HEXAGON

Brochure

MSC Autonomous vehicle

Modeling and simulation services

How many miles of driving will it take you to demonstrate that your Autonomous vehicle is reliable?

Autonomous vehicles need to have a comprehensive understanding of their environment to drive safely and reliably. As automotive and truck OEMs and their suppliers rush to deliver highly automated vehicles, it has become clear that physical testing can never be enough to deal with all the dangerous conditions that may arise. Thus, a massive amount of virtual simulation must be performed to support the commercialization of autonomous vehicle technology.

To demonstrate with 95% confidence that an autonomous vehicle's failure rate is lower than the human driver failure rate, 11 billion miles will need to be driven. This validation effort would take 500 years to complete (leveraging a fleet of 100 autonomous vehicles, driving 24 hours a day, 365 days per year.) From this, it is clear that virtual testing must supplement physical testing and be constantly iterated to gain sufficient confidence in the operational safety of autonomous vehicles.

To accelerate the development and continuous extension of your virtual test environment, MSC offers virtual environment modeling services. These services include 3d scene modeling, sensor model design, implementation, and verification, scenario development & execution and custom reporting.

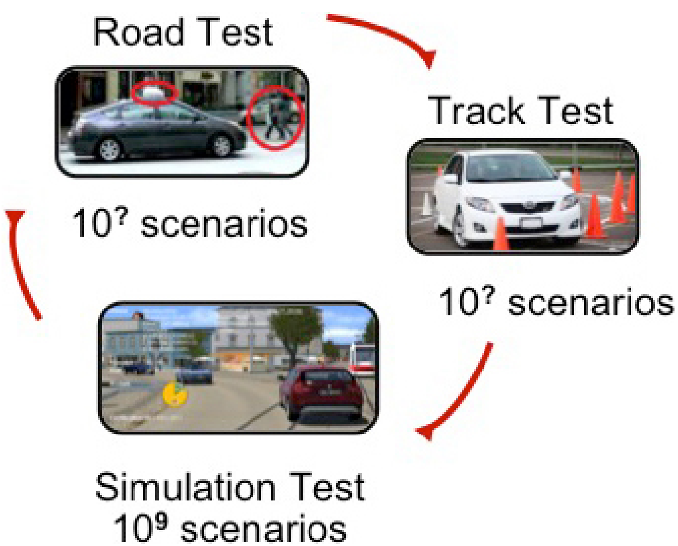
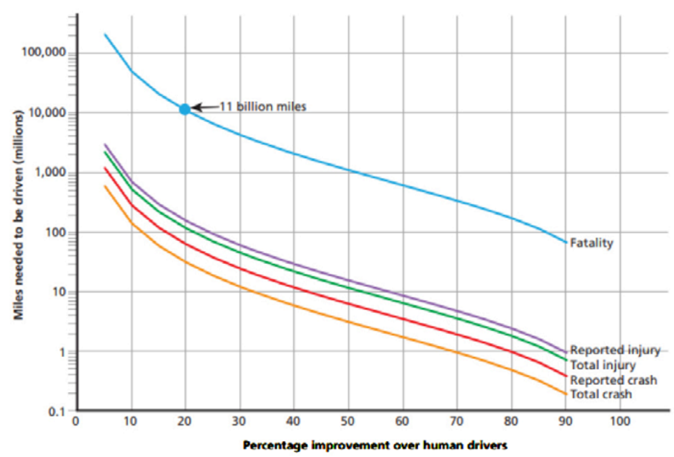


Figure 4. Miles Needed to Demonstrate with 95% Confidence and 80% Power that the Autonomous Vehicle Failure Rate Is Lower than the Human Driver Failure Rate



SOURCE: Authors' analysis.
NOTE: The results depend upon the estimated failure rate of autonomous vehicles. This is shown on the horizontal axis and defined as a percent improvement over the human driver failure rate. The comparison can be made to the human driver fatality rate (blue line), reported injury rate (purple line), estimated total injury rate (green line), reported crash rate (red line), and estimated total crash rate (orange line).
RAND RR1478-4

3D Scene modeling:

Rapidly create realistic environments (city streets to private test tracks) to test sensor locations and perception capabilities, autonomous vehicle control strategies, the effects of weather & lighting and many others. These environments can include:

- Map data - Detailed map data (e.g. derived from OpenStreetMap (OSM)) which can be at a road, town, city or country level (supports OpenDRIVE)
- Road or Street Furniture - Traffic control equipment including signs, signals, lights, guardrails, complex roadmarks, overpasses, bicycle lanes, etc.
- Road Surfaces - Concrete, asphalt, cobblestone, etc. (supports OpenCRG)

Sensor building:

From RADARs, to cameras, to ultrasonic to LiDARs, a host of standard and unique sensors can be modeled and incorporated in the virtual environment. The performance of these sensors can be evaluated based on off-the-shelf performance, or parameterized to evaluate sensor performance under unique conditions (angle, width, beam quantity, scan speed, signal processing, etc.)

