
Brief description

What is the software needed for
and how is it used?

TrainOptimizer[®]



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TrainOptimizer® - Brief description

What is the software needed for and how is it used?

In order to be "competitive" as a public transport system, economic efficiency is an important requirement. In the context of vehicle layout planning this is often subordinated to other essential aspects such as practicality, which in practice leads to the opposite of what is desired. Incorrectly understood approaches to economy such as maximum space utilisation for seats, can in reality lead to increasing economical and operational problems, and in the event of an emergency can become a serious safety risk!

1 Efficient vehicle layouts - basics

Particularly in railways, and here again especially in long-distance transport, there has long been a tendency to build in as many seats as possible in order to achieve the best possible economic efficiency through the high capacity thus created. However, this circumstance not only leads to a loss of comfort but also poses serious operational problems in many respects, which are often not considered especially when purchasing vehicles. The often applied evaluation criterion of the highest possible number of seats and the expected lower acquisition and operating costs per passenger is one-dimensional and thus insufficient, as it clearly contradicts reality in several respects.

Particularly in long-distance train traffic, but also on many short-distance routes especially when serving cruise ships or airports, the volume of luggage is often underestimated and a factor not taken seriously enough thus influencing the criteria for dwell time, achievable seat occupancy, passenger satisfaction and safety.

1.1 Luggage volume

The type, size, weight and number of the respective pieces of luggage depend significantly on the parameters of the purpose in combination with the duration of the journey as well as the age and gender of the travellers and the existing group size.

Over 20 years of intensive observation it can be seen that the volumes of individual pieces of luggage tend to become larger. This is due to an increase in comfort during transport, especially in combination with equipment with wheels. For example, pieces of luggage that have to be carried and weigh approx. 14 kg are perceived to be equally as heavy as pieces of luggage that weigh approx. 21 kg but are equipped with two wheels. Whereas about 20 years ago 50% of suitcases taken on train journeys were not equipped with wheels and therefore had to be carried, ten years ago this proportion was only about 5%. In the meantime, almost 100% of suitcases are so-called trolleys, which are equipped with wheels.

In line with the comfort gained by rolling, increasingly larger pieces of luggage are being produced and used by travellers. On the one hand, this leads to an increase in the size of the individual pieces of luggage and also in their weight. Meanwhile, the majority of trolleys are equipped with four wheels. In many transport situations this results in a further increase in comfort, which leads to the assumption that these pieces of luggage will be perceived as

even more comfortable or even lighter in comparison to their weight, and that a further increase in luggage volume and packing weight can be expected in the near future.

Both the increase in weight and size pose corresponding challenges for operations, as in the case of boarding the train via steps as well as the frequent need to lift luggage during stowage; the castors do not provide support and the difficulties for travellers increase accordingly.

In order to be able to design sufficient and efficient luggage racks, the first step is to know the luggage volume in terms of type, size, weight and number per person. Statements on this cannot and must not be generalised with regard to an efficient overall interior design. It has been shown that the luggage volume can also vary from region to region. Above all, the total volume that must be expected per wagon depends very strongly on the respective routes and their passenger or travel purpose mix. However, due to the amount of data available very specific statements can be made.

For example, on holiday trips on statistical average 50% of the luggage is medium and large trolleys. At the same time, it can be stated that on average one piece of luggage is taken per person going on holiday. Even for short trips, the statistical average is 0.8 pieces of luggage per traveller, 35% of which are medium trolleys and 10% large trolleys. With regard to the required luggage accommodation, it is relevant to know as precisely as possible the mix of travel purposes to be expected in the area of operation of the respective vehicles. From this, the actual average luggage volume to be expected per person and thus the corresponding total volume per vehicle can be determined.

1.2 Luggage storage

1.2.1 Passenger behaviour

There are two main principles regarding luggage storage. Travellers do not want to have to lift their luggage, and for safety reasons they want to have visual contact with it at all times. If these two criteria are not sufficiently taken into account from the beginning of the planning, inefficient and in the event of an emergency, quite dangerous conditions are to be expected in the vehicles.

For 88% of passengers, visual contact with their luggage is important or very important. This means that luggage must be able to be stored in the immediate vicinity of the passengers. If there are no such possibilities and luggage has to be stored at a greater distance, such as in luggage racks near the boarding door, this leads to a corresponding loss of comfort for most passengers. From an operational point of view, however, the risk of obstructively stored luggage due to a lack of visual contact is even greater. Seventy-five percent of passengers explicitly state that they are willing to place luggage in an obstructive way in order to satisfy the desire for visual contact.

Luggage is placed on or in front of seats or in the aisle. This leads to an increase in unusable seats and obstructions to the flow of passengers.

The second essential criterion regarding the planning of suitable luggage racks is the willingness to lift luggage. For example, only about 20% of travellers are willing to lift heavy luggage to the overhead racks, more than 50% are not willing to do so at all. For medium luggage, at least 50% are willing to lift it to the overhead compartment. With regard to luggage racks, at least 50% of travellers are willing to lift heavy luggage up to waist height.

These figures show that it makes no sense to provide overhead racks without exception. The number of available luggage racks must also be sufficiently dimensioned!

The questioned readiness is confirmed by extensive objective observations regarding the placement of luggage. Although in some cases up to 50% of the overhead racks are not used, a large number of pieces of luggage are placed on the floor in front of seats, in the aisle or on seats!

1.2.2 Accommodation options

The basic options for luggage storage are: Overhead racks, luggage racks, defined storage areas on the floor such as multi-purpose areas and areas between the seat backs. In some cases, areas under the seats can also be used, but usually only for items of luggage that correspond to the category of hand luggage.

In order to design the luggage storage areas in such a way that all items of luggage can be properly accommodated even at very high occupancy rates, it is essential that the following principles are adhered to:

- Above mentioned principles "avoid lifting" and "visual contact"
- Determination of the actual volume of luggage
- Reliable knowledge of the shape of the luggage

In order to efficiently design the popular storage options between the seats and in luggage racks, it is essential to know the shape, size and volume of the luggage. Experience shows that luggage racks which are only a few centimetres too narrow, often only 5 cm to 10 cm, or whose compartment heights are set too high or too low, can hold up to 50% less luggage than suitably dimensioned racks!

The same applies to the space behind or between the seat backrests. Here, 10 cm to 15 cm too little available space can already lead to 70% less storage space being available!

In addition to the appropriate sizing of the luggage racks and seat spacing, attention must also be paid to a well-considered distribution of the luggage storage facilities in the vehicle. These must be distributed as evenly as possible throughout the vehicle to allow good visual contact with the luggage from every seat and to avoid impeding the flow of passengers.

1.3 Consequences of unsuitable luggage accommodation

If essential basic needs of luggage storage space design are not observed, two serious operational effects in particular can be observed. The dwell time in the stations can increase many times over and the actually available occupancy rate drops to a value of 80%!

1.3.1 Passenger changeover time

There are many factors that influence the passenger changeover time. These include passenger-dependent factors that cannot be influenced by the manufacturers and operators, such as age gender, the luggage carried and any kind of possible mobility restrictions.

However, the important factors are those on the vehicle side, which can mitigate the passenger side factors if planned correctly or exacerbate them if planned incorrectly. These include, for example, the boarding height and door width, any level boarding, the location and number of doors, the suitability of the entrance area as fall arrest areas, any restrictions on passenger flow and the overall design of the vehicle interior.

