

# Flying Car: Risk-On Risk-Off Sensor Model

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**Abstract**— Currently, numerous AI-driven autonomous driving pipelines are employed in the operation and control of vehicles, significantly advancing the development of autonomous vehicle technology. However, these models still fall short in ensuring optimal safety margins and maintaining high levels of driver and passenger engagement, which has contributed to a substantial number of fatalities and injuries in vehicular accidents, particularly those involving autonomous systems. To address these critical safety challenges, this research introduces the a-Risk-On-Risk-Off (RORO) model, a novel safety assurance framework designed to enhance reliability and resilience in autonomous driving systems. The RORO model aims to provide robust safety guarantees, especially in emerging transportation modalities such as the autonomous flying car, where safety standards must be substantially elevated to accommodate complex aerial navigation and collision avoidance. Our ultimate goal is to leverage this innovative safety paradigm to benefit society at large, ensuring safer skies and roads for all citizens and paving the way for the industrial deployment of safe, reliable, and efficient urban air mobility solutions.

**Keywords**— Risk-On-Risk-Off Sensor Model, (RORO), Flying Car, Aerial System.

## I. INTRODUCTION

Recently, there has been a significant rise in the frequency and severity of automotive accidents, including a notable increase in incidents involving autonomous vehicles, as documented in recent studies [1][2]. Current driving systems mainly focus on distance goals such as optimizing route efficiency and reducing travel time. However, these systems often neglect critical safety protocols and risk mitigation strategies, creating a gap in the integration of safety-focused driving behaviors. This oversight has been linked to the rising number of traffic collisions, highlighting the need for better safety measures. To address these urgent issues, this research introduces an advanced and comprehensive framework for safety-critical autonomous navigation, applicable to both ground vehicles and aerial mobility platforms, such as flying cars equipped with cutting-edge vertical takeoff and landing (VTOL) technology, along with our innovative Risk-On Risk-Off (RORO) automatic stabilizer system. The proposed approach emphasizes rigorous safety assurance, real-time obstacle detection, adaptive control strategies, and resilient decision-making algorithms to ensure strong performance in complex, dynamic environments.

The proliferation of artificial intelligence (AI) models in autonomous driving systems has significantly advanced the capabilities of intelligent transportation infrastructures. These models facilitate vehicle control, navigation, and environment perception, contributing to safer and more efficient mobility solutions. However, despite remarkable progress, current AI-driven autonomous systems face critical challenges related to safety robustness, reliability in complex scenarios, and driver

engagement, which have culminated in a concerning rate of fatalities and injuries in autonomous accidents. This issue is especially pronounced in the context of autonomous operations, where high-stakes decision-making directly impacts human safety.

To mitigate these safety risks and enhance system resilience, this research proposes a sophisticated Risk-On-Risk-Off (RORO) modeling framework tailored for the emerging industry of piloted and autonomous flying cars, also known as Vertical Takeoff and Landing (VTOL) personal aerial vehicles. The RORO framework employs an adaptive risk management paradigm that integrates advanced probabilistic modeling, real-time sensor data fusion, and machine learning-driven hazard prediction algorithms. These components work synergistically to generate dynamic risk assessments, allowing the system to detect, evaluate, and respond to fluctuating operational hazards in real time.

The primary objective of this framework is to establish a robust safety assurance mechanism that dynamically adjusts to the complex, multi-dimensional risk landscape inherent to autonomous aerial mobility. By doing so, it aims to foster the development of secure, reliable, and scalable flying car systems that can seamlessly navigate urban environments, ensure passenger safety, and meet regulatory standards. Ultimately, this research seeks to contribute to the evolution of next-generation urban air mobility, supporting societal adoption of personal aerial vehicles and accelerating the transition towards a more interconnected, efficient, and sustainable safety system.

