THE CASE FOR AWSM:

AN ACCIDENT WARNING SYSTEM FOR MOTORCYCLES

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EXECUTIVE SUMMARY

The fully autonomous vehicle is on its way. That's a fact, but the day when riders entirely surrender control of their motorcycles to autonomous driving systems is one we hope will never come. There is a purity to motorcycling that no rider would voluntarily relinquish in favor of convenience or simplicity.

Basic versions of Advanced Driver Assistance Systems (ADAS) featuring pedestrian detection, adaptive cruise control, collision avoidance, and lane correction are already a reality. The technologies enabling driverless cars are not without their merits, but when applied to making motorcycling safer, the picture is quite different.

Developing unique methods to applying this technology for the specific needs of a motorcycle is one thing, but a much greater opportunity exists than the mere creation of a collision avoidance system.

This future vision of the ultimate rider safety system will bring with it an industry-wide paradigm shift. Every mile ridden will not only make riding perpetually safer for the individual, but also the entire motorcycling community and all vulnerable road users in this massive overlooked transportation segment.

In this future, the idea of rider accidents being inevitable and unavoidable will be a thing of the past. Such never before achieved levels of safety will bring with it a potential for cataclysmic change within the entire motorcycling community, from manufacturer to commuter.

Damon's vision is to unleash the full potential of personal mobility for exponentially safer, smarter motorcycling. The aim of this whitepaper is, therefore, to look at the current state of the motorcycle industry, the challenges constraining its evolution and the key opportunities this can bring for the 160 million annual motorcycle buyers worldwide.

To further this aim, we will expand on the following key points:

- Fundamental Problems the Motorcycle Industry Faces
- Why Has the Industry Failed to Address these Problems?
- Applying technology to advance safety in motorcycling
- What Are the Trends in the Automotive Industry and How Can they be Applied to Motorcycling?

