RLS Release Layer System®

ROTATIONAL PROTECTION · MOTORCYCLE HELMETS

The Release Layer System® and the Goal of Reducing Brain Injuries from Motorcycling Accidents

Test data, accident evidence, and engineering rationale supporting the introduction of RLS rotational-protection technology to the motorcycle helmet market — on the AGV Pista GP R³ under FIM's FRHPhe-02 impact protocol.

Published by RLS · Release Layer System · September 2026

1. Introduction

1.1 Background

Riders of motorcycles and other powered two- and three-wheelers carry a disproportionate share of global road risk: nearly 30% of all road crash deaths involve powered two- and three-wheeled vehicles such as motorcycles, mopeds and scooters, [1] out of the world's 1.19 million annual road traffic deaths each year, as reported by the World Health Organization (WHO). [2]

This white paper draws on two in-depth crash investigation datasets, collected twenty-five years apart, to make the case for Release Layer System (RLS) as a step toward reducing brain injuries in motorcycling accidents:

- **COST 327** reconstructed 253 motorcycling collisions across Finland, Germany and the United Kingdom between 1996 and 1998, matching helmet damage to injury outcome case by case. COST 327 found that two-thirds of the riders in that sample sustained a head injury. [3]
- **Baker et al. 2026** found that twenty-five years of helmet and vehicle design improvement have reduced the prevalence of head injury without resolving the problem. After analysing 353 motorcyclists from collisions recorded in the UK Road Accident In-Depth Studies (RAIDS) database from 2013 to 2025, they reported a head injury in a third of riders and a clinically classified traumatic brain injury in a quarter of them (24.9%), of which 19.0% were moderate-to-severe. [4]

1.2 How do head injuries affect the brain?

The brain is often imagined as a firm organ, yet it more closely resembles a gel. Like most biological tissue, the brain is mostly water, so it resists compression, making it relatively tolerant to being pushed in a straight line. In contrast, it is very sensitive to shear, which is what happens when neighbouring parts of a material are pushed in different directions. When the head is rotated sharply, the brain inside the skull lags, twists, and the tissue is stretched. Nerve fibres (axons) running through the whole volume can be strained at once.

Serious head injury falls into two broad mechanical families:

- **Focal injuries** resulting from direct impact force concentrated at a point and causing damage to the skull, such as skull fractures.
- **Diffuse injuries** resulting from indirect force that rotates the head, straining brain tissue across its whole volume and causing **Traumatic Brain Injury**, such as concussion.

When the brain is concussed, its function is disturbed, causing headache, dizziness, confusion, memory loss and sometimes loss of consciousness, without there necessarily being visible damage. The severity is judged from the symptoms, not from a diagnostic image. That is precisely what makes it challenging to design against.

COST 327 had to analyse concussion separately from every other brain injury in its database since its location and occurrence were difficult to identify, yet it was prevalent and happened at speeds riders would consider ordinary. The median head impact speed at which concussion occurred was 43 km/h, [3] so this is not just a high-speed racing problem.

> COST 327 concluded that, for head injuries of AIS 2 or greater, rotational motion was the cause of over 60% of the injuries, with linear motion accounting for around 30%.
>
> COST 327 FINAL REPORT[3]

1.3 Standards are catching up with the accident evidence

The above is clear evidence that reducing the risk of brain injury means designing and testing helmets against both **linear** shock absorption, to mitigate focal injury, and **rotational** energy deflection, to mitigate diffuse injury. Historically, most helmet standards tested almost exclusively for linear impact attenuation. Now, two internationally recognized test protocols are evaluating a helmet's ability to protect against rotational forces:

- **ECE R22.06** includes oblique-impact testing, recognising both that this is a more realistic accident scenario and that limiting head rotation is crucial to preventing brain injury.
- **FIM's FRHPhe-02,** now required for professional circuit racing, goes further: oblique-impact testing is a central pillar of the protocol with strict pass/fail thresholds, and the four oblique impact locations tested cover key head and facial-impact areas.[4][5]

2. The Release Layer System (RLS) in motorcycle helmets

RLS is a patented technology designed to mitigate head rotation and thus, reduce the risk of traumatic brain injury. As described in a recent, peer-reviewed journal article, RLS consists of an array of 2 mm polycarbonate spheres bonded to the helmet's outer shell and covered by an additional outer panel. On an oblique impact, the panel's fasteners and adhesive bonds sever, freeing the spheres to roll and the panel to flex away from the main helmet shell. This release mechanism disperses and transforms a substantial share of the impact's rotational energy before it reaches the head, complementing the EPS liner's absorption of the remaining linear force.[6]

FIG. 1 RLS equipped motorcycling helmet. AGV Pista GP R³. Key components: 1. RLS Release Panel · 2. Bearing Layer · 3. Force Activated Shear Pins.

