windpact

New Helmet Technology that's Scoring Big Gains In Safety

The definition of "protection" for helmets is rapidly changing. Meet the new game-changing technology that's a perfect fit for reducing the risk of concussion and traumatic brain injury in the modern world.

Safety comes first: helmets save lives and preserve their wearers' well-being, but new research is shifting the market's understanding of what helmet "protection" means.

Sports are the second leading cause of traumatic brain injury (TBI) for Americans between the ages of 15 and 24 years old.[i] Every year athletes suffer more than 3.8 million sports-related concussions. The average professional football player will receive as many as 1,500 head impacts each season,[ii] and As Fast Company writes, "In the eyes of physics, a big hit on the field can be just as devastating as a car crash – or in many cases, worse."[iii]

But severity doesn't have to reach skull-cracking force to result in brain injury. In fact, it is the repetitive or routine low-to-medium level hits that can pose the greatest risk of TBI.

That is because even weaker, sub-concussive hits can have a cumulative effect over time that leads to outcomes just as tragic as catastrophic hits: an increasingly notorious example is chronic traumatic encephalopathy (CTE – also known as "boxer's dementia"), which is a form of brain damage caused by repeated head impacts that can result in dementia. In 2006, former Philadelphia Eagles player Andre Waters took his own life; studies of his brain revealed he suffered from CTE.[iv]

The emerging awareness of the dangers of low and medium energy impacts is a problem for many helmets, which are optimized to prevent skull fractures in catastrophic impacts but do little to mitigate the risk of concussion or other TBI resulting from sub-concussive hits.

Manufacturers are facing a wide array of growing pressures (see Table 1), but perhaps none greater than new research, standards and testing. Researchers are increasingly studying a wider range of impacts and incorporating measures of rotational force in addition to linear acceleration in testing.

In such tests, modern helmets fall short: one leading helmet safety study found three-quarters of market-leading hockey helmets to be unsafe.[v]

Organizational safety standards, which have historically favored protection against catastrophic impacts, are one of the primary culprits for the current suboptimal helmet performance. For example, the Hockey Equipment Certification Council (HECC) requires that helmets be able to withstand 300 G-force units (G's); the CSA, 275.[vi] The National Operating Committee on Standards for Athletic Equipment (NOCSAE) certifies helmets according to a high-force vertical drop test measuring linear acceleration.

Understandably, most manufacturers closely track government-mandated standards in helmet safety, but those standards are falling behind the science of safety and are increasingly becoming outdated. NOCSAE's standards, for instance, have remained largely static since 1973.[vii]

Rising Pressures on Helmet Manufacturers

Table 1.

Liability and Litigation

More than 2,000 former NFL players have filed a class-action lawsuit against the NFL as well as Riddell, the largest manufacturer of football helmets. The lawsuit alleges that they have promoted misleading science around brain trauma.

Public Perception

Public perception has real-world impact: according to ESPN, rising coverage of concussion concerns is making more than half (57%) of parents less likely to allow their children to play youth football.

Government Inquiries

Legislation is slowly tightening: the Children's Sports Athletic Equipment Safety Act imposes new safety standards and punitive measures. Senator Tom Udall (D-NM) has also called for a Federal Trade Commission to investigate the football helmet industry for misleading claims.

Commercial Viability

Manufacturers still have to meet customer demands when it comes to attributes like cost, looks, weight and safety – and they're facing more competition than ever.

Competition

Recognizing an opportunity, new companies and startups are beginning to produce their own "safer" helmet designs. While few of these are likely to make it to market, they are pushing innovation in the helmet and safety equipment industry.

The Problem: new safety research findings, testing methodologies, and design standards are creating a whole new playing field for manufacturers.

Current helmets are optimized for high-velocity, linear impacts, and address the risk of severe TBI and skull fracture more than the risk of concussion or other TBIs resulting from sub-concussive hits. And consequently, they have reduced high impact risk – in football, for example, improved helmet design has reduced brain fatalities enormously over the last four decades.

