LogForum
> Scientific Journal of Logistics <
2012, 8 (3), 231-245
http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

AUTOMATION OF THE LOGISTICS CHAIN IN THE FORM OF AN INNOVATIVE CONCEPT CONTAINER TRANSPORT SYSTEM FOR LUGGAGE HANDLING AT AIRPORTS

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ABSTRACT. Background: The transport of luggage units between the check-in terminal and airplanes is realized by the use of very simple transport solutions and manual reloading of the luggage. The luggage trolleys are used for the transport purposes, which are hitched to the mover and moved directly to the surroundings of the airplane. The loading and unloading of luggage is performed manually. Regarding actual safety requirements there was a need to create a new transport system, working in a closed cycle and based on the device for automatic loading and unloading of luggage units.
Methods: Various potential variants of the device were generated based on results of analytical researches by the use of the morphological schema. The detail evaluation and the optimization of individual variants allow to prepare the concept of the complex method to solve problems of the reliable transport of luggage units within an airport.
Results: The closed transport system was created as a result of the innovative project. The main element of this system is a container trolley, which is equipped in five storage layers. By the use of the special mover and gravitational forces, luggage units can be transported and placed inside this trolley as well as being loaded and unloaded. This solution enables to move 200 pieces of luggage in one transport cycle from the check-in terminal to the hatchway of the airplane.

Key words: automation, supply chain, innovative transport system, container trolley, logistics, luggage handling, transport space between chek-in terminal and the airplane, airports.

ASSUMPTIONS OF THE CONCEPT AND PRESENTATION OF TRANSPORT SYSTEMS OPERATING IN THIS AREA

The unsatisfactory state of systems of luggage transport at airports (from the check-in point until placing them in the luggage holds of an airplane) operating at present in this area was the starting point for the development of this concept.

The present situation can be described as follows:

- The luggage, labelled with the destination address, is taken over at the exit of the terminal usually by two persons of the ground staff (truck driver and ground worker), who manually arrange the luggage on luggage trolleys. This operation is performed in rather chaotic ways, resulting in the mutual pressure of individual units of luggage, and which in turn can cause the potential damages.
- This transport process is usually supported by wheel sets, which consists of 4-5 trucks, all connected with the front mover. When the loading space is fulfilled up to maximum, the whole sets are transported from terminals to waiting airplanes (within terminals or internal taxing areas).

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Citation: Hentschel B., Richtsteig G., Górski K., 2012, The concept of the development of cargo caontainer transport system within airport. LogForum 8 (3),231-245
URL: http://www.logforum.net/vol8/issue3/no5
Accepted: 08.06.2012, on-line: 30.06.2012.

- After reaching the airplane luggage hutch area, the luggage units are manually located (or rather thrown) on the conveyor belt. Then they are moved by the conveyor to the airplane hutch and placed within cargo space of the airplane. Usually this operation is conducted by two persons of the ground staff (driver and manual worker).
- Developments trends, observed currently in this field, aim to the change of characteristics of the physical load performed by workers employed in this area and lead to create and develop concepts of high mechanized luggage handling systems, operating within airport areas.
- Concepts of the use of luggage containers are one of postulated variants in this area. The use of luggage containers are expected to be implemented within big airports, where luggage units are reloaded within loading spaces of very big transport airplanes and warehouses used as the pre-storage of the luggage prior to the departure or in the buffer zones.
- The concepts proposed by innovation departments of companies "Lödige Industries" (www.loedige.com) and Projektlogistik GmbH (www.projektlogistik-gmbh.com) are ones of already introduced to the practice in this field. The company group Grenzebach (together with its departments "Airport" www.grenzebach.com) is another leading competitor in this field.

  Lödige company developed and implemented the concept of LSYS Putter, intended for mechanical loading and unloading of luggage containers, along with the function of taking the luggage units on conveyor belts.

Fig. 1. Solution LSYS Putter by Lödige company
Rys. 1. Rozwiązanie LSYS Putter firmy Lödige

Projektlogistik company developed the concept based on the solution called "Zero-G-Loader". This solution is concentrated on the loading and unloading of individual transport trolleys.

Fig. 2. The mechanized transport trolley. This solution was developed only until the prototype stage.
Rys. 2. Zmechanizowany wózek transportowy. Rozwiązanie to nie wyszło poza fazę wykonania prototypu doświadczalnego.

– Grenzebach company specializes in the field of loading and unloading of luggage containers. It prefers the simple, uncomplicated spilling of containers onto operating surfaces of conveyors.

The Danish company PowerStow A/S (www.powerstow.com) should be placed among the leading dynamic operators and specialists in the field of luggage handling within airports, thanks to its innovative solution of luggage units transport automation, called RampSnake. The RampSnake solution creates the essential coupling point with already existing solutions, which are used in the area of transport support of airports, especially within InterAirport in Monachium. This feature makes this solution an important and significant one.

Fig. 3.RampSnake in use (in coupling point: airplane and roll conveyor)
Rys. 3. RampSnake w użyciu (w punkcie sprzężenia: samolot w kontakcie operacyjnym z przenośnikiem rolkowym)

Other leading producers of this type of solutions operate on American market, among others: JBT AeroTech Corporation, Ground Support Servie Cart Corporation, Spokane Industries and others. JBT company already introduced the RampSnake solution to the practice as an effective transport system. It should be stated, that main selected solutions (expect this of Projektlogistik GmbH) were already patented.

Based on the pre-researches, conducted in the cooperation with specialists from selected airports (mainly Schönefeld as well as Tegel), it was concluded, that the desired solution should fulfill the following conditions:

- The possibility of the mechanical acceptance of luggage units at the exit of the check-in terminal without the physical handling by ground staff.
- The possibility of the luggage inspection with respect to its destination (there is a requirement of no mistakes with respect to the assignment of luggage units to their final destination). The external control at the end point of the conveyor at the exit from the terminal building is the preferred one.
- The possibility of the transport of the whole luggage (all luggage units) in one transfer operation between the terminal and the loading space of the airplane.
- The possibility of mechanical/automatic transfer of luggage units from transport trolleys to the device of Rampsnake type or of other type of the luggage transport device under condition that

the physical work of the ground staff will be eliminated or highly limited or the ergonomics of this work will be significantly improved.

