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Transitioning to safer streets through an integrated and inclusive design

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ABSTRACT

The demand for enhanced traffic safety has been growing with rapid increases in the elderly populations of super-aging societies. To cope with the increasing rates of traffic fatalities and injuries among the elderly, co-creative thinking and community-rooted approaches are becoming more important in shaping policy and actions for safer and sustainable transportation and traffic. To enhance safety, road space has to be designed as a social space with improved social usability to meet diversifying needs in the future. After discussing multifaceted aspects of an integrated design, this paper aims to identify a possible direction of transitioning to safer streets through an integrated and inclusive design that covers road design, built-environment and land use design, and community design. While detailing the rapidly increasing fatalities among elderly pedestrians crossing roads, this paper provides a set of logical ideas and arguments for changing the way we address traffic safety and proposes a governance framework for transitioning to safer streets with a focus on the habitus of unconscious separation and externalization of risk that spoils the compactness of road spaces and the appropriate priorities among traffic participants, thereby inhibiting the safety and autonomy of traffic participants on streets.

Contents

1. Introduction

Most cities in both developed and developing countries are grappling with issues of traffic safety, a prerequisite to the promotion of a sustainable urban future. However, conventional transport planning and traffic engineering have often overemphasized mobility: the speed at which people and goods can travel from one place to another and the capacity of the corresponding movement. This approach mistook means for objectives and brought unfavorable societal and environmental consequences. More appropriate objectives would be enhancing people's quality of life through safer mobility, improving the accessibility of activity opportunities, and ensuring better social usability to meet the demand of diverse traffic participants in the community.

In Japan, the total number of road traffic fatalities has significantly decreased since peaking at 16,765 people in 1970. During the 1970s,

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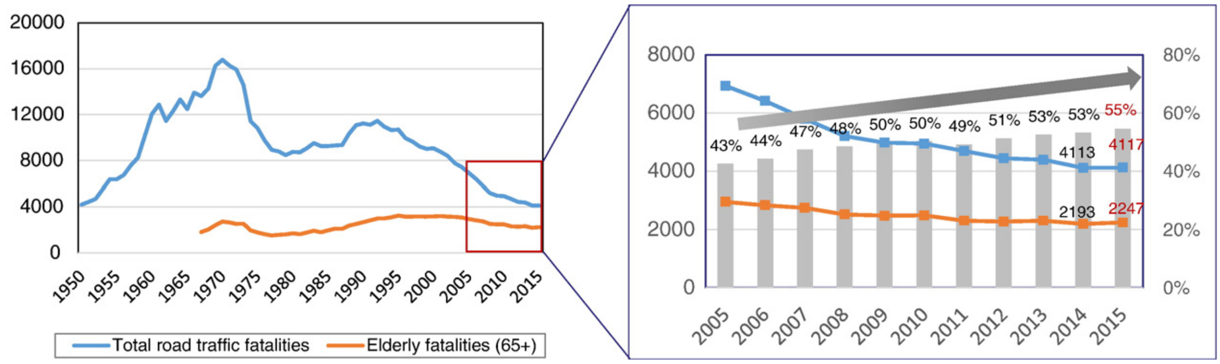

Fig. 1. Recent trends in road traffic fatalities in Japan (source: Ref. [2]).

fatalities dropped by 50% while the number of motor vehicles doubled and the total vehicle travel distance increased 1.7 times (see Fig. 1). The reduction in the 1970s was largely attributable to improvements in the road user environment via devices, infrastructures, and road space design aimed at improving safety rather than improving the road users themselves. During the 1990s and 2000s, the focus shifted to improving the behaviors of road users, especially drivers, in hopes of achieving further reductions in fatalities [1].

Regardless of these efforts, however, the reduction rate of traffic fatalities has been slowing down in the 2010s; moreover, there was even a slight increase in 2015, as shown in Fig. 1. The rapid progression of the super-aging population in Japan is one of the major factors keeping traffic fatalities up. According to the data, elderly fatalities now account for 55% of all traffic fatalities. Looking at the fatalities by road user type in Fig. 2, elderly killed while walking represent 49% of the total, with 76% killed crossing the road and 71% of those deaths attributable to at-risk crossings away from pedestrian crosswalks.

Given these facts and a marked change in social conditions, society needs a more holistic approach that enables transitioning to safer streets in addition to conventional approaches like traffic engineering, vehicle engineering, psychology, education, and medical science.

This paper aims to identify possible methods of transitioning to safer streets through an integrated and inclusive design that covers road design, built-environment and land use design, and community design. We first address the relationship between urban structures, vehicle travel speeds, and traffic fatalities from a nationwide macroscopic viewpoint and then underline the importance of taking an integrated approach for the promotion of traffic safety.

2. Urban structural factors affecting traffic safety

2.1. Urban form, travel speed, and traffic fatality

Observers have often shown that a rapid increase in traffic fatalities over the course of the motorization process is associated with the development of design-deficient road infrastructure and higher-speed vehicles. One of the most problematic aspects of motorization is the standardization of travel speed. Whether in towns, suburbs, or between cities, most vehicle drivers pursue speed—and the desire to travel long distances at high speeds is ever-present, regardless of whether the driver is inside or outside an urban area. The pursuit of speed irrespective of place results in uniform expansion that impairs the hierarchy of urban spaces. Even after the development of efficient road networks, safety problems rooted in people's desire for speed persist.