The difference in the passenger changeover time between the best and worst vehicles currently is a ratio of 1:4. In concrete terms, this means that with an assumed passenger changeover time of one minute, at best the passenger changeover for the same number of passengers can be up to four minutes in the worst case! It should be noted here that with a few exceptions, current, younger generation vehicles in service tend towards the higher values!

The influence of the interior design already has an effect of 1:2 between the best and worst case. This means that in the best case, even with conventional vehicle designs, a passenger changeover time of two minutes can be achieved with a high passenger turnover, whereas in the worst case this takes four minutes.

1.3.2 Seat occupancy rate

The seat occupancy rate can drop noticeably with unsuitable and insufficiently designed luggage storage facilities. For conventional passenger coaches with a length over buffers of 26.4m, a maximum of 80 seats are to be provided for standard days. This number can be achieved if the remaining space is used in a suitable way for luggage racks. If this is the case, up to 100% of the seats can be occupied. If there are more seats beyond these limits, this is at the expense of suitable luggage storage and the number of seats actually available as well as the occupancy rate drops sharply. Previous studies by the Research Centre for Railway Engineering at the Vienna University of Technology show that the average degree of utilisation to be achieved in comparable vehicles with 88 seats is only about 80%. This means that on average only 70 of the 88 seats installed can be used!

The reason for the strongly declining occupancy rate is that, on the one hand there is not enough luggage storage capacity available, and on the other hand the existing areas are often not designed according to the requirements of the passengers. This leads to the fact that some of the luggage is not only placed in the aisle but also on and in front of seats.

1.3.3 Economic efficiency

The effects of inadequately and incorrectly planned luggage storage facilities ultimately have a noticeable economic impact. The hope or the goal of being more economical through a high number of seats is usually turned into the opposite. Always under the premise that the goal is to utilise the high number of available seats, the following correlations become apparent:

Delays: Seat maximisation inevitably leads to long dwell times. With a high number of passengers, four to six minutes are required per station, whereas ideally designed vehicles only need one to one and a half minutes. This circumstance leads to corresponding delays in a dense sequence of stations.

Decreasing operating quality: If the delays mentioned cannot be made up, it leads to decreasing operating quality. This is particularly significant if delays are transferred to connecting or crossing trains or if connection breaks are the result!

Higher energy consumption: If it is possible to make up for the delays, this can only be done by constantly using the respective maximum line speed, which means a noticeable increase in energy consumption especially at a high speed level.

Lower occupancy rate: Seats are installed that are not available in practice. At the same time, the achievable seat occupancy rate drops by up to 20%!

Decreasing passenger satisfaction: On the one hand, the decreasing seat occupancy rate results in a correspondingly high number of standing passengers, which reduces passenger satisfaction accordingly. On the other hand, the sometimes "chaotic" conditions in "overcrowded" vehicles significantly reduce comfort. For almost 18% of passengers, a high occupancy rate with the associated effects already mentioned several times means a high stress factor!

1.3.4 Security

Probably the most essential criterion, which is often overlooked, is safety. If a train has to be evacuated in an emergency, the high number of seats at a high occupancy rate combined with the aforementioned effects poses a high safety risk. In air traffic, an evacuation time of no more than 90 seconds must be demonstrated before aircraft can be certified. In rail transport there are no such known regulations, but it can be assumed that for most vehicles this time cannot be observed. For a fully occupied carriage with 88 seats, the pure disembarkation time of all passengers under ideal conditions (no luggage during the disembarkation process, no bottlenecks due to crowds in front of the boarding door, only two steps) is approx. 120 seconds for the best vehicle designs and approx. 160 seconds for the worst designs.

In the event of an emergency, panic that does not allow for an orderly disembarkation process must also be taken into account. In this case, luggage that has not been properly stored becomes a safety risk! For this reason alone, it must be ensured that there are actually suitable luggage storage facilities for each seat installed.

1.4 Basic planning errors

Fundamental errors in the planning and ordering process, which lead to the inefficient conditions described above, can be identified from the past both on the part of the purchasers and on the part of the manufacturers.

Error 1: Volume calculation: Every cuboid-like body has a volume and also three concrete dimensions. In the tender documents there is usually only information on the required total volume for the luggage accommodation. For cuboids, the volume is the product of width, length and height. This means that a volume of approx. 0.125m³ per passenger, which is often demanded, can either correspond to the dimensions of a medium-sized trolley of 50x70x35cm, but at the same time can also be 1x4160x30cm! Accordingly, it is also common practice to multiply every cross-sectional area, no matter how small, by the available depth and to add up the resulting volumes to a total volume! As a rule, in practice a maximum of 50% of the calculated volumes are available! It is therefore necessary to have precise knowledge of the statistical distribution, the shape and the dimensions of the luggage!

Error 2: Disregard of passenger behaviour: If the principles of "avoid lifting" and "visual contact" are disregarded with regard to the luggage rack design, the planned racks are only partially accepted by the passengers. In practice, this leads to up to 50% of all racks remaining unused and yet a large amount of luggage being deposited in an obstructive manner.

Error 3: Incorrect knowledge of baggage volume: The actual baggage volume must be calculated for each route and the expected passenger or travel purpose mix. Flat-rate assumptions are often made or days are used as a basis for the calculation, which only allows for a below-average expected luggage volume.

Mistake 4: Wrong dimensioning: Meanwhile, luggage racks are increasingly being installed in vehicles or the space between the seat backrests is also taken into account for luggage accommodation. However, it can be observed that the dimensions of luggage racks are often based on seat dividers, which leads to very inefficient dimensions. The same can be observed for the spaces between the seat backrests. When dimensioning the respective racks, it is advantageous to take into account the shapes and dimensions of the luggage items as well as the storage behaviour of the passengers. Seat spacing and luggage racks are often too small by a few centimetres, which can then lead to an actual loss of storage space of 50% or more!

Error 5: Incorrect evaluation criteria for orders: In vehicle orders, it is often observed that evaluation criteria that are not logically comprehensible are applied. A popular evaluation criterion in tenders is the definition of the minimum number of seats. In most cases, this involves information that is to be classified according to psychological perception, i.e. often jumps in the 100s. If, for example, a fictitious figure is specified in the tender that a train must have at least 500 seats, the manufacturers' hands are usually already tied in the tender phase and efficient solutions are lost from the outset. These figures are usually based on a pre-calculated maximum number per vehicle and disregard reality. In the fictitious example given, it can be assumed that a maximum of 450 seats are actually available in the entire train. It would therefore be much more efficient not to impose a corresponding requirement but to let the manufacturers look for efficient overall solutions. If appropriate solutions are found, it can be assumed that vehicle concepts will be found that offer approx. 470 seats in the example mentioned, which can then ultimately actually be used!

1.5 Conclusion

More than 20 years of research, development and involvement in numerous vehicle planning projects make it clear that an overall optimum for vehicle interiors must always be sought in vehicle developments and orders. Many negative examples illustrate that the exclusive pursuit of a maximum number of seats can lead to inefficient and dangerous situations in practice. In particular, luggage storage facilities need to be planned precisely and thoughtfully in order to contribute to efficient overall systems. Experience also shows that it is very critical not to base the design on blanket assumptions. Each vehicle must be assessed individually in terms of the overall efficiency that can be achieved, which ultimately leads to an actual maximum seat occupancy.

