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# Rapid Conversion Principles and Requirements for Railway Passenger Carriers to Be Utilized in Casualty Evacuation

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***Abstract*—To drive a fast shift from peacetime potential to wartime support strength, and realize casualty evacuation function of railway passenger carrier such as smooth boarding, safe placement and en-route nursing, four pairs of relationships were discussed in-depth, and four principles and relevant demands were deduced from that discussion. This article can serve as a theoretical guidance for our army in utilizing passenger train and electrical multiple unit to carry out similar military tasks.**

***Keywords—railway passenger Carrier; casualty evacuation; conversion principle; requirement; fastness***

## I. INTRODUCTION

As a type of special transport objects, the wounded and sick are liable to tension, nervousness, horror and unstable mood besides their physical pains, and should be quickly evacuated to strategic rear hospitals for further treatment and rehabilitation.

Railway passenger carriers, including every type of ordinary passenger cars and EMU, are suitable for long-distance transportation of large number of casualties due to their adaptability to natural environment and weather conditions, large carrying capacity and huge inventory. During war or emergencies, if those carriers were fast converted to complete-function equipment for casualty evacuation, their peacetime potentials would be quickly transformed to wartime support strength. It is favorable for winning more valuable cure time for the patients.

## II. RAPID CONVERSION PRINCIPLES

The similarity between passenger movement and casualty evacuation functions is the prerequisite for railway passenger carriers to exert national defense function. The time limit of casualty evacuation requires that railway passenger carriers be converted during war as soon as possible. In order to improve the fastness of conversion, some relationship such as retrofitting vs. modification, utilization vs. modification, removal vs. replacement, and mobility vs. fixing, should be analyzed in-depth in the process of scheme design and kit development. That detailed analysis will contribute to some principles for fast conversion.

### *A. Retrofitting VS. Modification*

In order to realize casualty evacuation function, modification measure is that some parts of a railway carrier will be temporarily altered and those alterations can be restored later; while retrofitting is a kind of technical means that related kits, which are temporarily added, will be combined with a railway carrier in a certain way and can be removed later.

As can be seen from above definitions, if modification measure is taken, some parts or facility of railway passenger carrier must be changed. The removal and storage of original facility commonly takes place in certain workplace, needs related tools and qualified personals, and follows standardized operating process. Then, newly-designed conversion kits are to be used on the same positions as original facility are installed, and removed in line with reverse process of conversion after the completion of casualty evacuation missions. Due to ready-to-use and unneeded alteration of a carrier, retrofitting means that some conversion kits are simply added if needed, and removed afterwards, making the operation more convenient and conversion obviously quick. Therefore, the first principle for fast conversion is retrofitting instead of modification.

According to that principle, it is necessary to take into consideration conversion practice of railway passenger carriers, aims at fast conversion and easy recovery, abandon technical schemes of heavy conversion workload and long construction time, and try to realize the function of casualty evacuation with retrofitting means. As for plateau railway passenger car, due to its difficulty for litter patients to turn into the passenger room, caused by narrow passage area behind the door and small turning radius, it's a common practice to replace original fixed windows with movable ones so as to open boarding passages for the wounded. During the replacement, the original windows will be disassembled and then wallboard as well as a serial of parts such as tea-tables, seats or berths and baggage-rack, equivalent to a major overhaul. To eliminate that conversion workload, two technical plans can be adopted. One plan is to dismantle the window glass. The original glass with electricity turned on is taken down from the window frame, thus creating a temporary boarding passage. Under such a circumstance, lift auxiliary device should be designed for usage on ordinary or low platforms and after the recovery of the glass, folded and carried with the car. In fact, this plan belongs to modification-retrofitting combined one. The second plan is pure retrofitting, that is, to design a kind of boarding equipment with foldaway

bearing surface. When this equipment turns at the passage area, its front part can be folded up along the line corresponding to the waist of a patient, making it smoothly entering into the passage room (Figure I).