Based on a causality analysis of urbanization, motorization, and the environment by Hayashi et al. [3], Fig. 3 illustrates the causality among urban form, travel speed, and quality of mobility in terms of efficiency, safety, and the environment. Urban form, characterized by the hierarchical structure of urban spaces and transportation networks, has a determining influence on the quality of mobility—especially traffic safety through a sense of travel speed.

Until recently, vehicle travel speeds have been a low-priority area in urban road design in Japan and Asian countries. This problem seems to be associated with the loose controls of urban structures lacking the hierarchy of urban spaces.

Fig. 4 shows the influence of urban structural factors on traffic safety. These three figures illustrate the relationship between urban population density, vehicle travel speeds, and rates of road traffic fatalities between 2008 and 2010 for 65 metropolitan and regional-core cities in Japan

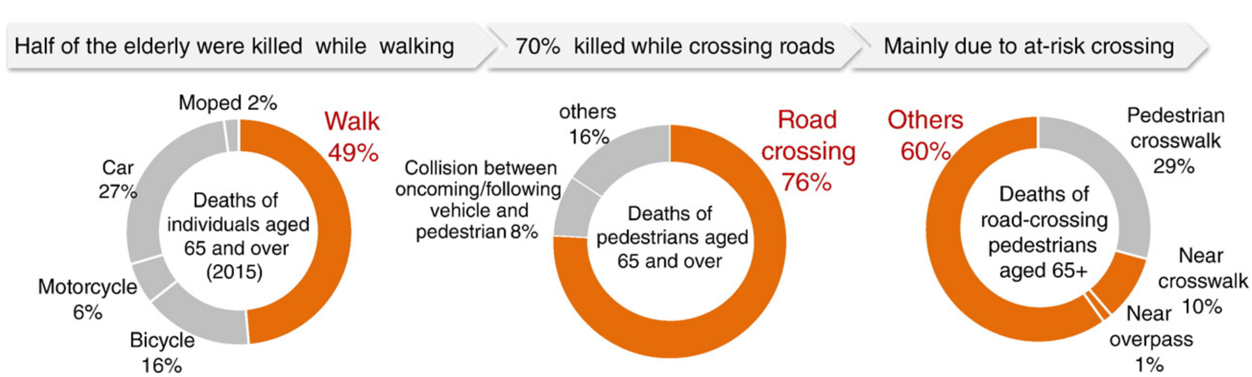

Fig. 2. Characteristics of road traffic fatalities among the elderly population (source: Ref. [2]).

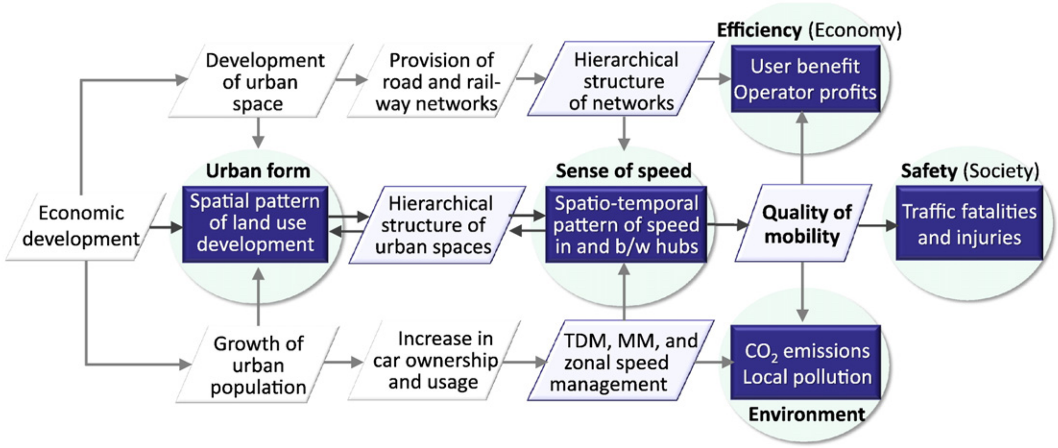

Fig. 3. Causality among urban form, travel speed, and quality of mobility.

with populations of over 300,000 inhabitants. The sizes of the bubbles in the Figure represent the populations of the cities, among which Tokyo is the largest. With respect to vehicle travel speeds, we calculated 12-hour average speeds using car probe data from the HONDA Internavi Floating Car System.

Fig. 4 (a) shows that the rate of traffic fatalities increases as urban density decreases [4]. Considering that this relationship may vary by city due to differences in development stage and the usage rates of urban public transportation, we focused on automobiles only and analyzed two conditions: the relationship between population distribution and average vehicle travel speed in intra-city travel and the relationship between average travel speed and traffic fatality rate. As the results in Fig. 4 (b) and (c) show, we found causal relationships in which the more two-dimensionally dispersed a city was, the higher its average automobile travel speed, and the higher the average travel speed, the higher the traffic fatality rate.

Designing cities and communities to have higher density levels appears to help reduce traffic fatalities by not only encouraging the use of public transportation but also, and more importantly, reducing vehicle travel speeds and providing walkable environments where people interact with each other.