The requirements for luggage storage must be carefully formulated in the tender. Furthermore, when planning the vehicle it is important to consider exactly where and which luggage racks can be installed in order to achieve the greatest possible efficiency. Subsequent changes can usually only be achieved with great effort or with little effect.

Fortunately, an awareness of the problem in this regard has recently become apparent. Numerous recent projects confirm that interest and willingness to develop efficient overall systems have arisen on the part of both operators and manufacturers, and that some efficient overall solutions could be developed with negligible additional expenditure.

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2 Data basis

The Research Centre for Railway Engineering at the Vienna University of Technology, now in cooperation with netwiss OG, has been dealing intensively with questions concerning the optimization potential of passenger coaches on a scientific level for more than 20 years. The core of all research and development projects as well as the resulting scientific work is the serious examination of the needs and wishes of passengers but also of their problems and difficulties when using the railway. An essential contribution to the objectification of the findings is the data on passenger behaviour collected over two decades, which was gathered through observations and continues to be collected on an ongoing basis. The aim is to record the real behaviour of passengers under a wide range of boundary conditions, unaffected by any personal feelings that may influence the results of surveys. Surveys formed an additional basis for the scientific analysis.

In over 20 years data has been collected to the following extent:

Passenger changeover analyses: Approx. 20,000 passengers were observed during passenger changeover in approx. 100 different boarding areas or vehicle types. Video analysis was used to determine to the nearest tenth of a second how long a person takes on average to board and deboard. In addition to the knowledge about the individual time required, decisive insight can be gained into the extent to which the entire vehicle concept influences the passenger changeover time.

Passenger changeover tests: In addition, passenger changeover tests were carried out on five days with 70 test persons each on more than 10 different layouts; during which the exact movement sequences were recorded and analysed in all phases of boarding and deboarding: from boarding at the doors, to storing luggage, to finding a seat and in the opposite direction when deboarding.

Passenger surveys: Approximately 50,000 passengers in almost 10 different countries were interviewed about their problems and difficulties as well as their needs and wishes in all phases of travelling in a rail vehicle. This concerns boarding as well as moving around in the train, finding a seat, storing luggage and the demands during the journey itself.

Passenger behaviour analyses: The behaviour with regard to seat selection, luggage storage and time use during the journey of approx. 400,000 passengers in over 100 different vehicle types was analysed. Depending on the parameters of age, gender, occupancy rate in the vehicle and room concept, the data can be used to derive exactly which seats or seating

areas are preferred, how and where luggage is stored and which activities travellers carry out.

Luggage data collection: By counting, precisely measuring and weighing several thousand pieces of luggage in combination with surveys, the exact types and volumes of luggage to be expected per person, per vehicle or per train could be determined depending on the purpose of the journey, the age and gender of the person and the size of the group.

With regard to new vehicle concepts, the data allow precise conclusions to be drawn about how the envisaged space concept will be used, how the concept will affect passenger behaviour in terms of seat selection, luggage accommodation and activity performance and what impact the behaviour will ultimately have on the parameters of passenger changeover time, proper accommodation of luggage and the actually achievable seat occupancy.

All this data forms the basis for the TrainOptimizer® software tool and the associated consultancy services.

3 What is TrainOptimizer®?

TrainOptimizer® is a software tool based on all above mentioned data, with which you can check the efficiency of any vehicle-interior design with just a few clicks. The big advantage compared to other software tools for passenger flow analysis, e.g. in buildings, is that the large data set specifically maps the real behaviour of people in the vehicles when boarding and deboarding and during the journey. Therefore TrainOptimizer® is a unique tool.

You can compare any variants of a wagon or train and get a clear picture of how long the average dwell time will be, how many pieces of luggage cannot be stored properly and how high the proportion of unusable seats is or the actual achievable capacity degree. A variety of special queries are possible with the aim of determining the most efficient layout. TrainOptimizer® is an online tool optimized for Google Chrome Browser with the big advantage that time-consuming installations and updates are no longer necessary, and you can access all functionalities from any computer.

With TrainOptimizer® you can easily create different vehicle layouts, adapt them at any time and compare them to each other with just a few clicks. You have the possibility of adapting different basic parameters, e.g. you can select special travel purposes or determine whether a train will serve an airport or not. There are many options for configuring your evaluations according to your needs. In addition, it is possible to use regionally-specific data packages. You can either purchase these as additional features when they are available, or if required, we can work with you to develop special data packages tailored to your areas of application.

TrainOptimizer® delivers concrete results per vehicle layout or by comparing the layouts with each other:

- Storage possibilities for luggage/number of luggage items that cannot be stored
- Actual achievable seat-occupancy rate /number of unusable seats
- Average value of the passenger boarding and deboarding time

The goal of TrainOptimizer® is to compare different layout variants with each other in order to determine the most efficient variants with regard to short dwell time and the highest possible degree of seat occupancy. The absolute data per wagon are inevitably subject to passenger distribution, since in reality homogeneity can never be achieved with regard to

the number of passengers and passenger behaviour; in comparison of the parameters, the results offer the best possible accuracy!

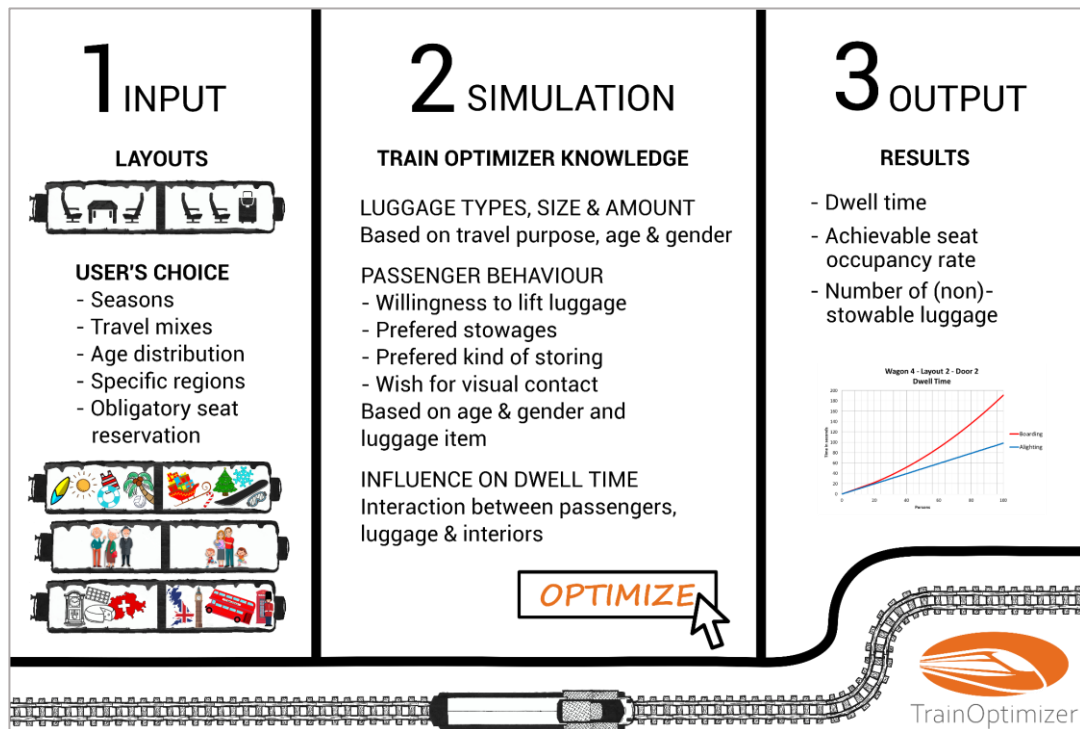


Figure 1: Schematic of TrainOptimizer® operation

With TrainOptimizer® you can optimize any public transport vehicle. The spectrum ranges from high-speed trains to inter-city trains, night trains, local trains and suburban trains. TrainOptimizer® can also be used for undergrounds, trams and even buses.