The above-mentioned criteria determine the success of the research works concerning the devices for mechanical/automatic transport of luggage units and they are an indispensable part of innovations in this field, especially under condition of existing competition.

THE PATENT EXAMINATION

The patent examination was conducted by the use of DepatisNET system. This analysis was focus on the following expressions:

- Baggagehandling AND Systeme
- Handling AND Freight AND Container
- Front AND Loading AND Baggage
- Transportation AND Baggage
- Transportation AND Luggage
- Baggage AND Security
- Airport AND Transportation
- Ground AND Transportation AND System
- Container AND System AND Airport
- Airport AND Container
- Airport AND Baggage

No patent rights similar to devices of this project were found during the patent examination. Regardless of that, it was recommended to obtain the opinion of the patent attorney, who will determine the patent rights and conduct necessary additional analysis.

To protect the patent rights, the application was sent on 8th Sept. 2011 to the Office for Patent Protection Kietzmann, Vosseberg, with request to set the patent rights for above-mentioned prototype and its protection as an utility model. The protection of the utility model was legally set on 29th Sept. 2011 and registered under the No 20 2011 105 486.5. The patent application concerning the luggage units transport system in airports was registered under No 10 2011 112 898.8 in German Office of Patents and Utility Models on 29th Sept. 2011 and at present waits for the final decision.

THE GEOMETRY OF LUGGAGE UNITS AND THE KIND OF BUILDING MATERIAL

The following conclusions can be provided based on the analysis of the geometry of luggage units:

- The transported luggage units are of various geometry as well as of various hardness of building material, therefore they have various durability.
- The maximal weight of the transported suitcase is usually app. 20 kg, but there are many situations that there are suitcases of higher weight up to 30 kg (passenders usually accept such situations and without problems pay the additional manipulation charges).
- The relations of dimensions (length x width x height) range from minimal dimensions 20 x 20 x 20 cm up to size level of 70 x 28 60 cm for big suitcases in form of hard cuboids or soft travel bags.

- The hardness and the kind of building materials of luggage units range from textile bags (susceptible to crashing) to suitcases made of the leather or its imitations (partially susceptible to crashing), travel and sport bags (susceptible to crashing) and suitcases and other units made of inflexible materials (metal, plastics - not susceptible to crashing).
- There is a problem of various types of safety belts (of various clamp strength) individually applied in case of almost all types of luggage units. Especially the belts of loose clamp strength can cause problems during the implementation of the automation of the transport within airports (falling off such belts can cause very danger situation of hooking, catching, etc.).

LOGISTIC PROCESSES OCCURRING IN THE TRANSPORT AREA BETWEEN THE TERMINAL BUILDING AND THE AIRPLANE, PERFORMED BY THE SET OF TRANSPORT TROLLEYS

The following conditions must be fulfil by all devices of the airport transport system operating between the starting point of the transfer of the luggage unit from the belt conveyor, located in airport terminal to the final point within the luggage space of the airplane:

- The possibility of the reliable and collision-free coupling of elements of mobile transport system with the internal belt conveyor at the point of its exit from the wall of the airport terminal.
- The possibility of the immediate inspection of luggage units with respect to their assignment to the final destinations (the inspection of individual luggage units or in future, remote verification of the given destination by the use of the radio-frequency identification system (RFID) together with the return of the incorrectly assigned luggage units by the transfer of such units from external zone onto the elements on the transport system, operating between the airplane and the terminal (such kind of the inspection was not possible so far in presently used transport systems)).
- After the verification of the assignment of the luggage unit to the given destination, there is a possibility to transfer standing suitcases and bags onto the devices of the internal transport system and to assign them the location within the internal waiting interoperetional zone.
- The determined number of luggage units can be transported depending on the given system. The required transport efficiency of individual systems are presented below (based on data of Frankfurt (Main) airport:

  The typical types of airplanes with the manual loading of the luggage:

  B737 version 300 - 800

  B757 version 200 + 300

  A319, A320/A321 (partially manual loading, depending on airlines)

  TU154, ATR42 + 72 Cargo

  The share of airplanes with the manual loading of the luggage in total number of loadings is about 30% (B737, B757, A319) or even 40%, taking into consideration such types of airplanes like MD80, Embraer, etc.

  The average quantity of luggage units is:

  B738 = approx. 160 pieces

  B752 = approx. 180 pieces

  B753 = approx. 200 pieces.

  The ULD type devices are used in case of bigger types of airplanes (B747, A340 and bigger).

The decrease of transport cycles between the terminal and the airplane is the preferable goal in this case.

- The possibility of trolley transport (by the use of a mover of with the own drive) within the surroundings of a hatchway of the airplane, where the belt conveyors or RampSnake type devices are used. It allows the reliable coupling of distant points of both systems and the mechanical transfer of luggage units on the conveyor belt. There is no need for another verification of suitcases in respect of their proper destination. The driver of the transport set is the last control instance to exclude possible mistakes.
- The possibility of the extension of elements of each system as well as to repeat the transport operations.

THE PRESENTATION OF VARIANTS BY THE USE OF THE MORPHOLOGICAL SCHEMA

The morphological schema was created at the stage of study researches to describe the specific requirements of individual solutions of the transport between the terminal building and the storage spaces of the airplane. It allows to identify individual, technically workable variants of handling and transport devices.

The description of components of this schema is presented in the table 1, where six basic variants of the solution are distinguished. It was created based on consultations with specialists, who work at the airport Schönefeld as well as on the specialist knowledge, provided by the international company Vanderlande Industries. The prepared internal evaluation matrix allows the evaluation of factors with respect to their importance and significance. Based on it, two variants of the significant importance for proposed solutions were selected.