RLS technology, previously integrated in cycling helmets, has been tuned for motorcycle helmets with the mandate to:

- Be a first line of defence during an impact, by deflecting rotational energy away from the wearer's head and brain.
- Reduce head rotation for primary and secondary impacts, and work in tandem with the energy absorbing liner of the helmet to attenuate direct impacts.
- Reduce the risk of brain injury without compromising aerodynamic performance, weight, rider comfort, or aesthetics.

2.1 Evaluating RLS integration on the AGV Pista GP R³ Helmet

To isolate and measure the effect of RLS in motorcycle helmets, this white paper presents test data of an AGV Pista GP R³ helmet, with and without RLS, tested using the FRHPhe-02 ("FIM2") protocol. FIM2 was chosen for four reasons:

- It is the **compulsory homologation programme for MotoGP helmets** such as the Pista GP R³. [5]
- It applies **strict thresholds across four head-kinematics and injury metrics**: PLA (Peak Linear Acceleration), PRA (Peak Rotational Acceleration), SFC (Skull Fracture Criterion) and BrIC (Brain Injury Criterion), where two of the four are rotation-related. [5]
- It tests rotational shock absorption at **4 impact points on a single helmet**, covering key areas of head impact and also facial impact, as discussed in Baker 2026 (Figure 2). [4][5]
- It produces **independent test data from the official FIM lab**: the Impact Laboratory, Aragón Institute of Engineering Research (I3A), University of Zaragoza. [5]

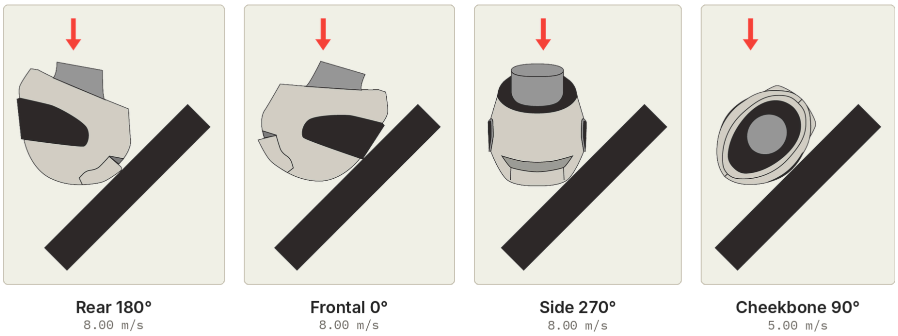

FIG. 2 FIM2 oblique-anvil impact locations and test velocities.

Following the FIM2 protocol, two kinematic metrics were collected for each impact test:

- **Linear acceleration**, used for the PLA and SFC thresholds.
- **Rotational velocity**, used for the PRA and BrIC thresholds.

This paper will focus on the rotational velocity, as the directly measured metric for head rotation, and **p(AIS2+)**, the estimated probability of an AIS2+ brain injury calculated by the Brain Injury Criterion (BrIC), as a metric more directly related to injury outcome and likely more interpretable by the reader. [7]

3. RLS significantly improves effectiveness of motorcycle helmets in oblique impacts

3.1 Results

The effectiveness of the RLS technology in mitigating rotation and thus, brain injury as tested at the FIM lab is presented in Figures 3 and 4 below.

The figures show results from the FIM2 oblique impact locations tested on a single helmet model, the AGV Pista GP R³. The standard, No Tech helmet (hatched bar) is presented against the RLS Equipped helmet (solid red bar). The helmets tested have the same shell, liner and standard components; the RLS system is the only variable evaluated and its effectiveness is presented as a percentage reduction.

RLS was found to offer 77, 45 and 5% reduction in Peak Rotational Velocity (PRV) at the 0, 270 and 90° impact locations, respectively (Figure 3). The highest reduction in head rotation corresponded to frontal, upper face impacts (0°), representing a substantial decrease of the PRV from 29.2 radians per second (rad/s) to 6.8 rad/s.