The problem? Concussions can result from lower levels of force, and as mentioned, even sub-concussive impacts can have dangerous cumulative impacts. Further, helmets that conform to high-impact standards may not adequately protect against other kinds of hits (see Figure 1). This is apparent in the data as well as in the news, where reports of disabling head injuries continue dominate headlines.[viii]

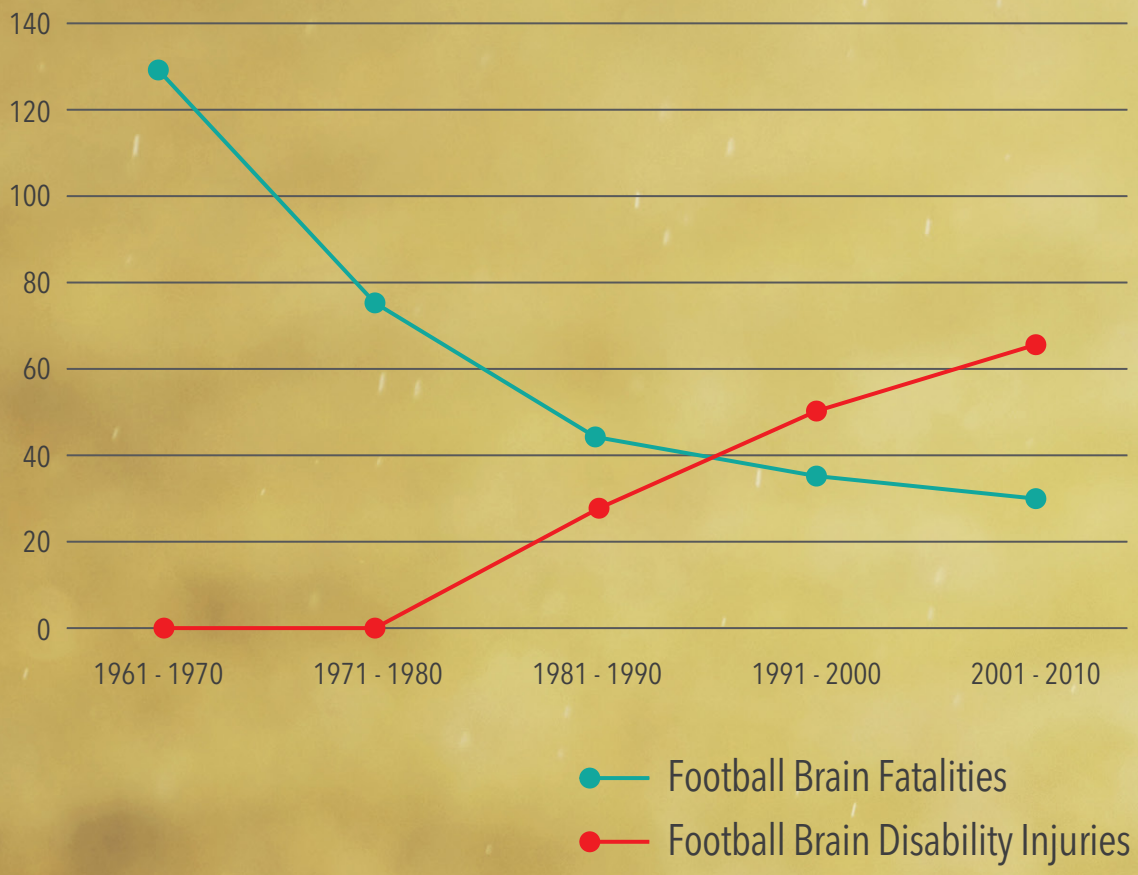
In light of the dire findings, the question becomes: how can we build a helmet that protects against a broader spectrum of impacts? The Consumer Product Safety Commission's Safety Standard for Bicycle Helmets summarized the the apparent tradeoff challenging helmet design:

> "Decreasing the linear stiffness [of the helmet liner] would benefit those who experience injuries with minimal or no liner deformation of current helmets. However, a decrease of liner stiffness could increase the number of head injuries that occur during more severe impacts that cause the helmet liner to bottom out."[ix]

Researchers are beginning to ask how helmets can both protect against skull fracture, and also reduce concussion risk, instead of solving just high energy impacts at the expense of brain injuries resulting from lower energy collisions.[x]

Success in this goal requires a shift in how we define helmet protection.

