Journal of Traffic and Transportation Engineering 11 (2023) 45-53
doi: 10.17265/2328-2142/2023.02.001

Potential Application of iRap for Road Safety Assessment under Mixed Traffic Condition Case Study: Le Van Viet Street in Ho Chi Minh City

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Article info
Article history:
Received 23 March 2023
Received in revised form 25 April 2023
Accepted 9 May 2023
Available online 25 May 2023

Abstract: Road transport safety policies have emphasized road infrastructure safety design and engineering as a core function. However, in developing countries like Vietnam, this approach has been slower to adopt, resulting in substandard roads. In-depth studies of accident locations indicate that road environment factors contribute significantly to road accidents in Vietnam and road design features are associated with specific accident types and hazards. Proactive and reactive approaches, such as road safety audit, inspection, assessment, and treatment of hazardous locations, are necessary to ensure that the road and its environment are safe. This paper provides an overview of road safety in Vietnam in general, and Ho Chi Minh in particular, including its factors and characteristics, as well as road infrastructure safety improvements. The iRap tool for road safety inspection and assessment is highlighted as a potential method for systematically analyzing road infrastructure deficiencies and providing targeted countermeasures to improve road safety under mixed traffic conditions.

Key words: Traffic safety, road safety assessment, mixed traffic condition.

1. Introduction

Traffic crashes cause great damage to people, property, and socio-economy, particularly in low- and middle-income countries. It is estimated that annual traffic crashes cost the world between 1% and 3% of the GNP (gross national product) [1].

Vietnam is classified as a middle-income country by the WHO (World Health Organization) (1,740 USD/capita), with the proportion of deaths due to traffic crashes per 100,000 people being 24.5 and traffic crashes cause annual losses accounting for 2.9% of GDP (gross domestic product) [2, 3]. Thus, traffic crashes clearly affect not only individuals but also the whole society. Nearly 54% of deaths due to traffic crashes are related to pedestrians (23%), bicycles (3%) and motorbikes (28%) [4].

In Vietnam in 2022, the numbers of fatalities, injuries were slightly decreased, accounting for 6,384 (fatalities); and 7,804 (injuries), while in HCMC (Ho Chi Minh City), these rates were 635, and 1,321, respectively. However, this showed that in comparison with 2019, the numbers of fatalities, and injuries in HCMC in 2022 were slightly decreased (0.9%, 45.2%), respectively [5, 6].

Several literatures indicate that traffic accidents are primarily caused by human behavior, vehicles, roads,

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the environment, and the interactions between these factors. As a factor contributing to traffic accidents, road infrastructure should be planned and constructed with safety in mind for all users, in order to reduce the likelihood of accidents occurring.

Until now, there is lack of empirical research about proactive road safety assessment under mixed traffic in MDCs (motorcycle-dependent cities), like HCMC (Vietnam), where more than 90% people use motorcycles as a major means of transport.

Traffic accidents can be caused by a variety of factors such as narrow road widths, non-compliance with road standards, sharp curves, steep inclines and declines, pavement surface damage, and poorly illuminated roads. It is unfortunate that road infrastructure, which is meant to provide safety and comfort for users, can actually contribute to traffic accidents. Therefore, it is crucial to conduct a thorough investigation to understand the impact of each element of road infrastructure on traffic accidents in order to effectively address road safety issues.

Road width that is too narrow or does not comply with standards, sharp curves, steep downhill and uphill, pavement surface damage, and non-illuminated roads are some of the factors that cause traffic accidents. Road infrastructure that should provide the users safety and comfort, ironically becomes the cause of traffic accidents. Therefore, a profound study to reduce traffic accidents due to road infrastructure and to understand the influence of each element that forms road infrastructure on traffic accidents should be performed so that the process of handling road safety can be more effective.

Lack of resources is a major obstacle in maintaining the road network, and it is crucial to develop cost-effective methods of evaluating the safety levels of roads in order to prioritize upgrades. This research project evaluates the potential of iRap's star rating system, which can quickly and easily assess road safety issues under mixed traffic conditions without relying on crash data. The study specifically looks at the use of the Star Rating system to assess the safety of Le Van Viet street. Whether this system has the potential to be used regularly as a quick and easy method of determining relative degrees of safety on roads, even when crash data are lacking.

