

# **ENTRANCEWAY AND CAR BODY DESIGN: EBD 3.1 - A THREE-LEVEL (DOUBLE DECK) RAILROAD CAR BODY WITH FULL HEIGHT AISLES THAT CONFORMS TO NORTHEASTERN CLEARANCES**

by Edward K. Morlok  
UPS Foundation Professor of Transportation  
and Professor of Systems Engineering  
University of Pennsylvania

10 May 2002 (minor editing 6 June 2002)

## 1. Abstract

This car body design provides the following features:

- It has a full double deck section between trucks, with a full height aisle on both of these sections as well as the normal floor height end sections, while remaining compatible with the limited clearances of Northeastern railroads (including the New York and Philadelphia terminals).
- By virtue of this unique triple level design, seating capacity is increased substantially over that of a single level car, and space is easily provided (near the doors and lift between car floors) for wheelchairs and mobility-impaired travelers.
- It can incorporate the EBD 2.1 entranceway and drop-center car body design, so that full wheelchair (and other mobility-impaired traveler) accessibility is provided to either (1) the lower and normal car floor levels or (2) all three levels.
- By use of the EBD 2.1 design, high level HL station platforms (including mini-HL and set-back mini-HL) and low level (LL) station platforms are fully accessible.
- This car body design can also be used with standard end vestibules (stairways, traps, and doors), and with HL platform-only or LL platform-only entranceway arrangements.
- Various passenger amenities can be provided in the ample body space, for toilets, storage of bicycles and luggage, etc. The upper level can be provided with vista-dome style end windows, affording passengers fore and aft as well as side visibility.

### *Contact information:*

Edward K. Morlok, Ph. D.  
UPS Foundation Prof. of Transportation  
Electrical and Systems Eng. Dept.  
University of Pennsylvania  
220 S. 33<sup>rd</sup> St – Room 293  
Philadelphia, PA 19104-6315  
Tel: 215.898. 8346  
Fax: 215.898. 5020  
Email: morlok@seas.upenn.edu

## 1. Basic Design

The basic design is shown in Figure 1. The double deck section is between the trucks (the lower level being designated level 1, and the upper level, level 3), while the floor sections above the trucks are at the usual height (level 2). Figure 1(a) provides a side view of the car, along its center, showing the location of the seats, doors, and stairways. Levels 1 and 2 are almost identical to those levels in design EBD 2.1, the main difference being the addition of two stairways to level 3.

The unique feature that enables provision of full aisle ceiling height is the nesting of the ceiling and the seating areas of the levels 1 and 3, as shown in Figure 1(c). Full height ceilings are not necessary above seats, and often are not provided in transportation vehicles. As detailed in Appendix A, while meeting the vertical height limit of 14 ft. 10 in. (4521.2 mm) imposed by the two major New York (Manhattan) passenger terminals and some other locations in the Northeast, this nesting yields an aisle ceiling height of about 82.5 in. (2095.5 mm). The ceiling above the seats is about 74 in. (1879.6 mm). The latter is higher than most persons are. A standard U.S. door is 80 in. (2032 mm) high, and ceilings 79 to 80 in. (2006.6 to 2032 mm) high are common in many railroad cars. The level 1 floor is maintained at 17 in. (431.8 mm) above the rails, the standard for drop center passenger car floors. Below 15 in. (381.0 mm) above the rails, the car body must be drastically narrowed in order to conform to AAR Plates B and C.

The nesting presented in these designs results from the floor of the seating areas on level 3 being one standard step—8 in. (203.2 mm)—above the aisle floor. Thus passengers step up to be seated there. This design provides considerable flexibility in vertical dimensions. For example, if a somewhat lower overall car height is desired, this can be achieved by having a larger vertical separation between the aisle floor and the seating area floor—increasing it from one step height to two. The wide car facilitates having such a gap. For example, two steps each 6 in. high (152.4 mm) results in a car only 14 ft 6 in. (4419.6 mm) high.

