

Traffic is One of the Foundations of Economic Development

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Abstract

Traffic represents an economic function focused on the movement of goods and individuals along with the transmission of information from one location to another. It encompasses infrastructure, transportation modes, technology, and organizational structures. Traffic is categorized into three main types: land, aerial, and maritime traffic. Land traffic refers to both road and rail transportation, while water traffic includes both river and sea transport. Additionally, there is traffic within pipelines, postal systems, and telecommunications networks.

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1. Introduction

To grasp the operational and functional dimensions of traffic on roads and highways, one must recognize how different components of the traffic system interact [1]. Moreover, the nature of traffic flows is significantly shaped by the features and constraints of these components. A traffic system comprises five essential elements that interact

- Users of the road—drivers, pedestrians, cyclists, and riders
- Types of vehicles—both private and commercial
- Roadways and highways
- Traffic management devices
- The general environment

The general environment also affects traffic flow, but assessing its influence in specific cases can prove challenging. Factors such as weather conditions, illumination, population density, and local enforcement measures all contribute to traffic behavior. Generally, these aspects are evaluated qualitatively, with some quantitative data sometimes provided to aid decision-making.

Efforts to enhance road safety differ based on the specific type of roadway [2]. Motorways (known as ‘freeways’ in North America) are designed with the highest standards for safety, speed, and fuel efficiency, resulting in fewer fatalities per vehicle-kilometer compared to other types of roads by

- Prohibiting more susceptible road users, such as novice drivers.
- Segregating oncoming traffic with protective barriers, thereby lowering the chance of head-on accidents.
- Separating intersections by implementing interchanges, which reduces the likelihood of side-impact crashes—considered the most vulnerable area of a vehicle.
- Removing roadside hazards and surrounding roadways with energy-absorbing devices, such as guardrails or wide grassy zones and sand barrels.
- Improved road design features, such as banking around curves to improve vehicle stability and reduce tire traction requirements sloping to mitigate standing water and ice to improve grip in adverse weather and using permeable asphalt in certain road areas to improve drainage. On local roads, where many at-risk users like pedestrians and cyclists are present, traffic calming measures have proven effective in enhancing road safety.

2. Characteristics

The main components that form traffic activities include drivers, vehicles, roads, and the surrounding environment [3]. Among these, the driver is deemed the most crucial element impacting driving behavior, with over ninety percent of traffic incidents attributed to hazardous driving practices. Investigating the factors that lead to dangerous driving is vital for promoting traffic safety, and research in this domain has gained significant attention within

the transportation field. Operating a vehicle is a multifaceted task, and ensuring its safe operation depends on various elements such as traffic conditions, weather, terrain, and road design, as well as individual factors like the driver's levels of experience, mental health, and physical fitness. By examining the changing and uncertain aspects of drivers' conditions, studies on the factors contributing to dangerous driving can offer insights and assist in enhancing drivers' behavior behind the wheel. Current studies can guide the training of those drivers who frequently engage in risky driving or help them evaluate their own driving skills.

Traffic management would become significantly easier if all elements within the traffic system had similar attributes [1]. Designing traffic controls would be straightforward if every driver responded to them in an identical manner. Achieving safety on the roads could also be less complicated if all vehicles had the same size, weight, and performance features. However, drivers and other individuals using the roadway display a broad range of characteristics. The traffic engineer faces challenges with a diverse group of road users, including senior citizens, young adults, aggressive drivers, cautious drivers, and individuals dealing with countless distractions both inside and outside their vehicles. Even basic factors like reaction times, visual abilities, and walking speeds become intricate since no two road users are identical.