Figure 1. Fatalities versus brain injuries in football



New Standards On The Horizon

Altogether, a growing body of evidence suggests that remediating the risks of concussion and other head injuries requires addressing more than just high velocity and linear acceleration. For example, rotational acceleration can cause or contribute to injury resulting from a collision. [xi] With that growing awareness, industry, government agencies and consumers are beginning to look at safety in new ways. field for manufacturers.

Figure 2. The modern understanding of the risk of impacts and brain safety.

Manufacturers are paying attention. "I don't think you're going to see the NFL flat-out endorsing a product," says Kevin Guskiewicz, a sports medicine researcher and chair of the NFL's Subcommittee on Safety Equipment and Playing Rules, "but they certainly feel that they're responsible for trying to help prevent these injuries. So we're going to be reviewing these technologies."[xii]

Certifying authorities are also reacting. The NOCSAE, for instance, has issued a grant to the University of Ottawa to develop a new safety standard that incorporates rotational impact. [xiii] Remember, that's the body whose standards haven't previously changed since the 1970s.

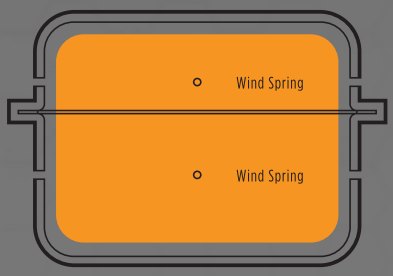
Safety Testing Evolving:

New safety testing methodologies are beginning to incorporate these concerns. As protection standards evolve, the burden falls to manufacturers to stay ahead of that curve, or risk falling behind. New rating agencies are emerging and advocating a shift in safety standards as well as new approaches for safety testing. For example, Virginia Tech has developed a rigorous new helmet testing protocol that broadens the historically narrow focus on skull fracture.

Specifically, these tests are looking at a far wider range of impacts and testing whether helmets protect against the full range of impact, from a low energy jostling to a high impact collision. And Virginia Tech's pioneering new standards favor helmets that can "reduce acceleration across the range of energy levels" and protect not just against 100-G impacts but also against lower force impacts as well.[xiv] Prior to VT's new protocols, safety testing primarily focused on injuries like skull fractures and subdural hematomas.

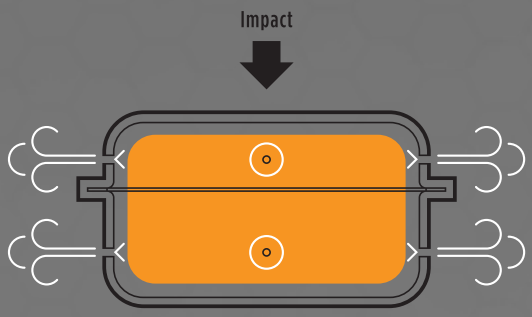
"We want to push the envelope and look at how we can reduce concussion risk," Virginia Tech researcher Stefan Duma says.[xv] His early rounds of tests were grim. Their report on hockey helmets yielded no top performing helmets and found that "more than a quarter of all helmets worn by hockey players, from the NHL to youth leagues, are unsafe."[xvi] The Virginia Tech study has been applied to football and hockey and is expanding into other sports and activities, like cycling and lacrosse.

The Solution: Crash Cloud technology is designed to address real-world impacts, the majority of which happen at low to medium velocities.