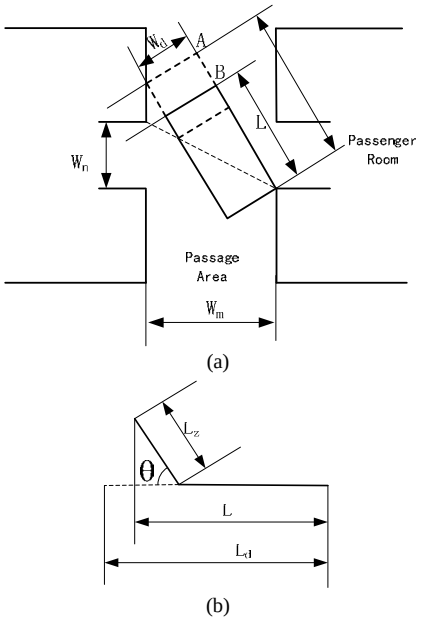


FIGURE I. ENTRANCE OF A LITTER PATIENT ON BOARDING EQUIPMENT INTO 25G RAILWAY PASSENGER CAR

It is supposed that the average height of the patients is 1775mm[1], and the ratio of upper part of the body is 0.382. Therefore, the length above waist $L_z$ is 687.6mm. The original length of bearing surface $L_d$ is assumed to be 1800mm. When the bearing surface is folded up, the projection of the boarding equipment on the floor moves from A to B(Figure I(a)), meaning that length of the equipment is shortened to L (Figure I(b)). If the intersection angle is expressed as θ, then:

$$L = L_d + L_z \cdot (\cos\theta - 1) \tag{1}$$

The width of boarding equipment is expressed as $W_d$. θ is set to be 0 (originally horizontal state of bearing surface), 30, 60 and 90 degrees (completely foldaway state), respectively. After calculation, two expressions holds if θ 81°:

$$L \cdot W_d < W_m \cdot W_n \text{ [2]} \tag{2}$$

$$L \cdot W_d < W_z \cdot W_p \tag{3}$$

From (2) and (3), it can be known that this equipment can turn into the passenger room from the passage area, and can turn into the compartment from the corridor(Table I. So a patient could be put on the berth. Obviously, the retrofitting plan aforementioned can realize casualty evacuation function with zero conversion contents when it satisfies following conditions:

- Window passages are inconvenient to be opened on an ordinary passenger car or EMU;
- The passage area is narrow and difficult to pass by; and
- The movement of a patient's waist has no influence on his pains.

### *B. Utilization VS. Retrofitting*

Utilization is to reuse the original parts removed from a carrier for other purposes, or intentionally retain them and extend their functions, helping realize the goal of recirculating original parts and lessen the number of conversion kits. Due to lower technical complexity and less conversion time or cost than retrofitting measure, utilization always tops among all conversion ways. Utilization includes three types.

The first type is shape-based similarity. In the conversion practice of casualty transport car with 25G semi-cushioned sleeper car, the space can be left for opening a nursing station when original middle berth is dismantled. That berth itself has similar wide and large surface as an operation table of nursing station, and if reversed up-down and fixed to the original position, can basically meet the needs for medicine preparation, medicine distribution and dressing preparation. Therefore, the middle berth can be directly utilized and there is no need for a specially-designed operation table.

The second is utility-based similarity. It means full expansion of the purpose of original facility, and compression of conversion contents to the utmost extent. For example, original door can serve as boarding passage for the patients, original berths can be used for placement of the wounded, the luggage-rack can place litters, the unwanted berths or seats can put some medical materials, sites in the EMU for storage of lengthy luggage may be an operation table, crew room in the ordinary railway passenger car can be used for opening a nursing station, and original electric outlets can supply electricity for medical devices.

The third is structure-based similarity. Opening of boarding passages by removing original windows and fixing new movable ones is a better solution to boarding of the wounded from the door. When used in peacetime, the movable window will be opened, and its lower part turned up and fixed. Common idea for suspension and confinement of the lower part is to add a tension fixture on the wallboard along the corridor and right above the window. Because of the cantilever beam structure, original luggage-rack can bear downward pulling force or pressure, and the gaps permits hooking objects, the handle on the lower part of movable window can be linked to the luggage-rack with belts. Another case is soft fixation of casualty. The chest and leg can be confined respectively with left and right straps parallel to each other. This sort of position-kept method is commonly used in litters. The position of a patient on lower berth will be confined with two soft straps inserted into the small gap between the wallboard and berth. This is a left and right parallel confinement structure (Figure II(a)). As for the patient on middle berth, because the berth is attached to the wallboard with a fixture base extended from left

to right side, there is no room for the soft strap. In this case, a v-shaped structure will be adopted with one end of the soft belt tied to nearby berth brace, the middle part twisted around the guardrail of middle berth, and another end tensely tied to the corresponding brace (Figure 2(b)). This structure is a transformation of the first confinement structure. As the guardrail is above the berth, the soft strap with v-shaped confinement structure is not close to the patient body.