Most human traits show a normal distribution pattern. This distribution is noted for its strong central tendency, meaning the majority of individuals possess traits that fall within a recognizable range. For instance, most pedestrians navigating a street typically walk at speeds between 3.0 and 5.0 ft/s. Nevertheless, some pedestrians either move significantly slower or much faster. A normal distribution helps identify the expected proportions of the population within these speed ranges. Due to this variation, it is unfeasible to design a system based solely on average characteristics. For example, if a traffic signal is timed to meet the average speed of pedestrians crossing, approximately half of the pedestrians would navigate at a slower pace, thereby facing unacceptable dangers.

Thus, the majority of standards focus on the 85th percentile (or 15th percentile) feature. Broadly speaking, a percentile indicates a value within a distribution where a specific percentage of the population exhibits a characteristic equal to or less than this value. For instance, when considering walking speed, safety requires us to account for individuals who walk more slowly. The walking speed of the 15th percentile is referenced because only 15% of the population moves at a pace slower than this. In the context of driver reaction time, the value for the 85th percentile is referenced, as 85% of the population has a reaction time that is equal to or lower than this measurement. This methodology results in design practices and protocols that safely serve 85% of the populace. What about the other 15%? One trait of normal distributions is that the outer extremes (the top and bottom 15%) extend indefinitely. In practical implications, the top and bottom 15% consist of exceptionally extreme values that cannot be effectively incorporated into design standards. Qualitatively, while it is acknowledged that road users may exhibit characteristics

outside the 85th (or 15th) percentile, most conventional practices and guidelines do not specifically address them. When possible, characteristics from higher percentiles can be utilized.

Just as the traits of road users differ, so too do the characteristics of vehicles. Highways must be engineered to accommodate motorcycles, a diverse array of cars, and various types of commercial vehicles, including combinations of double and triple tractor-trailers. Therefore, lane widths, for instance, must be designed to fit the largest vehicles anticipated to utilize the facility. A degree of control over the diversity of road user and vehicle characteristics is exercised through licensing regulations and federal and state vehicle design and operational standards. Although these are significant measures, traffic engineers must still contend with a broad spectrum of road user and vehicle traits.

3. Drivers

Humans are intricate and possess a variety of traits that can impact the driving task [1]. In a system where the driver entirely governs vehicle operations, effective traffic engineering necessitates a comprehensive understanding of driver traits. A significant part of a traffic engineer's role involves finding ways to convey information to drivers clearly and efficiently, prompting safe and appropriate reactions. The two most critical driver characteristics are visual acuity factors and reaction processes. These two aspects are interconnected, as reaction depends on vision for most driving signals. Comprehending how information is perceived and processed is vital for the design of roadways and control systems.

Additional important characteristics also exist. Hearing plays a crucial role in driving (for instance, in recognizing horns, emergency vehicle sirens, brake squeals, etc.). While acknowledging the importance of this aspect, it must be noted that no traffic component can be designed solely around auditory signals, as those with hearing impairments cannot rely on such cues. While physical prowess may have been a significant factor historically, advancements in power-steering and power-braking technology have largely mitigated this concern, except perhaps for those who drive trucks, buses, and other substantial vehicles professionally. Certainly, a key human aspect that affects driving is the driver's character and mental state. However, this aspect is challenging to measure and hard to integrate into design considerations. It is mainly addressed through policing and licensing practices aimed at eliminating or limiting drivers who frequently exhibit unsuitable behaviors, as demonstrated by their history of accidents and violations.

4. Alcohol

Development of reliable technology for assessing alcohol content in the body and linking that to impairment and heightened accident risk formed the foundation for a major change in preventing drink-driving [4]. Norway was the pioneer in implementing legislation that criminalized driving with a blood alcohol concentration (BAC) exceeding a designated limit, initially established at 0.05%, with similar regulations quickly being passed by other Scandinavian nations. These laws were distinctive as they rendered driving at a

particular BAC level an offence on its own, commonly referred to as per se laws.