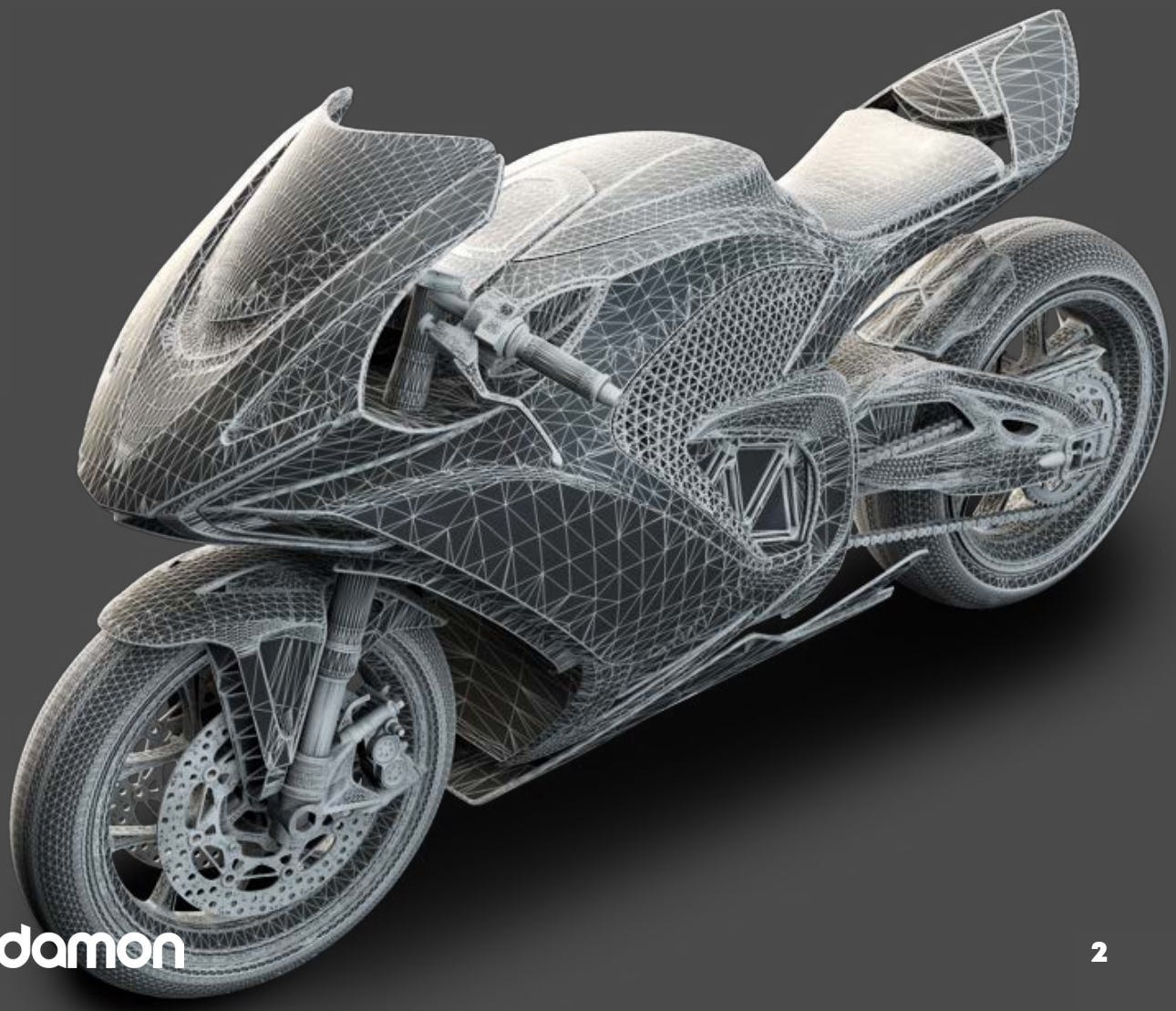
INTRODUCTION:
SAFETY – THE PRIME MOVER

This whitepaper will unpack the results of Damon's 360-degree hazard detection system, CoPilot™ and the anticipated effect it will have on motorcycle safety worldwide. We will show that the timing for Damon's emergence into this vastly untapped and urgently needed market is now. We will also add to this the reasons why we ignore it at our peril.

This document will highlight the key problems of a stagnating motorcycle industry. It will also look at why the next generation of riders is completely underwhelmed by what's currently on offer and the perception of its inherent danger.

We will continue with technical insight into CoPilot. Plus, we will look at how it will create a safer and therefore more enjoyable riding experience for Damon motorcycles and its ability to expand exponentially as the market and technology evolve.

At the conclusion of this whitepaper, the reader will understand not only the concept of the technology involved but also its practical application. The effect Damon motorcycles will have in the evolution of motorcycle safety will be apparent as well as the company's potential to lead the industry towards a safer future.



EXPANSION OF OUR KEY POINTS

- **Fundamental problems the motorcycle industry faces**

Ranging between 19-39 years old, Millennials now make up one-quarter of the world's population. They account for 25 percent of the workforce and will purchase one-quarter of next year's cars.

With a combined spending power of $13 trillion, the next five years will see this increase to a staggering $22 trillion; a figure that dwarfs every generation before them.

This age group is one that historically embraces the two-wheeled culture, which the motorcycle industry fully expected to take the baton from the rapidly diminishing baby boomers. Instead, despite the benefits of time, money savings and convenience, Millennials as a whole have not adopted motorcycles as their previous generations, and the resulting void has the industry clamoring for answers.

Resting on the laurels of 100 years of history, and with an inventory of bikes nostalgically designed for specific riding styles, the complacency shown by manufacturers has resulted in today's motorcycles simply not meeting Millennials' generational needs.

Having been shuttled throughout their formative years in vehicles with seven airbags followed closely by automatic-geared driving lessons, Millennials consider motorcycles with their hand clutch, six-gears, and loud pipes intimidating and potentially dangerous.

In plain terms, today's motorcycles are out of alignment with the needs of the world's first digital generation, who cite safety and practicality as significant factors in their decision making.

- **Why the industry has failed to address these problems**

Today's motorcycle manufacturers are legacy-driven. Bound by their dealer-distributor networks, they are required to continually ship the bikes that dealers can sell to their aging customer base.

Motorcycles currently filling showroom floors across the land are therefore defined almost entirely by the ones that precede them, with few features to sell on, besides horsepower and style.

Viewing their performance one fiscal quarter at a time, manufacturer's react to dropping sales with paint scheme changes, aggressive financing offers or by launching a new bike named after a model from a back catalog.

The resulting industry-wide, short-sightedness consequently creates blind spots that hide advances in technology and changes in customer wants and needs.

- **Applying technology to advance safety in motorcycling**

Little has been done to advance motorcycle safety since the introduction of anti-lock brakes in 1988. Currently, in the United States alone, approximately 90,000 motorcyclists are injured with more than 5,000 killed each year.

As well-meaning as they are, no amount of awareness campaigns, compulsory riding lights or neon vests has significantly reduced these numbers. Damon, therefore, believes that the only way to bring about a paradigm shift in motorcycle safety is through the use of radically disruptive technology.

