WHY SIMULATION IS CRITICAL TO SUCCESS IN DEVELOPING AUTONOMOUS SYSTEMS

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Report Highlights

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The challenge of autonomous systems is their complexity, according to 37% of respondents.

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To cope with this complexity, simulation usage among the Best-in-Class has soared, rising from 75% to 87% from 2014 to 2016.

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Best-in-Class firms were 56% more likely to meet their product launch goals than All Others.

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Best-in-Class firms were 25% more likely to hit product quality targets upon design release than All Others.

Autonomous cars, drones and robots: The vast life-changing potential of these devices is enormous, but only if we can overcome the intractable challenges of designing such smart, connected devices. This report explores how simulation makes the design and testing of such devices a reality.

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AUTONOMOUS VEHICLES:
Road vehicles that can drive themselves from one point to another using lasers, radars, and cameras, as well as software, map data, GPS and wireless data communications with other vehicles or infrastructure devices.

DRONES:
Commercial quad- or octo-copters, military unmanned aerial vehicles (UAVs) and other such drones, are capable of fully autonomous flight, incorporating a bundle of GPS technology, radar and laser sensors, and navigation agents that guide the vehicle.

ROBOTS:
Smart appliances, such as robotic vacuum cleaners, robotic lawn mowers and warehouse robots, are autonomous robots that simplify everyday life for the ordinary consumer and expedite complex industrial tasks.

Autonomous systems independently operate with contextual awareness of their surroundings and artificial intelligence. These capabilities allow them to function autonomously, making decisions based on sensor perception and mission objectives defined by onboard software. Examples of these “intelligent machines” are autonomous vehicles, drones (unmanned aerial vehicles), robots (smart appliances), autonomous ships, extraterrestrial rovers, and so on.

Developing autonomous systems is a challenge without precedence. Whole new engineering fields — such as artificial intelligence (AI) — need to be developed, yet time-to-market is short and competition is intense. For instance, billions of miles of road testing will be necessary to ensure the safety and reliability of autonomous vehicles. This seemingly impossible task can only be accomplished with the help of engineering simulation. With simulation, thousands, or millions, of operating scenarios and design parameters, can be virtually tested with precision, speed and cost economy.

Complexity Is Growing Rapidly

The challenge in developing autonomous systems is their inherent complexity (Figure 1, next page). These products operate in varying and complex environments, and must perform long, complicated missions without any human supervision. Design flaws are not acceptable, as a misstep can be catastrophic, resulting in injury, loss of life, expensive maintenance issues or product recalls. Many autonomous systems are consumer-oriented products, where continual innovation and product differentiation are de rigueur, yet development resources are limited. Against a backdrop of shortened product development cycles, consumers want more “smart” functionality, less environmental impact and greater economic appeal.

