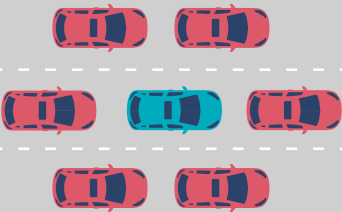
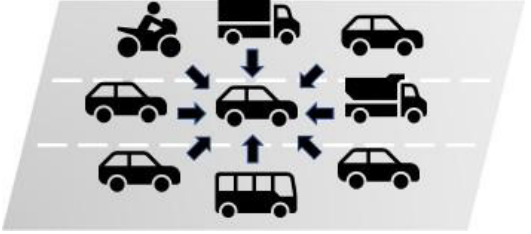
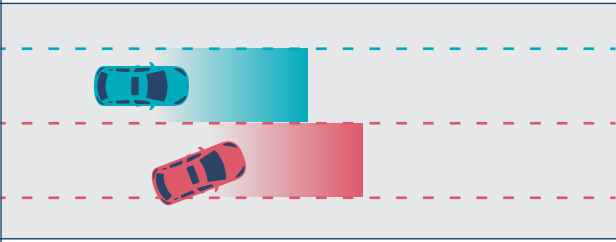
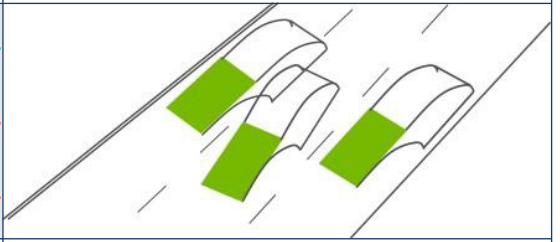
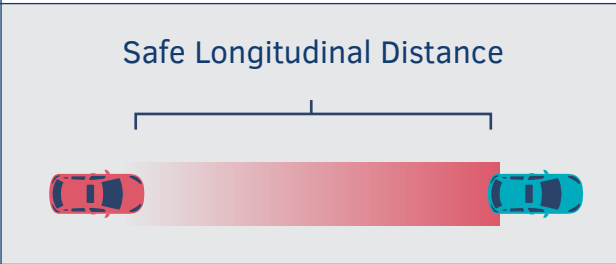
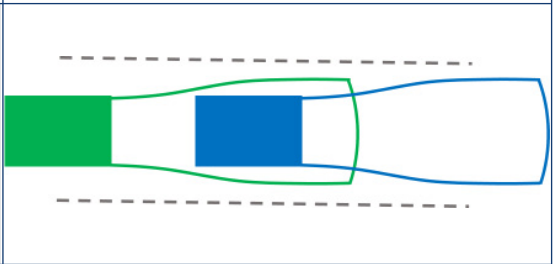
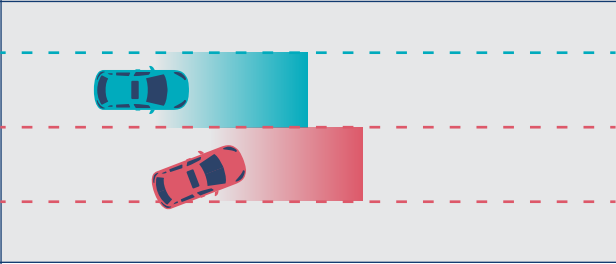
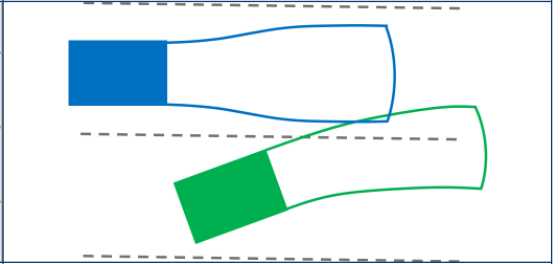


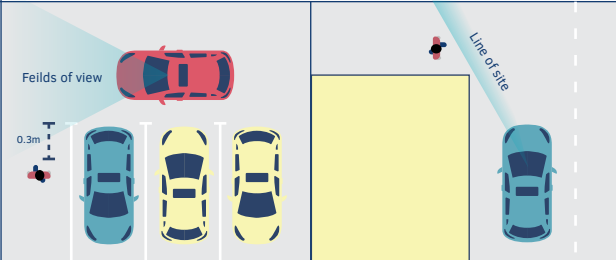
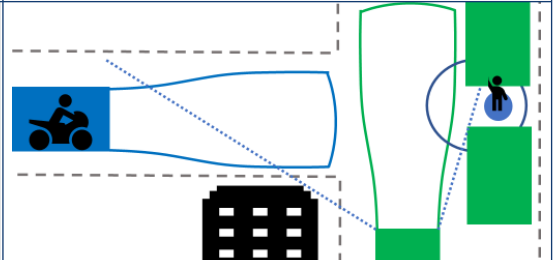
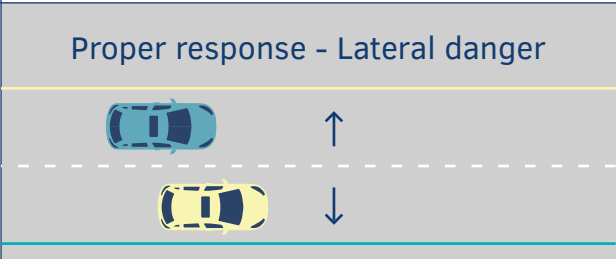
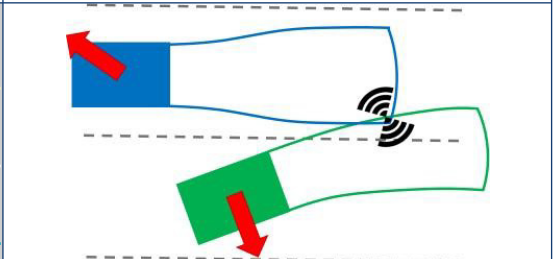
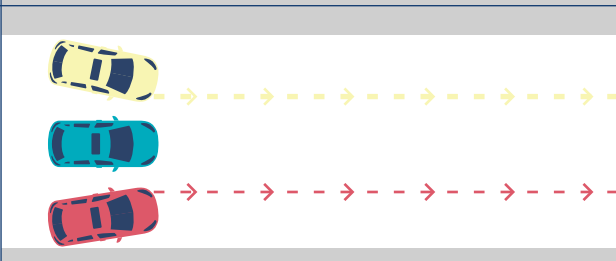
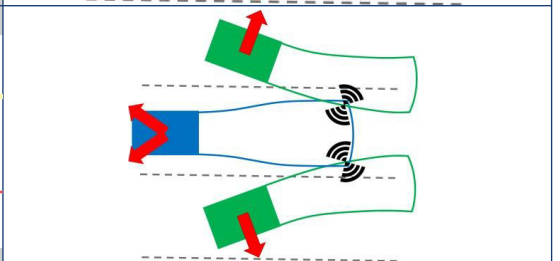
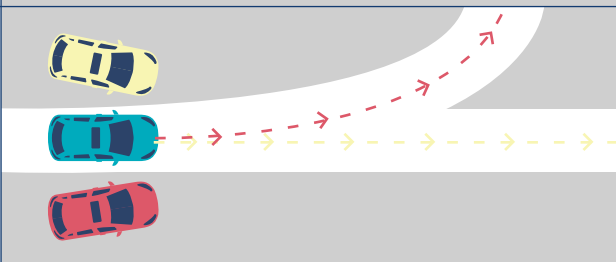
RSS Concept	RSS - Mobileye	SFF - Nvidia
Safety Goal	“Guaranteeing that an agent will never be involved in an accident is impossible. Hence, our ultimate goal is to guarantee that an agent will be careful enough so as it will never be the cause of an accident.”	“It is not possible to guarantee safety regardless of what the other actors do, but it is possible to guarantee that we do not contribute to an unsafe situation.”
Utopia	“if all agents follow RSS’s interpretation then there will be zero accidents.”	“If all actors in traffic had such a guarantee, no unsafe situations or collisions would occur.”