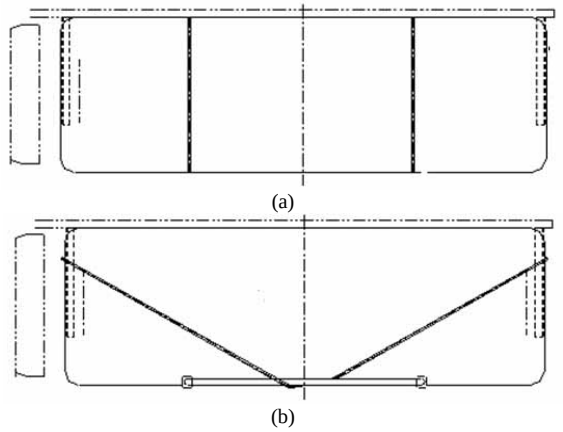


FIGURE II. CONFINEMENT STRUCTURE OF SOFT STRAP FOR PATIENT ON LOWER BERTH AND MIDDLE BERTH

Frankly speaking, the v-shaped structure in confinement effect is inferior to left and right parallel confinement structure.

### *C. Removal VS. Replacement*

In the field of conversion, both removal and replacement are modification means. Replacement is used to substitute original part with a piece of conversion kit for special demand of patients. Generally, conversion kit has the same function, installation and fixture mode as the original part, while its structure remains different.

It's necessary to consider removal instead of replacement means if removal of some original part can satisfy certain need for casualty evacuation in spite of weakened passenger transport function and inconvenient routine usage. The conversion of a railway passenger carrier should be balanced between realization of military utilization function and quality of casualty evacuation. In other words, it's essential to slightly reduce convenience, comfort and mankind-machine engineering requirement in order to speed up the conversion. For example, during the design of casualty transport car converted from 25G semi-cushioned sleeper car, the original tea-table will limit the work space for personals standing inside of the compartment, resulting in difficulty in lifting a litter patient to the middle berth with full manpower in normal standing posture. To solve this problem and meet the need for placement of related medical devices carried by medical staff for bedside medical care, a foldaway tea table is developed. From the standpoint of practical conversion construction, replacement of original eleven fixed tea-tables with foldaway ones requires two teams with two personals each should work continually about 35 minutes[3]. After the replacement of foldaway tea-tables, the locking device on the pin sleeve should be loosened, and the tabletop be lifted up and then placed to the floor. After the placement of casualty on berths, the tabletop should be unfolded in reverse order and the pin sleeve be locked, thus restoring tea-table's carrying function.

From the viewpoint of optimization of conversion scheme, it's inadvisable to replace tea table for pure expansion of work space inside the compartment because this operation needs longer conversion time, more skilled personals than removal. If mankind-machine engineering was not taken into account, the medical devices could be placed on the floor. So, compared with replacement, removal means not only simplifies conversion operating procedures, but results in less amount, lower construction cost and more convenient storage of conversion kits, direct military and economic benefits.

This principle of removal instead of replacement contains a simple truth——simplify and save as you can, don't pursue perfection so as to meet the need of casualty evacuation.

### *D. Mobile VS. Fixed Retrofitting*

The so-called mobile retrofitting means that medical devices only contact with the carriers without physical combination, generally including anti-slippage, addition of base, and binding. As for anti-slippage, a anti-slip mat will be used to increase the friction between an object and floor of the passenger room, preventing a medical device against movement when the railway carrier starts or urgently brakes. This means is suitable for an item to be stacked in single layer due to its large bottom contact area and low center of gravity. The medicine and consumable materials case is an example. As far as addition of base, frequently accessible medical devices are placed within the base, and can keep the position unchanged by their gravity. This method is applicable for objects with small height and weight such as electric sucker, cardiogram monitor and medical ventilator. The size of upper opening of the base should be determined by the contour of an object to be loaded in it. Binding means the positions of medical devices will be retained with straps tied to related facility in the passenger room. This method can be applied to multiple-layer stacked objects with large length or width, and often used with bottom anti-slippage measure.

Fixed retrofitting is a physical combination of conversion kits with a carrier such as affixing and hook. The original places to be retrofitted would be repaired after the removal of conversion kits. The affixing method is to adhere medical devices to a passenger carrier, and is applied to small object requiring certain position and installation height such as beeper. Hook method is to connect medical devices with hooks added to some places in the passenger room. This method can affix the objects with high center of gravity and rotating wheels such as treatment trolley, which is liable to roll-over.

Compared to fixed retrofitting, the advantages of mobile one are as follows:

- It is easy to handle without special tools, helping realize required functions.
- Facility in a passenger room are not substantially changed, and no conversion trail will be found in the carrier afterwards.