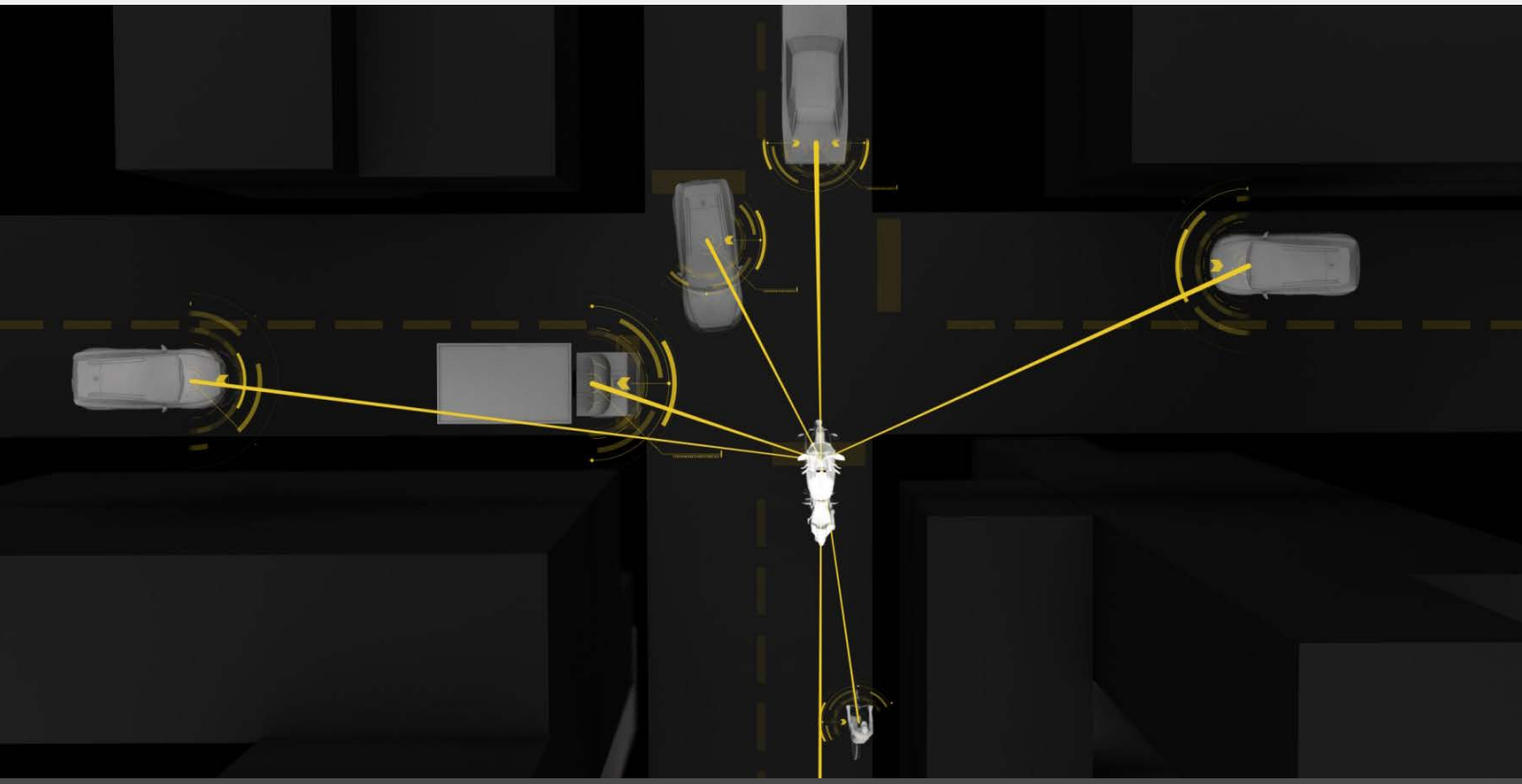
Such technology-driven safety systems need to be appealing in their ease of use, unintrusive to the rider and unambiguous in their communication.
Like a modern fighter jet, Damon's 360-degree CoPilot system uses embedded radar, cameras, and other sensors to track the speed, direction, and velocity of dozens of objects at a time.

Using an onboard neural net, it anticipates a threat to warn the rider who is then alerted with LED's for blind spot warnings, vibrating handlebar grips for forward collision warnings, and displays rearward threats with a digital rear-view mirror, fed by the motorcycle's embedded, wide angle rear-facing camera.

Every time a rider responds to a threat warning by way of swerving or braking, the onboard system captures and tags the incident details in 360-degrees. It then transmits data to Damon's cloud over its embedded wireless connection, so that the system can learn to detect more threats faster.

Damon's sophisticated AI engine aggregates tagged data across all Damon motorcycles and runs it through its patented traffic simulator. Using real-world visual data, it re-creates causational traffic behavior to develop and test more advanced algorithms in the simulated traffic environment.

Damon deploys these updates to its internal test fleet for extended testing, resulting in an iterative develop, test and deploy feedback loop between the real world and the Sim. Once perfected, updates are sent to all Damon motorcycles and authorized by each owner before going live on their own motorcycle.



