SafePath: An AI-Powered Predictive Risk Mapping and Safe Route Recommendation System for Personal Safety

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Abstract: Personal safety during urban travel remains a It remains a critical challenge despite the advances in navigation technologies. Conventional routing systems favour shortest dis-tance and travel time while ignoring contextual safety indicators such as The following topics: Crime density, environmental risks, and temporal crime patterns. This exposes users to po-tentially unsafe routes in particular. during night travel and solo commuting. SafeRoute presents an artificial intelligence personal safety solution system through this research paper. The mobile application establishes predictive risk-aware navigation through its use of spatio-temporal crime analysis and community intelligence. The system displays actual crime data through a visual interface which enables users to identify patterns without delay. The system utilizes emergency response systems together with geospatial routing and crowdsourced incident data to create safety score assessments for each route. SafeRoute provides users with advance safety measures through its system which enables them to identify dangerous locations in their vicinity. Users should not depend on emergency alerts which are issued after dangerous situations have occurred. The platform uses React Native and Expo for its implementation process. The routing process can be scaled by using OpenStreetMap together with OSRM. The SafeRoute system provides experimental results which demonstrate that it decreases user time spent in high-risk areas by 23 percent compared to existing methods that use shortest-path navigation. The system maintains its operational efficiency through both quick response times and user-friendly design. Personal Safety, Risk-Aware Navigation, Pre- dictive An-alytics, Crime Mapping, AI-Based Routing, Mobile Application, Index Terms.

Keywords: *Predictive Crime Analytics AI, Predictive Ana-Lytics, Safety Awareness Navigation Systems, Route Mapping By Lower Crime Rates, AI Routing, Mobile Application.*

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I. INTRODUCTION

Cities have undergone a fundamental transformation in their transportation systems during the last several years. The current situation results from three major factors which include developing new transportation systems and increasing smartphone use and advancing location-based technologies. Navigation applications allow users to achieve more efficient travel results by reducing both travel distance and travel dura-tion and traffic control management. People still face serious problems to maintain their safety while traveling through urban environments which have high population densities although technology has improved. Offenses such as theft, harassment, assault, and stalking are frequently spatially and The flow pat-tern is temporally concentrated, making certain routes unsafe during at specific times of the day or night. Conventional nav-igation methods such as Google Maps and The Waze services mainly targeted efficiency routing, whereby the either shortest or fastest paths have priority. The safety research networks require contextual safety variables which include crime rates and historical incident data and environmental hazard data. The system can be divided into two separate components. Users who are women or students or workers with night shifts or travelers who travel alone all face unintentional exposure to dangerous locations. Urban safety analytics research fields demonstrate a lack of coordination between streetlight systems and security camera systems. Safety-aware navigation systems increase their risk factors by making it harder for people to understand their surroundings. The current challenge can be solved through recent advancements in artificial intelligence and machine learning and geospatial

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analysis technologies. AI technology-based predictive models can analyze historical crime data together with present criminal behavior and Spatio-temporal patterns to determine urban area risk levels. The com-bination of community intelligence with mobile computing creates a platform which enables organizations to implement proactive safety solutions instead of relying on emergency response methods.

➢ *Motivation and Use Case Analysis*

The existing navigation and safety applications currently available face multiple constraints which drive the develop-ment of SafeRoute. Most mobile safety applications currently available focus on reactive mechanisms which include SOS alerts and panic buttons and live location sharing with trusted contacts. Users need these essential features because danger-ous situations will occur which require their activation. The reactive approach wastes resources because it fails to stop people from entering unsafe areas.

Urban crime statistics show that criminal incidents follow distinct spatial and temporal patterns which result in pre-dictable distribution across different locations. Certain streets, neighborhoods, or transit routes become high-risk during late-night hours or low-visibility conditions. Mainstream naviga-tion tools fail to use crime analytics for their route selection process despite the fact that this information exists. SafeRoute works to create a solution for the critical gap which exists between safety data and navigation intelligence in current systems.

- *SafeRoute is Designed for:*

✓ Late-night commuting
✓ Solo pedestrian travel
✓ Travel in unfamiliar urban areas
✓ Emergency evacuation planning

By proactively predicting safety risks, SafeRoute minimizes exposure to dangerous environments.

