Reverse Engineering-
Re-Designing the existing seat layout of the
unreserved compartments

ABSTRACT:

Though unreserved coaches are a major revenue contributor to Indian economy, people travelling in unreserved coaches lack many comforts. 60% of the people in unreserved coaches travel without seats. In the current layout, the improper seat design allows limited space even for standing. Moreover, the current Ergonomics of the seat is not comfortable for long distance journey. The objective of this work is to create a layout which allows space both for sitting and standing of passengers thereby avoiding congestion and one that meets the design standards for system safety, maintains acceptable passenger comfort, achieves maximum design speed and operating service, provides for efficient maintenance activities, accommodates projected ridership capacity, and promotes design consistency.

So, the present work deals with the analysis of the design of Japanese Green Car 211 series, Cal train, Canadian Bi-level cars and other European trains. Keeping in view the constraints like overhead structures, bridges, electric traction equipment, platforms etc. the layout is generated by optimally using the space between the two bogies.

The only way to increase the number of seats without increasing the number of coaches and its length is to make the coach a multi-decker. With the comfort as a constraint and considering our Indian standards, double decker would be more suitable. The major requirements of this idea are minimal increase of the car height and to lower the point of centre of gravity of the car to provide a proper balance for the passengers in both the deck while travelling. The height of the car must be increased in such a way that, no further modification of any fixed structures like bridge is required. So, the possible solution is lowering the bottom floor to below the top level of the wheels, closer to the rails, and then adding an upper floor above which can be achieved by the usage of Y-shaped bogies. Thus the new layout, suitable for Indian standards accommodating more number of people in the available space is proposed finally.
**Tools used:** Value Analysis, Design and Development, Facility Layout Planning, Ergonomics, Work System Design, CAD

**Keywords:** Unreserved coach, Green Car 211 series, overhead structures, bogies, CAD

**Design Evolution:**

With reference to the design layouts of Japanese Green Car 211 series, Cal train, Canadian Bi-level cars and other European trains and considering our Indian standards, we have generated three different possible designs.

**Layouts Designed:**

**Bi-Level Cars:**

![Figure 2:](image)

shows the side view of a bi-level car layout

(All dimensions are in feet)

**Issues Considered in designing Bi-Level Cars:**

The Bi-level cars can be constructed using Y-shaped bogies which lower the bottom floor to below the top level of the wheels, closer to the rails, and then adding an upper floor above.

Two doors would be provided, each preceding the wheel attachment on either side. These doors would be provided at a correct level entry height for wheeled objects, such as luggage, strollers, and wheelchairs so that no further modification of platform is necessary.

**Layout of Bi-Level Cars:**
The layout can be divided into four sections - two single floor area, an upper floor deck, a lower floor deck. A blower fan will be placed on all these four sections to provide more ventilation. On entering through the door, a passenger would be faced with three ways - a straight way to single floor area, an upper staircase leading to upper deck, a lower staircase leading to lower deck.

**Single Floor Area:**

The dimension of this single floor would be 11.48 x 10.8 x 13 ft. This part would margin the either side of the car, each including a toilet system and a single row-length foldable bunker type seat on either side of the car with a luggage rack placed above it. A window of dimensions 560x560 mm would be placed at a height of 920mm from the floor level on either side of the bunker. This single bunker can accommodate 3 persons in seats and with enough space to stand and for free movement. It can also be folded to provide more space for standing when more accommodation is required. So, the maximum capacity of this single floor area would be 6 persons. Since this part of the car is positioned just above the wheel, bi-level flooring is not feasible thus enabling single floor accommodation. This single floor area would have one window and an electric fan on either side of the car.

**Upper Deck:**

The dimensions of this upper deck would be 45.9 x 10.33 x 7.9 ft. The entire car excluding the area where wheels are attached (single floor area) would be longitudinally partitioned into two equal floors each with a height of 7.9 ft. The upper floor would have nearly 10 chairs placed in a row wise manner with the front face of each row facing the back of the row in the front. Each row can accommodate 6 persons on the either side of the coach and a luggage rack running through the length on the sides on the either side. The purpose of using row wise chairs is that, unlike the bays it permits only minimum space for standing. So, as standing in the upper decks will lead to the problem of congestion and ventilation, the design implication is to provide no space for standing in the upper decks. There would be 5 windows each of dimensions 560x560mm at a height of 920 mm from upper floor level and 5 overhead fan each covering 2 chairs making the upper deck comfortable even in the summer. This layout is similar to that of a passenger bus seat layout. The maximum capacity of this floor would be 60 persons.

**Lower Deck:**
The dimensions of the lower deck would be same as the upper deck with 5 compartments each accommodating 12 persons on the either side of the coach. The speciality of this deck is that there would be provision of space both for standing and sitting. Two luggage racks would be provided for each compartment and the space under the seats can also be used for keeping the luggage. Two windows each on either side of the bay would be provided along with 2 overhead fans. This layout is similar to that of our normal single deck passenger train. The maximum capacity of this layout would be 60 persons.

In all four sections space under chairs can be used for luggage-keeping.

**Layout 2:**

**Figure 3:** shows the side view of layout2 - INTERIOR DESIGN(A)(RIGHT SIDE VIEW)

**Figure 4:** shows the front view of layout2: INTERIOR DESIGN(B) -FRONT VIEW
Even though the above layout offers more capacity and optimum space, it also requires a good 16 feet height. This in turn leads to a very expensive designing process. So, there is a need to evolve a layout with a lesser height. This led us to evolve gallery cars. Instead of multi-deck, the gallery car, features upper levels, which are balconies running along both sides of the car, with an open area between them. But, still a gallery car need a 15 feet height, which can be managed by lowering the bottom floor to below the top level of the wheels, closer to the rails, and then adding an upper floor above using Y-shaped bogies.