Users may extend and customize the models further using the same SDK capabilities that are the basis for the original sensor model implementation.

Scenario development an execution:

In order to test the myriad of potential locations, conditions and situations that an autonomous vehicle will face, driving scenarios can be developed. These can range from tests based on government standards to unique scenarios that are too dangerous to test physically, but must be tested in order to ensure the highest level of safety. Each scenario is built to exacting specifications – to match the real world as closely as possible. Furthermore, custom actors and/or situations can be overlaid to produce unique test scenarios intended to validate algorithm performance and robustness under a variety of conditions.

Based on the standard and custom scenarios created millions of permutations can be derived and executed by leveraging the MSC tool chain - including an Artificial Intelligence (AI) Driver (software that requires training through virtual and physical testing.)

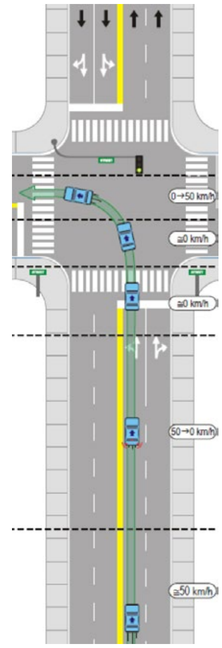
Run-time variant features that may be part of a scenario include:

- Moving objects - pedestrians, cyclists, animals, etc.
- Traffic - controlled and random
- Environmental conditions
- Lighting conditions - including day, night, tunnel and underground lighting conditions
- Weather conditions - sun, fog, rain, snow, sleet, etc.
- Driver models and driver parameterization.

Scenarios will be provided in OpenSCENARIO format.

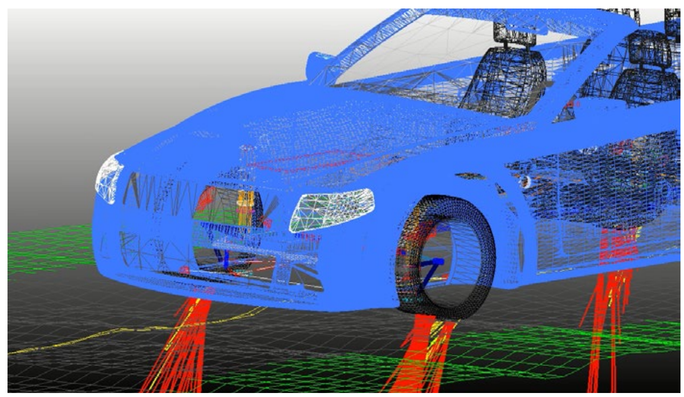
Data filtering and analysis:

As with physical testing, millions of miles of virtual testing generates a substantial volume of data for post-processing and analysis. Leveraging MSC tools, safety indicator reports can be quickly created to synthesize results to help engineers assess performance during each event.



Effects of vehicle dynamics:

Critical to achieving a high and reliable safety quotient is the incorporation of an accurate vehicle dynamics model into the driving scenarios. With MSC's comprehensive tool chain, this requirement can easily be met.



Physical to virtual correlation:

Leveraging the tools above, MSC can merge the physical and virtual worlds to enhance confidence. Using customer supplied data from physical testing coupled with results from virtual testing, validation metrics can be developed to quantify the accuracy and performance of either the virtual environment or vehicle control algorithm(s). Leveraging these metrics optimization strategies can be overlaid continuing to drive improvements in performance.

Table 1. Examples of Miles and Years Needed to Demonstrate Autonomous Vehicle Reliability

		Benchmark Failure Rate		
	How many miles (years*) would autonomous vehicles have to be driven...	**(A) 1.09 fatalities per 100 million miles?**	**(B) 77 reported injuries per 100 million miles?**	**(C) 190 reported crashes per 100 million miles?**
Statistical Question	(1) without failure to demonstrate with 95% confidence that their failure rate is at most...	275 million miles (12.5 years)	3.9 million miles (2 months)	1.6 million miles (1 month)
	(2) to demonstrate with 95% confidence their failure rate to within 20% of the true rate of...	8.8 billion miles (400 years)	125 million miles (5.7 years)	51 million miles (2.3 years)
	(3) to demonstrate with 95% confidence and 80% power that their failure rate is 20% better than the human driver failure rate of...	11 billion miles (500 years)	161 million miles (7.3 years)	65 million miles (3 years)

* We assess the time it would take to compete the requisite miles with a fleet of 100 autonomous vehicles (larger than any known existing fleet) driving 24 hours a day, 365 days a year, at an average speed of 25 miles per hour.

Source: Driving to Safety by RAND

HEXAGON

Hexagon is a global leader in digital reality solutions, combining sensor, software and autonomous technologies. We are putting data to work to boost efficiency, productivity, quality and safety across industrial, manufacturing, infrastructure, public sector, and mobility applications.

Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon's Manufacturing Intelligence division provides solutions that use data from design and engineering, production and metrology to make manufacturing smarter. For more information, visit hexagonmi.com.

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