- **What are the trends in the automotive industry and how can they be applied to motorcycling?**

In just a few years, collision avoidance systems have become almost commonplace on cars, statistically reducing forward collisions by 21 percent and blind spot related collisions by 14 percent in the US alone. Israel recently mandated these technologies on new cars and has reduced accidents by a staggering 35 percent.

"When properly utilized, ADAS technologies have the potential to prevent 40% of all vehicle crashes and nearly 30% of traffic deaths"
- AAA Foundation for Traffic Safety, 2018

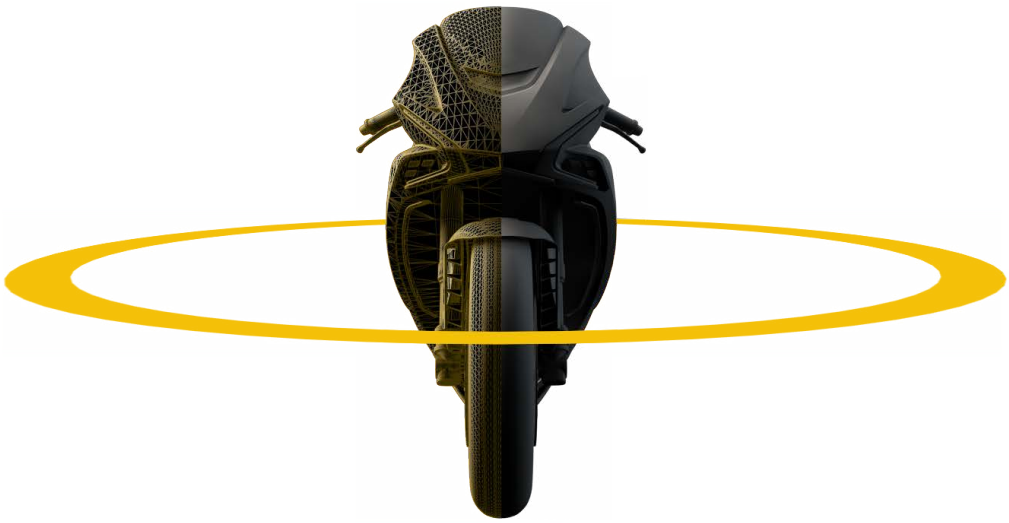
With human error reportedly the cause of 90 percent of all accidents; it is, therefore, safety that is the primary impetus behind the push towards autonomous driving. Advocates believe the number of crashes, injuries, and fatalities could dramatically drop by the removal of human error.

By using networks of sensors it is well understood that computers react more quickly than humans and make better judgments based on thousands of instantaneous calculations.

Applying this technology to motorcycle specific applications is not a simple task. Finding ways of building multiple components into the limited space of a motorcycle is just one consideration. Timing, however, is on our side.

Currently, the hardware footprint required to house complex decision-making systems is shrinking, while processing speeds and capacity are expanding. Furthermore, only five years ago, the cost of artificial intelligence, radar systems, hi-res digital, and environmental sensors was so prohibitive as to make their use on a motorcycle financially unviable.

Developments in commercial multi-core processors and virtualization software are behind this advancement and applying embedded virtualization to ADAS in automobiles creates an effective way to drive safety advancements in motorcycles.