2.2. Simultaneous management of space, speed, and priority on streets

Enhanced safety in urban traffic and transportation is the starting point for building a livable and sustainable city. It requires bold thinking on the management of space, speed in traffic space, and priority among traffic participants. In recent years, there have been more and more efforts to calm traffic via improved road design with compact spaces that aim to change driver behavior and ultimately reduce their travel speeds. Initiatives hoping to establish the harmonious coexistence of humans and automobiles through reduced speeds are evident in local speed management programs such as the “Zone 30” measure. There has also been a worldwide trend toward promoting “walkable cities,” which allow people to walk to places necessary for daily life. Priority denotes prioritization among various traffic users, a system of encouraging or discouraging the use of road space in question depending on its functional requirements. These are some examples where human-centered prioritization has represented the guiding principle for road and urban space design.

As a way of associating these efforts, Fig. 5 illustrates the necessity of simultaneously managing space, speed, and priority, each of which directly influences accessibility, safety, and social usability and has interrelations and interdependent connections with the others. Here, “social usability” is a new concept developed for the ergonomic assessment of public facilities, such as roads, and denotes the extent to which a diverse range of individuals can use facilities and infrastructures to achieve their functional requirements with effectiveness, efficiency, and satisfaction in a variety of contexts within the larger scope of usability [5,6]. This is a broader definition of usability than the standard one given by ISO-93,411, which identifies usability as the extent to which a product can be used by specified users to achieve specified goals in a specified context of use.

Social usability should merit the most consideration in the design of road-crossing facilities, which can trigger an increased risk of traffic fatalities, as evident in Fig. 2. Considering the correlations among the

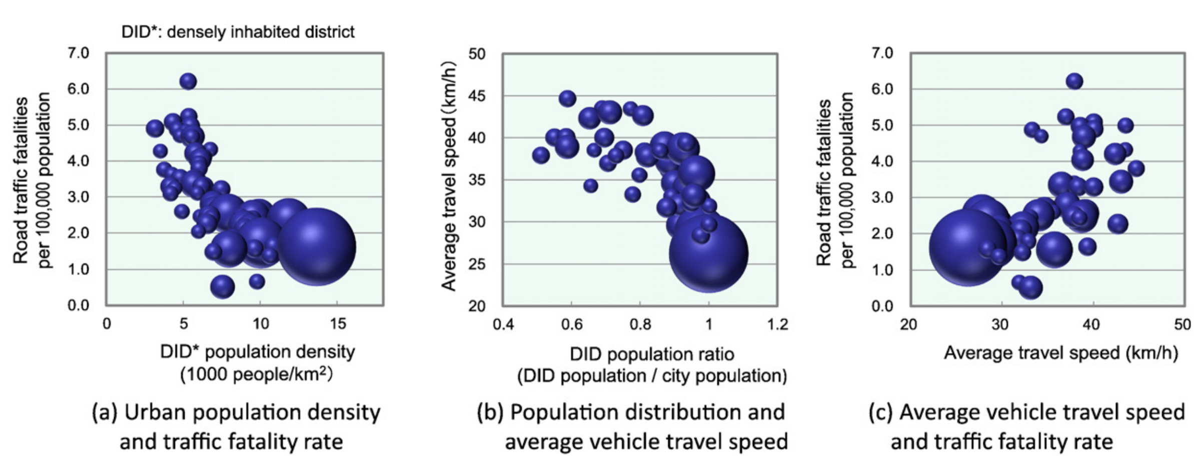

Fig. 4. Urban population density, average vehicle travel speed, and traffic fatality rate.

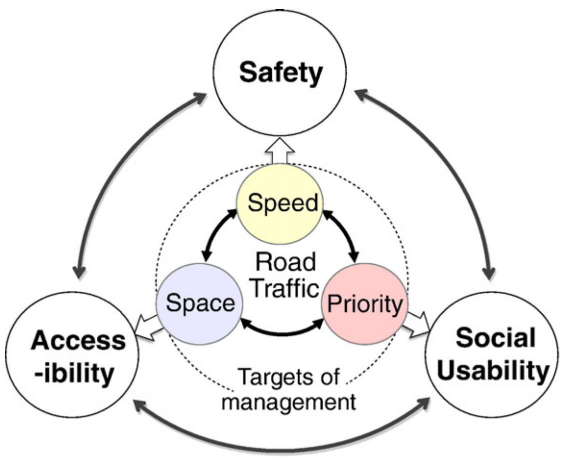

Fig. 5. Simultaneous management of space, speed, and priority.

accessibility, safety, and social usability of road-crossing facilities, Fig. 6 schematically illustrates three different cases of pedestrian crossing environments, namely a) pedestrian overpasses/underpasses, b) non-crosswalk surface crossing, and c) pedestrian crosswalks. The absence of usable crossing facilities poses the highest accident risk to pedestrians, followed by overpasses/underpasses that the elderly and disabled often avoid using.

The existing pedestrian overpasses and underpasses, which were installed to secure the safety of vulnerable traffic users by separating them from vehicle traffic, have been underutilized due to low usability among the increasing number of advanced elderly and the decreasing number of children. These realities often trigger increases in at-risk behaviors such as non-crosswalk surface crossing, which are deficient in social usability. Enhancing safety requires the creation of a harmonious balance between accessibility and social usability as shown in the case of improved pedestrian crosswalks (see case c).