4 Overview of the most important functions of TrainOptimizer®

The main features in TrainOptimizer® include:

1. Create a project
2. Create a wagon or train belonging to the project
3. Creation of various layout variants for each wagon or train
4. Selecting the desired evaluation parameters and evaluation

4.1 Create a project

After logging in, you will be taken to an overview of the projects that have already been created. There you can select a project for further editing or simply create a new project (see Figure 2):

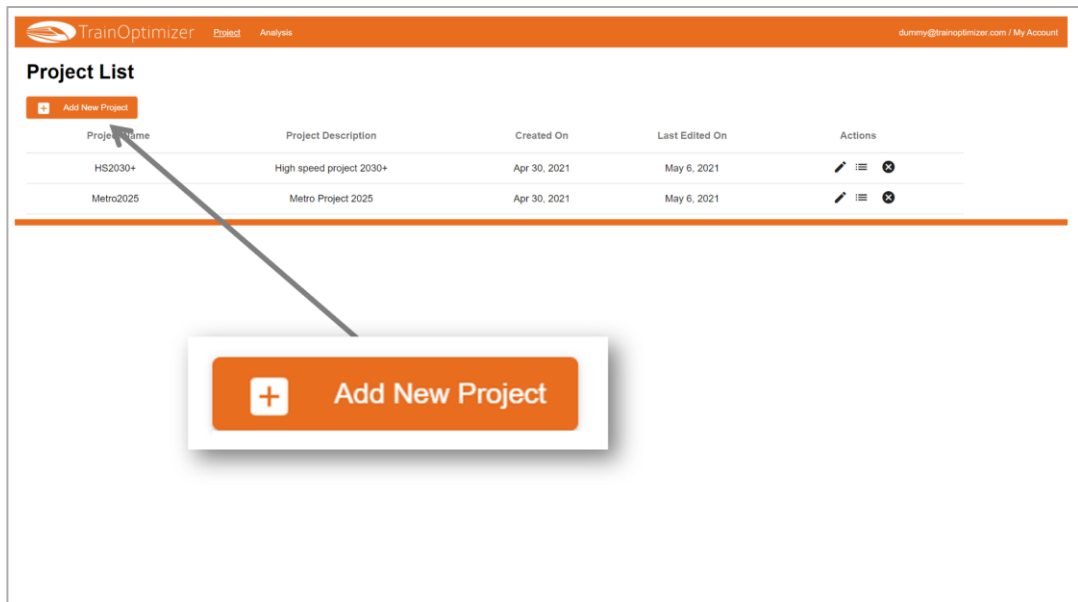


Figure 2: Creating a new project

When you create a new project (see Figure 3), you define a project name, a short supplementary project description and select the desired transport purpose. Here you can distinguish between:

- Urban public transport
- Regional public transport
- Long-distance transport

The transport purposes take into account the typical behaviour of passengers, which varies depending on the area of application.

In addition, you can select a specific region if you have region-specific data available or also use general average data sets.

The screenshot shows the 'Add new project' form. The form has the following fields:

- Project name
- Project description
- Mode of transport
- Region/Operator

A modal window is open over the form, showing the same fields. An arrow points from the 'Mode of transport' field in the form to the 'Mode of transport' field in the modal window.

Figure 3: Entering the basic data for the project

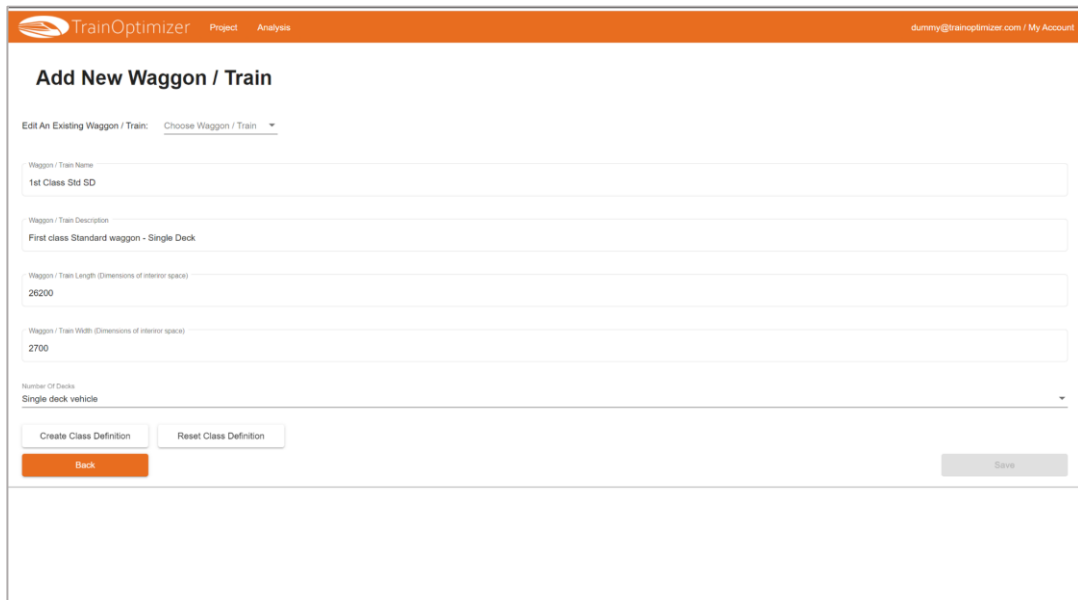
All relevant data in the background are already defined based on scientific findings. Nevertheless, you have the possibility to adjust the following data under Advanced Settings:

- Willingness of the travellers to lift the luggage
- Seat and standing-room occupancy rate
- Proportion of passengers boarding or deboarding
- Standing density (persons/m²) in different areas

4.2 Creating a wagon or train

You can create a wagon or a train formation. A train formation makes sense if the wagon connections are open, for example in metro vehicles, and when people usually move from one area to the other.

To create a wagon or train: assign a name for the wagon or train, an extended short description and enter the inner length and width of the wagon body or continuous train area (see Figure 4).



The screenshot displays the 'Add New Waggon / Train' form in the TrainOptimizer application. The form is titled 'Add New Waggon / Train' and includes a dropdown menu to 'Edit An Existing Waggon / Train: Choose Waggon / Train'. The form fields are as follows:

- Waggon / Train Name:** 1st Class Std SD
- Waggon / Train Description:** First class Standard waggon - Single Deck
- Waggon / Train Length (Dimensions of interior space):** 26200
- Waggon / Train Width (Dimensions of interior space):** 2700
- Number Of Decks:** Single deck vehicle

At the bottom of the form, there are two buttons: 'Create Class Definition' and 'Reset Class Definition'. Below these buttons are two more buttons: 'Back' (orange) and 'Save' (grey).

