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Advancing the Use of Simulation in ADS Safety Assurance

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Executive Summary

The rapid development of automated driving systems (ADS) holds potential for increased safety, mobility, accessibility, and efficiency. However, realizing these benefits requires responsible deployment of the technology, with safety as the primary consideration. This includes safe testing of these vehicles, where simulation plays a crucial role.

On-road testing of ADS presents significant safety risks. Many stakeholders believe that simulation methods should play a larger role in developing the ADS safety case. Simulation offers several advantages, including cost-effectiveness, safety, and scalability. However, there is reluctance to use simulation for safety assurance due to concerns about the quality of inputs and the proprietary nature of ADS.

MITRE's Digital Proving Ground (DPG) is a solution that addresses these challenges. DPG is a secure, accessible virtual test environment developed using open, industry-standard practices. It allows users to test their ADS in a variety of scenarios and offers unique efficiencies by providing a common resource and community of practice.

Despite sharing features with other simulation test environments, DPG's openness and accessibility set it apart. It also lowers barriers to ADS entry by democratizing access to startups, sub-system developers, and researchers.

DPG can safely accelerate ADS deployment by reducing safety risk for all stakeholders. It allows for thorough testing and analysis under specific or generic conditions, demonstrating safety performance while protecting intellectual property.

MITRE envisions DPG as a national resource for ADS testing, accessible to all stakeholders. As a trusted third party, MITRE has a long history of securing and analyzing sensitive transportation data. Together, we can accelerate the safe deployment and acceptance of ADS, maintaining U.S. leadership in this transformative technology.

Introduction

We are experiencing a remarkable time in the history of transportation. Advances in technology are transforming our vision of mobility and what we, as a society, demand of our transportation system. Concepts once thought of as futuristic are bursting onto the scene every day. Among the most intriguing of these is the development of automated driving systems (ADS) for motor vehicles. While ADS hold tremendous potential to increase safety, mobility, accessibility, and efficiency, realizing these societal benefits will hinge on responsible deployment of the technology. We can shape that safe, reliable, accessible future if we make safety the first consideration at every decision point. That includes ensuring safety during the testing of these vehicles, where simulation will have an increasingly important role to play.

The Challenge of ADS Safety Assurance

Industry and federal, state, and local government have critically important roles that can be especially challenging to coordinate. For example, while a comprehensive, final set of ADS safety standards and regulations may be years away, more and more developers are advancing their safety assurance programs into on-road testing phases under a regime of different government requirements.

On-road testing of ADS is a high-consequence endeavor. The passengers in ADS-equipped vehicles, as well as other users of the roadways, including occupants of other vehicles and vulnerable road users such as bicyclists and pedestrians, are all exposed to ADS testing safety risk. Recent incidents in several on-road testing programs illustrate the challenges and risks of achieving safety assurance with this approach, leading developers and regulators to abruptly restrict or terminate on-road testing operations.

Many industry, research, and government stakeholders believe simulation methods need to play a larger role toward developing the ADS safety case.[1] Chief among these are virtual test simulations that supplement physical road, track, and laboratory testing.

Simulation has many advantageous attributes that make it particularly attractive to ADS safety assurance. It can be cost effective in testing the multitude of scenarios and millions of miles[2] of exposure necessary for safety assurance purposes, and it can eliminate the safety risk associated with that testing. In fact, simulation can conduct test scenarios too risky or complicated to consider in the real world. Simulations can also be executed “at computer speed,” and they are easily scalable and elastic, all of which contributes to accelerating testing

[1] UL 4600: Standard for Evaluation of Autonomous Products, Underwriters’ Laboratories, Standard for Safety, 2020, https://ul.org/UL4600

[2] Kalra, Nidhi, and Susan M. Paddock, Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability? Santa Monica, CA: RAND Corporation, 2016, https://www.rand.org/pubs/research_reports/RR1478.html

and analysis. Additionally, simulation is more repeatable and controllable than physical testing, which facilitates the comparison and measurement of safety metrics and test requirements.[3]

Despite these advantages, there is reluctance to use simulation for safety assurance, particularly when regulatory interests are involved. Simulation results are only as good as the quality, thoroughness, and validity of the inputs. Resulting output can be unusable for safety assurance purposes for a variety of reasons, including invalidated physical behavior; overly simplistic, unrealistic, or inadequate test scenarios; and incomplete testing of the Operational Design Domain (ODD), such as environmental and operational parameters.

Then, there is the issue of trust. Because of the highly proprietary nature of ADS and the tools and methods used to create and test them, they are protected by restricted access, which makes it difficult to objectively assess and independently verify the factors mentioned above. Therefore, to bring to bear the incredible advantages of simulation to accelerate ADS safety assurance, a new approach to the use of simulation is needed.