More importantly, it will be difficult to make this ideal case a reality without simultaneously managing space, speed, and priority on streets. The Japan Automobile Federation reports that one of the most important factors behind the higher fatality rates among elderly individuals on pedestrian crossings is that they cannot walk fast enough to cross the road while the light is still green [7]. Two ways of securing their safety would be reducing the physical distance and time involved in crossing and reducing the motor traffic speed and volume that endanger pedestrians as they cross. Thus, space and speed management on streets have to reinforce each other, along with the priority management shown in Fig. 5.

Road design needs to address a set of conflicts implicit in the social context within which roads are built and transportation is provided. In the present society, with its ever-diversifying needs, it is mandatory for transport planners and traffic engineers to simultaneously manage "space, speed, and priority" to improve—and maintain a good balance of—the "accessibility, safety, and social usability" of streets as social spaces.

3. Integrated and inclusive design

3.1. Basic concepts and framework of integration

There is an increasing demand for an integrated approach that includes road design from an engineering perspective, built-environment and land use design from a planning perspective, and community design from a social and cultural perspective to enhance traffic safety and sustainability. Community involvement and collaboration among multiple sectors are essential to designing safer streets.

The term "integrated traffic" and "integrated transportation" have come into common use since the 1990s. Obviously, a unified perspective is key to developing transportation policy. The most important point is to create not an additive unification but an integrated approach that combines diverse aspects into a whole.

Fig. 7 shows several integrated design concepts and procedures. The figure illustrates the relations among the four domains of city, infrastructure, transportation and traffic, and society; transportation and traffic, located centrally, is positioned as a system where public transportation and private transportation/road traffic complement each other. "Street renovation" refers to a method of creating space for pedestrians, bicycles, and other medium- to low-speed vehicles by reducing the number and/or width of roadway lanes, an approach also known as a "Road Diet." This method, which allows existing roads to be renovated with an emphasis on ensuring the usability of road spaces for a broader range of users, has already been implemented in many countries. In addition, transit-oriented development and corridor development are also methods of supporting public and shared transportation from a land use standpoint [8].

As evident in the design process loop, which starts at "Safety," the primary objectives are priority-based road space management and traffic safety-oriented speed management; initiatives along these lines help improve the resilience of a community through increased risk awareness and preparedness. Another focus is the conversion to "compact cities," where urban spaces and functions are more aggregated. When these conditions are met, urban transportation and traffic becomes sustainable, and well-connected urban systems contribute to an improved quality of life through effective trans-modal functionality.

3.2. Integrated and inclusive design

Community leaders and residents need to know more about which community design and land use choices are most effective in improving traffic safety. However, communities still tend to neglect the interaction between community, land use, infrastructure, and transportation/traffic; even in the transportation and traffic field, then, people discuss public transportation modes, private transportation modes, and slow-mobility modes such as bicycles are as isolated entities without adopting a shared view.

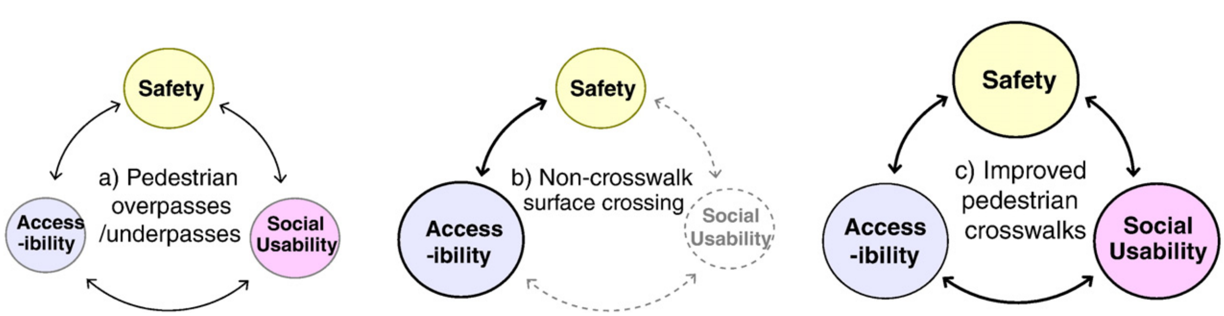

Fig. 6. Different cases of pedestrian crossing environments.