This paper is divided into four parts; following the introduction is the methodology of iRap star rating. Practical Application of the Star Rating System is the third part, and the last part is discussions.

2. Methodology of iRap Star Rating

iRap's Star Ratings are based on identifying the road attributes that have the most significant impact on common and severe types of crashes involving vehicle occupants, motorcyclists, bicyclists, and pedestrians. This provides an objective and straightforward measure of the relative risk associated with road infrastructure for all types of road users. The Star Ratings range from 1 to 5, with 5-star (green) roads being the safest and 1-star (black) roads requiring the most safety improvements for users.

Research has shown that every incremental improvement in the star rating can significantly reduce a person's risk of death or serious injury. In fact, the risk of harm can be reduced by almost 50% for each star rating increase. Therefore, the Star Ratings system provides a valuable tool for assessing the safety of roads and prioritizing safety improvements to help reduce the number of accidents and injuries on our roads.

The overall iRap methodology for Star Rating and Safer Roads Investment Plan process is shown in Fig. 1. The iRap methodology for the Star Rating and Safer Roads Investment Plan process comprises three main categories: road survey, road attribute coding, and analysis and reporting. A road segment is selected for a survey and 78 road attributes are recorded during this process, including traffic flow and speed data, pedestrian count data, roadway characteristics, and facilities for vulnerable road users. Each 100 m segment of the road is then coded to address the issues identified during the survey.

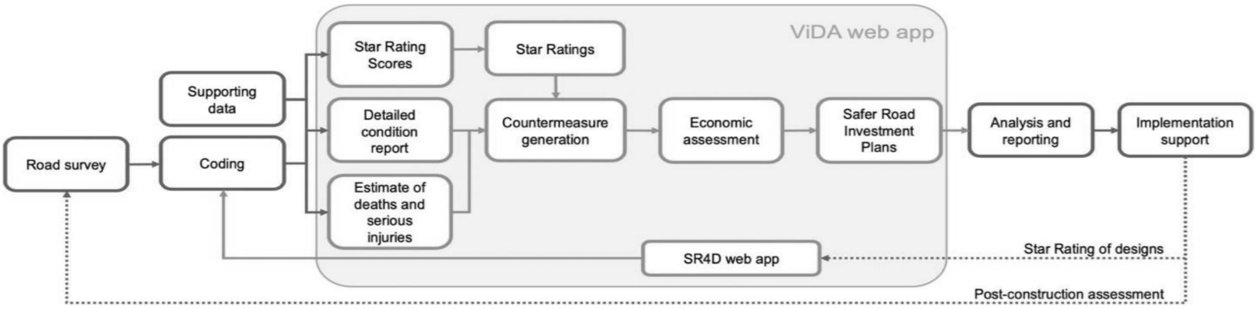

Fig. 1 iRap Star Rating and Safer Roads Investment Plan process.

The star ratings for motor vehicles, motorcyclists, pedestrians, and bicyclists are obtained for each 100 m segment. These coded files are analyzed using iRap's online software, ViDA, to establish a baseline condition. The baseline condition is then compared to a hypothetical scenario, such as a traffic capacity improvement scenario, by proposing countermeasures to evaluate the reduction in FSI (Fatal and Severe Injuries) and to perform an economic assessment, known as the SRIP (Safer Road Investment Plan).

This methodology provides a comprehensive and thorough approach to assessing road safety and identifying potential improvements to reduce the risk of accidents and injuries on our roads. By implementing the SRIP, governments and stakeholders can make informed decisions about which road safety interventions will have the most significant impact, ensuring that resources are allocated effectively to create safer roads for everyone.

3. Practical Application of the Star Rating System

The iRap system was used as a basis to evaluate the safety labels on Le Van Viet Street. The iRap analysis was complemented by an extensive on-site investigation and a study of traffic behavior, which involved determining conflict points. The objective was to determine whether the iRap analysis was sufficient to evaluate the safety of individual intersections or whether additional observations were required to identify factors that may be missed by iRap.