The Risk-On, Risk-Off (RORO) model offers a sophisticated framework for understanding the dynamic behavioral responses of various road users under different environmental and situational conditions. This model delineates the oscillation between high-risk (Risk-On) behaviors, characterized by aggressive or distracted actions, and low-risk (Risk-Off) behaviors, exemplified by cautious and compliant conduct. By elucidating the cyclical patterns inherent in decision-making processes, the (RORO) model facilitates the development of targeted interventions aimed at extending periods of Risk-Off behavior, thereby effectively mitigating the likelihood of Flying Car accidents. Incorporating the Risk-On, Risk-Off paradigm into comprehensive road safety strategies highlights the critical importance of behavioral modifications. When combined with engineering solutions—such as enhanced roadway design, aerial vehicle safety technologies, and robust policy measures—this approach offers a multidimensional pathway toward significantly reducing traffic-related injuries and fatalities in complex, high-density aerial vehicle transportation networks.

## II. METHODOLOGY

The proposed methodology utilizes an innovative Risk-On, Risk-Off (RORO) sensor framework, integrating cutting-edge sensor fusion technologies and sophisticated probabilistic risk assessment models. This system is designed to intelligently adapt air vehicular behavior by dynamically evaluating and responding to contextual risk variables in real-time. The paradigm represents a fundamental shift in automated mobility safety paradigms, aiming to substantially enhance the robustness and reliability of flying car operations. By seamlessly combining high-fidelity sensor data streams with advanced risk management algorithms, our approach seeks to optimize safety margins within complex, rapidly changing urban airspace environments, ultimately elevating the safety standards and operational resilience of autonomous aerial vehicles.

## III. LITERATURE REVIEW

Many studies [1][2][3][4] have shown that driving behaviors and states are often characterized by careless and emotion-driven deliberate conduct. These careless states are frequently prompted by various factors such as user sentiment, adverse weather conditions that impair visibility and infrastructural factors like road design or signage that influence driver behavior. Additionally, research [5][6][7][8] indicates that dangerous or risky behaviors tend to emerge in contexts where drivers perceive a lower threat level, which often leads to increased risk-taking actions such as speeding, aggressive driving, or distracted driving due to mobile device use or inattention. To better mitigate these behaviors, we explore the cyclical nature of road user decision-making processes, especially within the context of modern automation and vehicle control systems. Our development of the Risk On, Risk Off (RORO) Model incorporates automatic stabilizer interventions—such as adaptive cruise control, lane-keeping assist, and collision avoidance systems—that actively promote prolonged risk-off states, thereby reducing the likelihood of crashes. Ultimately, the integration of these Risk-On & Risk-Off dynamics in our safety strategies underscores the vital role of adaptive technologies, combined with engineering controls and automated safety interventions, to enhance safety not only in conventional vehicles but also in the emerging domain of aerial vehicles, including drones, cargo VTOL aircraft, and other autonomous aerial systems. These strategies are crucial as they help reduce traffic and aerial vehicle-related crashes and injuries, advancing the safety and efficiency of complex transportation ecosystems.

## IV. DISCUSSION

In real-world operational environments, particularly in emergency or unanticipated scenarios beyond standard system configurations, air vehicle malfunctions may manifest when specific functions are executed under adverse conditions. To mitigate such risks, we are deploying an advanced, dynamic safety framework termed the 'Risk-on Risk-off (RORO) aerial vehicles Sensor Model.' This model meticulously evaluates both anticipated and unforeseen operational contingencies,

enhancing overall safety reliability. Unlike traditional pipeline-based sensing systems positioned only on distance point to distance point. Our (RORO) model posit in longitudinally and laterally on aerial mobility platforms, this innovative approach incorporates a proximity alert mechanism optimized for complex navigational contexts. When an autonomous aerial vehicle or VTOL craft approaches within a predefined safety threshold, the proximity detection system activates the risk management protocol. The onboard sensors perform real-time analysis to determine if the intrusions pose a hazardous risk, thereby facilitating adaptive response strategies designed to safeguard the reliability of the aerial vehicle structure, its onboard systems, and passenger safety throughout dynamic conditions.

This Risk-On, Risk-Off (RORO) model is highly versatile and adaptable, making it not only suitable for any conditions but also effective in navigating unpredictable and unforeseen scenarios. For instance, in the context of advanced transportation technologies such as flying cars, this approach can be metaphorically applied to prevent mishaps or accidents, akin to avoiding traffic collisions in traditional vehicles. Its dynamic nature allows the automatic stabilizer to switch between safe mode and conservative stances, thereby optimizing safety and performance amid volatile environments.