Levels 2 and 3 have the usual two abreast seating on each side of a center aisle, as shown in Figures 1 (b) and (c). Level 1, however, has three abreast single seats, separated by two aisles. This places the center row under the aisle of level 3, as needed to provide full aisle ceiling height. The layouts are further illustrated in Figure 2, which shows top elevations. Furthermore, the single seats of level 1 avoid crowding and narrowing of the aisle and/or seats on this level.

Level 1 is also ideal for wheelchairs, because of the two aisles and access from both sides of the wheelchair spaces. This also places wheelchairs close to the lift, which would be used for passage to level 2, should the wheelchair passenger be using a HL platform station. Of course, the wheelchair spaces could be provided on level 2, in addition, or as a substitute for these on level 1.

The low ceiling at the center of level 1 extends for its entire length. Even though almost all passengers can walk under the low ceiling without stooping, the entire car has been arranged so that no passenger must pass under the low ceiling in order to get to any seat. Upon entering level 1, a passenger can choose from three options, described here for a passenger entering the LL door from the side opposite the lift in Figure 2(b). These are to: (1) go up the two-lane wide stairs to level 2, (2) walk along the adjacent level 1 aisle past the seats, and then possibly up the stairs to level 2, or (3) pass under the low ceiling and use the aisle or stairway at the other side of the car. Once on level 2, then the passenger can choose to go up to level 3, or down the other stairway to level 1, along the opposite aisle from the one just left. The only exception to having all three options immediately upon entering is on a car equipped with a lift on the side entered, in which case the stairway to level 2 is not adjacent to the doorway. Access to all levels is provided with full height ceilings, of course, but the route is more circuitous. However, realistically, very tall persons encounter low ceilings in many locations, and ducking under a ceiling for about 3 ft. (914.4 mm) should present no problems. A stairway connects levels 2 and 3 at both ends of the center section. Passengers boarding on level 2 from a HL platform clearly can go to either other level directly.

## 2. Capacity

The capacity of this design is considerably greater than that of single level designs. As a basis of evaluation, capacities will be compared for cars that are devoted entirely to seating. Naturally some spaces would be reserved for wheelchairs, and possibly for other uses that reduce seating capacity. Capacity of this car will be based on a design with two sets of double lane doors at approximately the quarter points (where levels 1 and 2 meet), providing for four passengers boarding or alighting simultaneously. Four lanes through the doors is identical to the number provided on many recent commuter service cars, including single level push-pulls for the New York, New Jersey, and Philadelphia areas, and MU cars for the New York electrified lines.

With seats that are of the usual wide variety, yielding four seats abreast with a center aisle on levels 2 and 3, and with a 33 in pitch (common but generous for commuter applications), the capacity of a car is:

Level 1: 11 rows x 3 seats/row = 33 seats  
 Level 2: 4 rows/end x 4 seats/row x 2 ends = 32 seats  
 Level 3: 14 rows x 4 seats/row = 56 seats  
 Total = 121 seats

If level 1 center row seats are installed facing sideways rather than along the car axis, then with 2 ft centers 16 seats can be provided, for a total capacity of 126 seats.

This compares very favorably with single level commuter car designs. Single level cars with four lanes of doorways can have a maximum of about 25 rows, yielding 100 seats. Thus this car design yields additional capacity of 21% to 26%.

In addition, this design has some unused space on level 1 under the stairway to level 3 that can be used to provide other passenger amenities. One likely use is for bicycle storage, as most commuter rail lines now permit bicycles to be carried on off-peak trains. Another is luggage space. And if maximum seating capacity were the goal, then this space could be used for a bench seat for two persons (somewhat narrower per person than other seats, in an uncomfortable location) increasing capacity to 129 seats.

In principal, it would be possible to have 3-2 seating on level 2 and 3 of this car, in which case the number of seats would increase to about 145. This compares to about 121 on a single level car. However, the narrow seats of the 3-2 arrangement are generally unpopular, and fewer commuter agencies are choosing this type of car.