- All conversion kits are off-the-shelf products with reliable supply resources.

Based on above discussion, if retrofitting method is needed, mobile retrofitting should be placed before fixed one.

Sequence for rapid conversion could be drawn from the analysis of aforementioned four relationships, and shown from high to low order in Figure III. Generally, in order to meet the need for fast conversion, utilization measure is firstly selected, then retrofitting and modification means. In modification domain, removal is better than replacement. Mobile retrofitting means is encouraged even if fixed retrofitting fits.

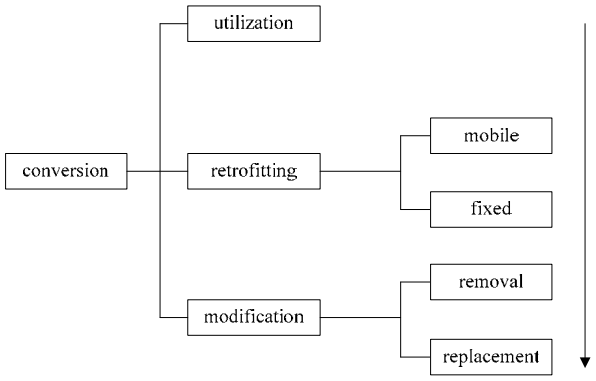


FIGURE III. SEQUENCE FOR RAPID CONVERSION (FROM HIGH TO LOW)

## III. RAPID CONVERSION REQUIREMENTS

As mentioned above, fast conversion principles should be followed in conversion practice. It's essential to apply use-oriented, reversible, mature and reliable idea to aim at especial needs of the patients, and to study easy and practicable techniques on indispensable conversion contents and construction flow.

### *A. Opening of Casualty Boarding Passage*

Wide and tall doors of an EMU can be directly used as casualty boarding passage without any conversion. If the dimension of certain door doesn't satisfy the demand for boarding, the door of adjacent car can be borrowed due to coupled cars and connected passages.

As for ordinary railway passenger cars, the passage opening technique depends on the type of casualty. If the waist of a patient cannot be bent, it's feasible to replace fixed windows with movable ones, and an electric lift auxiliary equipment for boarding of the wounded should be developed whenever conditions permit. This equipment should adapt to soft terrains and plateau environment, be self-powered or linked to external power supply, and be easy to be folded and unfolded. Otherwise, the door can be used to board patients, and at the same time a sort of boarding equipment with foldaway carrying surface should be designed, which also serves as a tool for transferring patients among cars.

### *B. Placement of Casualty*

The left-right parallel or v-shaped confinement structure should be adopted to retain normal position and lie-down comfort of a patient on original berth. Belts are inserted into the gaps between original facility and structure, or simply twisted to fast confine the patients. When a patient needs infusion, a hook will be suspended to luggage-rack of the guardrail of middle berth if required.

As far as a passenger room with seats is concerned, rational and comfortable placement spaces should be left for the wounded through simple conversion. The commonly-used approach is to dismantle original seats, settle exposed devices such as pipeline interface for oxygen supply or power supply, and develop and install double-layer equipment for placement of casualty. This equipment, installed in the same way as the seats in the passenger room of an EMU or ordinary passenger car, should be designed with a beeper, infusion stand and confinement straps, and be apt to assembled and disassembled quickly.

### *C. En-Route Medical Care for Casualty*

In order to open a nursing station which meets basically the needs for diagnosis and treatment of patients, materials at hand and existing original facility should be used such as crew room, seat, floor and storage site for large luggage. Meanwhile, medical devices should be reliably stored through mobile and fixed retrofitting method, realizing less retrofitting or even no conversion.

### *D. Optimization of Conversion Flow*

When conversion construction is to be performed, inherent features of a passenger carrier, such as large longitudinal length, high door above the ground, narrow passage or corridor of passenger room, and devious passage area behind the door, should be emphasized. The construction is a bridge linking conversion techniques with railway carriers. In order to minimize the number of personals and conversion time, it's necessary to apply streamlined operation means to optimize construction organization, and to avoid interference and influence among different working procedures.

## IV. CONCLUSION

As an innovative job, conversion of railway carriers is to realize the function of casualty evacuation in a limited space with the simplest conversion contents, reasonable design ideas and reliable technologies and crafts under rigid restrictions of overall characteristics and main body structure[4]. During war or emergencies, those converted carriers will provide substantial means for evacuation of large volume of patients from war zones or disaster areas to strategic rear areas.

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