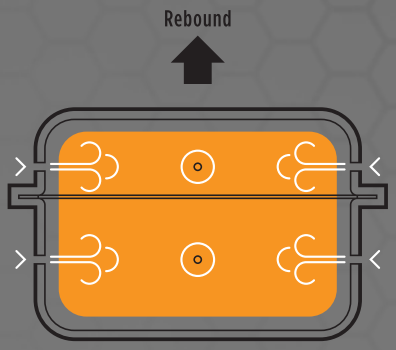
Absorb

The Crash Cloud™ system is made up of three important elements: Wind Springs™, Impact Vents™ and Refresh Vents™. These self-recovering airbags are activated instantly on impact, absorbing the energy of a hit.



Dispense

As each Wind Spring™ is compressed, energy is transferred through the Impact Vents™, away from the point of impact.



Recover

Wind Springs and Refresh Vents then work together to rapidly reinflate each Crash Cloud. This enables both the system and the user to withstand the multiple impacts that often make up a single event.

Specifically, Crash Cloud technology is an air-diffused impact system that combines energy absorption and dissipation techniques to lower peak acceleration (see illustration). Think "airbags for your brain" – in fact, that's an apt comparison because Crash Cloud was directly inspired by airbags from cars, developed by the largest child safety seat manufacturer, and backed by a two-year funded study in Kettering University. Unlike current impact products, the technology simultaneously absorbs and dissipates energy upon impact. Since energy remains constant in an impact, managing that energy to improve safety means finding alternative ways of moving impact energy away from the head. In fact, transferring energy should be the foremost priority in mitigating the severity of head trauma.

Windpact's technology features a series of crash clouds, refresh vents, and wind springs that instantly absorb and disperse impact energy. The refresh vents dissipate the energy generated by a collision and allow air to reenter the crash clouds. The wind spring system provides an immediate, nearly full recovery from each collision. All of this happens in the blink of an eye. All together, the patented system actually changes the characteristics and behavior to respond to a specific impact event. Crash Cloud uses a soft foam – like a mattress topper or the sponge material used to wash a car – to replace the "air" in the airbag concept. The Crash Cloud system, including the sealed chambers and vents, relies on the soft forgiving foam for low energy impacts, but uses the sealed wind spring chambers to resist high energy impacts. This makes it a uniquely "smart" system that adapts to individual impacts.

Crash Cloud Components

Table 2.

Crash Clouds	Wind Springs	Refresh Vents
Non-explosive "air" bags (with the air replaced with soft materials) respond instantly to linear, angular and rotational impacts.	A spring system provides nearly 100% recovery from impact through very controlled absorption dispersion of crash energy, followed by a nearly instantaneous re-inflation of foam, allowing for multi-impact use.	Relief vents disperse energy created by an impact; this controlled release of air energy creates about 50% of the force which resists impact. The air release can be controlled with vents sized to different sports or applications.

Crash Clouds Protect Against A Wider Range of Impacts

Different activities bring different impact risks. A motorcycle rider, for example, faces the risk of extremely high velocity impact in the event of a crash, while toddler helmets are optimized for a much lower impact profile, and contact sports such as football can expose players to multiple sub-concussive (low rate) impacts during the course of a season.

As a "smart" system, Crash Cloud is designed to adapt to the circumstances of the activity. The system itself, using the same basic design and materials, can be adjusted to account for situational variables. Specifically, the vents can be re-sized and the density of foam can be adjusted. Since the refresh vents create a portion of the force that resists impact, adjusting the vents can fine-tune the Crash Cloud to match its specific application.

So whether playing football, hockey, or baseball, cycling, or riding a motorcycle, Crash Clouds can keep the user's head better protected against risk of concussion from impact events.

The individual materials that make up the Crash Cloud show a clear but expected dependence on the rate of impact when tested separately. In other words, the components individually behave in a particular manner, with performance maximized at one specific velocity or set of velocities.