### 3. Design Options

There are numerous design variations that enable this basic tri-level design to be adapted to different circumstances. One such variation would be to use a standard end vestibule. This would be accomplished by simply eliminating the HL and LL doors, and placing a vestibule at one or both ends of the car. This vestibule could be of many types: the EBD 1.1 or 1.2 design, for remote control operation, a standard vestibule, a LL door only type, or a HL only type. Another variation would be to use the quarter point door design incorporated here, but to have only HL or LL doors. A third would be to retain the HL and LL compatible design, but have only one door instead of two leaves at one or more entrances. Also, different passenger accommodations could be installed, such as rooms or parlor car seating.

Another, covered in detail in the EBD 3.2 description, is to have entranceways at level 2 only. In this case complementary changes result in an increase in seating capacity over that possible simply by eliminating the level 1 doors. Such a car could have either the EBD 1.1 style door for HL and LL platforms, or HL doors only.

### 4. Conclusions

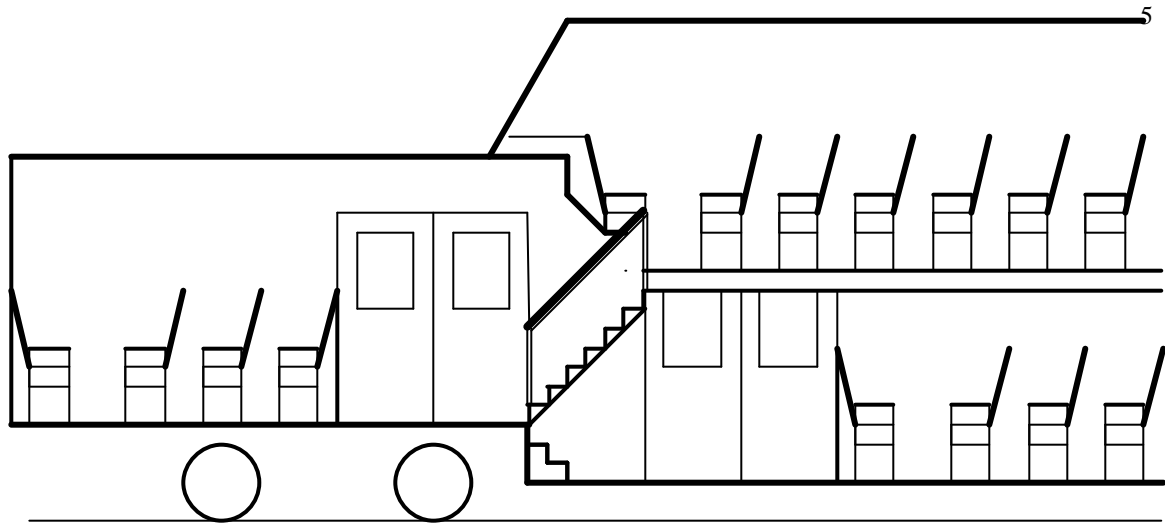
Thus the objective of a substantial increase in capacity over a conventional car has been achieved. Furthermore, this design is compatible with use of the EBD 2.1 entranceway design that provides fully remote control operation with all types of HL platforms, and with LL platforms.

Attachments:

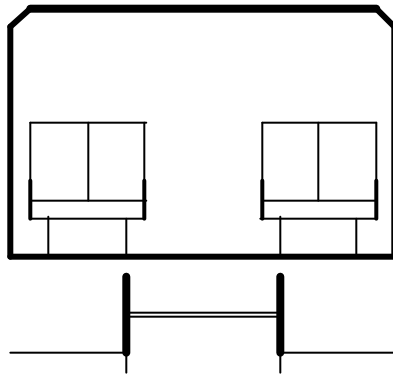
Figure 1

Figure 2

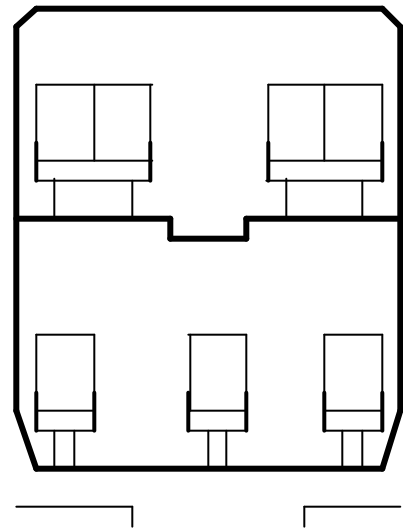
Appendix A



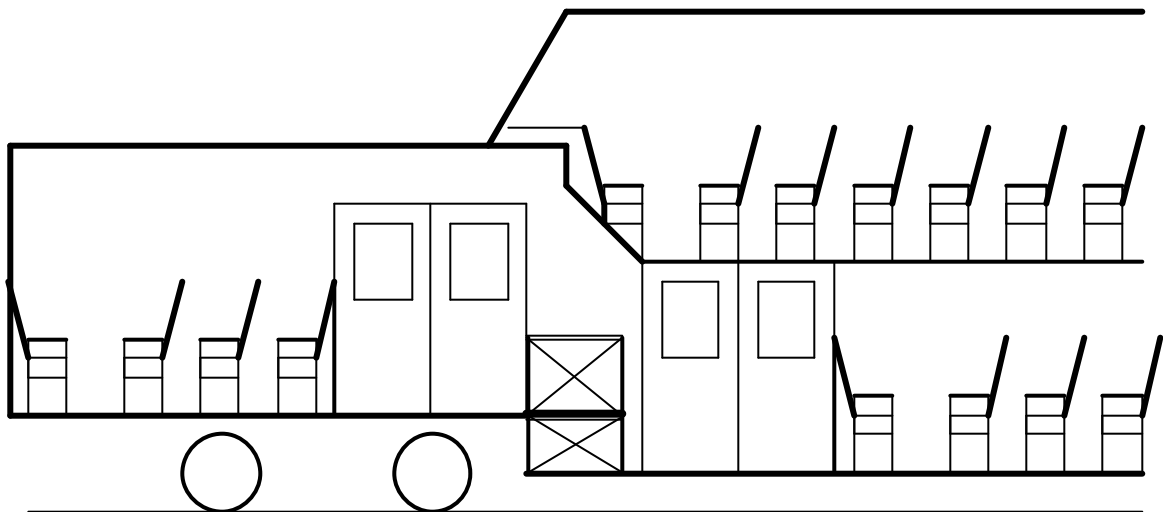
(a) Side elevation cross section through center aisle.



(b) Cross section through level 2 (above).