Some may argue that this autonomous driving framework is not entirely fresh within the automotive industry, as traditional autonomous vehicle systems primarily emphasize efficient navigation to designated destinations. However, these conventional models often lack the sophistication to effectively handle spontaneous and unpredictable scenarios, such as sudden obstacles, erratic approaches by other vehicles, or imminent collision threats. In contrast, the proposed Risk-On, Risk-Off model offers a more comprehensive approach, extending its applicability beyond ground vehicles to include urban air mobility solutions, such as autonomous flying cars and aerial taxis. This advanced model integrates multi-modal sensor fusion, real-time environmental analytics, and adaptive decision-making algorithms to ensure safety, reliability, and operational robustness in complex and dynamic environments.

Our cutting-edge autonomous mobility platform is equipped with an array of 14 advanced sensor modules strategically distributed to ensure comprehensive environmental awareness and collision avoidance. Specifically, the system incorporates 4 high-resolution lidar sensors positioned at the dorsal (top) and ventral (bottom) aspects, along with 3 sophisticated ultrasonic or radar sensors mounted on each lateral side, facilitating 360-degree ground and obstacle detection. This sensor fusion provides real-time, high-fidelity perception of terrain topology, surrounding vehicles, and dynamic obstacles, enabling precise spatial analysis.

The system continuously monitors the proximity of surrounding flying vehicles and objects relative to our flying car, utilizing this data to maintain safe operational distances. When the risk assessment algorithms detect a potential collision imminent due to decreasing separation—approaching the set safety thresholds—the integrated risk detection protocol will be triggered. Subsequently, the proprietary "Risk-On, Risk-Off" (RORO) logic evaluates the severity and urgency of the threat,

computing a dynamic risk level based on factors such as relative velocity, trajectory, and environmental conditions.

When a high-risk situation is detected like overspeed or other urgent safety hazards our advanced autonomous "Risk Off" control will instantly override and initiate a series of automated risk mitigation actions. These procedures include issuing precise and timely alerts to the Flying Car vehicle driver and ground control, engaging multi-layered automatic collision avoidance maneuvers utilizing state-of-the-art sensor fusion and trajectory recalculations, and, when critical, executing comprehensive emergency protocol sequences. These sequences may incorporate controlled emergency landings, or evasive maneuvers designed to preserve passenger safety, and mission continuity. This sophisticated, multi-tiered safety architecture highlights our unwavering commitment to pioneering resilient autonomous urban air mobility solutions, ensuring operational safety, redundancy, and compliance with the highest standards of aviation safety management and risk mitigation in complex aerial environments.

Our (RORO) Model is built on a sophisticated probabilistic framework that serves as a foundational risk anchor for comprehensive evaluation of Flying Road Path Risk across a defined temporal horizon. The model utilizes a series of natural logarithmic transformations to accurately estimate the state level within a stratified analytical architecture, thereby enabling precise calculation of selection risk. Initially, the model establishes a steady-state baseline condition, representing the inherent risk levels present under normal operating circumstances. Subsequently, a dynamic trend component is incorporated to simulate potential evolutionary trajectories of risk in response to various influencing factors, allowing for systematic and adaptive risk assessment over time. To improve the robustness and predictive accuracy of the risk evaluation, the model implements a transition dynamic mechanism designed to reduce the likelihood of collisions and enhance safety margins. This risk management framework is inherently adaptable, demonstrating its applicability to emerging transportation modalities including, but not limited to, autonomous air vehicles and innovative urban air mobility solutions such as flying cars and personal aerial transport systems, which demand advanced, scalable risk modeling methodologies.