The interest in using per se laws as a tactic to tackle the issue of drink-driving expanded to other regions. In 1967, Great Britain enacted a per se statute (the Road Safety Act) with a legal threshold set at 0.08%. The initial outcomes were considerably positive, showing a significant decline in the number of alcohol-related accidents however, over time, collision rates seemed to revert to nearly the levels seen before the law was enacted. Regardless, the initial effects of these regulations were remarkable, prompting other nations to adopt similar measures in the years that followed. The implementation of per se laws in various European nations, Canada, the United States, Australia, Japan, and beyond has consistently influenced rates of drink-driving and related injuries and fatalities. A crucial element determining the effectiveness of these laws is how much they affect the perceived probability of being apprehended for inappropriate drinking and driving.

As a result, many regions that initially established higher legal limits (for example, at 0.08% or more) have opted to lower the permissible BAC limits over time. The reasons for lowering these legal thresholds include findings that driving-related skills can become substantially impaired at very low BAC levels, that collision risks are notably increased at 0.05% BAC or possibly even lower, and that implementing and reducing legal limits can lead to declines in alcohol-related accidents, injuries, and fatalities within the community. Generally, the reduction of legal limits has led to decreased rates of collisions, injuries, and deaths across numerous countries. In various regions, young drivers, inexperienced drivers, and individuals with prior convictions for drink-driving have been recognized as being particularly vulnerable to involvement in collisions and have faced stricter BAC limits or complete bans on driving after consuming any alcohol. These focused BAC regulations seem to be effective in curtailing drink-driving among the targeted demographics, including young and inexperienced drivers and those with a previous drink-driving conviction.

Other initiatives based on deterrence have demonstrated effectiveness in decreasing fatal accidents related to drink-driving. Administrative licence suspensions (ALSs) involve the revocation of a driver's licence by the governing body, usually for a brief duration (ranging from a few days to several months), at the moment a drink-driving charge is filed or when an individual is caught driving with a blood alcohol concentration (BAC) exceeding a set limit. This practice was initially adopted in the United States to establish uniformity in licensing decisions concerning impaired drivers and to enhance the deterrent impact of such measures. Studies evaluating ALS regulations have indicated they can lead to diminished frequencies of self-reported drink-driving incidents and fatalities on the road. Implementing spot-checks, sobriety checkpoints, or 'blitz' operations serves as a strategy to uphold a heightened sense of the probability of being stopped by law enforcement. Research supports that spot-check initiatives, which combine public awareness campaigns with highly visible enforcement, can effectively lower accident rates during the operation of

these measures. In Australia and many regions in Europe, random breath testing (RBT) has been initiated, allowing law enforcement to request breath tests from drivers without any prior suspicion of impairment. This approach enables a larger number of drivers to be assessed, likely increasing the driving population's perception of the chances of being caught. Evaluations of RBT indicate it can considerably lower instances of drink-driving and traffic accidents associated with alcohol, especially when paired with visible enforcement practices.

Individuals who engage in impaired driving or face drink-driving charges exhibit significantly higher rates of alcohol-related issues compared to the general populace. Many jurisdictions have rolled out rehabilitative or corrective programmes for those convicted of drink-driving, often incorporating alcohol education and brief interventions, with some requiring extended treatment. These programmes offer significant advantages to participants, including enhanced traffic safety outcomes, lower rates of alcohol and drug consumption, and health improvements such as decreased mortality rates. Other strategies intending to modify drink-driving behaviors, particularly ignition interlock programmes, appear to hold potential for enhancing road safety.

5. Accidents

The evolving idea of a traffic incident permits, from a broad viewpoint, the categorization of evidence from traffic mishaps into a collection of types that are indicative of the area where the actions leading to the incident took place, and also the area where evidence from the main event is found, followed by the area where the aftermath is evident [5]. Given the significance of establishing a connection between the location of the accident and evidence of traffic offenses, it is also deemed crucial in practice to categorize the evidence in relation to the object it pertains to. As a result, evidence can be classified based on the offender, the victim, the method used, as well as the roadway and nearby items, in addition to other objects and the surrounding area.