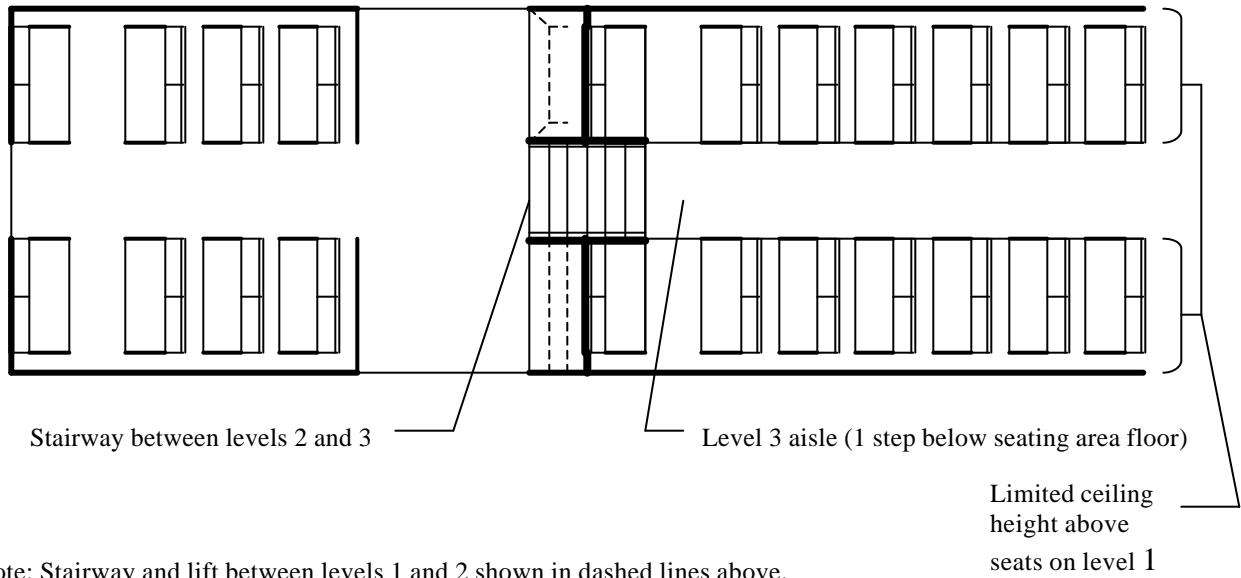


(c) Cross section through levels 1 and 3 (to right).

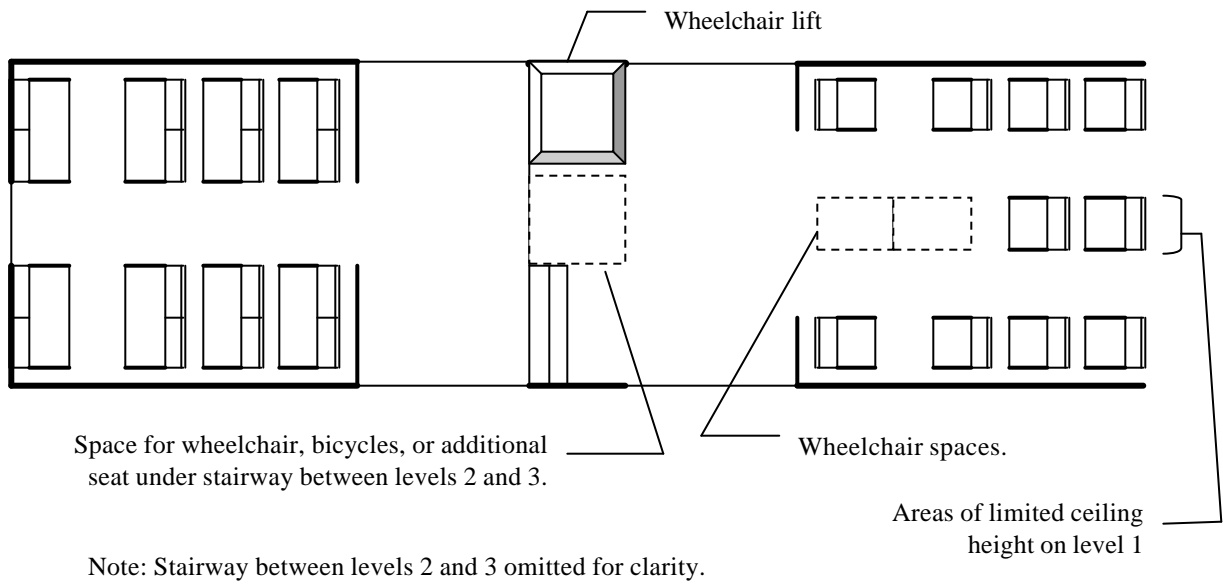


(d) Side elevation through far side seats.

Figure 1. Three level car body design.