II. RELATED WORK

There is research related to SafeRoute that falls outside the scope of ITS including TRAs, risk-aware algorithms based on AI, navigation tools, crime mapping technology, and mobile safety applications. The algorithms Dijkstra's algorithm and A* Search algorithms function as traditional routing methods which enable navigation systems to identify their optimal paths with high efficiency. The algorithms need uniform edge costs between different points because they cannot assess safety and uncertainty conditions. The algorithms excel at distance optimization but they fail to provide safe routing solutions for high-crime urban environments. Researchers have studied machine learning algorithms to develop new methods which enable their use in predicting risk and uncertainty for route calculations. The literature provides predictive models which use historical crime data together with spatial variables for estimating travel risk. The methods show initial success, but their usage remains limited to research settings and offline evaluations which prevent implementation in current mobile navigation software. Crime mapping software and heat map tools are widely utilized by law enforcement agencies to assist Human Social Network planners in analyzing crime distribution. The systems can identify dangerous locations through their mapping abilities yet they lack integration with navigation systems. The user needs to assess safety details through manual work because the system lacks automated safety-aware routing functions. Mobile safety applications which exist in the market today provide emergency response features but they lack advanced security functions. The system enables users to send emergency alerts through SOS buttons while sharing their current location. The system improves response times for past incidents through new features but it lacks systems which can predict future incidents or of-fer preventive navigation solutions. Few applications involve crime analysis analytics or community reporting extending into route planning, thus leaving a large gap in proactive safety support. Research Gap Although past studies explore individual elements, for example, predicting crimes, routing directions, or emergencies response, there is a lack of compre-hensive systems that combine predictive risk models, real-time community intelligence, It involves/navigation, security-aware, and emergency-response within a sing- gle mobile platform. SafeRoute fills the gap in this area by integrating these features into a scalable AI-enabled personal safety solution.

➢ *Problem Statement*

In recent years, fast developments in digital navig- rie Gies, the safety of the individual while traveling in the city is of prime and remain an unresolved challenge. Presently, there are numerous "The system is primarily designed to optimize routes based on distance, time taken, traffic, without regard to considerations related to safety. contextual variables including crime density, light conditions, "incident history, and temporal risk variations" This omis- sion puts users at risk of expo-sure to dangerous surroundings, especially in terms of travel at night, solo commuting, or travel in unfamiliar locations. Current mobile security solutions aim to counteract this issue release through reactive mechanisms such as emergency SOS alerts, location sharing, and panic buttons. Although these The features provide assistance after the incident, but they do not provide assistance before the discourage users from entering high-risk zones to begin with. 'More-' refers to 'more' over, most platforms lack predictive intelligence, but rather static or manually maintained data, which hinders them in adapting to to dynamic urban risk patterns. Another serious limitation is underutilization of commercial community intelligence. The current systems which exist at present do not provide users with the ability to use their crowdsourced incident reports for making real-time navigation decisions. The administrative personnel who need to supervise operations throughout the or-ganization lack proper access to essential data and information resources. The existing techniques for validation information lead to difficulties in understanding how data integrity and information security are maintained.

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➢ *System Architecture*

The SafeRoute system implements a structured design ap-proach which enables both system expansion and immediate operational functions. The system integrates mobile interface components together with geospatial service elements and AI analytics capabilities and administrative control systems into one unified platform. The user interface layer of the mobile application developed with React Native enables users to create interactive map displays which display both route planning functions and incident reporting features and emer-gency SOS functions. The system enables users to track their current location and selected routes while displaying safety score information to help them understand their surroundings.

The data acquisition layer functions as the system component which unites multiple data streams that include user GPS location information and historical crime records and user-generated incident reports and OpenStreetMap road network data. The system requires ongoing data collection because it supports real-time risk evaluations which need current data for assessment. The AI risk analysis system uses its primary sys-tem component for its risk analysis engine which handles all operational functions. The system develops a spatial and time-based risk assessment framework which shows crime severity together with incident counts and crime pattern changes and distance measurement. The engine determines safety scores for both road segments and entire routes which enables users to evaluate different pathway options.