However, when the materials are combined into the Crash Cloud, the system behaves in a strain-rate insensitive manner, meaning the efficacy of the Crash Cloud does not depend on the strain-rate of an impact.

Compare Figures 3 and 4 for an example. Figure 3 demonstrates the performance of FS170 Foam Stress versus strain. The foam at lower strain rates (stress as measured in psi) simply does not respond until high strain rates; the displacement of the foam (in inches) remains flat for lower-to-moderate stress. In other words, the foam is behaving in a static manner (indicated by the blue line). This is not effective for protecting the head at lower energy levels because the foam does not respond until more force is exerted: it's failing to manage the energy of the impact.

Contrast that performance to the Crash Cloud in Figure 4, where the deformation matches, in almost direct proportion, the force for all impact events, from low to high. Regardless of how you hit the product, low velocity at 25 in/sec or high velocity at 150 in/sec, the displacement of a Crash Cloud behaves optimally to address level of impact. Regardless of the impact, it just works.

This is particularly critical at low velocity impacts (25in/sec, for example) because most modern helmets are designed to protect against high velocity impacts while virtually ignoring law velocity impacts. New forms of testing, such as those from Virginia Tech, are changing that paradigm.

Figure 3.

Foams are not rate independent; they behave statically.

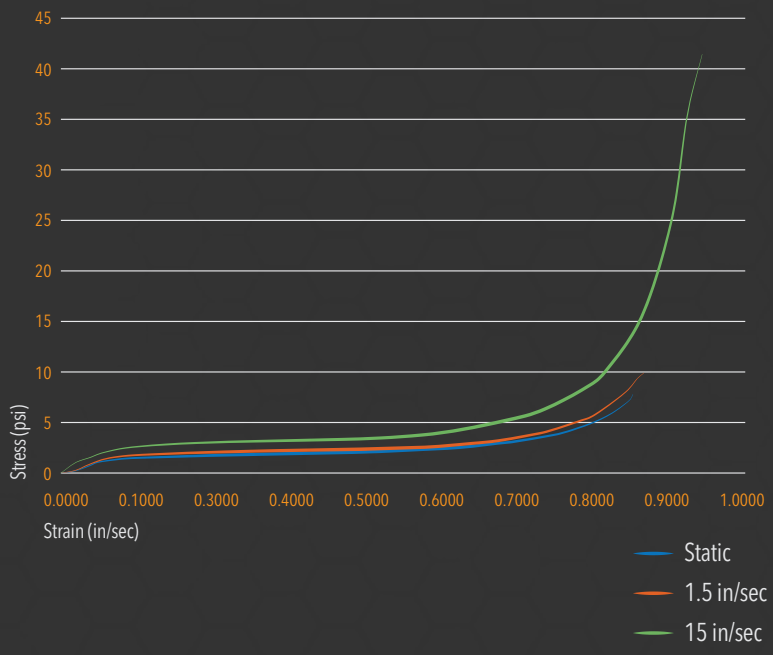
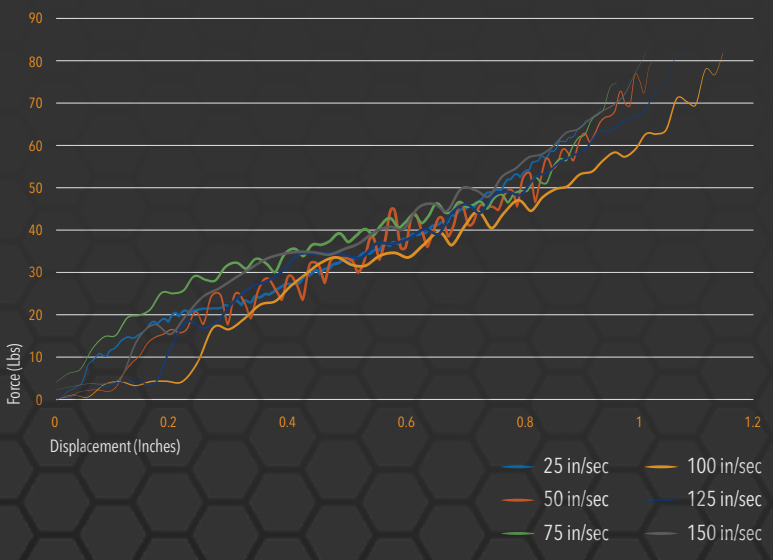


Figure 4.