An Open Access Simulation Environment for Safe and Secure Safety Assurance Testing

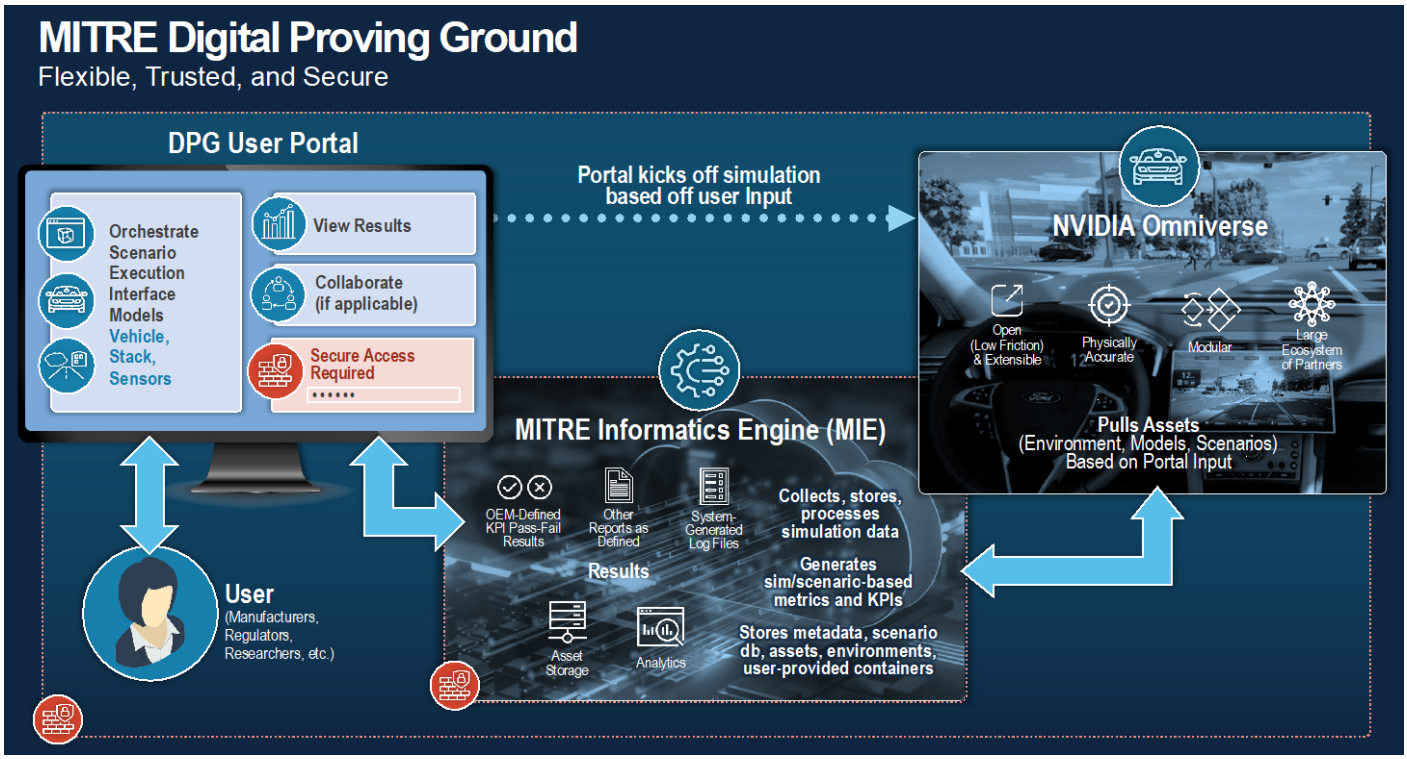
MITRE's Digital Proving Ground (DPG) is a game-changing solution that addresses the current challenges of simulation testing. DPG is a securely managed virtual test environment tailored for ADS safety assurance applications, developed using open, industry standard practices. DPG is validated, traceable, and accessible to all developers, operators, and regulators.

In many ways, DPG is the virtual analog to physical test tracks. It gives users the ability to test their ADS in a wide variety of environmental and operational scenarios across their ODD.

The DPG enterprise consists of three parts: A *Secure User Portal* for controlled access to the environment manages accounts, with provisioned user workspace to develop and submit jobs, and to facilitate information and results sharing within and outside the DPG. The *MITRE Informatics Engine* houses both user-developed and native digital assets. It operates on the simulation data output to generate key safety performance indicators, analytics, and data logs. The third component of DPG, the *Simulation Environment*, is built using Modular Open Systems Approach[4] principles for compatibility Scene Description (USD) application. It is

[3] Automated Vehicle Safety Consortium Best Practice for Metrics and Methods for Assessing Safety Performance of Automated Driving Systems (ADS), AVSC0006202103, March 2021

[4] Title 10 U.S.C. 2446a.(b), Sec 805, Modular Open Systems Approach (MOSA)



DPG consists of three elements: the User Portal, MITRE Informatics Engine, and the Simulation Environment (powered by NVIDIA Omniverse).

built upon NVIDIA's Omniverse[5] platform to execute the ADS tests.