PRODUCTS ARE ONLY BECOMING MORE COMPLEX

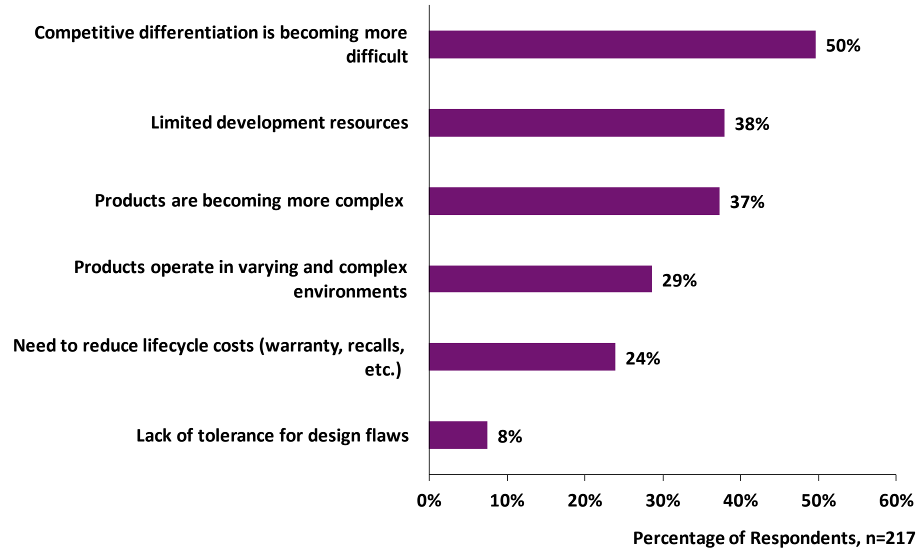
Past Two Years

Number of Mechanical Components:
14% increase

Lines of Software Code of Mechanical Components:
34% increase

Number of Mechanical Components:
21% increase

Figure 1: Top Autonomous Systems Challenges



Source: Aberdeen Group, June 2017

New product development is the engine that fuels growth. In fact, over a third of a typical company's total revenue is attributed to new products. However, bringing products with autonomous systems to market is no easy task. Delivering products with high profit margins and high-quality targets — all under short timelines — leaves developers little room for error.

Safety and reliability of autonomous systems are a major concern. An inaccurate sensor, a software bug, or a malfunctioning actuator on these intelligent machines, can easily cause expensive equipment failure, unintended human injuries or fatalities, and mission failures. Therefore, the electronics, software and hardware in these machines must be thoroughly tested during the engineering design process, through simulation, to ensure safety and reliability.

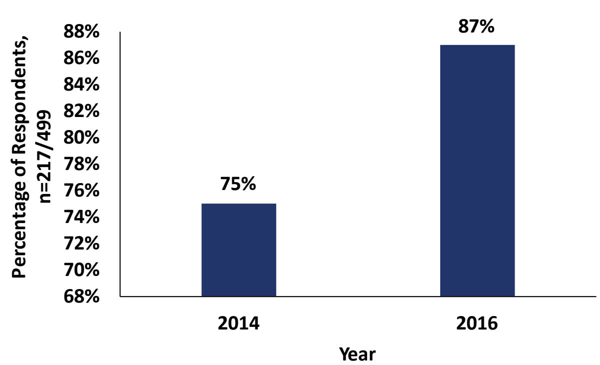
Defining the Best-in-Class

To identify best practices for developing products with autonomous systems, Aberdeen measured survey participants by their ability to meet product goals and overall profit margins on new products. (Participants were engineering executives from companies across all major industries.) Aberdeen categorized participants as Best-in-Class (top 20% of aggregate performers based on YOY decrease in development time; YOY increase in number of completed prototypes; and YOY change in engineering change orders after release to manufacturing) or All Others (bottom 80% of aggregate performers).

Aberdeen finds that the Best-in-Class companies clearly have much tighter control over their new product development and introduction. Even in the face of rising complexity and limited resources, these companies are able to deliver low-cost, quality products on time. When those targets are met, Best-in-Class companies more than double their increase in profit margins.

Because of how critical simulation is in developing products with autonomous systems, simulation usage has soared among the Best-in-Class.

Figure 2: Simulation Usage Soars Among the Best-in-Class



Source: Aberdeen Group, June 2017

The Power of Simulating Autonomous Systems

Virtual simulation is the simulation, or analysis, of a product's behavior in a virtual environment and is performed with digital prototypes. Best-in-Class companies are 53% more likely than their peers to conduct simulations and product scenario testing in this virtual environment.

The power of simulation software in autonomous system design is clear when examining the performance metrics of simulation users versus those who do not use simulation. And while the push to more innovative and complex designs helps to differentiate products from competitors, it means designers are forced to make trade-offs between speed, cost and quality. Simulation allows designers to make better decisions more quickly, ultimately leading to business successes.

Table 1: The Benefits of Simulation Cannot Be Overlooked

	Best-in-Class	All Others
Product Launch Dates Met	89%	57%
Product Cost Targets Met	88%	58%
Quality Targets Hit at Design Release	91%	73%
Product Revenue Targets Met	88%	60%
Profit Margin on New Products	13%	5%

In a competitive autonomous systems environment where the pressure to innovate is relentless, simulation platforms with virtual product testing capabilities help to shorten time-to-market, cut cost, and boost quality.