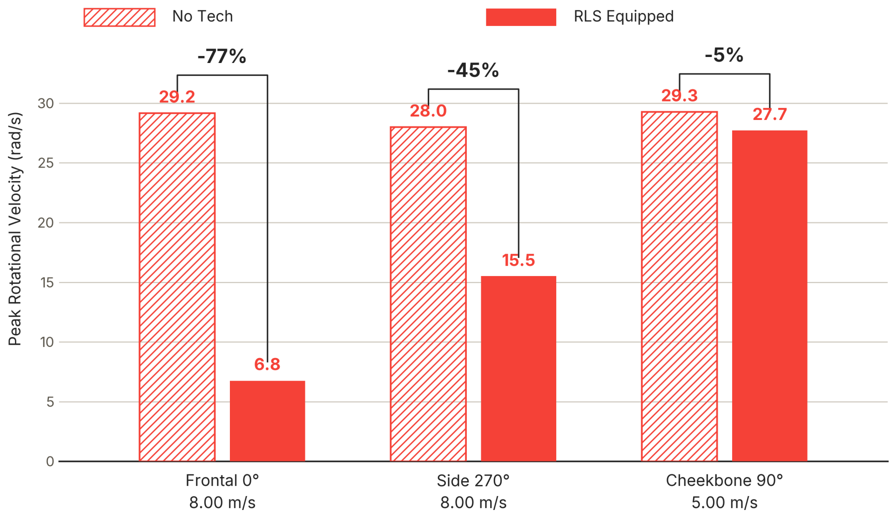

FIG. 3 Peak Rotational Velocity (PRV), No Tech vs. RLS Equipped, AGV Pista GP R³ — three sites tested under FRHPhe-02 (Rear excluded; RLS not implemented there).

Using the rotational velocity data, the BrIC was calculated and the risk of a brain injury (p(AIS2+)) was estimated.[7] **RLS was found to result in a 98, 78 and 12% reduction in p(AIS2+) at the 0, 270 and 90° impact locations, respectively (Figure 4).** In absolute terms, the data suggests that at the frontal, upper face impacts (0°), the risk of moderate-to-severe brain injury reduces from 48% to 1%. At the side impacts (270°), which are the second most effective impact location for RLS, brain injury risk is reduced from 32% to 7%.

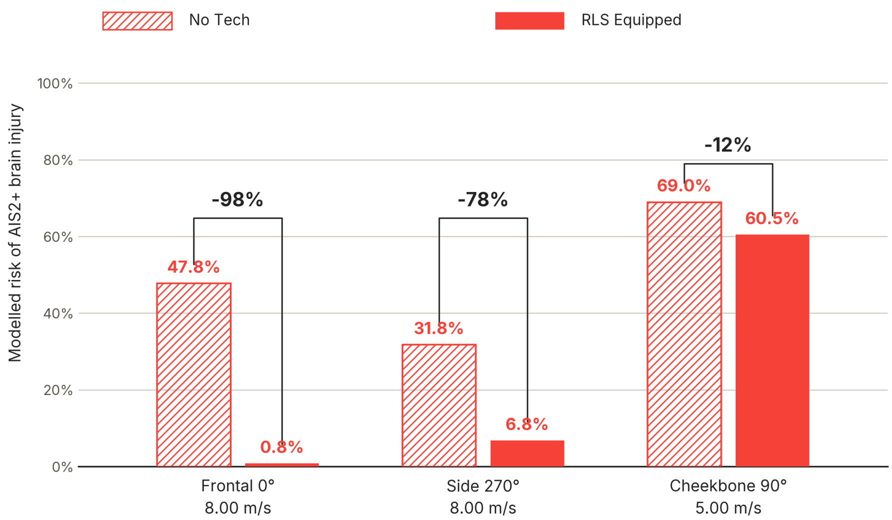

FIG. 4 Estimated probability of an AIS2+ (concussion-level) brain injury, No Tech vs. RLS Equipped, AGV Pista GP R³ - all three sites tested under FIM2.

3.2 Discussion

While all four FIM2 impact locations were tested in the specified order, Figures 3 and 4 present the results for the impact locations where RLS is implemented. This excludes the rear impact (180°) where there is no RLS and the impact is dominated by the helmet's aerodynamic components. While the cheekbone impact (90°) is included in this analysis, it should be noted that for this helmet model, the impact is influenced by the combination of RLS and the helmet's visor mechanism. As a result, the 0° and 270° impact locations are the most representative ones to isolate and showcase the technology's effectiveness.

