Responsibility-Sensitive Safety (RSS):
Forging a Universal Definition for Autonomous Vehicle Safety

Autonomous vehicles (AVs) have life-saving potential. But without a verifiable way to demonstrate their ability to drive safely, these vehicles will never get a license to drive.

Driving safely – and a universal definition of what that means – is the final and most crucial hurdle standing in the way of our autonomous future. Technology leaders, automakers and government bodies must collaboratively establish a methodology and standard for the assessment and verification of an AV to drive safely and thus be worthy of a license to drive.

To this end, Intel has contributed an open, technology-neutral framework as a starting point for the industry to align on what it means for an AV to drive safely: Responsibility-Sensitive Safety (RSS).

What is Responsibility-Sensitive Safety (RSS)?

At its core, RSS defines what it means for a machine to drive safely with a set of logically provable rules and prescribed proper responses to dangerous situations. It formalizes human notions of safe driving in a set of mathematical formulas that are transparent and verifiable.

RSS is independent from the AV's planning and decision-making system and provides a "safety envelope" around the decision-making capabilities of the AV. RSS is designed to reject proposed actions that could lead to a dangerous situation and properly respond to unsafe actions by other road users.

Technology-Neutral

RSS is technology-neutral, in that it is compatible with any automated driving system allowing for consistency in safety. Much like the commercial aviation industry, consumers should trust the safety of automated driving regardless of the vehicle manufacturer. To establish an AV safety standard that can be adopted around the world, Intel is committed to collaborating with all stakeholders across industry, governments, non-government organizations, standards bodies and academia.

Enabling Useful Automated Vehicles

Because RSS operates as a separate layer from artificial intelligence-based decision-makers, it is designed to allow the AV to drive right up to a precisely defined line of safe but assertive maneuvers that help enable it to drive safely in the most challenging environments. This is in contrast to the conservative behavior of other automated vehicles that proceed so cautiously that other road users become frustrated. Because RSS is a model that can be used to deterministically define what is safe versus unsafe, this approach helps give AVs the ability to make assertive maneuvers more safely.

Going Beyond Miles-Driven

RSS enables safety testing that can be verified without millions of miles of driving. Statistical argumentation is a last resort to claim the safety of an AV when its creators have no ability to formally verify the safety of the design. Because RSS is a formal mathematical model, it can be proved correct so testing is needed only to ensure the implementation matches the specification, significantly reducing the validation burden.

Gaining Support for RSS

Since RSS was first proposed in 2017, Intel has engaged in dialogue with government regulatory agencies and technology pioneers around the world to gather feedback on the model. Its real-world effectiveness has also been demonstrated through its AV development fleet on the busy streets of Jerusalem.

Support for RSS is gaining global acceptance among industry peers and standards organizations that have applauded Intel for taking the first step towards a verifiable safety framework. Signaling widespread commitment to a safer autonomous future, the following companies and organizations have so far lent their support to the model.

- **Baidu**, the Chinese technology leader, adopted RSS as part of its Apollo autonomous driving platform, and in 2019 incorporated the world's first open-source implementation of RSS.
- **Valeo**, the European-based automotive supplier, is contributing to research of RSS as it collaborates on policies and technologies to enhance the adoption of AV safety standards across Europe, the U.S. and China.
- **China ITS Alliance**, the standards body under the China Ministry of Transportation, has approved a proposal to use RSS as the framework for its forthcoming AV safety standard.
- **RAND Corporation**, a leading think tank, cited RSS in a recent report as a leading measure that defines safety as an "envelope" around the AV – an important aspect for AVs to achieve "roadmanship."
- **Arizona Institute for Automated Mobility (IAM)**, a group established to explore and deliver AV safety, is using RSS as the foundation for its research and testing.

Improving Road Safety Today with RSS

In 2019, Intel proposed the use of RSS in advanced driver assistance systems to apply its transformative safety benefits to vehicles on the road today. Using the same safety principles, RSS can be used as a passive yet proactive safety mechanism that improves automatic emergency braking (AEB). Called automatic preventive braking, the application of RSS to traditional AEB systems would use formulas to determine the moment when a vehicle enters a dangerous situation and use subtle braking to help return the vehicle to a safer position without waiting for an imminent collision to engage. This preventive approach would engage in a passive fashion similar to electronic stability control, rather than waiting for sudden AEB to prevent a collision.

More information:
- [Responsibility Sensitive Safety (RSS)](#)
- [Vision Zero: on a Provable Method for Eliminating Roadway Accidents without Compromising Traffic Throughput](#)

RSS SAFETY PRINCIPLES

Safe Zone
RSS defines what constitutes a safe distance – longitudinally and laterally – around an AV, helping ensure it operates within a 'safe zone'.

Danger Threshold
The last moment in time before a dangerous situation has been triggered is defined by RSS as the "danger threshold." This is considered the moment where the AV would take an appropriate response to remove itself from the dangerous situation and restore safe distances between itself and other vehicles on the road.

Turning & Merging
When it comes time to turn or merge, an AV – just like a human driver – must thread the needle between the safe zone and danger threshold. RSS defines safe distances in terms of the amount of time it would take to respond when crossing a danger threshold to successfully avoid a collision.

Adjusting for the Environment
The variables within the formulas that make up RSS can be tuned and adjusted in accordance with specific situations, countries or operational domains to ensure acceptance from respective societies and regulators.

Right of Way
A key principle for RSS is that right of way is given, not taken.