Figure 4: Basic specifications for a new wagon

Subsequently, you define whether you want to create a single-deck or double-deck vehicle. Then you define the comfort class, whereby you can also define different areas with classes. The class has a particular effect on the type of luggage carried and the behaviour of the passengers, which ultimately flows into the evaluations (see Figure 5).

Figure 5: More detailed information on individual sections such as floors or classes

4.3 Creating a layout

As soon as the wagon or train has been created, you can create as many different layouts as you like (see Figure 6), which can then be compared with each other within the evaluations.

Figure 6: Creating a new layout

You can also call up individual layouts from the layout list at any time to edit them or create new layouts (see Figure 7). Existing layouts can also be duplicated and saved under a new name in order to change them afterwards. This means that layouts that are similar to other layouts and differ only slightly from them do not need to be created anew each time.

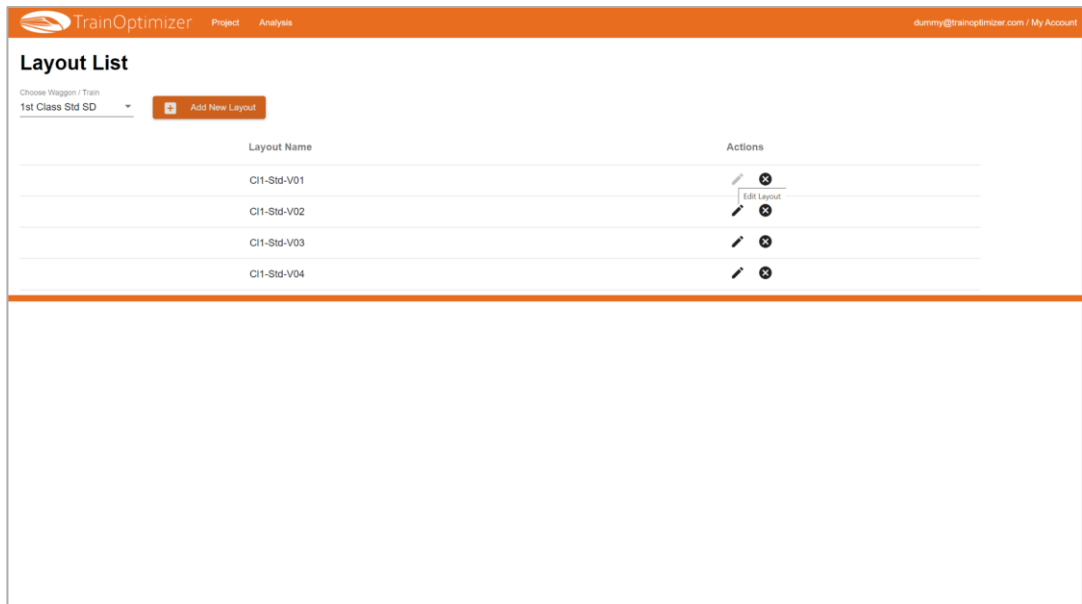


Figure 7: Layout list with selection option for editing

By selecting a layout, the editor opens in which you can configure the layout in a simple way. First an empty drawing opens with the interior boundary of the selected wagon or train (see Figure 8).

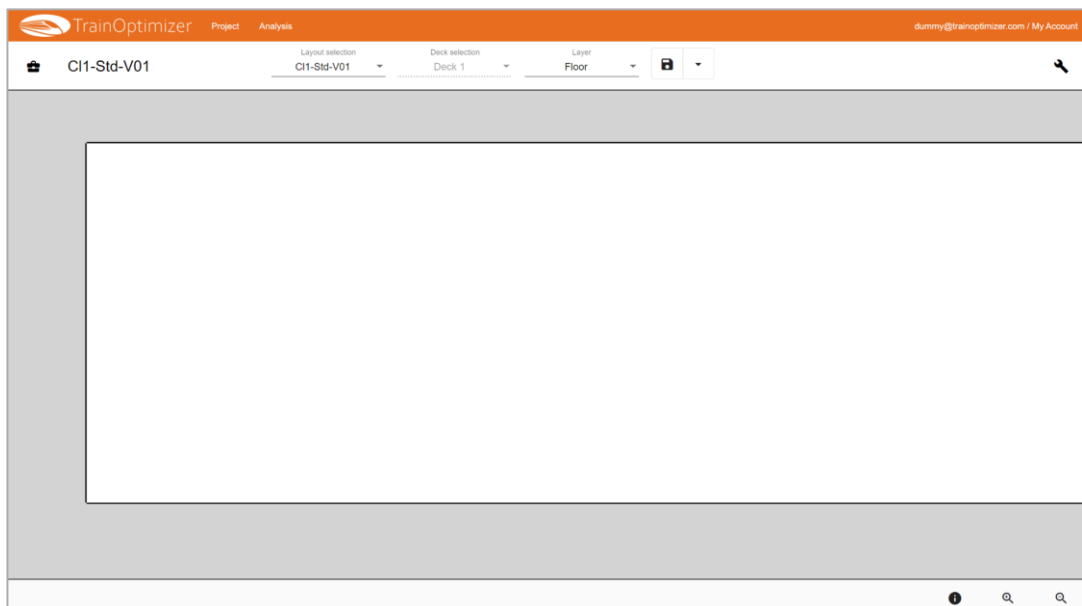


Figure 8: Editor with empty wagon floor plan

In the editor it is possible to switch between different layouts, and in the case of double-decker trains, also between the two floors. In the editor itself there is a separate toolbox containing pre-configured elements, such as seats, tables, walls, doors, stairs, etc., which are used to create layouts quickly (see Figure 9).

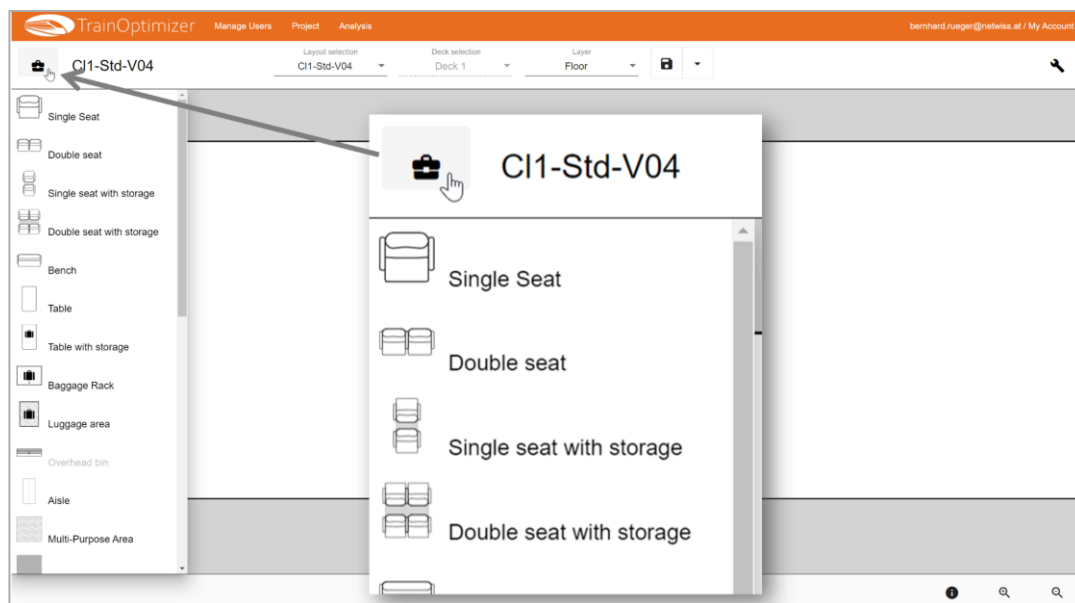


Figure 9: Toolbox with items in the editor

The following elements are available for layout creation in the toolbox (see Figure 10):