These two locations present roughly half of all real-world helmet damage locations recorded by COST 327 (23.6% frontal + 26.3% lateral-left = 49.9%). [3] Looking further to Baker 2026, analysis of confirmed primary helmet impact locations (125 cases) found: “Most primary impacts were to the front left (25.2%) followed by the front right (24.4%) and then rear left (22.8%).” [4] The side (270°) sits within this high-exposure region and is broadly indicative of both left- and right-side real-world impacts, given the near-symmetry of front-left/front-right/rear-left prevalence in the data. The same underlying rationale applies to the frontal (0°) site, which sits in the frontal area covered by the front-left/front-right impacts above. What's more, the frontal (0°) impact is coded as facial, specifically “upper face”. Baker 2026 found that 58.7% of all helmet damage (primary and secondary) was to the facial region. [4] The key data is summarized in Figure 5 below.

> At these two sites together, RLS reduces head rotation by more than half (61% average reduction), which translates to more than 6× average reduction in the predicted risk of concussion*.

*It is important to understand that this is not a prediction about any individual crash. Risk functions describe populations. No value on this axis, high or low, tells a particular rider what will happen to them on a particular day.

IMPACT SITE	IMPACT VELOCITY	NO TECH MODELLED RISK P(AIS2+)	RLS MODELLED RISK P(AIS2+)	REDUCTION IN MODELLED RISK	REDUCTION IN PEAK ROTATIONAL VELOCITY
Rear 180°	8.00 m/s	—	—	not compared*	not compared*
Frontal 0°	8.00 m/s	48%	1%	**−98%**	**−77%**
Side 270°	8.00 m/s	32%	7%	**−78%**	**−45%**
Cheekbone 90°	5.00 m/s	69%	61%	**−12%**	**−5%**

FIG. 5 Key data summary. AGV Pista GP R³ tested to FIM2 protocol. *RLS is not implemented at the rear (180°) location on this helmet model, so no with-and-without comparison can be drawn.

4. Conclusions

Two independent, in-depth crash investigation datasets studied twenty-five years apart, point to the same mechanism: rotational motion in the brain is a leading cause of serious injury in motorcyclists. [3][4]

Standards and homologation programmes have moved to test for this directly. FIM's FRHPhe-02 protocol subjects helmets to oblique-anvil impacts at four sites, with stricter rotational thresholds than any prior motorsport standard. [5]

Tested under this protocol, RLS reduces estimated AIS2+ (concussion-level) brain injury risk on an AGV Pista GP R³ by 98% at Frontal (0°) and 78% at Side (270°) impact sites; the two locations that together account for roughly half of real-world helmet damage. At the Cheekbone (90°) location, RLS reduces the estimated concussion risk by 12%, while no comparison is drawn at the Rear (180°) location of this helmet as RLS is not integrated there.

These results present an extension of the recently published study that evaluated RLS technology in three types of bicycling helmets (urban, road and mountain bike), and showed reductions to peak rotational velocity by 57–66% and estimated AIS2+ risk by 68–86% relative to conventional helmets. [6] The technology's mechanism of operation and effectiveness at a notably higher impact velocity are corroborated in this study.

4.1 For riders: an additional layer of protection

Until recently a rider could compare helmets on price, weight, and aerodynamics but not on the metric that causes most brain injuries. Rotation was not measured, so it could not be presented. That has changed: ECE 22.06 and FRHPhe-02 both now measure it. [8]

4.2 For helmet makers: a new innovation focus

A standard is a floor. FRHPhe-02 and ECE 22.06 both establish that rotation must now be measured and must not exceed a stated limit. This is a positive development, but a limit set so that today's best helmets can pass is not the same as a limit set by what the human head can tolerate. Those who design and build protective equipment carry the responsibility for the distance between those two numbers.

Above the standard performance is where future efforts should focus. Our collective duty should be to actively design safer products and communicate this effectively to the rider.

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DISCLAIMER

No helmet can protect the user from all head and brain injuries, and no helmet can protect the user against all impacts. Although the Release Layer System ("RLS") is designed to help reduce the risk of rotational motion to the head that may lead to brain injuries, there are limits to the protective capabilities of all helmets, including helmets with RLS technology. The results presented in this document were obtained under defined, repeatable laboratory conditions on a single helmet model in two configurations; real-world crashes vary in ways no laboratory test reproduces, and results obtained on one helmet model do not necessarily transfer to another. Figures expressed as a risk of AIS2+ brain injury are estimated probabilities derived from measured head kinematics, not observed injury rates, and describe populations rather than individuals. Meeting or exceeding any standard, including FRHPhe-02, and fitting any protective technology, including RLS, does not guarantee that a rider will avoid concussion or any other head injury. This document is provided for information only and does not constitute medical, legal or engineering advice.

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