DPG allows users to develop their own simulation test programs, which can take a multitude of forms and serve a variety of purposes. For instance, users can study technologies and sensors at a sub-system level, conduct incident reconstruction, test scenarios to prepare for on-road testing programs, benchmark their results against standard test scenarios, and more. The output data and analytic results can be configured to meet users' needs.

While DPG has many features common to other simulation test environments across the industry, its openness and accessibility make it unique. It also provides unique efficiencies. Because DPG offers a common resource and community of practice, users can focus time and resources on their specific safety and development interests, while avoiding costly and duplicative efforts developing and maintaining their individually owned simulation environments. Economies are also realized by the availability and reuse of scenario databases and other digital assets (e.g., coded traffic laws, lessons learned, best practices) that grow richer with time. By democratizing access to startups, sub-system developers, and researchers—who may not have the financial means to develop their own testing environments—DPG offers the added benefit of lowering the barriers to ADS entry.

[5] NVIDIA Omniverse™ is a computing platform that enables individuals and teams to develop USD-based 3D workflows and applications.

MITRE believes DPG can safely accelerate ADS deployment by reducing safety risk for all stakeholders. Countless miles and driving scenarios that accurately reflect real-world driving conditions can be tested without exposing the public to the safety risk of on-road testing. ADS performance can be analyzed, lessons can be learned, and design improvements can be made, safely and efficiently. Most importantly, this cycle of testing, analysis, and refinement—under specific or generic conditions—can be thoroughly and objectively demonstrated to other stakeholders. For instance, consider situations where a public authority is considering ADS operation within its jurisdiction. The developer/operator could test its ADS in DPG, using a digital twin of the actual geographic locations and in various traffic and environmental conditions jointly agreed to between the parties. MITRE's management of these tests and results can then enable secure sharing of results between the developer/operator and municipality, and objectively demonstrate the safety performance of the ADS, all while protecting intellectual property. Similar safety benefits are achieved when applied to active on-road testing programs. DPG gives users and authorities the ability to reconstruct and recreate incidents or close calls that occur during testing, so that a full understanding of the circumstances and safety implications can be obtained, forming the factual basis for subsequent testing decisions.

Moving Forward

MITRE's vision is for DPG to be a national resource for ADS testing, accessible to all developers, operators, and government officials who have a stake in ADS safety assurance. For safety's sake, we must break from the current paradigm of over-reliance on physical testing for safety assurance, and more swiftly embrace the benefits and increase our use of simulation as a key component in that process. DPG is an innovative means to do just that.

As a not-for-profit trusted third party to both the federal government and U.S. industry, MITRE has a long history of gathering, securing, and analyzing sensitive transportation data[6] and managing public-private partnerships.[7] Our many years of experience in this trusted role lend credibility to the results the DPG generates.

Together, we can accelerate the safe deployment and acceptance of ADS into our nation's transportation system. In doing so, we can maintain U.S. leadership in this transformative technology. But the time is now. There is an urgency for such a national simulation resource to be widely accessed by industry and government. MITRE's corporate mission to "solve problems for a safer world" emphasizes our commitment to ADS safety, and we enthusiastically join industry and government in that pursuit.

[6] Aviation Safety Information Analysis and Sharing, https://www.mitre.org/news-insights/impact-story/pioneering-partnership-celebrates-15-years-advancing-aviation-safety

[7] Partnership for Analytics Research in Traffic Safety, https://www.nhtsa.gov/parts-partnership-for-analytics-research-in-traffic-safety

About the Author

Joseph M. Kolly, Ph.D., is the director of the Integrated Systems Innovation Center, overseeing MITRE's multimodal transportation research portfolio and the work of several transportation-related departments and laboratories, including MITRE's Driver Research for Intelligent Vehicles and Environments (DRIVE) laboratory. Prior to MITRE, he was the inaugural chief safety scientist at the National Highway Traffic Safety Administration (NHTSA), focusing on automated vehicles and safety data analysis, and spent 18 years at the National Transportation Safety Board (NTSB), eventually becoming the director of the Office of Research and Engineering. Before NTSB, he was a senior research scientist at Calspan/University at Buffalo Research Center. He holds a Ph.D. and a B.S. in mechanical engineering from the State University of New York at Buffalo and Binghamton, respectively.

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