Table 1. The morphological schema of variants' description
Tabela 1. Morfologiczny schemat dla opisu wariantów

Function	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**	**Solution 5**	**Solution 6**
Acceptance from conveyor belt and transfer to con- tainer trolley F1	transfer directly on the roller- band device	manual handling	separate extendable device	direct transfer by the gravity usage	external manipulator at the access belt	
internal transport solution in con- tainer trolley F2	driven conveyor belt	roller band	friction band with side drive	roller band with side unloading	manual handling by ground staff	free running roller cart
storage in con- tainer trolley F3 (horizontally)	single deck	multiple deck of fix height	multiple deck of various height			
identification of luggage at the transfer point	label scanning at reloading point	RFID- identification	manual inspection by ground staff			
unloading of luggage on the external conveyor belt F5	direct transfer on transport conveyor, driven by motor	manual handling	extendable allocating device driven by motor	external manipulator on conveyor belt	free-running roller cart	
drive type F6	external towing vehicle	own petrol motor	own battery motor			
construction type of airport con- tainer trolley F7	connected individual trailers	flexible "Snake" construction	solid construction			

Variant 1: F1/L1 - F2/L2 -F3/L3 - F4/L1 - F5/L1 - F6/L3 - F7/L2
Variant 2: F1/L4 - F2/L2 - F3 /L3 -F4/L2 -F5/L1 - F6/L3 - F7/L2
Variant 3: F1/L1 - F2/L3 - F3/L2 - F4/L1 - F5/L1 - F6/L3 - F7/L2
Variant 4: F1/L1 - F2/L3 - F3/L2 - F4/L2 - F5/L1 - F6/L3 - F7/L2
Variant 5: F1/L4 - F2/L6 - F3/L3 - F4/L1 - F5/L5 - F6/L3 - F7/L3
Variant 6: F1/L4 - F2/L6 - F3/L3 - F4/L1 - F5/L5 - F6/L3 - F7/L3 - preferable target variant

The two from above-mentioned variants were selected and put to the further analysis, i.e.:

Morphological variant 1 ——————————

Morphological variant 6 - - - - - - - - - - - - - - - - - -

AT the beginning, the morphological schema included also the variant, represented by the conveyor, equipped in transport band using the static friction. The development of this variant was not continued due to the technical problems in the concept phase of this research. These problems were connected with the necessity of the implementation of the additional tilting device to enable positioning of units on side storage locations. The conducted researches and analysis indicated the variant 6, as the most promising one to be implemented in the form of the innovation project. This solution was also recommended by prominent experts in the field of the internal transport, i.a. Karl-Heinz Dullinger (long-term president of Vanderlande Industries) and Ing. Leichtweiß from Lödige Industries company.

Table 2. Analysis of the morphological schema of variants' description
Tabela 2. Analiza morfologicznego schematu dla opisu wariantów

Function	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**	**Solution 5**	**Solution 6**
Acceptance from conveyor belt and transfer to container trolley F1	transfer directly on the roller-band device	manual handling	separate extendable device	direct transfer by the gravity usage	external manipulator at the access belt	
internal transport solution in container trolley F2	driven conveyor belt	roller band	friction band with side drive	roller band with side unloading	manual handling by ground staff	free running roller cart
storage in container trolley F3 (horizontally)	single deck	multiple deck of fix height	multiple deck of various height			
identification of luggage at the transfer point	label scanning	RFID-identification	manual inspection by ground staff			
unloading of luggage on the external conveyor belt F5	direct transfer on transport conveyor, driven by motor	manual handling	extendable allocating device driven by motor	external manipulator on conveyor belt	free-running roller cart	
drive type F6	external towing vehicle	own petrol motor	own battery motor			
construction type of airport container trolley F7	connected individual trailers	flexible "Snake" construction	solid construction			

Variant 1: F1/L1 - F2/L2 -F3/L3 - F4/L1 - F5/L1 - F6/L3 - F7/L2
Variant 2: F1/L4 - F2/L2 - F3 /L3 -F4/L2 -F5/L1 - F6/L3 - F7/L2
Variant 3: F1/L1 - F2/L3 - F3/L2 - F4/L1 - F5/L1 - F6/L3 - F7/L2
Variant 4: F1/L1 - F2/L3 - F3/L2 - F4/L2 - F5/L1 - F6/L3 - F7/L2
Variant 5: F1/L4 - F2/L6 - F3/L3 - F4/L1 - F5/L5 - F6/L3 - F7/L3
Variant 6: F1/L4 - F2/L6 - F3/L3 - F4/L1 - F5/L5 - F6/L3 - F7/L3 - preferable target variant

Both solutions (variants 1 and 6) will be presented below in the form of the project, but the main focus is put on the realisation of the variant 6 (in agreement with common opinion of experts in the area of the airport transport logistics from Schönefeld airport as well as of the market practice of Vanderlande Industries company).

THE CONCEPT OF THE PREFERABLE VARIANT

The project conditions for the variants, which obtained the recommendation of potential users, are presented below.

The concept of the set used for the transport of luggage units is based mainly on a set of a few trolleys or one solid construction. The maximal number of transported suitcases was evaluated on the basis of experimental researches, conducted in the airport in Frankfurt am Main. It is equal to 200 pieces and the number was taken as an assumption to create the project of the transport system for the passenger service in airports.

The transported units were assumed to be delivered in the horizontal position and of maximal dimensions equal to 70 cm x 60 cm (length x width). The designed system must be able to handle also smaller luggage units of dimensions 20 cm x 20 cm.

To support and assure the transport of max. 200 pieces of luggage in one operation cycle, the transport device was equipped in multi-level system of parallel storage areas.