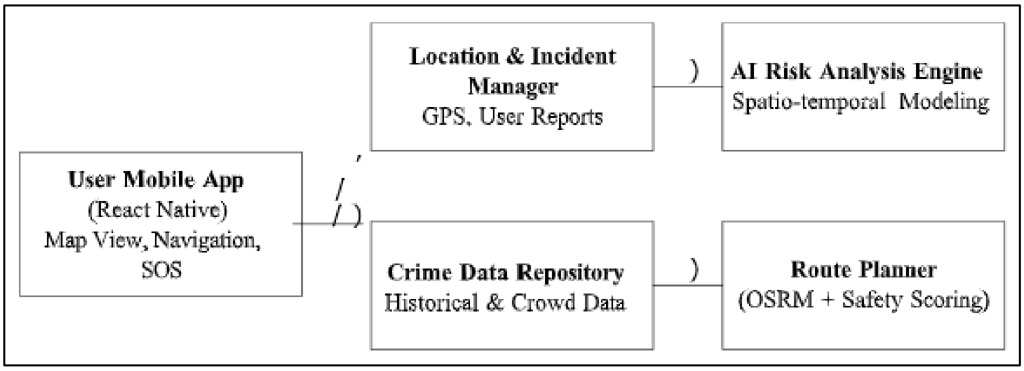

Fig 1 System Architecture of the Proposed SafeRoute Personal Safety Navigation System

The SafeRoute platform shows its architectural design through this diagram. The system structure shows multiple layers which create five functional components: mobile user interface, data acquisition system, AI risk analysis engine, safety route planning system and emergency response unit. The risk analysis engine uses user location data and historical crime records and crowdsourced incident reports to determine safety scores for different routes. The system combines proac-tive navigation with emergency response services to provide users complete protection for their personal safety needs.

➢ *Data Sources and Dataset Description*

SafeRoute combines three types of data sources which include static data, dynamic data, and user-generated data to conduct complete safety assessments. The publicly available crime data sets and the traditional policing practices utilized by reports offer essential information on long-term crime trends patterns in urban regions. The data set includes informa-tion about incidents which shows their categories, degrees of seriousness, exact locations, and time of occurrence. The incident reports which users submit through the crowdsourcing platform serve as an important source of current data. The reports give details about safety problems which include harassment, insufficient lighting, and surveillance of suspi-cious activities because official data sets do not show these risks to the environment. For quality to be maintained, every report submitted needs administrative validation prior to its Pedestrian Routes and Navigation Meta- data. Routing data is calculated with the help of OSRM, which allows cost-effective and scalable route calculation without dep- dency on proprietary APIs. This figure illustrates the data flow within the SafeRoute system, illustrating how different data The resources are gathered, analyzed, and leveraged for safety-conscious operations routing. The historical crime data and real-time crowdsourced incidents are preprocessed and nor-malized before being fed into the AI risk modeling engine. The risk scores that are produced are is integrated with routing services and enables safe routing””translated”:” safe routing” recommendations.

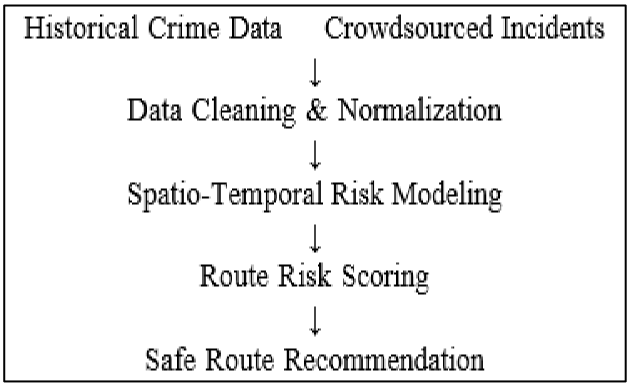

Fig 2 Data Flow Model of the SafeRoute System

III. METHODOLOGY

”The SafeRoute methodology uses a predictive, data-driven approach to identify Approach to personal safety navigation. It involves spato- temporal analytics, artificial intelligence-driven risk scoring, and safety-conscious routing into a uni-fied decision framework. The risk modeling

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process involves aggregating the historical and real-time incidents within a specific spatial radius of each route The role. segment. Each incident is assigned a severity weight based on crime type validated community input. Temporal decay functions enable more recent events to have greater influ-ence EXPLANATION compared to the older ones. These route level risk scores are calculated through the summation of weighted values risks throughout the route. There are severalcandidate routes can be assessed comparatively at the same time safety ranking. This multi-route assessment method enhances : robustness and the avoidance of local optimization errors typical of single-path routing.