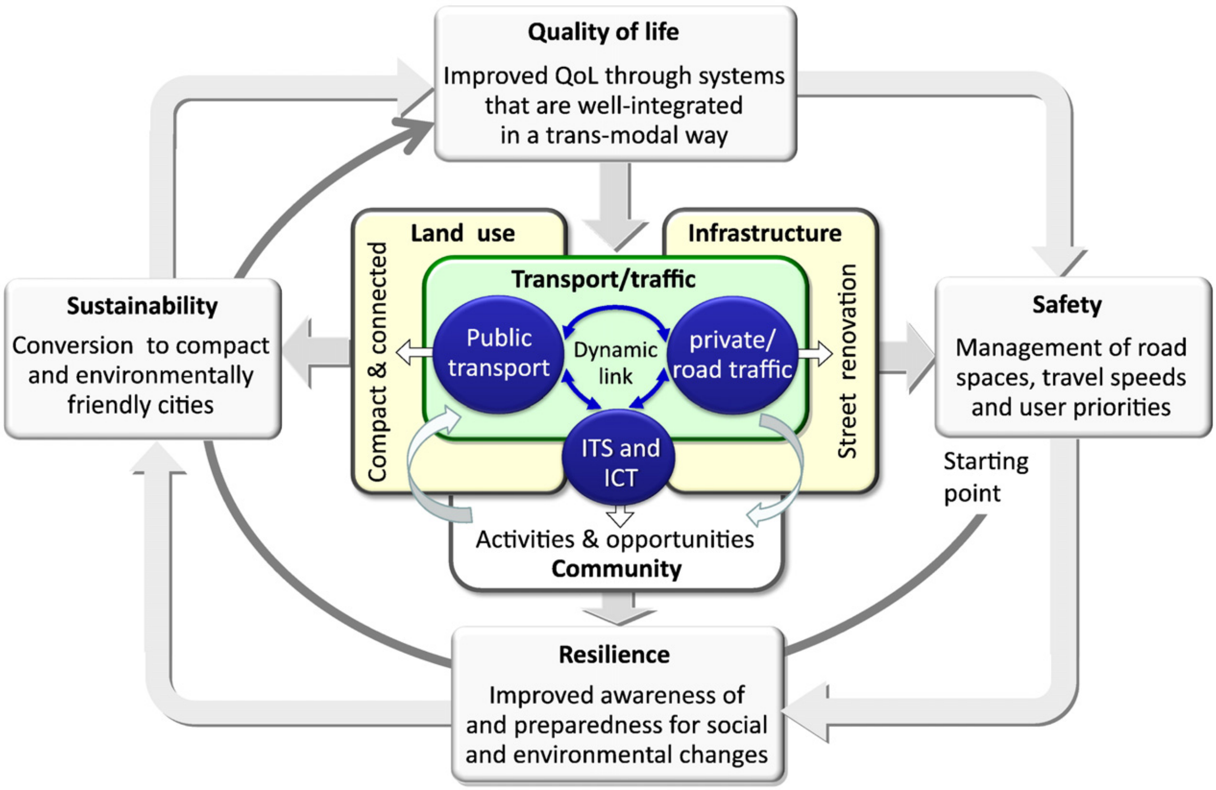

Fig. 7. Basic concepts and framework of integration.

Streets, built environments, land use, and communities have to be designed to comply with the requirements of the targeted urban structures and future changes in travel needs. Fig. 8 incorporates the basic concepts from Fig. 7 into the process of an integrated design of streets, built environments and land use, and communities. With respect to future travel needs, Doi et al. [9] suggested that the elderly place less importance on the speed and cost aspects of travel and more on safety, health benefits, and the environment. Rendering this direction of change as a ternary plot of the various transportation modes in Fig. 7 shows that the travel needs in an aging society follow a clear shift up and to the right, which represents a tendency toward demand for medium- to low-speed mobility.

Fig. 9 illustrates another aspect of the integrated design of urban transportation and traffic systems combining technology/product, business/economy, infrastructure/platform, community/culture, and space/place, which each correspond to different speeds of change. The recent frontier of "systems innovation" has paid much attention to building a platform that integrates not only the technological and business

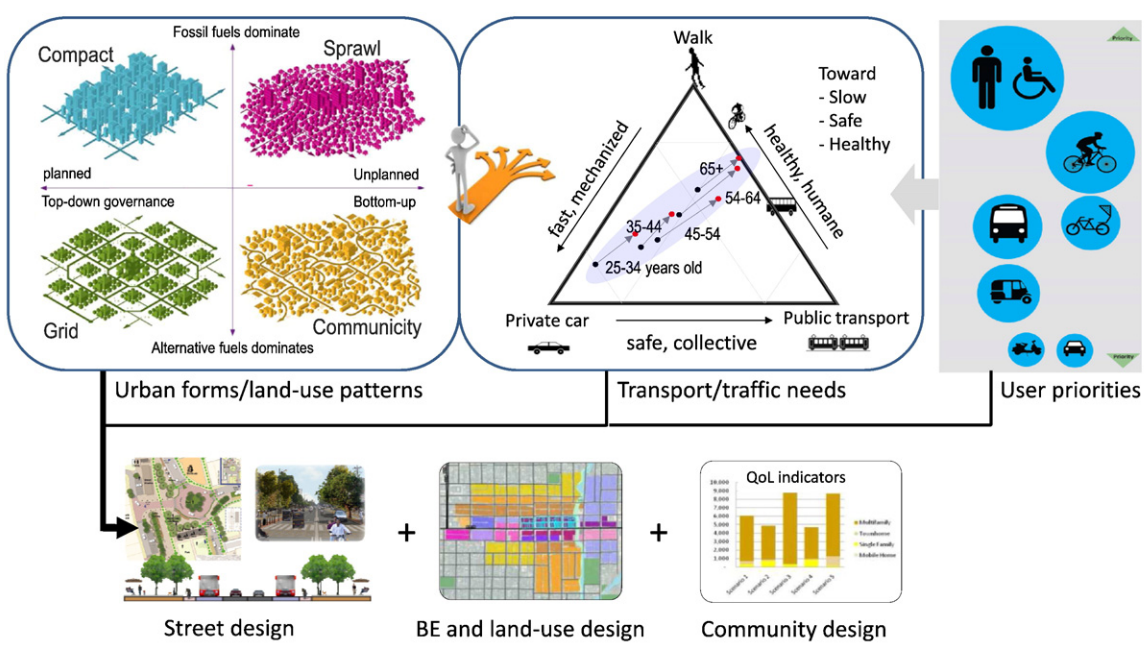

Fig. 8. Integrated design of streets, built environments and land use, and communities.