Likelihood of the Aerial Vehicle Crash Risk Anchor Formula

Absolute [Log (Expected Aerial Vehicle Crash Risk – Actual Aerial Vehicle Crash Risk/ Mean of Expected Aerial Vehicle Crash Risk\*100%)] Absolute

Safe	Tier 1
Non-Safe	Tier 2
Danger	Tier 3

Figure 1: The likelihood of the Flying Car Crash Risk Anchor in a Tiered Approach

Therefore, the Risk-off decision-making framework will systematically analyze both the anticipated (expected) and unanticipated (unexpected) scenarios by evaluating a range of variables and probabilistic outcomes. Subsequently, it will determine the optimal risk mitigation strategy, specifically tailored for various transportation modalities such as emerging

Flying Car systems. This process ensures a comprehensive assessment of potential risks and operational strategies within advanced, multimodal transportation networks.

*Suggestion:*

This cutting-edge autonomous safety protocol is a critical component of advanced vehicular technology, particularly for integrated flying car systems. It functions by continuously monitoring the proximity sensors and environmental data to assess collision risks. When the distance alarm system is activated indicating a potential obstacle or unsafe proximity the 'Risk-Off' system intelligently takes over control of the air vehicle's flight and navigation systems. This takeover is contingent upon a thorough situational assessment confirming that the maneuver can be executed safely without conflicting with other operational parameters. The system's design ensures seamless integration with various auxiliary driving and flight control modules, thereby enhancing overall safety, operational redundancy, and complex airborne and terrestrial environments.

Additionally, the Risk-On/Risk-Off (RORO) operational paradigm incorporates an advanced autonomous decelerating system. This system functions as an intelligent collision avoidance mechanism, utilizing real-time sensors and predictive analytics to detect potential threats from surrounding obstacles. When a potential collision risk is identified—such as an approaching vehicle encroaching into the flight path—the system proactively deploys automated braking to mitigate impact or avoid collision altogether. This sophisticated safety feature is seamlessly integrated into the vehicle's overall flight control architecture, embodying the Risk-On, Risk-Off (RORO) principle by activating specific safety protocols based on environmental risk valuation.

When the proximity detection system registers that another flying vehicle is encroaching within a dangerously close distance ahead, our Advanced Risk Management Protocol, integrated within the autonomous braking system of the flying car, will trigger a series of calibrated alerts. These alerts are part of a dynamic Risk-On/ Risk-Off operational model, designed to optimize safety responses. Upon detection of this imminent collision risk, the system autonomously engages the adaptive braking mechanism, deploying precise deceleration measures to mitigate potential collision severity and ensure safe separation distances are maintained, thereby significantly reducing the likelihood of an impact during high-speed or complex flying scenarios.

Our pioneering Risk-On, Risk-Off (RORO) sensor alert system is integrated with the advanced Risk-On, Risk-Off Methodology, which leverages cutting-edge sensor technology to continuously monitor the vehicle's proximity to surrounding objects. This system accurately detects the safety distance between vehicles, ensuring real-time assessment of risk levels. When the sensor detects a high-risk distance — indicating an urgent need for intervention — it triggers an immediate alert and transitions the vehicle into Safe operational modes. These modes dynamically adjust driving parameters to enhance safety and efficiency.

Furthermore, the system employs sophisticated algorithms to compute Expected and Observed event metrics, enabling a

comprehensive analysis of risk patterns. This data-driven approach facilitates rapid response adjustments, optimizing control strategies and maintaining optimal safety distances. By integrating real-time sensor data with adaptive control logic,

our innovation aims to elevate the safety, reliability, and autonomous capabilities of flying cars in complex airspace environments.

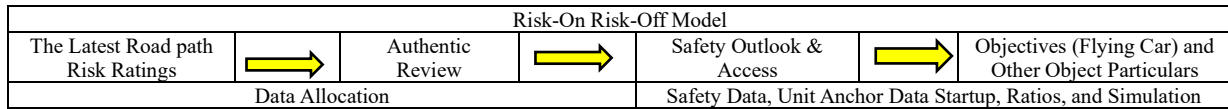


Figure 2: Framework in the Risk-On Risk-Off (RORO) Model

In the event that the opposing aircraft is positioned ahead of our air vehicle during flight, the onboard autonomous system—operating under the 'Risk On, Risk Off' mode—will initiate a series of safety protocols. This includes issuing alert signals to the pilot and engaging the automatic braking (deceleration) system. The system will continue to apply controlled deceleration until a predefined, secure separation distance from the leading aircraft is achieved, thereby ensuring collision avoidance and maintaining optimal flight safety margins.