Assuming, that the transport trolley is equipped in 5 storage layers and the maximum loading is 200 pieces, then 40 luggage units must be arranged on each layer. The presumed configuration of the layout of transported luggage units along three parallel lines (working version) and the length of one suitcase equal to 700 mm, determines the total length of transport device to be 9100 mm, having 13 luggage units arranged in one line and on one level (13 x 700 mm). Taking into consideration construction parts of the transport trolley, at this phase of the research, the total length of this trolley was assumed to be 10000 mm.

Both variants, intended to be realized, are presented as Attach. 1 and 2 of this paper.

THE CONSTRUCTION OF THE WHEEL SET OF SNAKE TYPE

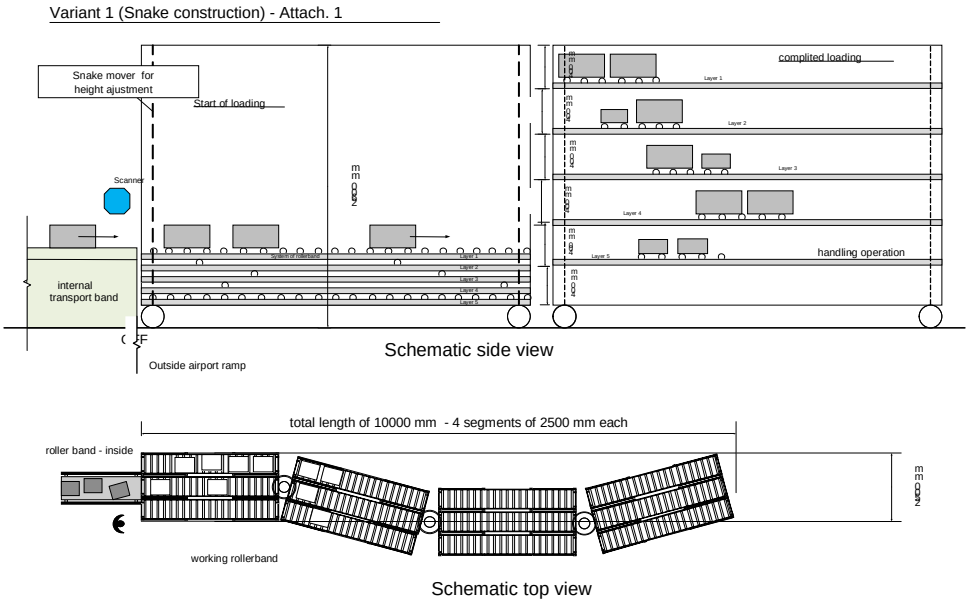

Fig. 4. The construction of multi-segment wheel set of Snake type purposed for the transport of luggage units
Rys. 4. Zasadnicza konstrukcja wieloczłonowego zestawu kołowego typu Snake przeznaczonego do transport jednostek bagażowych

The construction of wheel set of Snake type consists of four carriages, connected with each other. At the beginning of this work, the possibility of creating the one segment vehicle of flexible body was

taken into consideration. It turned out to be impossible due to technical problems. The biggest problem was the transfer of luggage units from one segment to another one in case the whole device is flexible like a snake.

The segmentation of the set into four separate carriages turned out to be not optimal because of the excessive time needed for handling operations, especially that each carriage had to be handled separately both at the terminal exit and at the hatchway of the airplane. Therefore the continuation of the work on this variant was ceased. Additionally in this solution, there was a necessity to employ two additional workers, which caused extra costs and did not fit to cost reduction condition of this project.

THE CONSTRUCTION OF ONE SEGMENT VEHICLE IN THE FORM OF TRANSPORT CONTAINER

The concept of one-segment construction in the form of transport container turned out to be the most optimal solution from the economical and technical point of view:

- It turned out, that it is possible to construct a "container trolley", equipped in three parallel storage flows, within which the luggage units move under gravitational forces over rolls till the hatchway.
- The construction of the space was adapted to dimensions and geometry of 200 suitcases (luggage load of an airplane of the average size) and equipped in five separately operating storage layers, each of them can be levelled up to the desired height by the snake device (its construction is not yet confirmed).
- The principle of operation is as follows:
  - the back of container trolley is placed up to the belt conveyor at the exit of the check-in terminal,
  - the arrangement of luggage units on the first storage level by gravitational forces until filling in the whole available space. It is available due to slopes of the surfaces inside the trolley where the units are placed.
  - the snake drive levels the storage layer in the top location of the container space,
  - all four storage layers are loaded with the luggage units. The storage layers 2-4 are also moved to the top and positioned in the transport configuration,
  - the fifth storage layer is loaded. Due to the fact, that at each level there are parallel configurated storage layers, each of them should be moved horizontally to allow the loading operation of each storage layer at each of levels. There is still no technical solution of this issue. There is still a need of further consultations with the logistics provider, responsible for luggage transport within the airport.
  - After loading all 200 suitcases (so the maximal quantity of luggage units) at the exit of check-in terminal onto all 15 storage layers, the special vehicle moves the transport container between the terminal container and the belt conveyor. The task of this conveyor is to move separate suitcases to the hatchway of the airplane.
  - At this moment, starting from the level 5, the luggage units are moved gravitationally (by the change of the rake of storage layer) on the external belt conveyor (there is still a need to conduct additional researches, due to the fact that belts and safety bands of different type, cause difficulties in free movement of units or even their blockage because of hooking).
  - After unloading, the storage layer 5 reaches its starting position (the lowest one) and is inactivated. Then, the storage layer 4 moves to the position, which enable the unloading of luggage units and the operation of unloading takes place.

– The above-mentioned operations repeat until the moment of unloading the storage layer 1, which means the return of the device to position "ready for new loading operation". There is also an assumption, that the external belt conveyor (it can be a device of RampSnake type) can change its position and take over suitcases located on the band of conveyor, which is configurated parallel.

– The operator of the transport system controls the whole time the loading and unloading processes, therefore there is no need for additional workers for reloading of the luggage on the belt conveyor within the check-in terminal or on the external belt conveyor, located within hatchways of the airplane. Therefore it was possible to resign from two additional workers in this investigated variant, especially that the trolley operator inspects all alone the whole process of loading and unloading of luggage units.