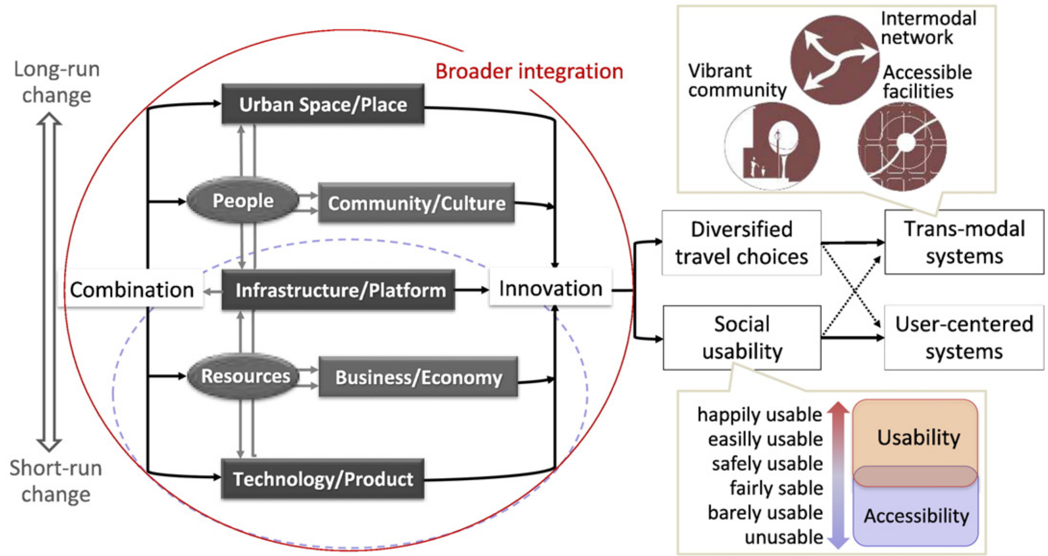

Fig. 9. Another aspect of the integrated design of urban transport and traffic systems.

elements of innovation but also the human aspect. However, to enhance the safety, resilience, and sustainability of urban transport and traffic systems on a comprehensive level, the framework of integration needs to expand beyond the conventional view—confined within the areas of technology/product, business/economy, and infrastructure/platform—to include community/culture and space/place. That type of broader framework would enable people to enjoy diversified travel choices with higher social usability in the forms of trans-modal and user-centered systems.

4. Transitioning to safer streets

4.1. Sustainable traffic safety

Having a common understanding of safety should favor better cooperation between the variety of disciplines and sectors concerned. There are two dimensions to safety: one is objective and assessed by behavioral and environmental objective parameters, and the other is subjective and understood based on the "feeling" of safety. Both dimensions can influence each other either positively or negatively. Any effort to improve safety thus needs to consider these two dimensions.

In addition, the state of safety can be classified into two categories: inherently safe and functionally safe. The former is the state in which hazards are removed at the source or hazardous energy/speed is restrained or controlled; the latter corresponds to the state in which either the probability of accident occurrence or the magnitude of harm/damage is reduced. An inherently safe traffic system first requires road infrastructure design by which the chance of an accident occurring is very limited. If an accident cannot be prevented, the chance of serious injury can be reduced by functionally safe measures directed at road users and vehicles through the enforcement of traffic rules and regulations and the installation of safety devices and infrastructure components.

This type of structured approach spanning both inherently safe and functionally safe measures was part of the "sustainable safety" approach that appeared in the 1990s in the Netherlands and aimed to give road safety a new impulse. The great successes of sustainable safety policy have come from consistent applications at the network level and efforts that have maximally tuned all the relevant characteristics of infrastructures, vehicles, and traffic regulations to the capabilities and limitations of the road users as well as their acceptance of the measures. Thus, the approach has promoted involvement and concern among all the relevant parties in the community and society in general [10,11].

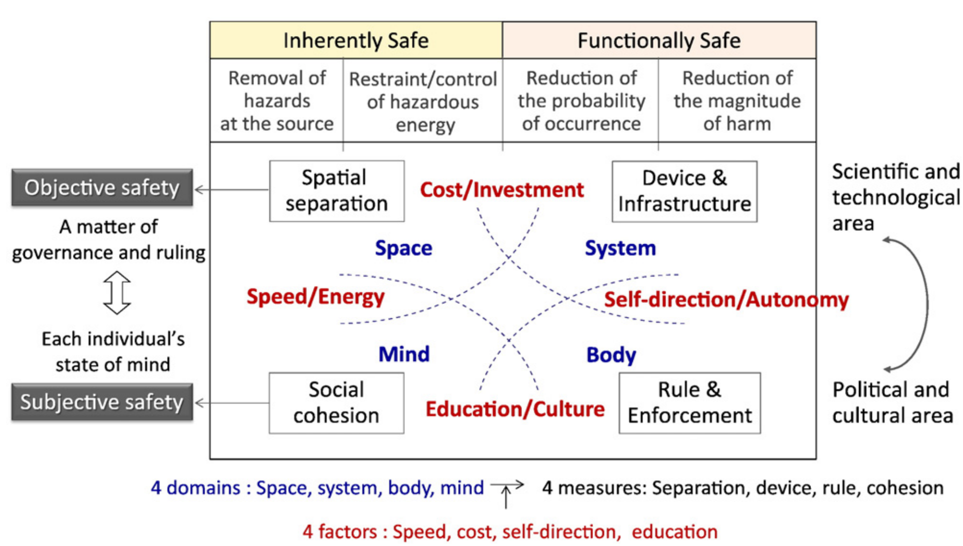

Fig. 10. Domains, factors, and measures pertaining to road traffic safety.

