a także udoskonalania rozwiązań już istniejących.

**Metody:** Na podstawie przeglądu literaturowego dokonano analizy aktualnie znajdujących się w użyciu sposobów mocowania i transportu samochodów osobowych w kontenerach.

**Wyniki:** W oparciu o uzyskane wyniki opracowano pożądane kierunki dalszych prac rozwoju innowacyjnych koncepcji transportowych, uwzględniających dwa podstawowe wymogi: użyteczność dla transportu morskiego i drogowego oraz przy pewnych warunkach również lotniczego oraz drugi postulat, polegający na możliwości integracji specjalistycznych stojaków o zmiennych gabarytach z danym kontenerem oraz ich operacyjnego przystosowywania do przestrzeni ładunkowej określonych typów kontenerów.

**Wnioski:** Na potrzeby logistyki morskiego transportu samochodów osobowych zaproponowano koncepcje systemu kontenerowego w oparciu o kontener 40-stopowy z możliwością jego rozciągnięcia do wielkości kontenera 53-stopowego przy jednoczesnym zwiększeniu możliwości transportu samochodów osobowych z czterech do pięciu, a nawet sześciu sztuk w jednym kontenerze.

**Słowa kluczowe:** transport kontenerowy, transport samochodów osobowych, modułowa konstrukcja kontenera, stojak dla samochodu.

## REMOVABLE VEHICLE RACKING CONTAINER (RVRC) FÜR DIE AUTOMOBILLOGISTIK

**ZUSAMMENFASSUNG. Einleitung:** In der gegenwärtigen Transportlogistik werden unterschiedliche Konstruktionslösungen von Transport-Racks und -behältern, die zur Beförderung von PKWs in standardisierten Containern über See, Straße und Schiene dienen, in Anspruch genommen. Die Hersteller derartiger Transportkonstruktionen bieten heutzutage Containers an, mithilfe deren bis 5 PKWs in einem Container befördert werden können. Es wird jedoch dabei nicht immer für eine volle Auslastung der im Inneren des Containers vorhandenen Laderäume gesorgt. Aus den internationalen Logistik-Verbindungen resultieren daher Versuche, die sich mit Containerlösungen für den überseeischen PKW-Transport befassen. Es wird also von mehreren Partnern der Wunsch geäußert, einen neuen Typ von PKW-Transport-Container zu beziehen, der eine hohe Packungsdichte von verschiedenen PKW-Typen sichert und somit zu einem beschädigungsfreien, flexiblen und zugleich ökonomischen Transport im Überseebereich führen kann.

**Methoden:** Gestützt auf die Übersicht der vorhandenen Fachliteratur wurde eine Analyse der bestehenden Verankerungs- und Beförderungsverfahren von PKWs in Transport-Containern über See vorgenommen.

**Ergebnisse:** In Anlehnung an die gewonnenen Resultate wurden erwünschte Ausrichtungen für weitere Innovationsarbeiten und Transportkonzepte ausgearbeitet. Sie berücksichtigen zwei grundlegende Anforderungen, die an konkrete Technik-Lösungen gestellt werden, dh. eine hohe Nutzbarkeit für den See- und Straßentransport und möglicherweise für den Lufttransport (bei Erfüllung gewisser Voraussetzungen) sowie eine Möglichkeit der Einbindung von Spezial-Tracks mit variablen Dimensionen in die bestehenden Containers und deren operative Anpassung an die Laderäume bestimmter Container-Typen.

**Fazit:** Als generelles Ziel aus den Vorbetrachtungen lässt sich die Entwicklung eines europäischen Baukastensystems „Removable Vehicle Racking System“ für 3 Containervarianten ableiten: Entwicklung des RVRC-40ft Cube-Container mit den Maßen L: 12,030m – B: 2,35m – H: 2,690m und einer Gesamtmasse von 28750 kg für den Vierfachtransport von PKW's mit einschiebbaren Racks sowie variablen Einbauracks, ferner die Entwicklung des RVRC.45ft Cube-Container mit den Maßen L: 13,55m - B: 2,35m – H: 2.695m und einer Gesamtmasse von 27910 kg für den gesicherten Fünffach-Transport mit innovativem Car-Rack als Einschublösung und als variables Einbaurack sowie die Weiterentwicklung des 45ft-Containers durch variable Wände, Böden und Decken und Dehnung auf die 53ft-Containervariante mit Einschubracks als statische Racks sowie interne variable Racks im Innenausbau des Containers. Diese neuen Containerlösungen stellen eine interessante Innovation im Bereich der Containertransportlösungen dar. Es wird erwartet, dass sich die 53ft-Containerlösungen in Europa mit einer Möglichkeit der Beförderung von 5 oder sogar 6 Pkws über See ab 2020 durchsetzen werden.

**Codewörter:** Container-Transport, Beförderung von PKWs, Modulbauweise des Container-Tracks, Car-Track

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