Usefulness	“the interpretation should lead to a useful driving policy, meaning it will lead to an agile driving policy rather than an overly-defensive driving which inevitably would confuse other human drivers and will block traffic and in turn limit the scalability of system deployment”	“The Safety Force Field achieves this guarantee while allowing normal everyday driving, even the kind of driving that is necessary in practice to, for example, make a lane change in congested traffic.”
Mathematical Proof	RSS’s mathematical proofs have been publicly published since the original 2017 paper.	“The guarantees it provides have been mathematically proven”
Absolute Safety	“Figure 1: The central car can do nothing to ensure absolute safety”	“Figure 5: Absolute safety is not possible with adverse other actors.”
Absolute Safety		
Absolute Safety	“every highway with more than 2 lanes will lead to [such a situation] and forbidding this scenario amounts to staying in the parking lot”	“unable to drive at speed on a congested highway due to the possibility that the other actors close in on us from all sides.”
Danger Threshold	“Definition 3 (Dangerous Longitudinal Situation and Danger Threshold) We say that time t is longitudinally dangerous for cars c_1 ; c_2 if the distance between them at time t is non safe...In particular, an accident can only happen at time t if it is longitudinally dangerous, and in that	“there is a critical moment when the safety procedures (claimed sets) of the two actors are just about to start overlapping. This is the moment when the sum of the stopping distances equals the distance between them, as illustrated in the figure below...”


	case we say that the longitudinally Danger Threshold of the accident is the longitudinally threshold time of t .”	At that moment, both actors will have to act, or a collision will occur.”
RSS Rule #1	RSS Rule 1: Do not hit someone from behind.	“we know that the lead car is required to stay ahead of the maximum deceleration profile, but no more, since common sense implies that if the lead car “is hit from behind, it is not at fault, nor can we reasonably require the lead car to not brake
Occlusions	“Figure 12: Illustration of the blame and exposure times.”	“Fig 16. Occlusion is handled by assuming invisible actors are present at blind corners and behind parked vehicles with reasonable velocity limits.”
Pedestrians	“The proper response rules for avoiding collisions involving pedestrians (or other road users) follow the same ideas described in previous subsections, except that we need to adjust the parameters in the definitions of safe distance and proper response”	“Fig 14. The Safety Force Field handles all types of actors - they just have different safety procedures.”
RSS Rule #3	“3. Right-of-way is given, not taken”	“Yielding: Right of Way is “Given, Not Taken”
Common Sense	“By and large, RSS is constructed by formalizing the following 5 “common sense” rules”	“Common sense: if you are about to crash into someone who has already obviously failed to yield, you would rather brake very hard to minimize damage than insist on your right to priority”
Safety vs. Usefulness	<p>The balancing act between safe & usefull</p>  <p>If we dont take this assertive, but reasonable action, we may never complete the merge</p>	“The Safety Force Field achieves this guarantee while allowing normal everyday driving, even the kind of driving that is necessary in practice to, for example, make a lane change in congested traffic.”