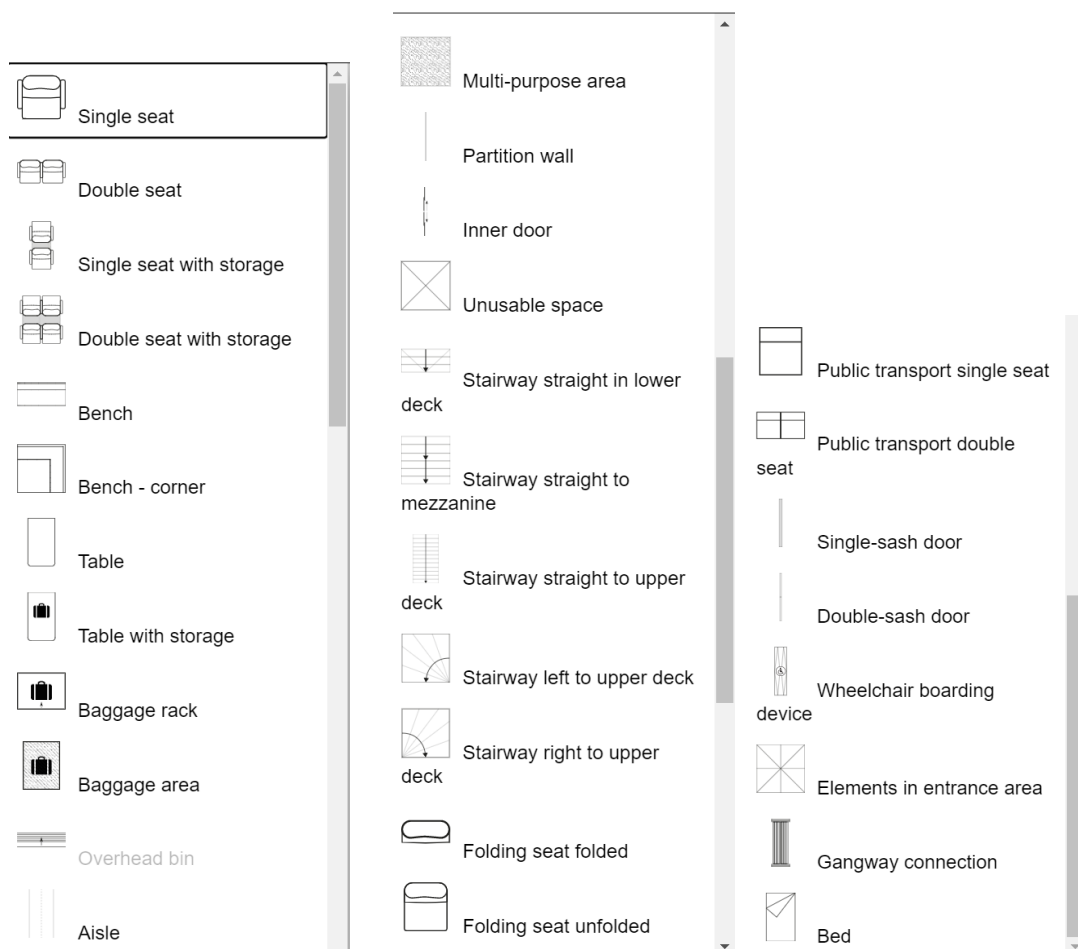


Figure 10: Overview of all selectable items

The elements include the groups:

- Seats
 - for railway vehicles
 - for public transport vehicles (e.g. metro)
 - Benches including corner seats
 - Seats with special luggage racks behind or below them
 - Folding seats
- Tables
- Luggage racks
 - Luggage racks
 - Luggage areas on the floor
 - Tables with luggage racks underneath
 - Luggage racks behind/under/between seats are automatically taken into account based on the seat configuration
- Stairs
 - Stairs for moving to the middle or upper floor
 - Straight and curved stairs
 - Stairs only for the basement (e.g. between low floor and high floor area)
- Entry elements
 - Entry doors (single and double-sash), configurable with different numbers of steps or gap bridging
 - Wheelchair ramps or wheelchair lifts
 - Fixtures such as door control
 - Partition walls
- Common areas
 - Aisles
 - Multipurpose areas
- Other elements
 - Partition walls
 - Interior doors
 - Beds for sleeping or couchette carriages
 - Gangway connection
 - "Non-usable" areas - to be used for WC, electrical cabinets, catering galley etc.

All these elements can be configured via the properties, which are displayed on the right-hand side of the screen (see Figure 11):

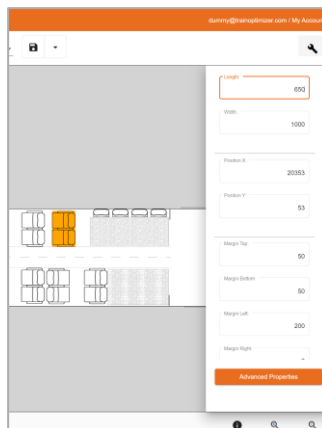


Figure 11: Settings for the different elements

The setting options vary depending on the item. Each item can be adjusted in terms of size; in principle, it is possible to place an item exactly in the layout using the coordinate system, although there are simpler options for this described below. Likewise, the distance in all four directions can be entered differently for each item, which is then used in the context of snapping.

For many items, further settings can be made in the Advanced Properties. In the case of seats, for example, different dimensions of the seat back can be specified, as can for example, the presence of a floor support, which makes it difficult to place luggage under a seat.

For luggage racks, the exact dimensions of the individual compartments are carried out in the Advanced Properties as well as for overhead storage.

In general, there are many Advanced Property options that allow you to configure "special constructions" such as luggage racks with sloping side walls.

4.3.1 Tools for easy layout creation

The layouts are created according to the track and drop principle; the operation is simple with the help of the keyboard and the mouse (see Figure 12):

To zoom the layout, the Ctr-key is used together with the mouse wheel, scrolling is only done with the mouse wheel or in combination with the Ctr + Alt keys.