Measuring impacts at multiple different velocities – regardless of level of impact, the behavior is the same.



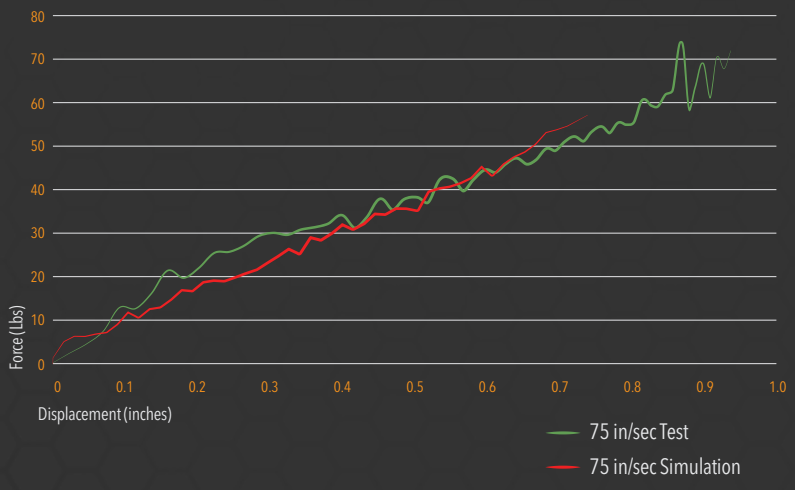
Crash Clouds Are Both Safe And Sales-Friendly

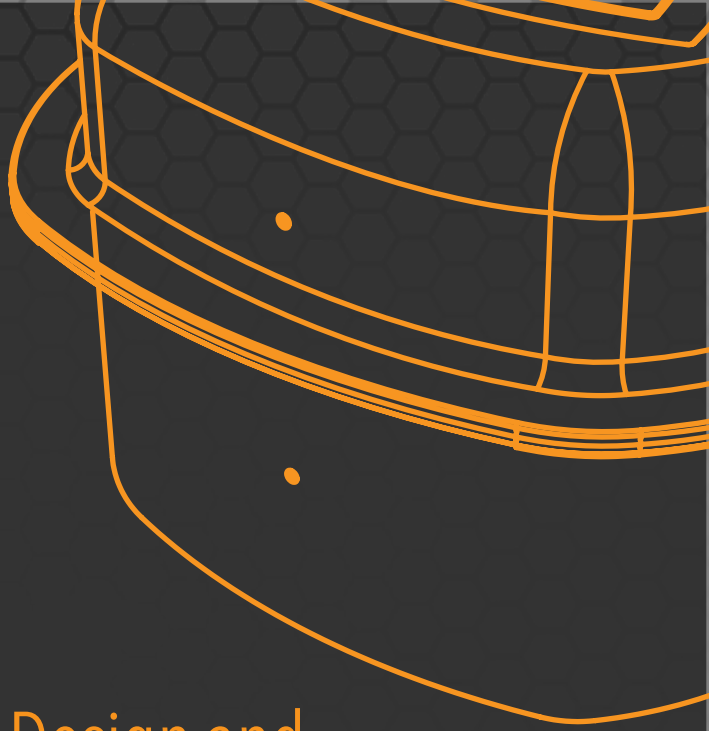
The technology satisfies manufacturers' major criteria for producing helmets that are both safe and sales-friendly. It provides an option for consumers to make smarter, more informed choices around their safety equipment needs.