– Each phase of this process is presented at the Figures 5.1-5.3.

– The construction of the container trolley requires still the detail solution of individual parts of this system:

  – Each storage layer using the gravitational forces by the implementation of slope, must be additionally equipped in an element, located in the middle, which will compensate the differences in length of individual levels.

  – It must be the possibility to move individual storage layer vertically by the use of snake gear or other driving system.

  – It is assumed, that the scanning of luggage units will take place within the check-in terminal (it will secure the conformity of each luggage unit to its destination). The rescanning before the arrangement of luggage units in the loading space of airplanes is taken additionally into consideration, which should ensure 100% reliability of the system with respect to avoid mistakes connected with luggage of travellers.

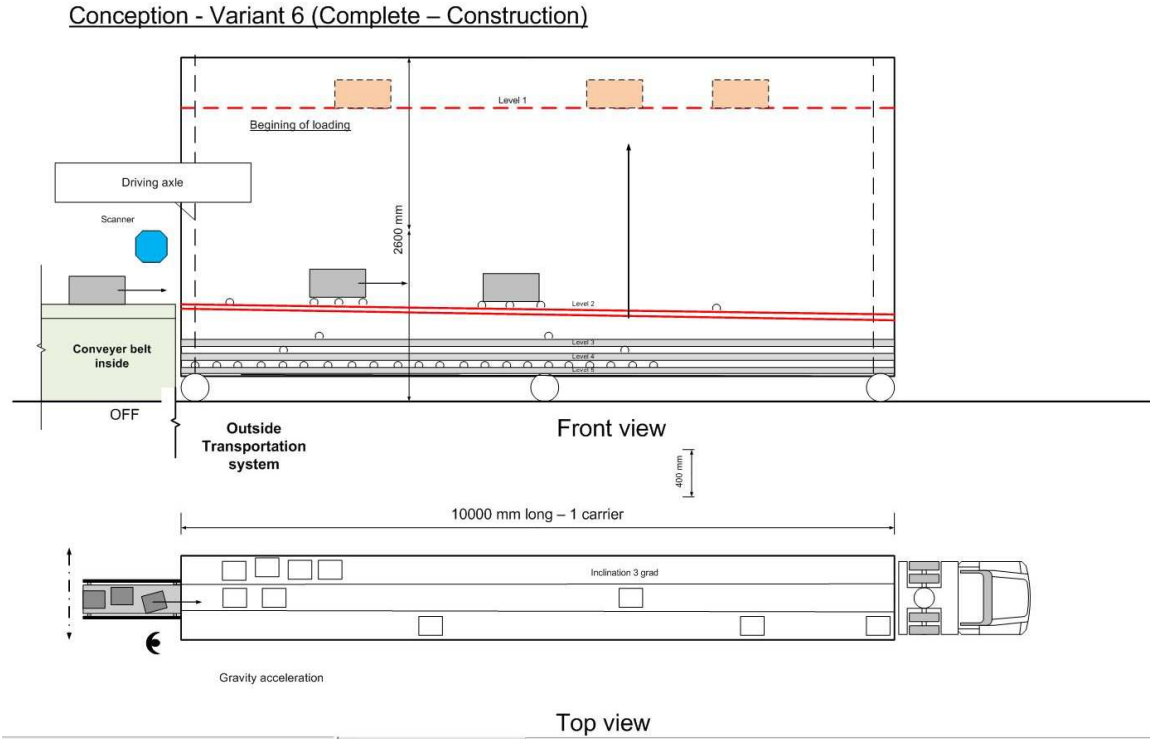

Fig. 5.1. The transport system of luggage units in airports using the container trolley - during the additional loading
Rys. 5.1. System transportu jednostek bagażowych w portach lotniczych przy pomocy wózka kontenerowego - w trakcie trwania operacji doładunku