To limit the scope of the study, it was decided to use the online Star Rating Demonstrator. Features documented for this study, as illustrated in Fig. 2, include:

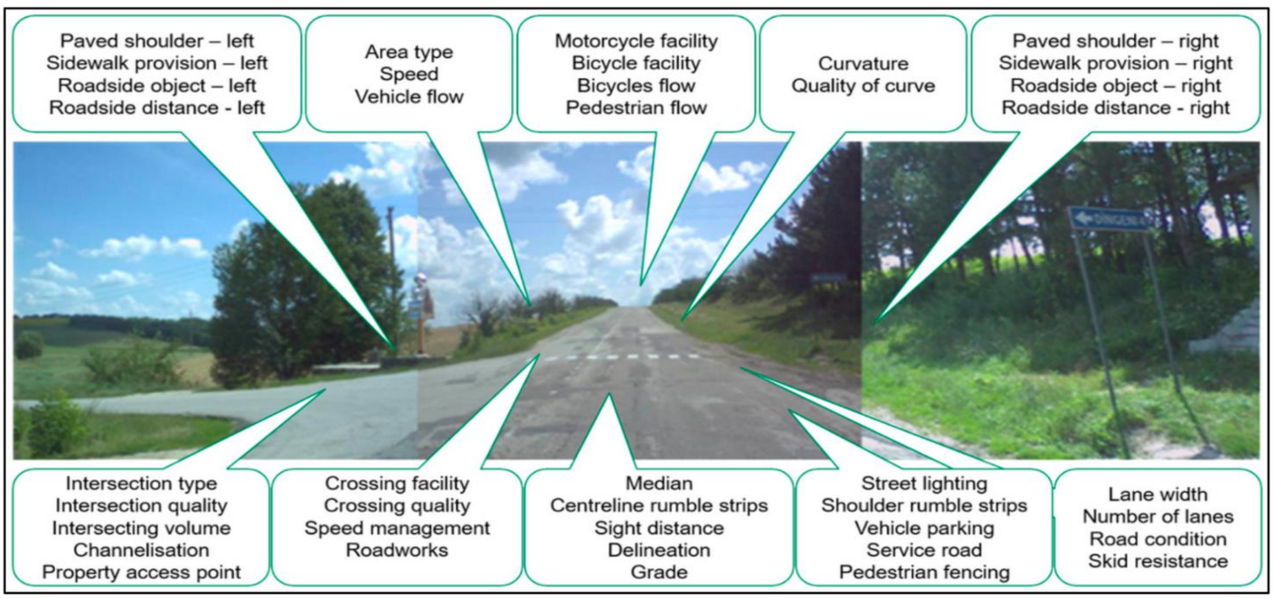

Fig. 2 Road structure elements assessed.

The information required was grouped into 6 tabs as described below:

- Roadside: To collect comprehensive roadside information, it is necessary to observe the severity of roadside hazards and measure their distance from the road on both sides. A total of 62 roadside objects are listed, with the highest risk object being a cliff and the lowest risk object being a wire rope safety barrier. Other features are also considered for potential inclusion or exclusion, such as the presence or absence of paved shoulders and shoulder rumble strips, as well as the quality of the road surface. Road conditions that are deemed poor, for instance those with potholes, can be recorded as “very poor”.
- Mid-block: Information to be collected for road assessment includes lane configuration (number of lanes in each direction and their width), road curvature and its quality, gradient, and median type. Additionally, the presence or absence of centre-line rumble strips, street lighting, vehicle parking, service roads, and road works should be noted. Further details on the road condition, skid resistance, delineation, and sight distance must also be included.
- Intersections: It is necessary to record the type and condition of intersections, including any channelization present or absent. Access points for properties located at or near the intersection should be counted and described, and the volume of intersecting road traffic must be measured.
- Flow: Information on the main through-road’s AADT must be furnished, in addition to data on pedestrian traffic on both sides and across the road, as well as bicycle and motorcycle traffic.
- Vulnerable road user facilities and land-use: Data on the type of area and land use on either side of the road, as well as the presence of NMT (Non-motorized Transport) and School Zone facilities, must be recorded.
- Speed: To provide information for this category, details about the speed limit, differential speed limits, and speed management must be recorded, along with the operating speed that is represented by the 85th percentile.

A portion of the aforementioned information could be obtained readily from municipal archives and road design blueprints. If the data were not obtainable from external sources, it was relatively simple to quantify it using satellite images or by directly measuring it on the field. After the completion of data gathering, the Star Rating Demonstrator was used to determine the star rating and dangers for different road users at each spot. After that, trials were conducted by changing variables to determine which characteristics could be modified to improve the star rating for various road user.