4.2. Desired direction of traffic safety enhancement

In the past, large-risk reductions were achieved via specific road safety measures targeted at high-risk groups and high-risk behavior. However, recent findings have made it clear that maintaining the declining trend in accident risk and reaching road safety targets will require further efforts to build on and foster the pioneering philosophy of the sustainable safety policy.

In order to indicate the desired direction of the efforts in traffic safety, Fig. 10 plots four domains, factors, and measures of safety on a cross-table consisting of an inherently safe environment vs. a functionally safe environment and objective safety vs. subjective safety. In pursuing an inherently safe environment, organizers have often taken spatial and physical separation measures to remove hazards at the source as well as the effect of speed reductions. On the other hand, "functionally safe" environments have been improved through protective measures such as devices and infrastructures along with the enforcement of traffic rules and regulations. In the Figure, "space," "system," "body," and "mind" are the four major domains; "spatial separation," "devices and infrastructures," "rules and enforcement," and "social segregation" are the four major safety measures; and "speed/energy," "cost/investment," "data/evidence," and "education/culture" are the four factors affecting the choice of safety measures.

The four safety measures and factors are mutually interdependent. As for "special separation," for example, the separation of activity spaces and traffic spaces by superblock developments often triggers higher-speed traffic, which has a strong correlation with increased incidences of traffic fatalities and injuries. Wide arterial roads around a given super-block lead to high driving speeds and aggressive behavior. In addition, separating pedestrians from automobile traffic by installing pedestrian overpasses and underpasses with low usability sometimes leads to the social fragmentation of the corresponding community and increases in at-risk crossings, as discussed in Section 2.2. Furthermore, excessive dependence on safety devices and infrastructures could discourage autonomy and self-directedness among road users. The desired direction of traffic safety appears to aim at the center of the existing four measures: a co-creative area that spans inherently safe environments and functionally safe environments and bridges objective safety and subjective safety.