<p>Technology Neutral Layer</p>	<p>Where does RSS fit?</p>  <p>“Intel has proposed a technology neutral formalization of what it means to drive safely”</p>	<p>“The computation can be combined with any driving software as a layer in the motion planning that monitors and prevents unacceptable actions.”</p>
<p>Dangerous Situation</p>	<p>“[In RSS] time t is dangerous for cars c_1; c_2 if it is both longitudinally and laterally dangerous”</p>	<p>“[SFF] It considers longitudinal and lateral constraints together.”</p>
<p>Proper Response</p>	<p>Same as RSS’s rule that a “Basic Proper response to dangerous situations” must be performed.</p>	<p>“Actors in traffic should apply a safety procedure or equivalent action before it is too late.”</p>
<p>Proper Response</p>	<p>Same as RSS’s requirement to apply the Proper Response before the Danger Threshold.</p>	<p>“..is about to intersect with the vertical shapes of static obstacles, and apply the safety procedure just before that happens, at the latest.”</p>
<p>Inductive Proof / Utopia</p>	<p>“Our inductive proof shows that if a car responds properly to dangerous situations then it will not hit another car from behind”</p>	<p>“It should be immediately clear that if we are in a one-dimensional world between two obstacles, and we apply the safety procedure (stay within the dark green area) whenever it is about to touch one of the obstacles, we never hit any of them.”</p>
<p>Proper Response</p>	<p>Defined in RSS as min_brake</p>	<p>“decelerate at least as much as a certain schedule”</p>
<p>Proper Response</p>	<p>Defined in RSS as max_brake</p>	<p>“understand maximum braking amounts when following another vehicle</p>
<p>Reasonable Care</p>	<p>“if all agents adhere to the proper response rules as given in Definition 26, then no accidents will happen”</p>	<p>“The core concept throughout the entire theory is that all actors will be required to help avoid or minimize intersections of claimed sets”</p>

Dangerous Situation	Basically the same definition as a Dangerous Situation in RSS. “We say that time t is longitudinally dangerous for cars $c_1; c_2$ if the distance between them at time t is non safe”	“moment when the sum of the stopping distances equals the distance between them, as illustrated in the figure below”
Proper Response	Same as RSS’s requirement to apply the Proper Response before the Danger Threshold.	“both actors have to apply their safety procedures just before they are about to overlap.”
Proper Response	Same as RSS Definition 4 Proper Response	“both actors will have to act, or a collision will occur”
Dangerous Situation	Same as RSS Dangerous Situation	“avoiding intersection of the claimed sets”
RSS Rule #1	“if someone hits you from behind it is not your fault”	“if the lead car is hit from behind, it is not at fault”
Longitudinal Proper Response	Same as RSS: if the following car applies a proper response at the Danger Threshold, then there will be no collision.	“it can guarantee no collision by applying its safety procedure just before the front of its claimed set touches the back of the claimed set of the lead car”
Proper Response	“if a car responds properly to dangerous situations then it will not hit another car from behind” (Remark 3)”	“All actors are required to apply their safety procedure or take an action that is at least as good before and whenever their claimed sets intersect.”
Proper Response	“if c_r will...brake by at least $a_{min,brake}$ ”	“By applying their safety procedure, we mean that they decelerate at least by the safety braking profile.”
Proper Response	This is the definition of max, brake in RSS.	“It is also implicit that the actors will not brake harder than the maximum braking profile”
Inductive Proof	Exactly the same inductive proof in RSS. “..and we reached a contradiction. This completes the inductive argument.”	“The main result then follows from proof by contradiction. If claimed sets intersect, all actors already had started applying their safety procedures before that happened. When they did, the claimed sets did not grow after that, which leads to a contradiction.”

<p>Response Time</p>	<p>Captured in RSS's minimum distance formulas as p, for example: "$v_r \rho + 1/2 a_{max}; accel \rho^2$" from Lemma 2.</p>	<p>"This, for example, means that additional distance margin has to be required when following"</p>
<p>Lane Change</p>		
<p>Lateral Proper Response</p>	<p>Captured in RSS Definition 8 (Lateral Proper Response).</p>	<p>"braking to a stop for the lateral dimension boils down to bringing the lateral rate of change towards zero as expediently as possible." "The lateral part of the safety procedures is about bringing down the lateral rate of change"</p>