3.1 Overview of Le Van Viet Street

This is an arterial road in Thu Duc city, starting point at Thu Duc intersection and ending at My Thanh T-junction with 4.6km length, as shown in Fig. 3. Based on the street patterns such as road width, sidewalk width, traffic volume, and land use, it has been divided into 4 sections:

- Section 1: from Thu Duc intersection to the intersection between Le Van Viet street and Truong Van Hai street;
- Section 2: from the intersection of Le Van Viet street with Truong Van Hai street to the intersection between Le Van Viet street and La Xuan Oai street;
- Section 3: from the intersection between Le Van Viet street and La Xuan Oai street to the intersection between Le Van Viet street and 385 street;
- Section 4: from the intersection between Le Van Viet and Road 385 to My Thanh T-junction.

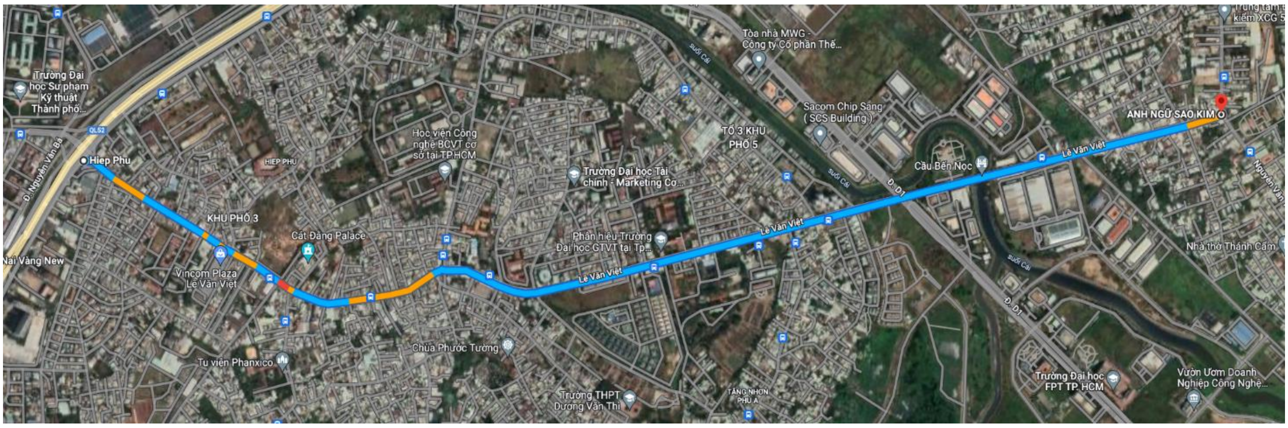

Fig. 3 Layout of Le Van Viet street.

3.2 Observation Results and Score Scale Star Rating

Section 1

The survey was conducted in 2 time periods (6 am-8 am) and 16 h-18 h, this is the peak hour with a huge traffic volume and heavy traffic congestion, Fig. 5.

This section is starting point at Thu Duc intersection and ending at the intersection between Le Van Viet street and Truong Van Hai street with 0.85km length, as shown in Fig. 4. The road surface is in good condition, the paint line is quite new, the lighting system on both sides, and the condition of the street lights is good. It is not obscured by trees, ensuring lighting ability. The sidewalk is relatively wide, However, there are also some defects that can cause injury to pedestrians if accidentally encountered, the situation of encroachment on the sidewalk still takes place. Illegal parking on sidewalks affects the visualization of drivers and pedestrians as well, Fig. 6.