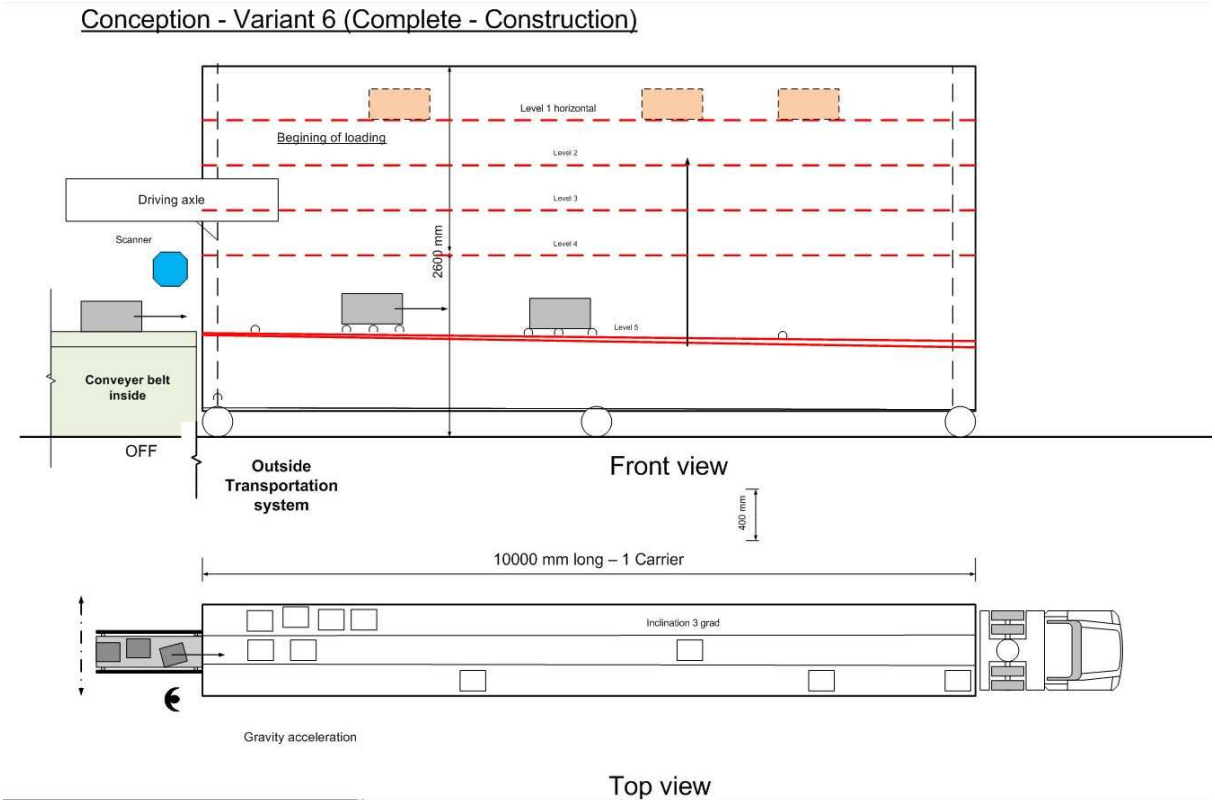

Fig. 5.2. The transport system of luggage units in airports using the container trolley - after additional loading operation

Rys. 5.2. System transportu jednostek bagażowych w portach lotniczych przy pomocy wózka kontenerowego - w stanie zakończonego doładunku

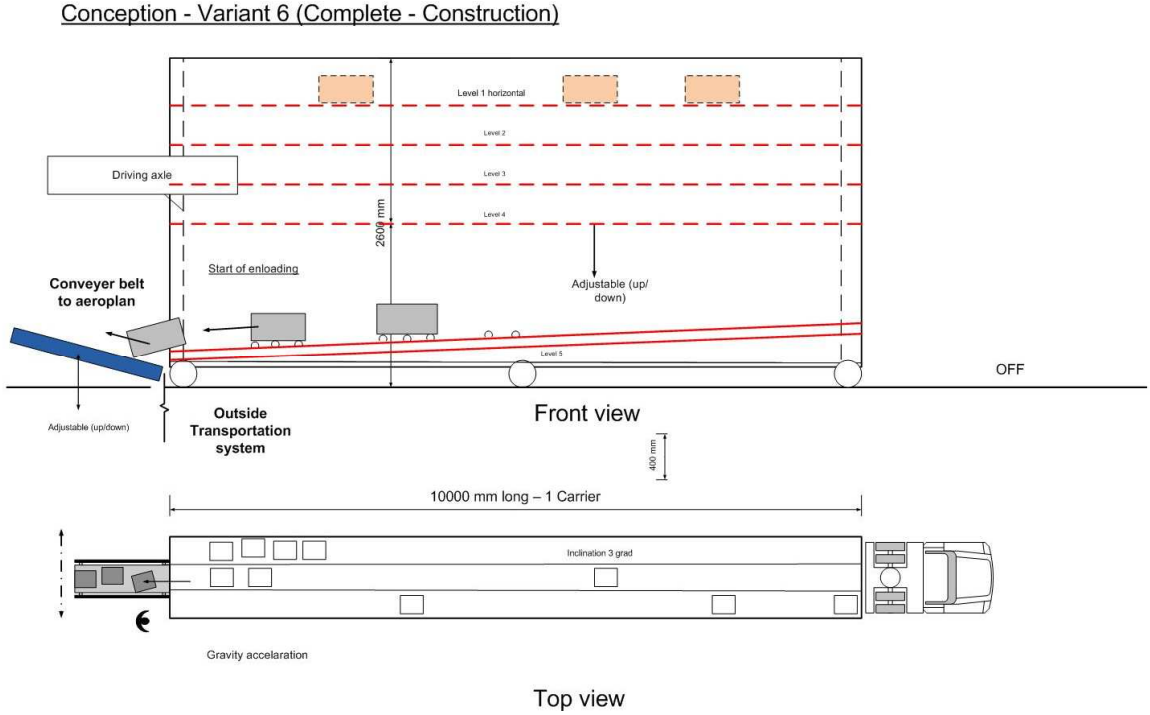

Fig. 5.3. The transport system of luggage units in airports using the container trolley - at the moment of coupling with external belt conveyor, working at the hatchway of an airplane

Rys. 5.3. System transportu jednostek bagażowych w portach lotniczych przy pomocy wózka kontenerowego - w stanie sprzężenia z zewnętrznym przenośnikiem taśmowym, obsługującym wloty do luków bagażowych samolotu

– There is still open topic of the selection of the cover of one-segment container trolley as well as its wheel construction and their integration with the undercarriage. The possibility to move separate storage layers lengthwise should be ensured to improve the construction variants of the trolley. It should be possible to extend and fold up lengthwise these layers by lifting and lowering them.