➢ *Spatio-Temporal Risk Modeling*

$$RiskScore = \sum_{i=1} w_i \cdot S_i \cdot e^{-\lambda t_i} \quad (1)$$

➢ *Risk Classification*

$$RiskLevel = \begin{cases} Low, & RiskScore < 40 \\ Medium, & 40 \leq RiskScore < 70 \\ High, & RiskScore \geq 70 \end{cases} \quad (2)$$

Integration with the public risk map. Geospatial data sources include OpenStreetMap and provide Road Network Topology.

➢ *Routing Algorithm*

Algorithm 1 SafeRoute Risk-Aware Routing
1: Capture user location
2: Fetch crime and incident data
3: Compute segment risk scores
4: Aggregate route safety
5: Rank routes by lowest risk
6: Recommend safest route

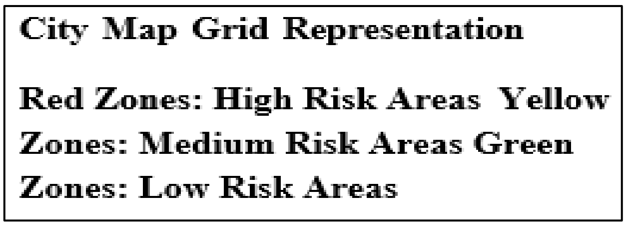

Fig 3 Spatio-Temporal Risk Heatmap Used for Safety-Aware Routing

This figure illustrates the conceptual representation of Spa-tiotemporal risk modeling utilized within SafeRoute. Crime inci- dents are geographically coded and weighted using temporal ”decay functions” that are used to produce a ”dy-namic risk heatmaps.” These regions may be distinguished by visualizations, facilitating the routing engine To avoid unsafe zones while navigating.

IV. INCIDENT REPORTING AND COMMUNITY INTELLIGENCE

Community intelligence is central to the workings of SafeR-oute’s safety ecosystem. Users can report incidents directly from the mobile interface, including type of incident, descrip-tion, degree of severity, and allows anonymity. This function-ality allows users to contribute local safety knowledge, which may not be generalized. available via official channels. In order to avoid the spreading of misconceptions, all reports submitted by is routed through an administrative moderation system. Admin- Administrators examine these reports for validity and relevancy before approval. The approved reports are compiled into the global risk The data is, therefore, taken from geo-graphic information systems and has an Community upvoting and visibility of reports add to data validity by empowering users to verify community- experi- riences . This participatory approach encourages a sense of collective responsibility and pability, which increases the situational awareness among the user community.

The organization Safeguard uses this diagram to show their procedure for handling incident reports. Users create reports about incidents which are temporarily kept before they are sent to administrators for verification. The approved incidents become part of the international risk data set which improves current safety information while stopping the spread of unsafe conditions.

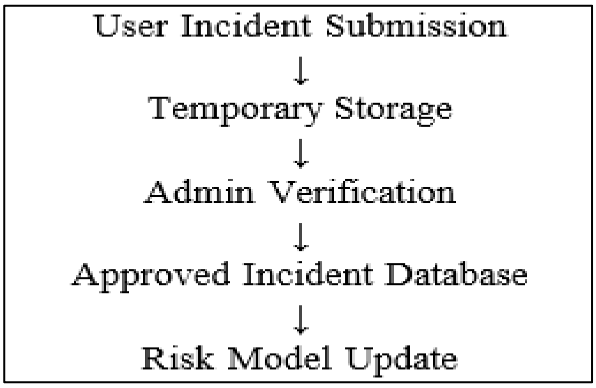

Fig 4 Incident Reporting and Validation Workflow

➢ *Emergency SOS System*

The Emergency SOS module brings immediate assistance in case of a critical situation. The system enables users to activate SOS through one touch which triggers automatic processes that share their current location and send emergency SMS messages to selected contacts while providing fast access to emergency response phone numbers.