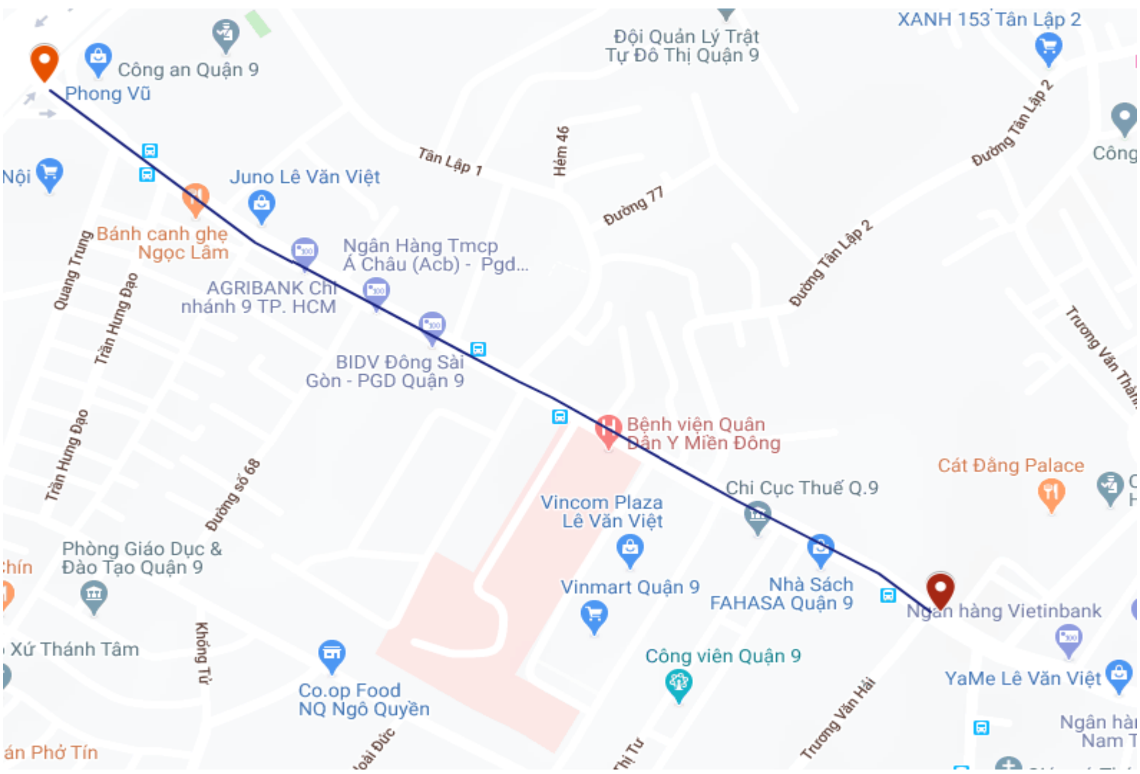

Fig. 4 Layout of Le Van Viet street under section 1.

Fig. 5 Heavy traffic of peak hour of section 1.

Fig. 6 Car illegal parking on sidewalk.

Based on the above survey results, we can determine the characteristics of the road, Table 1.

Table 1 Characteristic of road in Section 1.

Characteristic	Type	Characteristic	Type
Speed limit (km/h)	60 km/h	AADT	62000
Type of median	Center line	% Motorcyclist	81%-99%
Number of lanes/direction	Two	Pedestrian crossing of peak hour	From 6-25
Lane width	Width (≥3.25)	Pedestrian crossing of off-peak hour	From 6-25
Curvature	Straight or curved soft	Bicycle of peak hour	From 6-25
Curvature quality	Do not apply	Pavement	Roadside
Road condition	Medium	Crosswalk works for pedestrians	Pedestrian crossing without signal and refuge island
Slip resistance	With plastic spreading—enough quality	Quality of pedestrian crossing	Good
Road markings	Poor	Pedestrian fence	No
Light	yes	Works for motorbike drivers	No
Curb level danger—the object on the left side of the road	Signal, column or pillar	Construction for cyclists	No
Curb level—the distance on the left side of the road	0-1 m	Type of intersection	No
Curb level of danger—the object on the right side of the road	Signal, column or pillar	Quality of intersections	1,000 to 5,000 vehicles
Curb level—distance to the right of the road	0-1 m	Traffic volume of the intersection	No signal junction with unprotected turns
Measures to reduce speed	No	Home access point	No
Shoulders with coverings	No	School zone warning	No

The average SRS (Star Rating Scale) on the road segment is given by iRap software for motor vehicle users including vehicle and motorcycle, cyclists and pedestrians, Fig. 7.

The study used the same methodology which has been applied to determine the average SRS previously for sections 2, 3, and 4 with the layout of each section and their score scale star rating, respectively as shown Figs. 8~13.

Fig. 7 Score scale star rating of Section 1.