To pinpoint the site of the accident, accurate identification within a specific geographic region is essential. This necessitates, primarily, a precise localization which involves identifying the broader area where the event ensued, thereby requiring some navigational guidance. When necessary, this orientation can be achieved through precise techniques, utilizing instruments like a compass alongside a topographic map, adhering to all established rules of the scientific field of geography. However, such a process is likely to be infrequent, particularly in scenarios involving multiple locations and the fragmentation of the accident spot. The subsequent task involves positioning the accident site, which means identifying how the entire incident site relates spatially to surrounding objects, as well as discerning the internal relationships within the accident scene, which will be further analyzed in later processing stages.

6. Simulations

A simulation is broadly characterized as a representation of a system or process, while computer simulation pertains to the

recreation of such a system or process using a computer [6]. Simulations have been applied across numerous disciplines to gain insights into the relationships among system elements or to assess different design options. They are commonly employed in a wide variety of settings, such as pilot training through flight simulators, forecasting weather conditions, developing communication networks, and in entertainment like video gaming.

Within the realm of transportation, simulations are utilized to examine various facets of the transportation system, which include operations at ports, airports, and railways, modeling demand, examining the relationships between land use and transportation, as well as traffic management. The adoption of computer simulation models has become increasingly common among those working in transportation and academic researchers. Typically, these models imitate the movement of traffic units (such as cars, buses, pedestrians, etc.) across a simulated network, taking into account the interactions between the environment, the vehicle, and the driver. Simulation proves to be extremely valuable when evaluating different options for transportation systems when analytical methods are unsuitable or unavailable, and it can account for intricate factors such as specific driver behaviors and vehicle attributes.

There exists a variety of simulator types that vary according to their breadth, size, and methodology. Traffic simulators can be divided into micro-, meso-, or macroscopic classifications based on the traffic flow representation level. Microscopic models replicate the behavior of each vehicle by considering factors such as their speed and acceleration influenced by other vehicles and road conditions. These models are created using theories associated with car-following, lane-changing, and gap acceptance. Normally, vehicles enter a transport network based on a given arrival distribution, and their progress is monitored throughout the network at each time interval (such as every second). The simulator then computes overall performance metrics, like travel duration and delays, for all vehicles, often categorized by highway section and time frame.

In contrast, macroscopic models depict the movement of vehicle groups (such as platoons) and do not focus on the actions of individual vehicles. Macroscopic simulation techniques rely on deterministic connections between traffic flow, speed, and density within the traffic stream. Mesoscopic models serve as a blend of both microscopic and macroscopic approaches, generally illustrating the dynamics of vehicle clusters or platoons and employing formulas that describe how these groups operate with one another. Simulators can be categorized as time-based or event-based. In a time-based simulation, the system monitors vehicles at each time increment and compiles data accordingly. Conversely, event-based simulation updates the status and position of each traffic unit only

upon the occurrence of a specific event (for example, a vehicle's arrival or a traffic light changing from red to green). Most traffic simulators available commercially operate on a time-based system since algorithms like car-following require frequent updates of vehicle locations at short time intervals.

7. Conclusion

Traffic serves as a cornerstone for economic growth and population movement, with its efficacy relying heavily on the advancement of traffic infrastructure. Given that contemporary society necessitates increased traffic levels, particularly for transporting various goods across considerable distances, this human endeavor is confronted with numerous challenges. The rising effects of traffic emissions on both public health and the environment heighten the significance of promoting cleaner transportation options, which is essential for mitigating adverse impacts on human wellbeing, thus drawing attention from the public. Alongside the continuous emergence of technologically advanced solutions, strategies aimed at reducing traffic emissions are being implemented, as well as incentives for utilizing more energy-efficient vehicles and those that emit lower greenhouse gases. Moreover, the effective coordination of combined traffic systems also plays a vital role in decreasing health and environmental effects.

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