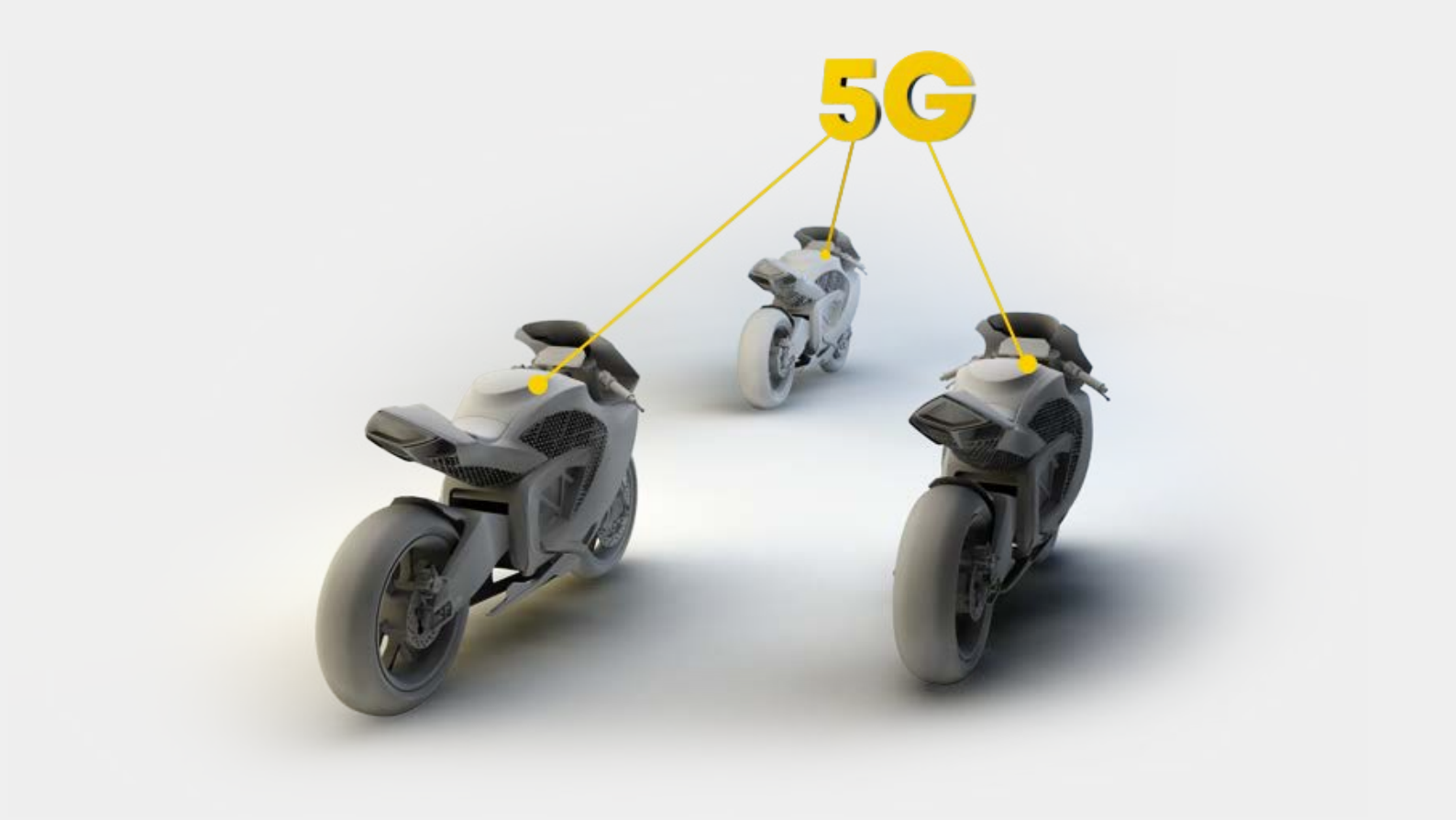
Commodity multi-core computer processors also make it easier to combine multiple applications on a single processor and the elimination of multiple custom boards also dramatically simplifies maintenance.

The result of this amalgamation process means that car manufacturers have reduced size, weight, power, complexity, and costs of the system making it ultimately a more practical and viable proposition for motorcycle applications.

FOCUS AREAS FOR DAMON

1. **COPILOT: Damon's proprietary Advanced Warning System for Motorcycles (AWSM)**
2. **SHIFT**
3. **CONNECTIVITY AND DATA**

To add further clarity, this paper will further argue the need for a specific Accident Warning System for Motorcycles (AWSM) and the importance of connectivity.



ADVANCED WARNING SYSTEM FOR MOTORCYCLES (AWSM)

In 2013, the U.S. National Highway Transportation Safety Administration (NHTSA) issued its first policy statement on automated vehicles. This document defined four levels of vehicle automation, which in effect, gave a unified roadmap for the auto industry to follow.

Whereas, it is highly unlikely that motorcycling will ever evolve towards complete automation, the evolution of accident avoidance for motorcycles is inevitable. With this in mind, a similar road map should be instigated as soon as possible along the following lines:

Level 1 – Basic Detection: A motorcycle is equipped with the necessary sensors to see a potential collision from all sides and warn the rider.

Level 2 – Anticipatory: A motorcycle is equipped with the necessary sensors and capability to track the direction, velocity, and speed of surrounding vehicles to anticipate their approach and potential for impeding the rider's right of way.

Level 3 – Critical Automation: A motorcycle is equipped with the necessary sensors and capability to understand the rider's abilities and intent. It combines this with real-time environmental and road condition information. These will adjust throttle, brake, and other control functions to ensure the motorcycle is not piloted to exceed the ability level of the rider and/or the conditions of the road. This advanced system can include tire traction, curve radius of a given corner, or available braking distance to a decelerating or fixed object.