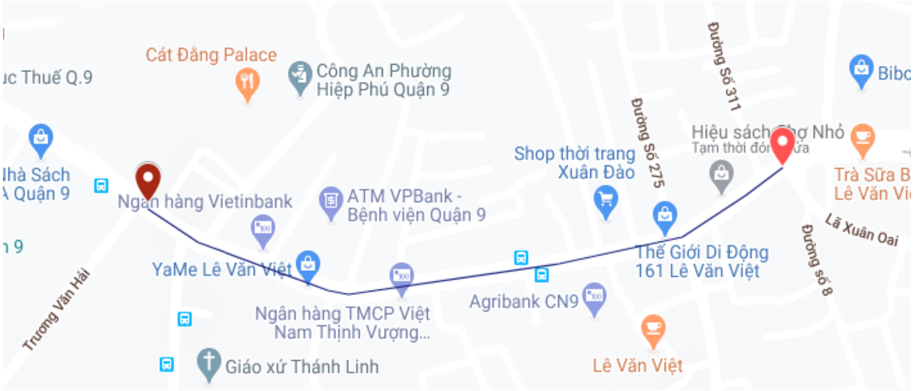

Fig. 8 Layout of Le Van Viet street under section 2.

Fig. 9 Score scale star rating of Section 2.

Fig. 10 Layout of Le Van Viet street under section 3.

Fig. 11 Score scale star rating of Section 3.

Fig. 12 Layout of Le Van Viet street under section 4.

Fig. 13 Score scale star rating of Section 4.

4. Discussion: Strengths and Weaknesses of the iRap as Tested

By registering for iRap and ViDA software, users gain immediate access to a wide range of online resources and tools for road safety assessment and improvement, based on global expertise. This registration is free of charge and includes training opportunities, as well as unlimited access to consultation with experts. The system is regularly updated to reflect the latest research.

The database enables the upload of road survey data, including images, for data storage, information sharing, and the creation of risk maps, customized investment plans, and progress tracking. The benefits of this system include access to existing risk maps which provide information on the current risk status of road segments that have been assessed. Investment plans can be generated for isolated road segments or entire road networks, taking into account various factors such as existing road features, traffic speed and volume, and projected fatalities and injuries before and after each possible treatment or combination of treatments, as well as the projected economic benefits of investing in a specific treatment. User-defined investment plans can also be developed, tailored to individual circumstances and priorities. The permanent storage of data allows for easy progress tracking, facilitating data recall, update, and comparison, enabling timely implementation of countermeasures or highlighting successful improvements.

The data collected for the initial project were uploaded to the Star Demonstrator, which provided access to most of the iRap information and expertise. While using the Star Demonstrator had its advantages and disadvantages, it was suitable for the project focus.

The advantages were that it was easy to apply and required minimal material and human resources. The data collection process was straightforward, and instant results were available once the data were uploaded.

However, the Star Demonstrator had limitations, such as only allowing assessment of a single 100 m stretch of road at a time and the lack of permanence of data uploaded to the system. Additionally, risk maps and investment plans could not be automatically generated, and cost-benefit investigations had to be conducted manually. The temporary nature of the data uploaded to the Star Demonstrator also meant that it was not accessible online.

In developing countries, road safety issues have historically been neglected, not only in terms of funding and upkeep, but also in terms of study and investigation. In most projects, a challenge was the lack of comprehensive crash data collection, storage, and accessibility. However, the iRap system is designed to accommodate both urban and rural environments, enabling the addressing of unique situations and issues in developing nations. The system can be used even without existing crash data, and countermeasure plans can be tailored to suit budget and priorities.

For assessing safety risk and potential countermeasures for specific road segments, particularly for high-risk locations like intersections or schools, the Star Demonstrator has proven to be highly effective and affordable. As it does not create a permanent online record, it is recommended for such specific locations where an immediate improvement is planned.

For longer road stretches and when resources permit, the use of the full ViDA software, which provides a comprehensive overview of the current situation and a clear idea of what is necessary to meet global road safety standards, is highly recommended. It also generates detailed investment plans that can be tailored to the situation and allows for regular updates of data and the creation of risk maps, making current information accessible to all stakeholders. In the developing countries context, the creation of a comprehensive and accessible database would be particularly valuable as it could compensate for the previously mentioned lack of reliable crash data.

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