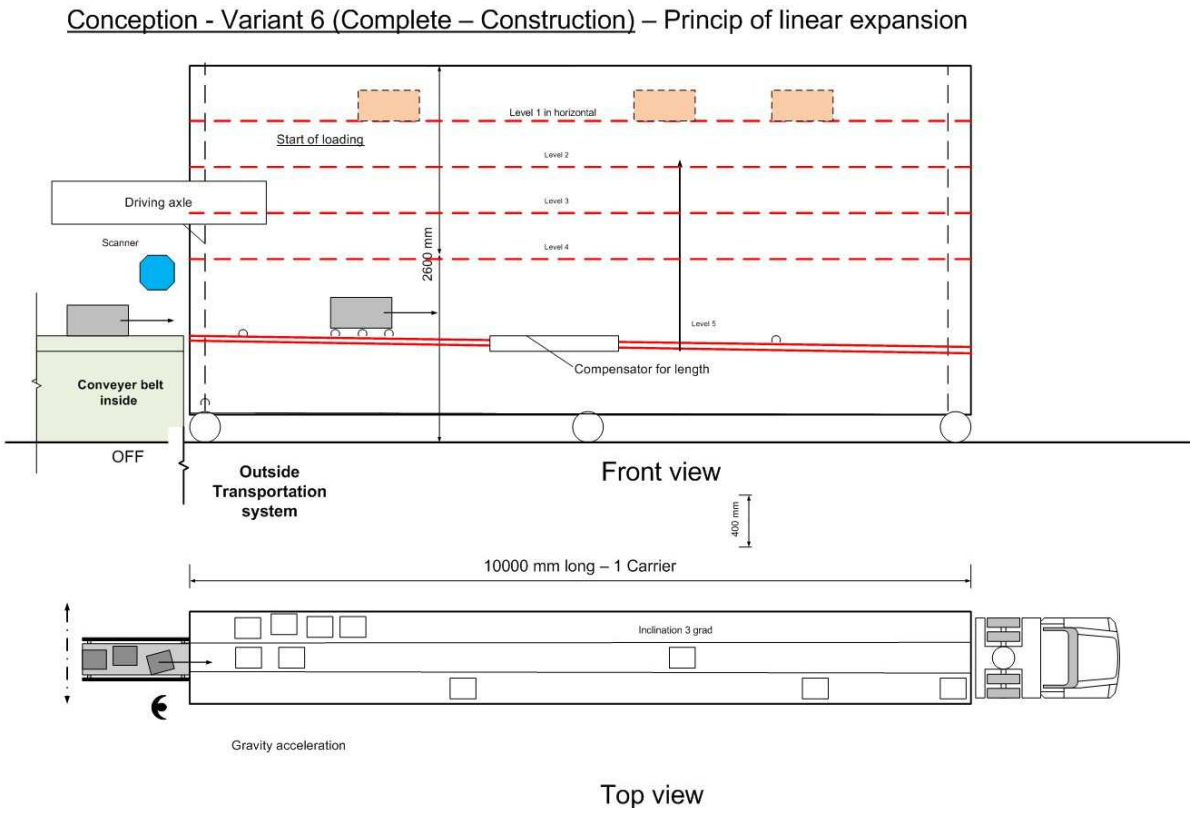

Fig. 5.4. The schema presenting the possibility to move layers horizontally
Rys. 5.4. Schemat obrazujący możliwość przesuwania poziomów w kierunku wzdłużnym

The front view schema of transport system is presented in figure 6, which allows to demonstrate the way how individual layers perform. The geometric dimensions of the system are also presented at this figure:

– the width is equal to 2700 mm together with additional size of both wheels of the trolley,
– the height is equal to 2625 mm.

This geometry allows an effective transport of max. 200 luggage units, and therefore the optimal service of airplanes of the average size.

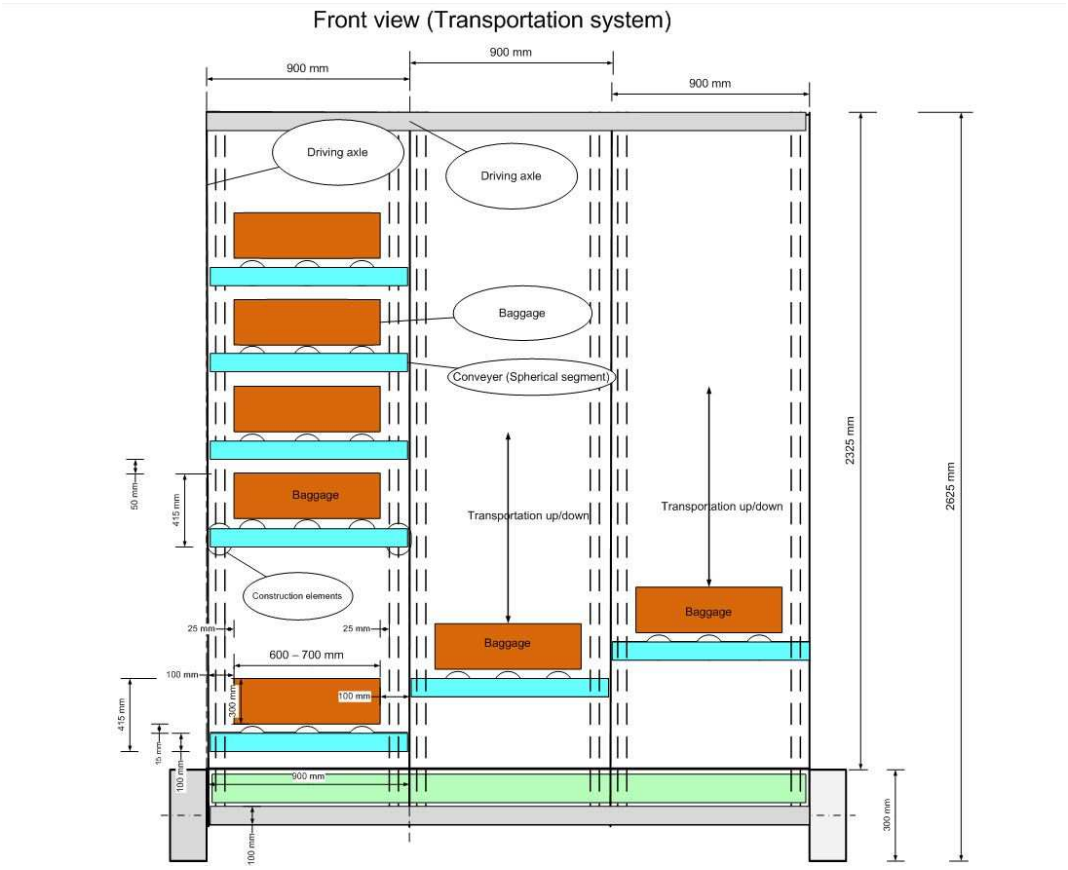

Fig. 6. The front view and the schema how three given loading spaces and storage layers operate
Rys. 6. Rzut czołowy wraz ze schematem funkcjonowania 3 poszczególnych przestrzeni ładunkowych i poziomów odkładczych

SUMMARY AND CONCLUSIONS

The potential automated solution how to create logistic processes inside the airport area, between check-in terminals and hatchways of airplanes was presented. The presented solution is a compact, uniform and complex concept, within which an attempt is made to create the possibility to transport a set of luggage units of one destination in one cycle, between check-in terminal and an airplane of an average size. It fulfils all actual safety requirements thanks to the great integration of identification systems for the luggage units with their content as well as to its closed structure. Therefore this system excludes the possibility to mistakenly change the luggage in regards to its destination, and at the same time it minimizes the risk of eventual terrorist attacks.