What's driving AWSM for motorcycles

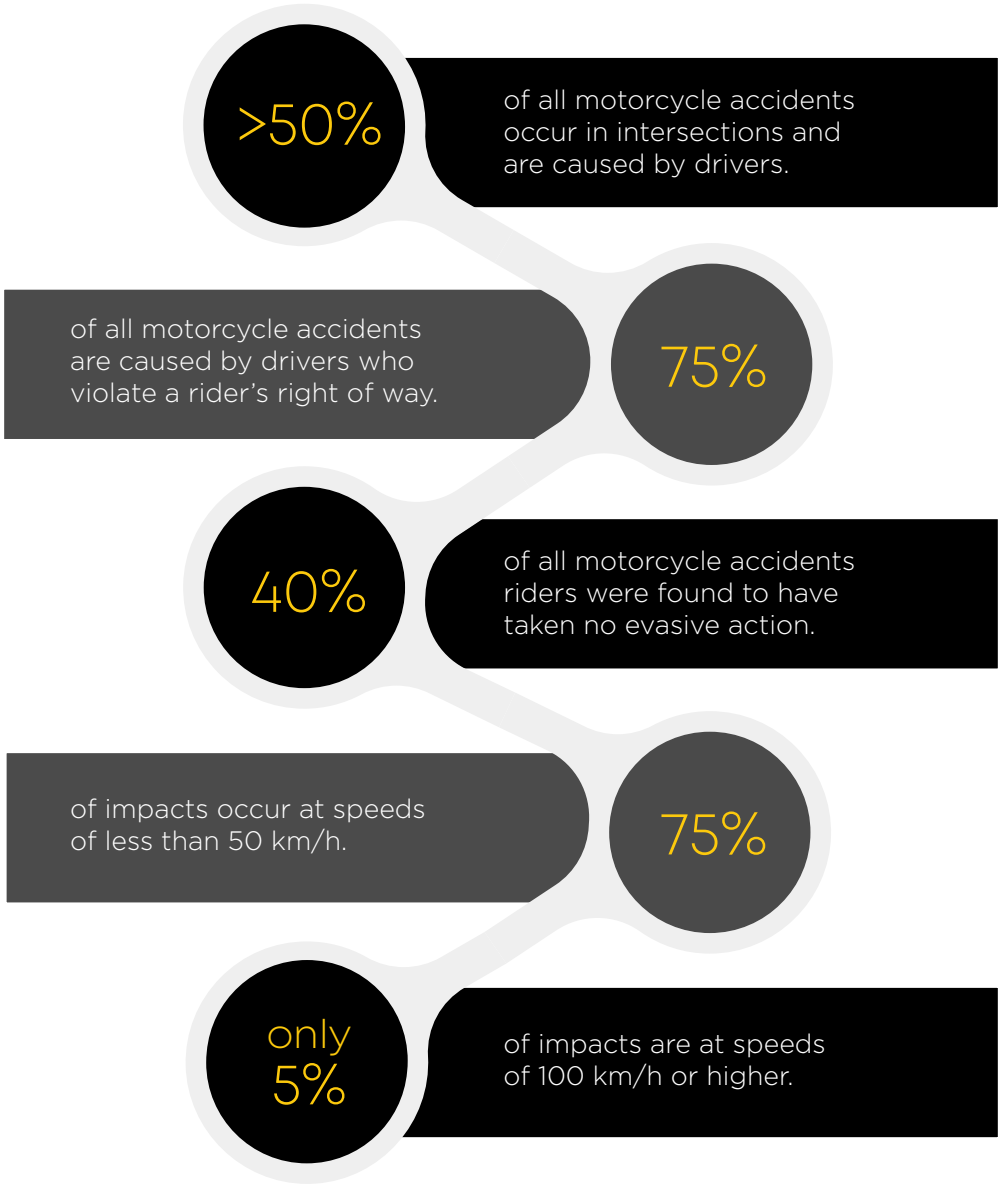
- Rapid development of autonomous vehicles
- Increasing public perception and awareness of motorcycle accidents
- Shift in public interest towards safer transportation options
- Generational changes in customer wants and needs