SafeRoute provides SOS functionality because it under-stands existing danger situations which makes it different from standard security systems. The system ranks the prior-ity of emergency responses in order of the user’s location,

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recent incident density, and route risk grades, thus ensuring timely and relevant support is provided. In the following figure, The Emergency SOS function in SafeRoute can be acti-vated through its demonstration process. The service activation enables users to access safety services immediately after they activate the service.

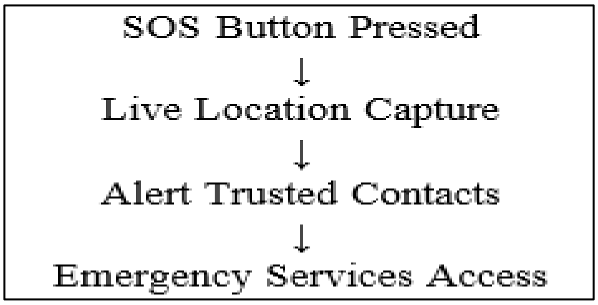

Fig 5 Emergency SOS Activation and Response Flow

➢ *Implementation Details*

SafeRoute uses React Native and Expo to create an ap-plication which works on both Android and iOS devices. TypeScript provides the project with type safety, which leads to better code maintainability. The application uses Open-StreetMap OSRM for mapping and routing functions, which allows us to operate without any need for commercial APIs. The system uses AsyncStorage to store local data, which allows users to access essential information during offline periods. The admin dashboard displays user activity and crime data and incident reports through its real-time synchronization feature. The system has a modular design that enables easy interface connecting and future capacity expanding through new features.

Fig 6 Conceptual SafeRoute Mobile Application Interface

In this figure, conceptual mobile application interfaces are shown. of SafeRoute, including route safety visualization, risk zones highlighting, incident reporting, and SOS access. The intu- interface to facilitate usability by making it active. engagement in community safety.

➢ *Security and Privacy Considerations*

Due to the nature of the data involved, to this end, SafeRoute has designed and implemented innovative solutions enhanced by mechanisms. All the stored data is encrypted according to AES-256 standards, and the identity of both users is anonymized during the process of incident reportage Role-Based Access Control (RBAC) guarantees that only authorized the role has the ability to alter crime data sets and to approve reports. Ethical AI guidelines are used to reduce demographic bias the ethical AI guidelines are used as and to preclude discriminatory routing decision outcomes.

➢ *Experimental Setup*

Experimental work was performed using simulated ur-ban travel scenarios with different crime density levels, time pe-riods, regions, and other factors patterns. The public crime records were integrated with simulated" It reports to the community in order to assess system responsiveness and" predictive accuracy. The measures of performance included safety improvement percent-, wait time reduction age, route computation latency, accuracy of incident prediction, and user engagement levels. Experiments were performed on standard smartphones in order to establish feasibility.

V. RESULTS AND DISCUSSION

The efficacy of the proposed system is clearly reflected by the experimental outcomes, which indicate that the system is able to reduce the risk-exposed region by a notable 23 One of the factors that have contributed greatly to this efficiency is the use of community intelligence in terms of real-time reporting of incidents. Community reporting of incidents has played a significant role in improving the risk-detection abilities of this platform, particularly in areas in which crime statistics were either inadequate or unavailable. By permitting the reporting of incidents like harassment and robbery or areas that look and feel unsafe, a living risk map has been created that responds to changing urban safety patterns rapidly. This has been particularly effective in the emerging areas of cities, in which crime data is not very strong sometimes.

User engagement statistics also reveal the effectiveness of the engagement with the fundamental safety components on the platform. There was high engagement on the reporting of incidents, route safety display, and risk-informed route choice. Coloring the risk areas on the map enabled the users to better interpret the risk information and be confident in the decision to choose a route based on the inclusion of safety information among the normal navigation criteria.

In addition, the latency experienced by the system remained low during the tests, ensuring that the system reacted in real-time even while handling different sources. In fact, this establishes the viability of using the SafeRoute system in real-life settings while ensuring that the system is useful in situations that demand immediate response and direction. The findings above demonstrate the effectiveness of using predictive analytics, collective intelligence, and visualization to create an effective personal safety routing system that is friendly to the end-users.