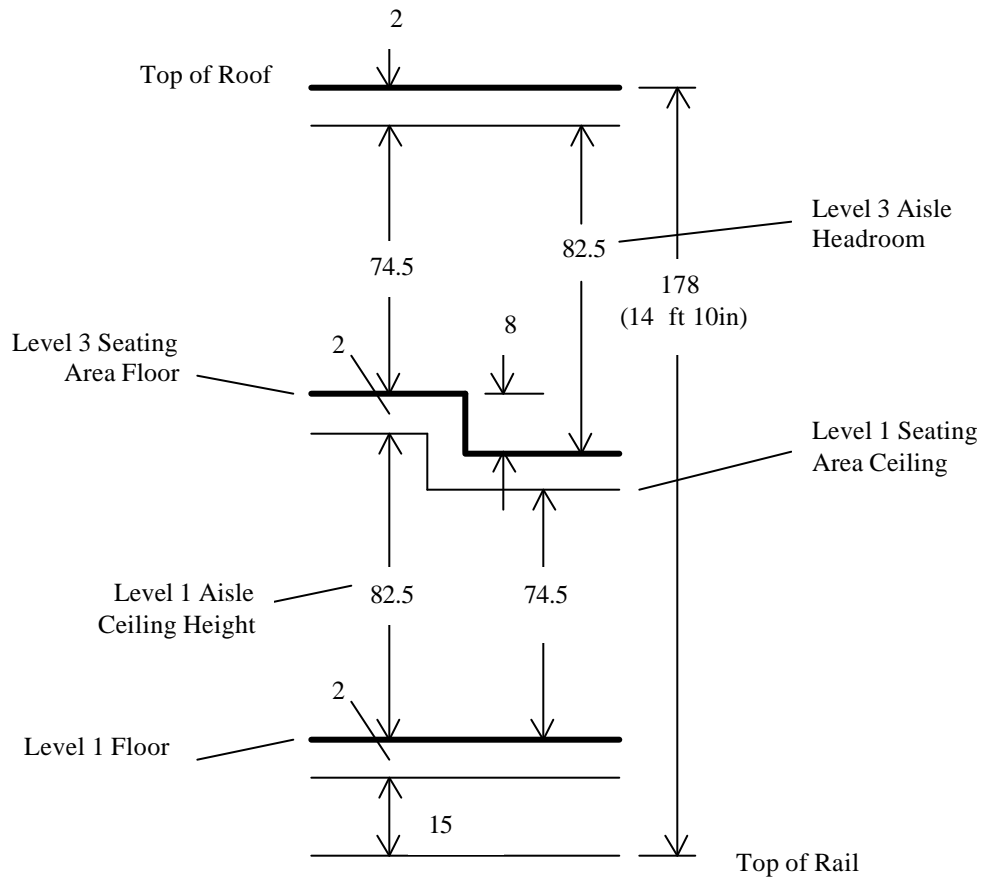
(a) Top elevation cross section just above level 3 seats, also showing level 2 area.



(b) Levels 1 and 2, showing single seats and spaces for wheelchairs and bicycles.

Figure 2. Top elevations of levels 1, 2, and 3.

## Appendix A. Principle Dimensions of Levels 1 and 3



All dimensions are in inches, except as noted.

### Notes:

1. Both aisle ceilings have 82.5 in. headroom as shown. If floors are thicker, either the level 3 seating area step height is increased, or the aisle ceiling height is correspondingly reduced.
2. Both seating areas have a ceiling height (at center of car on level 3) of 74.5 in.
3. An 84 in ceiling height results from a level 3 aisle to seating area floor height difference of 12 in, which can be achieved by two 6 in steps. Seating area headroom is then 72 in.
4. The overall height of the car can be reduced to 14 ft. 5 in., with ceiling heights of 80 and 72 in.
5. Thus there is room for dimensional variations, including thicker floors.
6. Level 1 floor is 17 in. above the rail, and thus 9 in above a standard location LL platform. This is consistent with EBD 2.1. A significantly lower floor requires a narrower body at level 1.