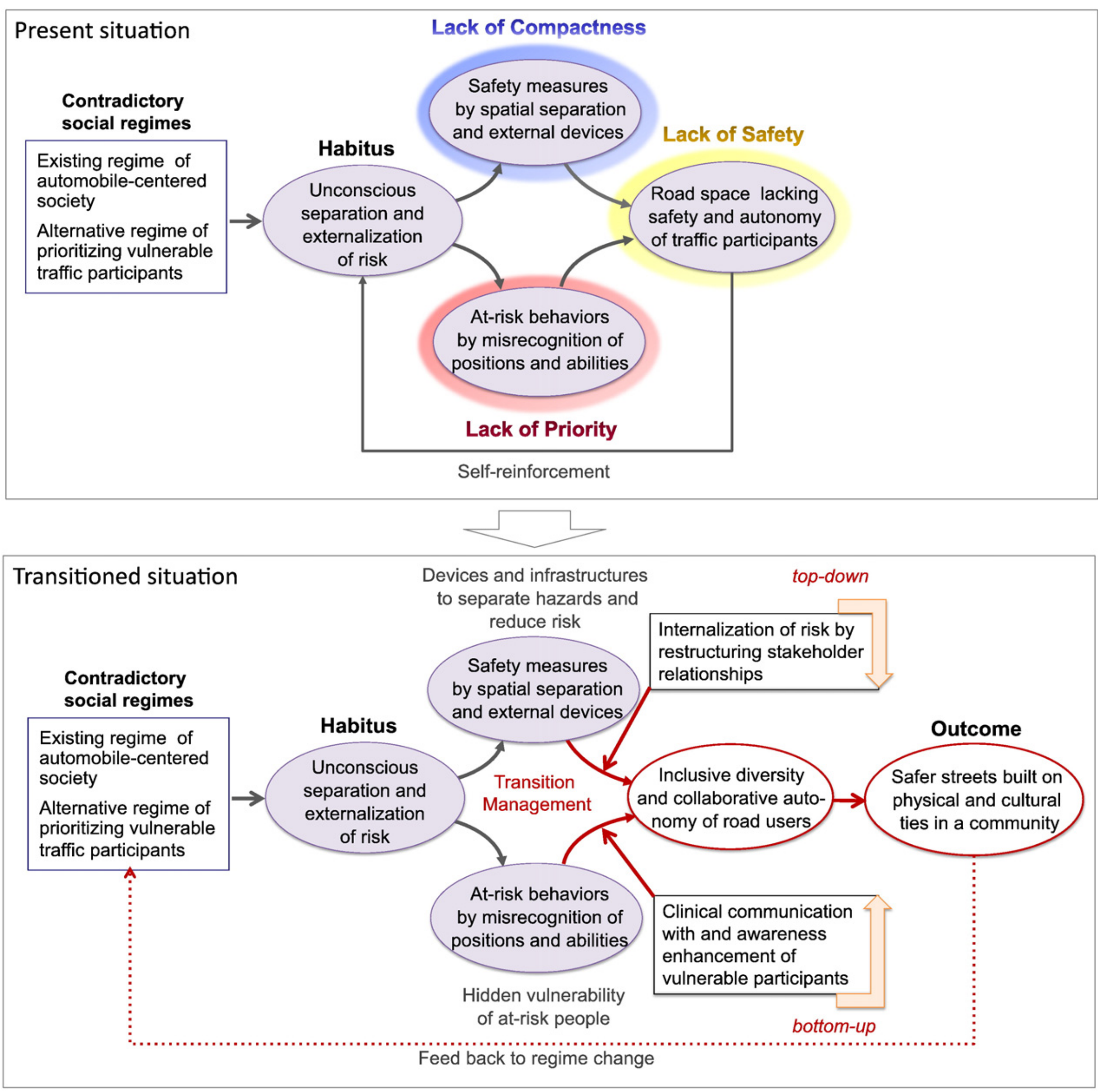

Fig. 11. Problem structures and the process of transitioning to safer streets.

4.3. Transition management toward safer streets

Transition management as a governance model can be considered a promising approach that seeks to guide the gradual, continuous process of transforming the structural character of society from one equilibrium to another. This model is often used in reference to sustainable development and is useful as a method for explaining changes in social regimes. It steers the outcome of change to lessen inherent risk, produce desirable social outcomes, and enhance resilience during the transformation of socio-technical systems [12–16]. It also tries to utilize bottom-up development in a strategic way by coordinating different levels of stakeholders and fostering self-organization.

In applying the governance model for transition management to traffic safety issues, one needs to include a consideration of people's habits and cultures along with regimes, which have gone relatively neglected. Fig. 11 illustrates the present situation of road traffic safety. Contradictory social regimes generate the habitus of “unconscious separation and externalization of risk” and bring both excessive reliance on safety measures via external devices and spatial and at-risk behaviors via misrecognition of positions and abilities of traffic participants. The figure emphasizes the influence of the “durably installed generative principle” habitus, or a complex net of structured dispositions into which we are socialized [17,18]. In this concept, social relations among stakeholders conform to and, in turn, contribute to the structuring scheme. The present situation shows that the habitus of “unconscious separation and externalization of risk” spoils the compactness of road spaces and appropriate priorities among traffic participants, resulting in a lack of safety and autonomy among traffic participants in road space—a condition that is in turn self-reinforced.

While traffic safety concerns were central to the practice of community design, examinations of their relationships have been scarce. The above process of transitioning indicates a possible solution for spurring a breakthrough in the present situation—one that has been long locked into the regime of an automobile-centered society [19].

5. Conclusions

The demand for enhanced traffic safety has been growing with rapid increases in the elderly populations of super-aging societies. To cope with the increasing rates of traffic fatalities and injuries among the elderly, co-creative thinking and community-rooted approaches are becoming more important in shaping policy and actions for safer and sustainable transportation and traffic. Traditionally, road traffic safety policies have aimed to reduce the risk of an accident by improving road infrastructure and educating road users and to reduce the injury outcome of a crash by improving vehicle technologies and enforcing safety devices such as seatbelt and helmet usage by law. With the reduction rate of traffic fatalities slowing down in recent years, however, it has become clear keeping the trends in accident risks on a downward slope and attaining the set road safety targets will demand more innovative efforts.

This paper examined the desired direction of traffic safety in the context of an integrated and inclusive design of streets, built environments and land use, and communities. There is now a growing need for a trans-disciplinary and integrated approach that reconciles the conflicting regimes and diverse demands of traffic participants. We first clarified the empirical relationships among urban structures, travel speeds, and traffic fatalities and suggested that it would be possible to enhance traffic safety by strictly managing urban density levels and travel speeds from a macroscopic viewpoint.

Building safe transportation and traffic systems for cities requires a collective understanding of the safety culture. Individuals, communities, governments, and others have to work to realize the co-creative safety beyond fragmented disciplines of traffic engineering, vehicle engineering, psychology, education, medical science, and the like. This paper provided a set of logical ideas and arguments for changing the way we address traffic safety and proposed a governance framework for transitioning to safer streets with a focus on the habitus of “unconscious separation and externalization of risk.” This habitus tends to spoil the compactness of road spaces and the appropriate priority among traffic participants, thereby resulting inhibiting the safety and autonomy of traffic participants on streets. In the paper, we argued that spatial separation measures in pursuit of creating inherently safe environments appear not to improve safety but rather to substitute one set of safety problems in for another in a super-aging social context. Furthermore, we pointed out that, in designing road space as social space without causing serious conflicts, one needs to embrace the importance of social usability along with accessibility and safety to meet the more diversified needs of the future.

Aligning strategic, tactical, and operational activities is the best way to ensure the success of the transition [20]. Strategic activities encompass the process of visioning: the collective action of goal setting, norm setting, and the formulation of long-term goals that conform to the desired direction of enhanced traffic safety described in Section 4.2 of this paper. Strategic activities will lead to changes in the culture of the societal system. Tactical activities, meanwhile, relate to the interactions among stakeholders, focusing on translating the visions created by strategic activities into the regime level. Popular attitudes and culture can be changed through operational activities, such as “learning by doing” through experimentation and implementation of road space reallocation, as well as clinical communication with and awareness enhancement of vulnerable traffic participants.

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