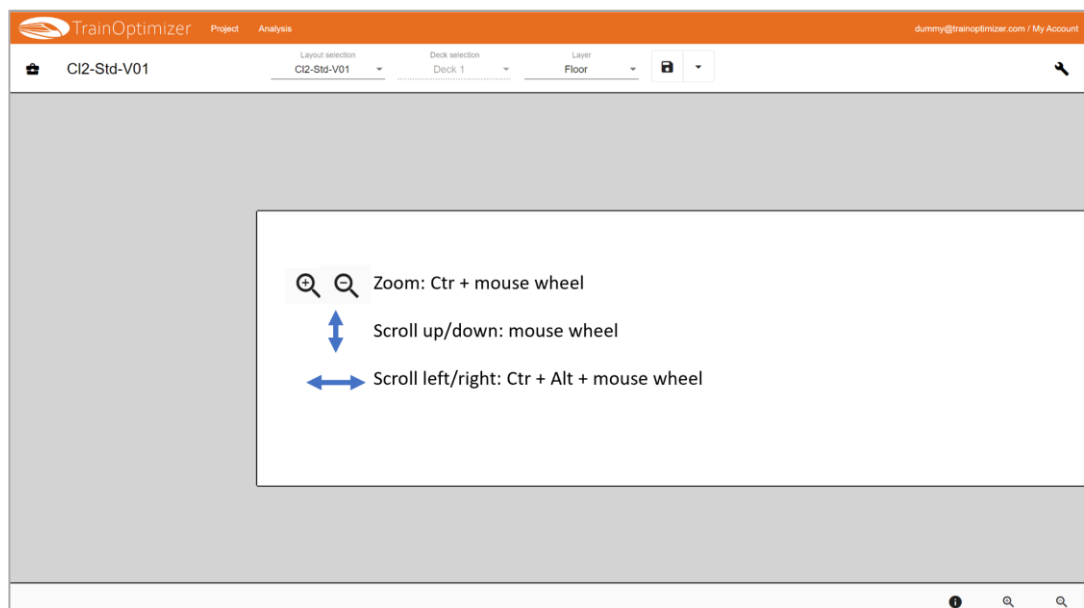


Figure 12: Simple operation with buttons and mouse wheel

To place elements in the layout, they are clicked in the toolbox and then placed in the layout or on the grey workspace. Elements that occur several times with the same properties, such as seats, only need to be configured once in the properties and can then be copied as desired. In order to be able to easily align elements with other elements, there is a snapping function. Here, the usual distance to another item is specified once and an item of the same type is then snapped to another item at this distance. For example, the distance to the next seat can be specified with a distance of 250mm and the distance to the wall with 50mm. The seats are then lined up with a few clicks.

The following functions are available at a glance (see Figure 13):

- **Copy:** You select an item by left-clicking on it and pressing the key combination Ctr + C. This copies the item with all its properties.
- **Snapping:** In the properties of the item you can specify the distance on all four sides to other items. This distance is also transferred to the new objects by copying. Now click on an item and move it. If you press the space key at the same time, a blue line appears automatically and the object is placed at the specified distance from another object.
- **Rotate:** Objects can be rotated in 90° steps by clicking on them with the right mouse button.

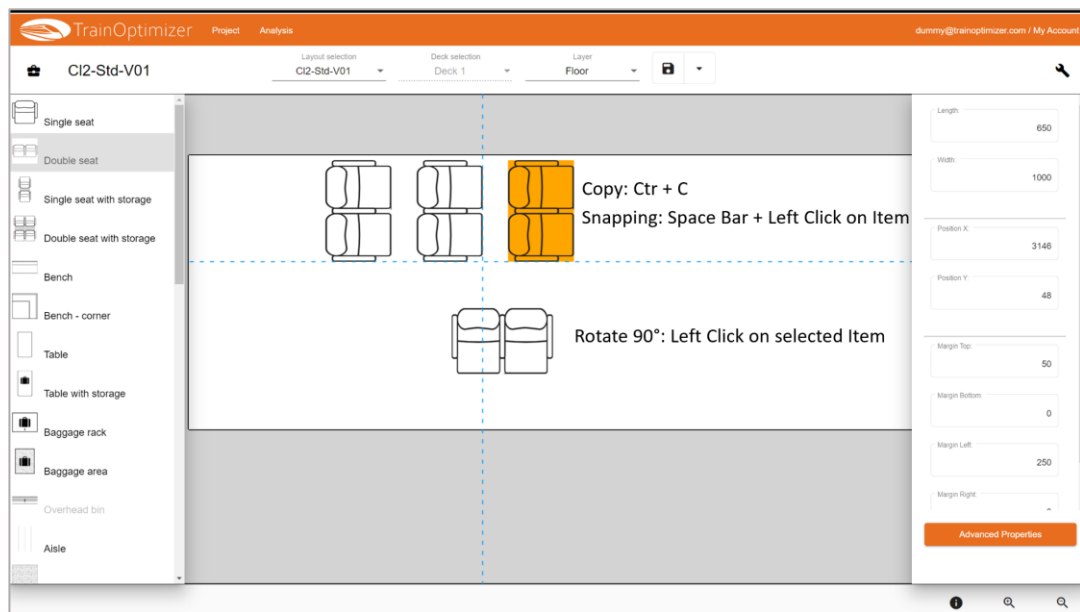


Figure 13: Editing the items: snapping, copying, rotating

In the way described above, with a little practice and without CAD knowledge, wagon layouts can be created in about 15min, which can then be evaluated. In order to obtain the most accurate evaluations possible, the layout does not need to be planned exactly. Even if not all dimensions are known exactly, sufficiently accurate calculations of the layout can be made.

Below (see Figure 14) is an example of a layout completed for the evaluations:

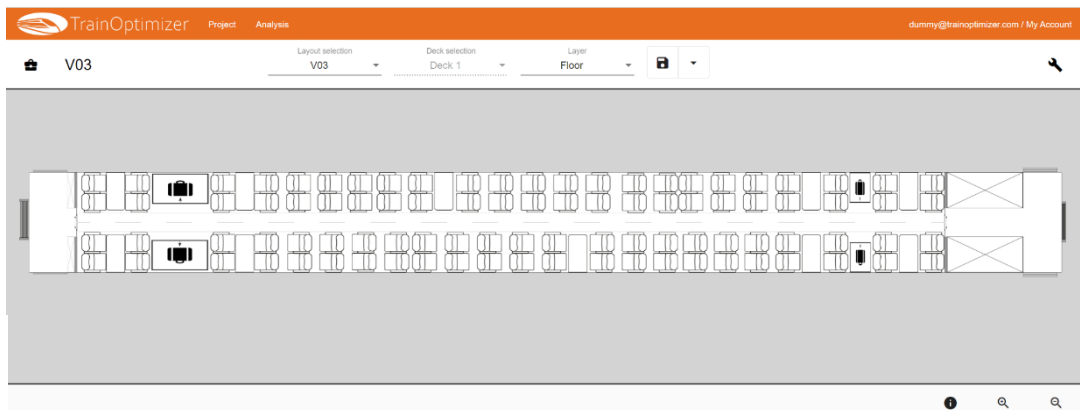


Figure 14: Example of a finished layout

4.4 Evaluate the layouts

The created layouts are then evaluated in the Analysis section (see Figure 15). The following selections are to be done for the evaluation:

1. Project and wagon
2. Layouts to be compared with each other
3. Desired travel purposes
4. Subject areas to be evaluated (selectable charts)
 - Luggage storage
 - Seat usability
 - Passenger changeover time
5. The doors for the passenger changeover time calculation