INTERSECTIONS – THE PRIME MOTORCYCLE DANGER ZONE

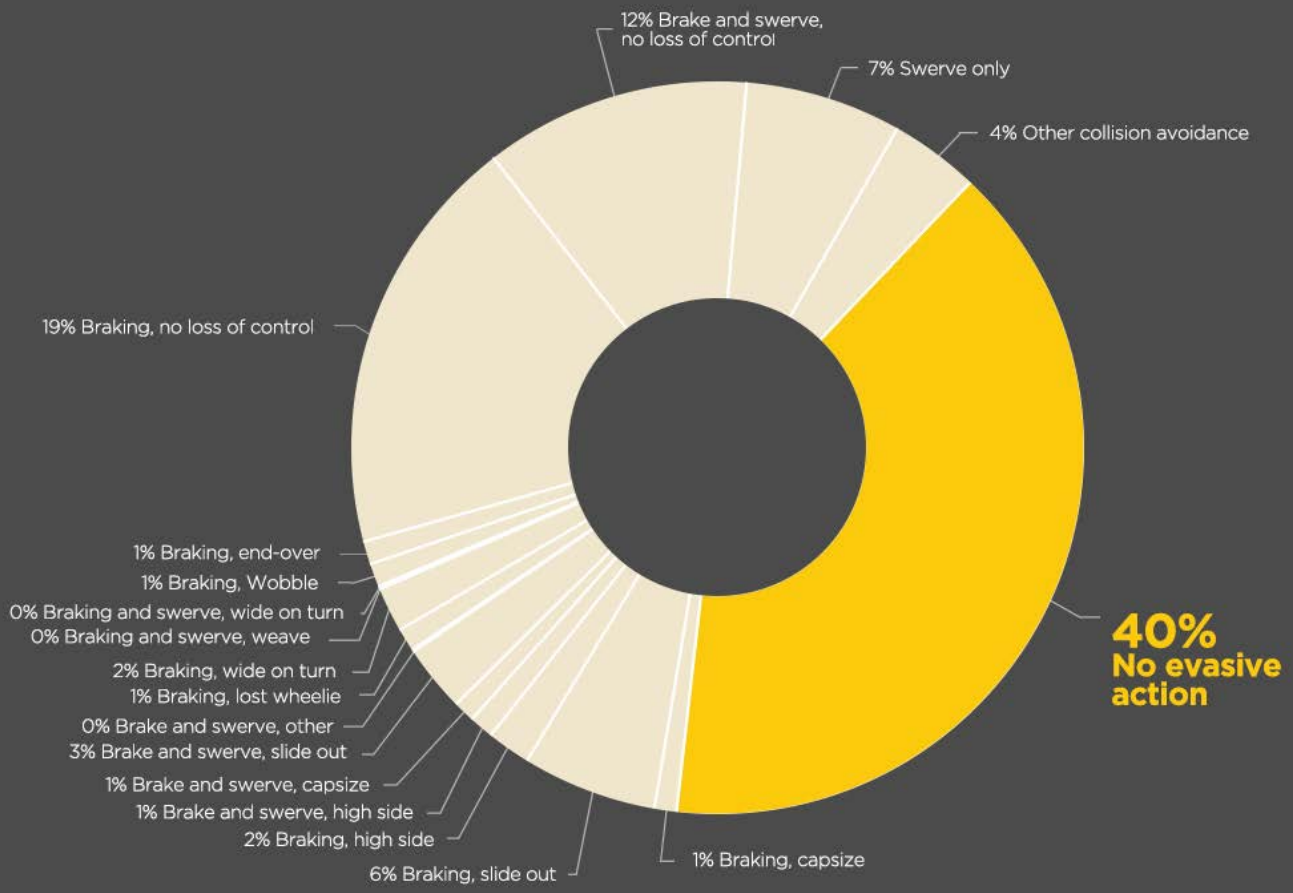
To develop a sophisticated accident warning system for motorcycles, the first step is to understand the different types of accidents and the causes behind them.

In 2009 the Maids Report reverse engineered almost 1000 accidents. Their findings concluded that over half of all motorcycle accidents occur at intersections, the cause of which is by drivers violating the rider's right of way.

Interestingly, in almost 50 percent of all motorcycle accidents riders were found to have taken no evasive action, meaning they were not aware of the threat in time or didn't see one coming.



Ungoverned by emotional distractions or irrational reactions, computers react far more quickly than humans. As the world shifts towards autonomous driving, the need for safer, more intelligently enabled motorcycles will grow at the same pace. A comparable system of safety features will, therefore, become a critical factor for their continued growth as a viable means for interurban transportation.



The report goes on to state that the speed differential of motorcycles in 18 percent of cases is a contributing factor and that a visual obstruction invariably contributed to the accidents studied.

Therefore positive habit-forming features such as tailgating alerts to advise the rider to fall back are of prime importance. In addition to providing additional reaction time by identifying accidents before the human eye detects them, such features can also have a significant effect on reducing collision outcomes.

WHY ADAS WON'T MAKE THE TRANSITION TO TWO WHEELS

Understanding these factors as well as the unique vehicle dynamics of motorcycles is what sets Damon's CoPilot system apart from conventional ADAS systems found on cars. Here's why.