<p>Unstructured Roads</p>	<p>Same as RSS, which contains different Proper Responses for structured vs. unstructured: Definition 8 (Lateral Proper response) and Definition 22 (..Proper Response in Unstructured Roads)</p>	<p>"The Safety Force Field provides easy and seamless transition between unstructured and structured paths since the only change is in the definition of the safety procedure, and all other calculations proceed the same way."</p>
<p>Car Following</p>	<p>Safe Longitudinal Distance</p> 	
<p>Lane Change</p>		
<p>Pedestrians</p>	<p>"In some cases, a pedestrian's route is well defined...In other cases, like a typical residential street, we follow the approach we have taken for unstructured roads"</p>	<p>"For example, pedestrians and children in particular can change direction erratically, and move in less structured ways."</p>
<p>Cautiousness</p>	<p>"it follows that vehicles must yield and be cautious with respect to pedestrians"</p>	<p>"This can be used for cautious zone driving"</p>

<p>Pedestrians</p>	<p>Given by example in RSS: “For example, setting a delay of 500 ms, and maximal acceleration and braking of 2 m/s^2”</p>	<p>“Safety in this case comes from the reasonable limits on how fast the pedestrian is capable of moving.”</p>
<p>Exposure Time</p>	<p>Definition 23 (Exposure Time). The Exposure Time of an object is the first time in which we can see it (meaning that nothing blocks visibility along the line from the object to the ego vehicle).</p>	<p>“Visibility is also taken into account.”</p>
<p>Occlusions</p>		
<p>Occlusions</p>	<p>Same as Definition 24 (Unreasonable Situation due to Unreasonable Speed)”</p>	<p>“Occlusion is handled by assuming invisible actors are present at blind corners and behind parked vehicles with reasonable velocity limits.”</p>
<p>Proper Response</p>	<p>Proper response - Lateral danger</p> 	
<p>Proper Response, Same geometry</p>		
<p>Proper Response, Multiple Geometry</p>		<p>“note that if the safety procedure is structured by the road, the road shape breaks the tie for the choice of lateral course”</p>
<p>Dangerous Situation</p>	<p>Same as RSS. Claimed Set is the same as Dangerous Situation, and RSS will not allow an AV on its own to take an action that will create or contribute to a Dangerous Situation.</p>	<p>“If the following vehicle continues at the same velocity it contributes to pushing the claimed set into the other, and it is worse than the safety procedure, so is not allowed.”</p>

Proper Response	Same as RSS: Cars in a Dangerous Situation must perform a Proper Response, such as brake by at least min_brake .	“do at least as well as the safety procedure whenever claimed sets intersect”
RSS Rule #3	“Right of Way is Given, Not Taken”	“if another actor has failed to give way, we cannot try to take it.”
Ordering	Same as RSS, where “who is in front” determines who should respond. Per Definition 16 (Longitudinal Ordering for Two Routes of Different Geometry)	“our responsibility to yield turns into the common sense that if we are ahead, it is the responsibility of the other traffic to slow down”
Assumptions on others	<div style="text-align: center;"> <p>Safe Distance- Longitudinal</p>  $d_{min} = \left[v_r \rho + \frac{1}{2} a_{max,accel} \rho^2 + \frac{(v_r + \rho a_{max,accel})^2}{2 a_{min,brake}} - \frac{v_f^2}{2 a_{max,brake}} \right]_+$ <p> $a_{max,accel}$ Max acceleration during response time for c_r $a_{max,brake}$ Max braking applied by c_f </p> </div> <p>”not physical limits, but upper bounds on reasonable behavior”</p>	“We also have to define what is reasonable to expect regarding acceleration of any actor”
Response Time	Defined in RSS as Response Time.	“An actor with high latency will have to send their braking commands sooner relative to the sensor data they observe compared to an actor that can sense and turn around ultra-quickly to actuate braking’
Vision Zero jerk-bounded braking profile	“The idea is that we start decreasing our acceleration linearly (with slope $jmax$), until reaching a max brake parameter (denoted $amin,brake$), and then we continue to brake with a constant deceleration until reaching zero velocity.”	“It is possible to make the safety potential smooth and to make sure that it rejects intersections before they actually happen by making a smooth but tight bump function that rises right before overlap occurs”
Proper Response	Same as in RSS where all agents must perform the proper response.	“Our main principle is that each actor should do at least as well as the safety procedure.”
Utopia	“Corollary 2 (Utopia is possible) If all road agents comply with the proper response rules given in Definition 26 then no collisions can occur”	“That is how the main result is achieved that if the definitions are followed by all, there will be no collisions”

Induction	Same as RSS's inductive proof.	"Since all actors are required to apply the safety procedure before an intersection of claimed sets happen, it follows by contradiction that an intersection can never occur."
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