Based on presented system, the problem of transport logistics inside airports can be solved in a complex way. The technical solution of a proposed container trolley, which works in the form of RampSnake device, assures the reliable and collision-free transport of luggage units from the check-in terminal to the hatchways of airplanes.

The innovative input of originators of this project (Hentschel, Richtsteig) relates to the creation of sophisticated solutions of highly efficient systems of goods flow, based on automatically controlled storage fields of this trolley as well as automatic stations for picking luggage units in check-in area and transporting them to hatchways of airplanes. The innovation of this solution consists mainly of the speed of transport processes realized. The challenge of this task lies in the differentiation of the geometry of transported luggage units and the threat of their blocking during their flow within the transport system. Richtsteig company possesses all engineering competences for effective realization

of this project as well as is supported by the scientific environment. All these factors ensure the creation of such sophisticated solutions in the area of material flow systems. The internal steering system of such multilevel system cannot be an easy one, only the transfer of luggage units on transponder band manually and in automatically steering one should be considered as a very innovative challenge.

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AUTOMATYZACJA ŁAŃCUCHA LOGISTYCZNEGO W FORMIE INNOWACYJNEJ KONCEPCJI ROZWOJU SYSTEMU TRANSPORTU KONTENERÓW DO TRANSPORTU BAGAŻU W PORTACH LOTNICZYCH

STRESZCZENIE. **Wstęp:** Transport jednostek bagażowych pomiędzy budynkami terminali portów lotniczych a samolotami pasażerskimi charakteryzuje sie obecnie stosowaniem prostych rozwiązań transportowych i ręcznym przeładunkiem bagażu podróżnych. Do realizacji przedmiotowego transportu używa się wózków bagażowych, które podczepione pod ciągnik, przemieszcza się bezpośrednie w otoczenie obsługiwanego samolotu. Zarówno załadunek na wózki, jak również rozładunek w obrębie luków samolotowych odbywa się w ramach obsługi ręcznej.
Ze względu na współczesne wymogi bezpieczeństwa powstała potrzeba wygenerowania nowego, pracującego w cyklu zamkniętym systemu transportowego, opartego na automatycznym urządzeniu do za- i rozładunku jednostek bagażowych.
Metody: Na podstawie analitycznych wyników badań przy użyciu schematu morfologicznego wygenerowano szereg potencjalnych wariantów urządzenia. Ich szczegółowa ocena oraz optymalizacja poszczególnych wariantów pozwoliły na opracowanie koncepcji kompleksowego rozwiązania problemów w zakresie niezawodnego transportu jednostek bagażowych w portach lotniczych.

Wyniki: W wyniku realizacji innowacyjnego przedsięwzięcia powstał zamknięty system transportowy, którego istotę tworzy kontenerowy wózek, wyposażony w pięć poziomów odkładczych, które w oparciu o mechanizm unoszący oraz działanie siły grawitacji mogą zarówno przejmować i pozycjonować w swym wnętrzu jednostki bagażowe, jak również umożliwiać ich za- i wyładunek. Rozwiązanie w tym kształcie pozwala w ramach jednego cyklu transportowego na przemieszczenie 200 szt. bagażu z budynku terminala odpraw do luków bagażowych samolotu.

Słowa kluczowe: automatyzacja, łańcuch logistyczny, innowacyjny system transportu wewnętrznego, wózek kontenerowy, logistyka transportu bagażu, przestrzeń transportowa pomiedzy terminalem odpraw a samolotem, porty lotnicze

AUTOMATISIERUNG DER LOGISTIKKETTE FÜR DAS FLUGHAFENVORFELD IN AIRPORTS DURCH EIN INNOVATIVES FRACHTGUTTRANSPORTSYSTEM

ZUSAMMENFASSUNG. Einleitung: Gegenwärtig ist der Gepäcktransport im Bereich des Vorfeldes, somit zwischen Flughafengebäude und Flugzeug, durch eine einfache Transportlösung charakterisiert. Bevorzugt werden Einzelgepäckwagen, die von einer Zugmaschine gezogen, zum Flugzeug gefahren werden. Die Beladung der Wagen und auch die Entladung erfolgt manuell. Aus Sicherheitsgründen ist es erforderlich, eine neue, geschlossene Lösung mit automatisierter Be- und -Entladung zu entwickeln.
Methoden: Aus den analytischen Ergebnissen lassen sich über ein Morphologisches Schema unterschiedliche Varianten ermitteln.
Mittels einer Variantenbewertung und -optimierung ist eine Lösung für eine ganzheitliche Frachtgutlösung entwickelt worden.
Ergebnisse: Das Ergebnis ist ein geschlossenes Containersystem, das in fünf Ebenen über ein Hubsystem und unter Nutzung der Schwerkraft die Koffer aufnimmt und sowohl eine automatisierte Be- als auch Entladung ermöglicht. Es ist die Lösung so entwickelt worden, dass sie für 200 Gepäckstücke ausgelegt ist und somit nur einen einzigen Transport vom Flughafengebäude zum Flugzeug notwendig macht.

Codewörter: Automatisierung, Logistikkette, innovatives Frachtguttransportsystem, Containerwagen, Gepäcklogistik, Flughafenvorfeld, Airports

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