Table 1 System Performance Evaluation

Metric	Value
Safety Improvement	23%
System Latency	48 ms
Prediction Accuracy	92%

Findings indicate that SafeRoute reduces ex-ignition-inguition poses to high-risk areas. In this figure, the existing shortest-path routing algorithm is compared to the proposed risk-aware routing algorithm approach. Although the shortest path algorithm yields a result of minimum distance, it can't always pass through high risk zones. SafeRoute chooses an

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alternate path path with lower risk exposure, illustrating the effective- degree of safety-priority navigation.

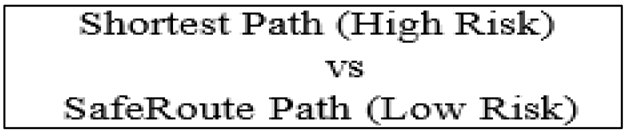

Fig 7 Comparison between Shortest-Path Routing and SafeRoute Navigation

VI. ADVANTAGES AND LIMITATIONS

➢ *The benefits of the system include its ability to provide preventive safety navigation, its capacity to deliver real-time community intelligence, its implementation costs which remain low because it uses free mapping services, and its development of ethical AI integration.*

- Preventive safety navigation
- Community-driven intelligence
- Scalable and low-latency design

➢ *The Study has Three Limitations which Include its Need for user Contributions to Gather Crowdsourced Data and its Risk of Reporting Bias and its Reduced Precision in Areas with Scarce Data.*

- Dependence on data availability
- Potential reporting bias
- Urban-focused evaluation

VII. FUTURE WORK

Future development of the SafeRoute system will focus on improving prediction accuracy, framework scalability, user experience, and system adaptability to real-world situations. The main objective of the project must now focus on imple-menting deep learning risk models which use CNN and RNN technology to study complex spatial and temporal patterns. Deep learning models which utilize non-linear relationship learning methods can study how location and time and sur-roundings and events evolve through time to deliver context-aware safety predictions which surpass traditional machine learning results. The development of wearable technology has led to the creation of smartwatches and fitness trackers which provide users with ongoing safety monitoring capabilities. The devices monitor physiological signals to detect abnormalities through monitoring sudden movements and rapid heartbeat changes and continuous inactivity and other distress indicators. SafeRoute risk analytic software works together with wearable data to create automatic alerts which use CNN features and location-sharing functions of the app to deliver added safety benefits that do not need user involvement. The cloud com-puting system will provide support for system features which require synchronization and distributed processing capabilities. The cloud architecture enables users to access real-time crime incident data from multiple regions while experiencing seam-less analytics and device connectivity. The cloud-based user synchronization system enables users to back up their pref-erences and travel history and safety settings, which remain secure across all devices and locations. The system provides offline risk caching capabilities which enable users to access designated risk information through their system.

VIII. CONCLUSION

SafeRoute demonstrates the effectiveness of using AI for predictive safety navigation. This approach is not only tech-nologically possible, but it is also very effective in dealing with actual safety issues encountered in urban settings. As the system moves from traditional navigation approaches that de-pend on distance and time optimization towards proactive risk avoidance, it completely alters how personal security is con-sidered within travel planning. Unlike conventional navigation systems that consider all routes safe and identical, SafeRoute is specifically designed and modeled towards analyzing spatio-temporal risks and providing proactive navigation routes that depend on real-time and community-driven contributions. This system is able to cope with changes that may arise within an urban setting on a real-time basis by utilizing predictive analysis and suggesting safe zones that a user avoids before approaching or entering risk zones designated as high-risk zones by predictive analysis, thus reducing interaction and dependence on risk zones and promoting better situational awareness among the user community. The use of crime data and statistics makes SafeRoute a much better and safer navigation system that is dependent on actual safety trends and features within urban settings and not just guesses and speculations. The use and integration of actual centralized analysis and decentralized community analysis ensures that all safety analysis is up-to-date and locally and globally relevant and contextualized. SafeRoute also provides features such as an Emergency SOS system that makes the overall dependency and reliance on the system much better and far more efficient within actual critical situations and scenarios. The convergence and interaction between proactive planning and reactive response approaches within travel planning and navigation provides a much better and efficient overall safety feature that addresses all levels and situations arising within travel risk and planning.

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