Applying Simulation to Accelerate Autonomous Systems Development

Autonomous systems have two things in common: They are machines that move, and machines that incorporate artificial intelligence (AI) created with neural networks and machine learning. They make their own independent decisions and move about autonomously. The problem is that it is impossible to develop the highly sophisticated “machine perception” needed for autonomous operation with traditional, rule-based algorithms. Therefore, artificially intelligent machines are trained, rather than programmed. Since these machines make sophisticated decisions in highly complex environments, the number of use cases and scenarios that must be trained and tested for is prohibitively enormous. This seemingly impossible task can only be accomplished with the speed and cost economy of engineering simulation.

Engineering simulation accelerates autonomous systems development in six areas:

- **Mission Scenario System Simulation.** Simulates mission scenarios with detailed physics. Virtually tests control algorithms, sensor accuracy and motion dynamics.

- **Sensor Performance Simulation.** Accurately models radars, wireless communications, GPS antennas, and ultrasonic and other sensors with high fidelity physics.

- **Software and Algorithm Modeling and Development.** Develops control and HMI software with model-based development tools; integrates neural networks and machine learning.

- **Electronics Hardware Simulation.** Optimizes signal integrity and thermal, structural, electromagnetic reliability of electronics and mechanical hardware.

- **Functional Safety Analysis.** Ensures safety of autonomous systems with reliability analysis methods, using simulation for verification.

- **Semiconductor Simulation.** Optimizes power efficiency, power noise integrity, and thermal mechanical reliability of integrated circuits.

Every component of an autonomous system affects the performance, safety and reliability of the entire product. Only by simulating the complete control loop of an autonomous system can a developer truly address the machine's safety, reliability and liability burden in a responsible, effective manner. Thus, autonomous systems product developers should adopt a simulation solution that effectively addresses all six areas of autonomous systems development.

Takeaways

The stakes are high, but the benefits of engineering simulation in autonomous systems product development are clear:

- **Simulation.** Simulation is happening now among the Best-in-Class, and it is crucial when designing and testing autonomous systems that independently make decisions in millions of operating scenarios.

- **Liability.** When a machine is made autonomous, liability for accidents is transferred from the machine operator — for instance, a car driver — to the machine maker. Therefore, self-driving cars, drones and intelligent robots must all be tested thoroughly by the manufacturer. Engineering simulation is the best (and arguably the only) way to accomplish this task in a comprehensive, cost effective manner, while meeting the manufacturer's burden of due diligence.

- **Autonomous Systems.** Engineering simulation covers the key areas of autonomous systems development by enabling realistic system simulation and virtual testing of all engineering aspects of its sub-systems and components.

The business case for autonomous systems is extremely compelling. Anyone purchasing a new car in the last year recognizes the tremendous potential that autonomous systems represent. Advanced driver assistance systems — such as adaptive cruise control, lane keeping assistance and automatic braking — all offer a tantalizing look at embryonic technology components that will one day be part of a fully autonomous self-driving car.

On the other hand, the complexity of autonomous systems greatly multiplies the possible failure mode paths. Since autonomous systems have inherent safety implications, any failure can easily be catastrophic, even fatal. Conducting functional safety analyses of such complex systems is tedious, error prone, and vulnerable to gaps and flaws. Automated functional safety analysis tools are therefore essential to ensure the safety of autonomous systems.

Engineering simulation is the best tool to bridge the gap between the risks and rewards of autonomous systems today, firmly tilting the odds in favor of reward. Best-in Class designers are deploying simulation now to streamline and expedite virtual training and testing of AI, as well as to ensure reliability of all components. With engineering simulation, the seemingly impossible becomes possible, and the task of developing autonomous systems is accomplished with a level of speed and cost economy that isn't available any other way.

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