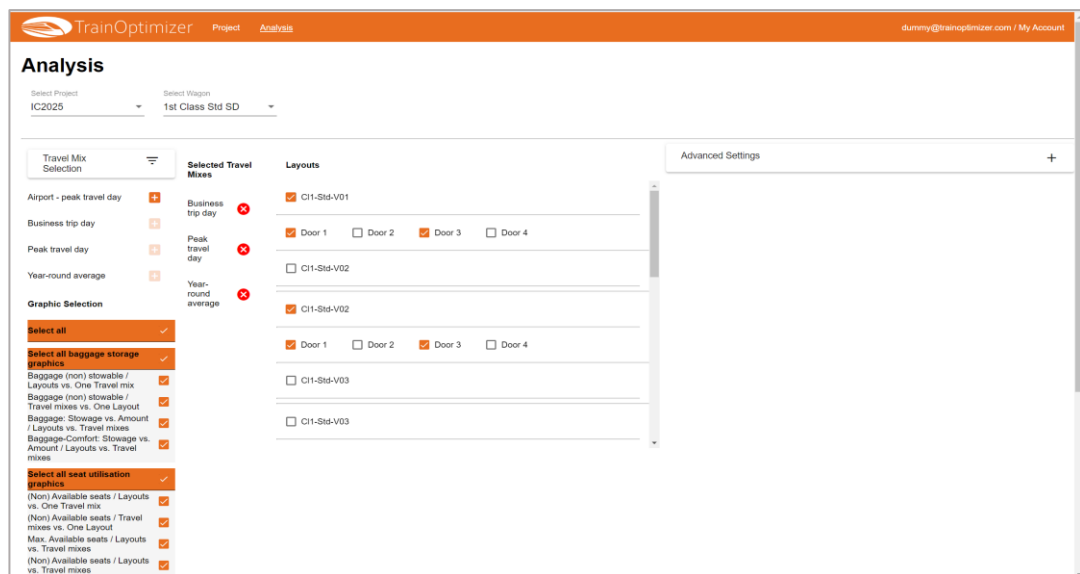


Figure 15: Basic selection for the evaluations

In addition to the standard selection options, advanced settings can then also be made (see Figure 16). Essentially, the settings made at project level can be adapted for individual evaluations or also generally for the project:

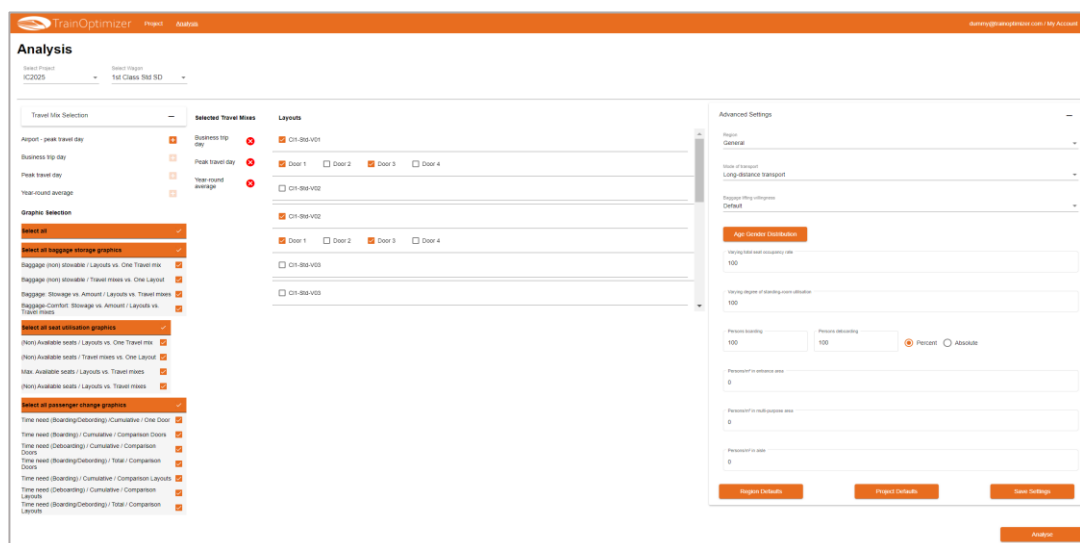


Figure 16: Extended selection options for the evaluations

4.5 Analysis results

The results are displayed in the form of line and bar graphs, with many possible combinations. Evaluated are:

- Number of (non) stowable pieces of luggage
- Number of (non) usable seats
- Duration of the passenger changeover time

The results can be shown per layout and per door (when boarding and deboarding), but combinations are also shown by different comparisons (see Figure 17. These are e.g.:

- Luggage accommodation with multiple layouts compared to each other for one travel purpose
- Luggage accommodation for one layout and for multiple travel purposes in comparison
- Seat availability for multiple layouts compared to each other for one travel purpose
- Seat availability for one layout and for multiple travel purposes in comparison
- Passenger changeover time with multiple doors compared to each other for one travel purpose
- Passenger changeover time with the same doors and different layouts compared to each other for one travel purpose
- Passenger changeover time with the same doors and different travel purposes compared

The passenger changeover time is shown both as a line diagram over all passengers and as a bar for a selectable number of passengers, which can also be given as a percentage (e.g. 60% passenger change).

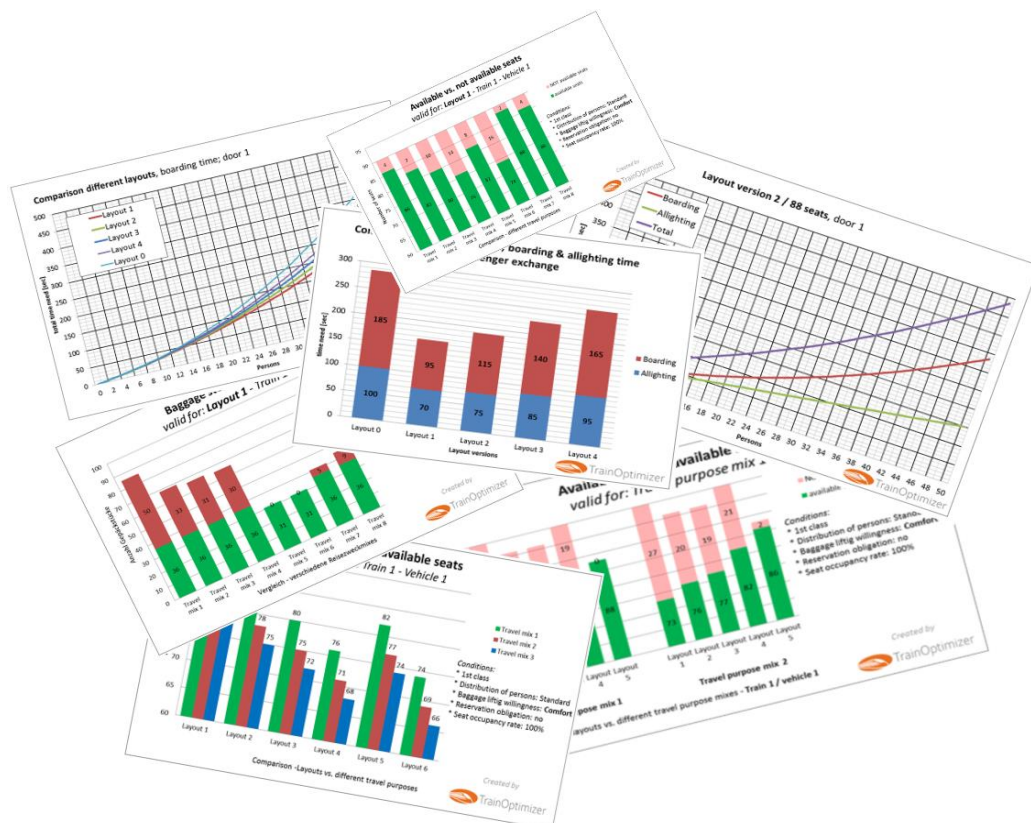


Figure 17: Examples of evaluations by TrainOptimizer®.