The layout can be divided into four sections- two single floor area, a upper floor deck, a lower floor deck. On entering through the door, a passenger would be faced with three ways-a straight way to single floor area, an upper staircase leading to balcony, a lower staircase leading to lower deck.

The single floor area and the lower deck would be of same design as in the above mentioned layout.

**Balcony:**

Instead of the car being longitudinally partitioned into equal floors, an upper level balcony would be fixed on either side of the car at a height of 8 feet above the floor area. So the balcony alone would occupy a height of 7 feet. Since there would be no provision for standing on the balcony, this height would be ideal and comfortable for a seated passenger.
Each balcony would have 10 single chairs placed in a row wise manner accommodating only 1 person each. There would be 5 windows and 5 overhead fans, on either side of the upper car, each enclosing 2 chairs. A luggage rack running through the length on the sides can be provided on either side of the deck. The maximum accommodation of the balcony would be 20 persons. Although, the seat capacity is lesser compared to the double decker, there is more ventilation and lesser congestion in this design.

**Final Layout:**

**Figure5:** shows the side view of the final layout.

The final design is evolved by combining the positive features of the above two layouts, keeping cost as a constraint. The dimension of this layout would be 68.8 x 10.33 x 13.8 ft. With a constraint of making as less modification as possible in the current layout, our final layout has passenger compartments alternating between two levels (upper and lower). By using Y-shaped bogies thereby reducing the floor level of the passenger area by 2.5 feet, implies no further increase in the height (from the rail to the top roof) is required and thereby requiring only minimal changes in the existing coach. And also enough extra depth would be gained to squeeze in the stepped compartments. The upper seats (in new layout) would occupy the relative position of the luggage rack (in the present passenger train layout) of the compartment below, each 'high' deck being accessed by the same entrance door; so not a 'double decker' in the strictest sense. The way to achieve two levels is to interleave upper and lower level compartments along the length of a car, the upper level compartments being reached by a short, narrow, central flight of steps from a neighbouring lower compartment.

In this layout, the upper-level seats would be squeezed in between the lower-level seats to ensure that the overall height of the unit would be within the clearances necessary to pass through tunnels and under bridges. The upper level compartments would be properly ventilated by the provision of a large window.

The layout can be divided into three sections - two single floor area and a central floor area with two different types of compartments. On entering through the door, a passenger would be faced with two ways - a straight way to single floor area and a lower staircase leading to the central floor.
The single floor area is similar to above mentioned layouts.

**The Central Floor:**

Replacing the luggage rack in our current passenger train layout with additional upper compartments is the special feature of this layout. The space below the upper compartments are well utilised for luggage keeping. Both the lower and upper compartment would have a predominately face to face seating layout which would be a great asset for long and lone journey passenger. This upper deck would be heavily supported by grid beams running along the length of the seats.

Two windows would be provided for each compartment at both the levels. The window provided for lower deck would be at a higher height of 1100 mm above the lowered floor level so that the dust from rail can be avoided. The lower level deck passengers would have the provision for luggage keeping under their chairs. In addition to that, a sideways rack for luggage would be provided at a right angle to the compartments on either side of the car. The central floor area would have 5 lower and 4 upper level compartments on either side of the car with each compartment accommodating 6 persons. This floor area would also be very spacious providing the provision for standing. For the safety of the standing people, holders would be provided at a side angle on the seats of lower level compartment. The maximum capacity of this area would be 120 passengers. The total capacity of this layout would be 140 passengers.

Each lavatory in above two layouts would have a dimension of 3220x1734 mm. In order to envelope the needs of more people eight lavatories each of dimension 3220x867 mm must be designed four on each end of the carriage.

In case of safety precautions, emergency windows must be designed both in upper and lower level compartments with an ladder attached to the outer end of the upper deck.

**Conclusion:**

The paper has presented the tools, the methods and the procedural flows adopted in the re-designing of a railway locomotive, in virtual environment, for ergonomic requirement fulfilment. Several aspects could be pointed out. First, the necessity of a collaborative environment to perform the adequate mixing of competencies that is necessary to the development of redesign
activities. Therefore, the existing tools and methods for the collaborative design, from an integrated point of view, have to be stressed and extensively adopted. The efforts to develop a re-design activity in an integrated way produce an initial time consuming. Nevertheless in the successive phases of the activity the advantages can be measured in terms of efficaciousness of proposed solutions and in terms of overall time consuming. Even if a significant set of tools are now available for the CAD modelling of complex products, a greater availability of tools and procedures for the carrying out of the parametric models could help to reduce the initial time consuming.

This project has given an optimal solution for the congestion problems faced nearly by all unreserved passenger train travelers. Even though the other two layouts are feasible they are not economical to construct and not much suitable for congested unreserved coaches. The increasing population in the unreserved coaches is in definite need of design changes and we hope our design has made an impression on our Indian Railways and thereby make necessary steps to solve the congestion problems.

Based on the finished work, the further research for optimization of train seat dimensions will be carried out. Additionally, the methods proposed in this paper can be also applied to other vehicle layout which serve for a large amount of population, such as highway bus, metro train, etc.

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