Windpact's patented technology is compliant with the NOCSAE (National Operating Committee on Standards for Athletic Equipment) football safety standard. The core technology meets the National Highway Traffic Safety Administration (NHTSA)'s standards for side-impact crash testing, and has been sold in over 900,000 safety seats since 2009. The Crash Cloud technology has also been subjected to rigorous, third-party testing. See Figure 5, demonstrating a Crash Cloud FEA Simulation vs. test.

A simulation generally gives optimal results, indicating how, under optimal conditions, an impact should behave at a certain velocity to help protect the individual. In Figure 5, the Crash Cloud provides superb results in testing, with no damage to foam or "blow-out" of Crash Cloud skin observed during highest rate testing. Altogether, Crash Cloud is a different approach to managing the many different types of impacts. Each Crash Cloud automatically adjusts to manage a wide range of impact rates, rather than focusing solely on the worst case scenario.

Figure 5.
Real-world testing shows excellent agreement with optimized simulations.





Design and Construction Standards

Table 3.

Exceptional safety

Exceeds standards evaluated & verified by third party labs for high speed, low speed and rotational impacts.

Lightweight, user-friendly design

Weighing approximately 1200 grams, the lightweight helmet is waterresistant, washable and feels comfortable when worn.

Manufacturer-friendly fabrication

Crash Clouds are built to the highest standards based on customer-driven specifications.

Attractive to consumers

The components allow for a sleek, modern and fresh design.

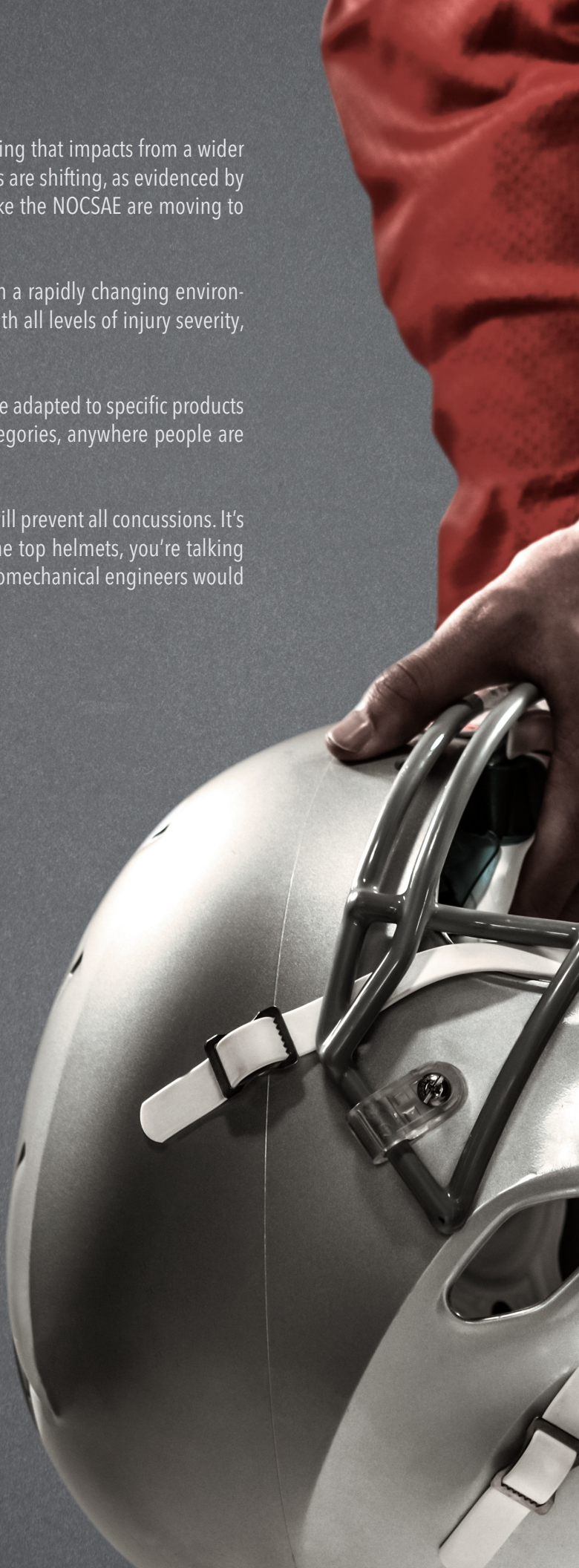
Conclusion:

The definition of "protection" in helmets is changing. Research is showing that impacts from a wider range of velocities can cause serious harm. As a result, testing standards are shifting, as evidenced by the emergence of new third party testing protocol. Certifying bodies like the NOCSAE are moving to keep up.

Now the pressure is on manufacturers struggling to find the right fit in a rapidly changing environment. What's needed is a helmet design or technology that can deal with all levels of injury severity, from catastrophic to sub-concussive hits, with a single form factor.

Enter the Crash Cloud, a patented approach to helmet design that can be adapted to specific products and applications. Crash Cloud has broad applications across many categories, anywhere people are exposed to the risk of impact.

Dr. Stefan Duma agreed that "there will never be a perfect helmet that will prevent all concussions. It's about risk reduction. The reality is when you look at the bottom and the top helmets, you're talking about massive reductions in acceleration, over half. I think almost all biomechanical engineers would agree that that's a significant difference." [xvii]



References:

i Gessel, L.M., Fields, S.K., Collins, C.L., Dick, R.W., & Comstock, R.D. (2007, Oct-Dec). "Concussions among United States high school and collegiate athletes." The Journal
of Athletic Training 42(4): 495-503. Retrieved September 2015 from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2140075/.

ii Foster, T. (2012, Dec 18). "The helmet that can save football." Popular Science. Retrieved September 2015 from http://www.popsci.com/science/article/2013-08/helmet-wars-and-new-helmet-could-protect-us-all.

iii Wilson, M. (2013, Jan 31). "Why NFL helmets will never be concussion-proof." Fast Company. Retrieved September 2015 from
http://www.fastcodesign.com/1671752/why-nfl-helmets-will-never-be-concussion-proof.

iv Fainaru, S. (2015, Mar 30). "Study: many hockey helmets unsafe." ESPN. Retrieved September 2015 from http://espn.go.com/espn/otl/story/_/id/12564082/virginiatech-
study-hockey-helmets-finds-many-unsafe.

v Fainaru, S. (2015, Mar 30).

vi Fainaru, S. (2015, Mar 30).

vii Foster, T. (2012, Dec 18).

viii Walton, A.G. (2012, Jun 4). "Fatalities in football are down, but traumatic brain injuries are up." The Atlantic. Retrieved September 2015 from
http://www.theatlantic.com/health/archive/2012/06/fatalities-in-football-are-down-but-traumatic-brain-injuries-are-up/258023/.

ix Federal Register (1998, Mar 10). "Safety Standard for Bicycle Helmets."

x Fainaru, S. (2015, Mar 30).

xi Foster, T. (2012, Dec 18).

xii Foster, T. (2012, Dec 18).

xiii Foster, T. (2012, Dec 18).

xiv Steinbach, P. (2015, May). "Virginia Tech professor explains helmet research." Athletic Business. Retrieved September 2015 from
http://www.athleticbusiness.com/athlete-safety/virginia-tech-professor-explains-helmet-research.html.

xv Fainaru, S. (2015, Mar 30).

xvi Fainaru, S. (2015, Mar 30).

xvii Fainaru, S. (2015, Mar 30).

Tomorrow's Technology Today

Windpact is a safety technology company. Our flagship offering, Crash Cloud™, amplifies the benefits of protective gear by increasing the level of impact protection, without sacrificing its ability to perform, degree of comfort or sense of style.

571.291.2222
info@windpact.com
www.windpact.com