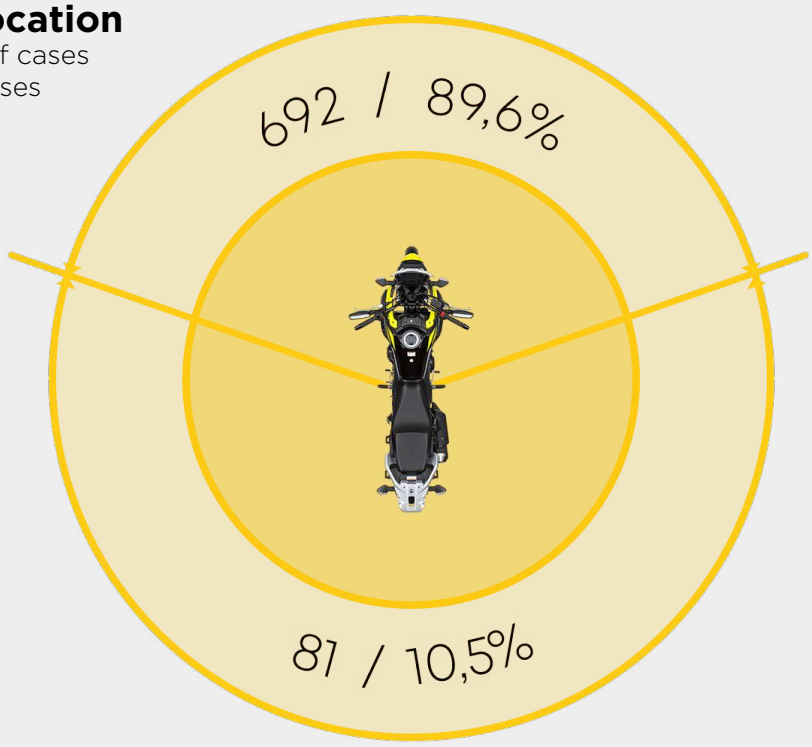
A motorcycle's high degree of maneuverability and lean angle, as well as its ever-changing lane positioning, are just some of the considerations. This constantly adjusting mobility also requires advanced camera vision, object detection, and segmentation supported by carefully engineered algorithms.

These algorithms require testing over thousands of virtual and real-world miles before a motorcycle can consistently detect, and anticipate accidents on all sides of the rider.

Furthermore, possible collision scenarios must be recorded, dissected for causation and captured in the AWSMs' algorithms to be correctly interpreted and provide an advanced warning to the rider.

The 'cageless' conditions that add to the rider's vulnerability are also a prime consideration as even the smallest of collisions can have life-altering consequences.

Risk Location
Number of cases
% of all cases



Unlike cars, Damon's forward, side and rear detection systems inter-communicate to form a complete 360 degree 'birds' eye' view of what's happening around the motorcycle at all times.

By locking onto dozens of moving objects at a time, it can anticipate traffic behavior.
This anticipatory response is possible thanks to onboard software capturing data every time a Damon motorbike senses a potential problem and reacts.

This data is then sent to a dedicated cloud platform where a sophisticated AI engine can continually learn and create new algorithms. Eventually, updates will bounce back to the bike's onboard processor with the rider alerted to the availability of an update.

These updates will result in a faster more sophisticated system, alerting the rider to potential hazards in a seamless, self-learning loop.

Situational awareness and the benefits of interconnectivity

By the time fully autonomous vehicles are a common sight on our roads, additional safety benefits will come from their ability to communicate with one another. Promoted by the NHTSA, among others, vehicle-to-vehicle (V2V) communications will provide the basis for a fully integrated smart-road, traffic system.

The car's V2V system will increase situational awareness by sharing information about their location, speed, and direction. They will also communicate additional warnings related to forward collisions, blind spot and lane changes, and control loss for crash avoidance.

There is no doubt that digitized integrated networks are the future of road transport. For this reason, Damon will be a forerunner in providing V2V information with market-leading connected cars to ensure their part in the true intercommunicating superhighway.

CONCLUSION

The era of autonomous driving is dawning. As consumers become more accustomed to ADAS and active safety features, their expectations for safer motorcycling will continue in proportion.

The technology behind these safety systems is as groundbreaking as it is incredibly complex. For those motorcycle manufacturers and start-up developers who can solve the challenges of complexity, security, and time-to-market, the clear competitive advantage in this race is evident.

At Damon, the journey is everything.

ABOUT DAMON MOTORS INC.

Damon is unleashing the full potential of personal mobility for the world's commuters. With its proprietary electric drivetrain, the company has developed the world's safest, smartest, fully connected electric motorcycle employing sensor fusion, robotics and AI. Designed as a platform for worldwide line extension, Damon motorcycles will ship direct to consumer on subscription plans to drive scale.

Based in Vancouver, Canada, Damon is a Techstars Mobility company founded by serial entrepreneurs Jay Giraud and Dom Kwong. Damon's investors include Round 13 Capital, Techstars, Fontinalis, Extreme Venture Partners and Pallasite Ventures.

Learn more at **DAMONMOTORCYCLES.COM** and follow us on Instagram **@DAMONMOTORCYCLES**.

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