*Our innovative model have several advantages:*

First, our sophisticated Risk-On, Risk-Off (RORO) model is engineered to deliver exceptional interoperability within the complex ecosystem of autonomous flying vehicles and advanced aerospace systems. This is achieved through the integration of industry-standard communication protocols, combined with an up-to-date, scalable architecture that accommodates the dynamic configurations of cutting-edge aerospace control modules. The model is designed to seamlessly interface with various sensor arrays and actuator modules that are essential to the operation of modern, intelligent aerial platforms. By leveraging these standardized interfaces, our (RORO) model enables real-time, high-fidelity risk detection and decision-making processes, ensuring the safety and reliability of both crewed and uncrewed flying vehicles across diverse operational environments. This robust interoperability supports scalable, flexible deployment in sophisticated aerospace applications, from urban air mobility solutions to long-range autonomous systems.

In addition, our sophisticated Risk-On, Risk-Off (RORO) sensor model leverages a cutting-edge, real-time analytical technique equipped with advanced machine learning algorithms and high-frequency data processing capabilities. This enables precise, instantaneous assessment of fluctuations along designated flying road paths, providing a granular, real-time-driven understanding. This technological augmentation elevates the strategic responsiveness, akin to a high-velocity, multi-dimensional corridor with precision and agility.

Moreover, our Risk-On, Risk-Off (RORO) strategy is engineered to be fully integrative and interoperable, enabling connectivity among a diverse array of auxiliary sensor systems. This modular architecture ensures comprehensive system cohesion, thereby eliminating potential operational conflicts and interference. By utilizing advanced communication protocols and standardized interfaces, the strategy facilitates efficient data exchange and real-time coordination across heterogeneous sensor platforms. This robust framework enhances the precision and responsiveness of risk assessment and mitigation processes, particularly within the complex,

multilayered environments of risk managing, ensuring the system's agility, resilience, and optimal performance in rapidly evolving threat landscapes.

Furthermore, our Risk-On, Risk-Off (RORO) paradigm presents a highly adaptable and comprehensive framework, capable of accommodating a wide spectrum of dynamic conditions. Unlike traditional models that primarily focus on distance-to-distance metrics, our approach integrates cutting-edge flying Road path risk assessment methodologies. These methodologies employ advanced statistical models, machine learning algorithms, and high-performance computational techniques rooted in the principles of road safety engineering. This integration enables a more nuanced and precise evaluation of risk, enhancing predictive robustness and accuracy across varied temporal horizons and complex regimes. Such sophisticated analytical capabilities position our framework at the forefront of quantitative risk management, facilitating more informed decision-making in the volatile landscape.

Our proprietary Innovation Risk-On, Risk-Off (RORO) model utilizes cutting-edge computational algorithms and sophisticated data processing methodologies designed for real-time monitoring and predictive analytics within environments. By integrating advanced machine learning techniques and high-frequency data streams, the system is capable of detecting early warning signs of potential system instability or operational anomalies with minimal latency, thereby enabling prompt intervention. Upon identification of a risk event, the model automatically initiates predefined suspension protocols and contingency measures to reduce risk, aligning with the highest standards within the innovative mobility landscape.

## V. CONCLUSION

The concepts of Risk-On, Risk-Off Sensor Model (RORO) are particularly pertinent when emerging and transformative transportation technologies, such as the development of autonomous flying vehicles and advanced air mobility safety systems highlight the vital importance of strategic road safety (airborne) risk management frameworks and extensive sentiment analysis in guiding the technological development and widespread adoption of innovative mobility solutions. The (RORO) architecture in these systems ensures highly reliable responses, supported by risk-avoidance features that improve resilience and continuity in complex, high-stakes environments. Additionally, this architecture meets strict industry standards for safety-critical systems. Deploying such integrated systems promises significant progress in urban air mobility, leading to safer, more efficient, and scalable transportation networks. It is hoped that this research will provide valuable insights into the

ongoing development of revolutionary transportation technologies, ultimately benefiting society and humanity.

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