STORY **DARRYL FLACK**
PHOTOGRAPHY **DON MORGAN COLLECTION**

CONE-HEAD

The biggest innovation in helmet design in 40 years is heading home thanks to American helmet brand Kali

"And the winner is Don Morgan and Cone-head!" With these immortal words, a persistent inventor from Queensland bowed his head in disbelief then raised it in triumph to claim the 2007 New Inventor of the Year prize on ABC-TV. Don Morgan had finally put his Cone-head helmet liner design into the limelight after 15 years of hard toil and knock backs.

Now that American helmet brand Kali is launching its Naza model in Australia that incorporates the crumple zone Cone-head design, this is also story of Don's desire to lift helmet standards worldwide, and his dream to produce a Cone-head helmet in Australia and why that never happened.

THE IDEA

Don's journey as an inventor of the Cone-head liner for helmets began in the mid-1980s when he was a member of a research project investigating the effectiveness of motorcycle and bicycle helmets conducted at the Queensland Institute of Technology. Investigating helmets that had been involved in fatal crashes, the team noted that the foam liner showed little or no evidence of damage or crushing; that led them to the conclusion that the liners in helmets were too stiff, and that they should be made from low density foam.

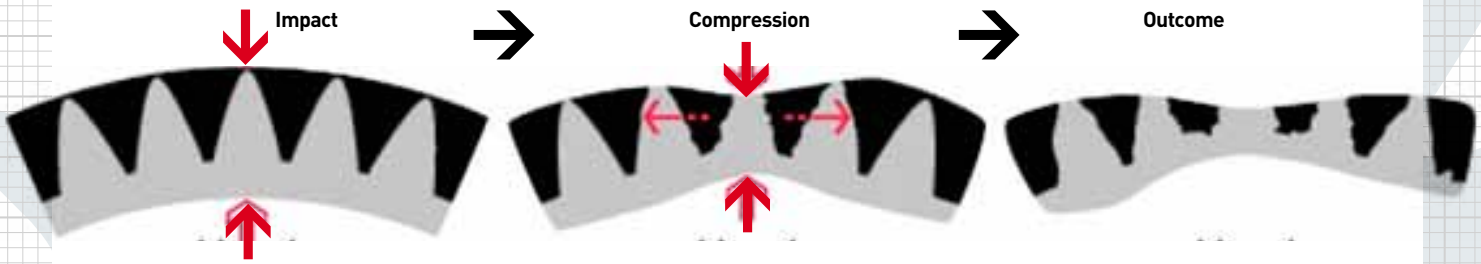
"In the early 1990s, my eldest daughter, who was about five at the time, was learning to ride a bicycle. When I looked at her helmet and pressed my thumb up against the hard foam liner I was shocked that it was hard as a brick. That went against every bit of research that I had been doing, which was to make the foam softer. Some of my early designs included low-density strips sandwiched within the thickness of the high density foam, and low density cylinders embedded into the thickness of the liner, but I was never completely happy with that design."

What sparked the cone idea was Don watching waves hit a research water tank wall at an angle, then noticing how the energy dissipated laterally away from the point of contact. "I tried to visualise how what I saw in the water tank could be applied to foam liner of a helmet. That's when I thought of embedding low density foam cones with the thickness of the high density foam, initially though with square-based pyramids; but moments later I thought cones would work even better because they have a wonderfully unique property. They will initially compress or crush and, as you continue to apply a force, they become

Main: The Kali Naza incorporates Cone-head technology
1. Don (left) started testing helmets in the mid-1980s
2. Setting up an impact test rig
3. Testing included impacts into the front and sides of motor vehicles

REDIRECTING IMPACT FORCES

The diagram below clearly shows how Cone-head technology directs impact forces sideways, away from the head. The base of the cones compress which alows the wearer's head to gradually slow down, therefore reducing the g-force to the head.



Head 0 ms	Head 6 ms	Head 12 ms
Impact force directed towards head	Top of cones compress thereby directing the energy/force sideways with foam	Energy/force absorbed
Head pushing in opposite direction	Base of cones compress thereby gradually allowing head to slow down	Small g-force to head

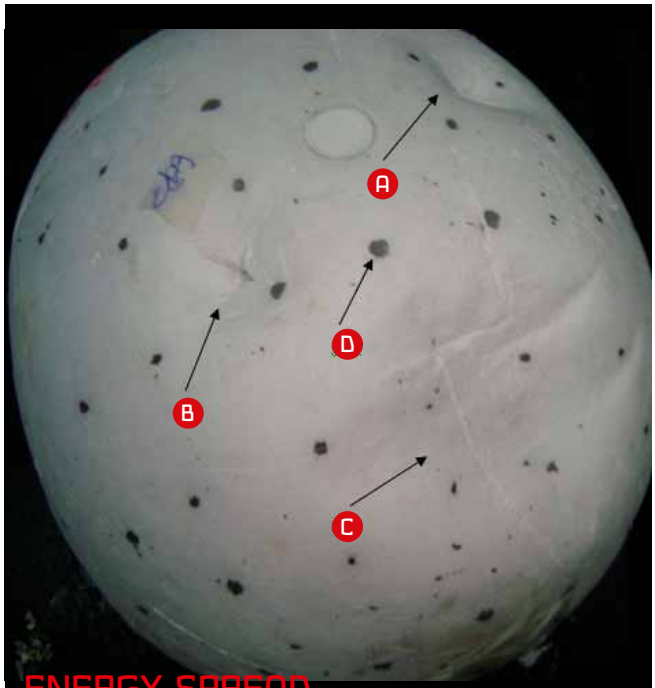
IMAPCT CUTAWAY

This photo shows a motorcycle helmet, incorporating Cone-head technology, cut into halves revealing the cross-section of the inner and outer foam layers and the fibre-glass outer shell. The motorcycle helmet was tested to the 2010 Snell Standard. The test involves dropping a helmet, which has a headform inside the helmet, onto a hemispherical steel anvil.

The arrows left rear (A), right rear (A), left front (B) and right front (B) show the result of compression to the tops of the low density cones and the outer foam layer of high density under the flexible fibre-glass outer shell (D). The compression of the low density cones spreads the energy sideways throughout the foam liner instead of towards the head.

The arrows (C) show compression to the bases of the soft low-density cones of the inner foam layer caused by the head-form impacting against the inner foam layer. The approximate outline of the test head form is shown by the red dashed lines.

It can be observed there is a decrease in the thickness of the inner layer in several areas where the cones emanate. This decrease in thickness is the result of the head-form compressing the inner-foam layer thereby reducing the g -force.

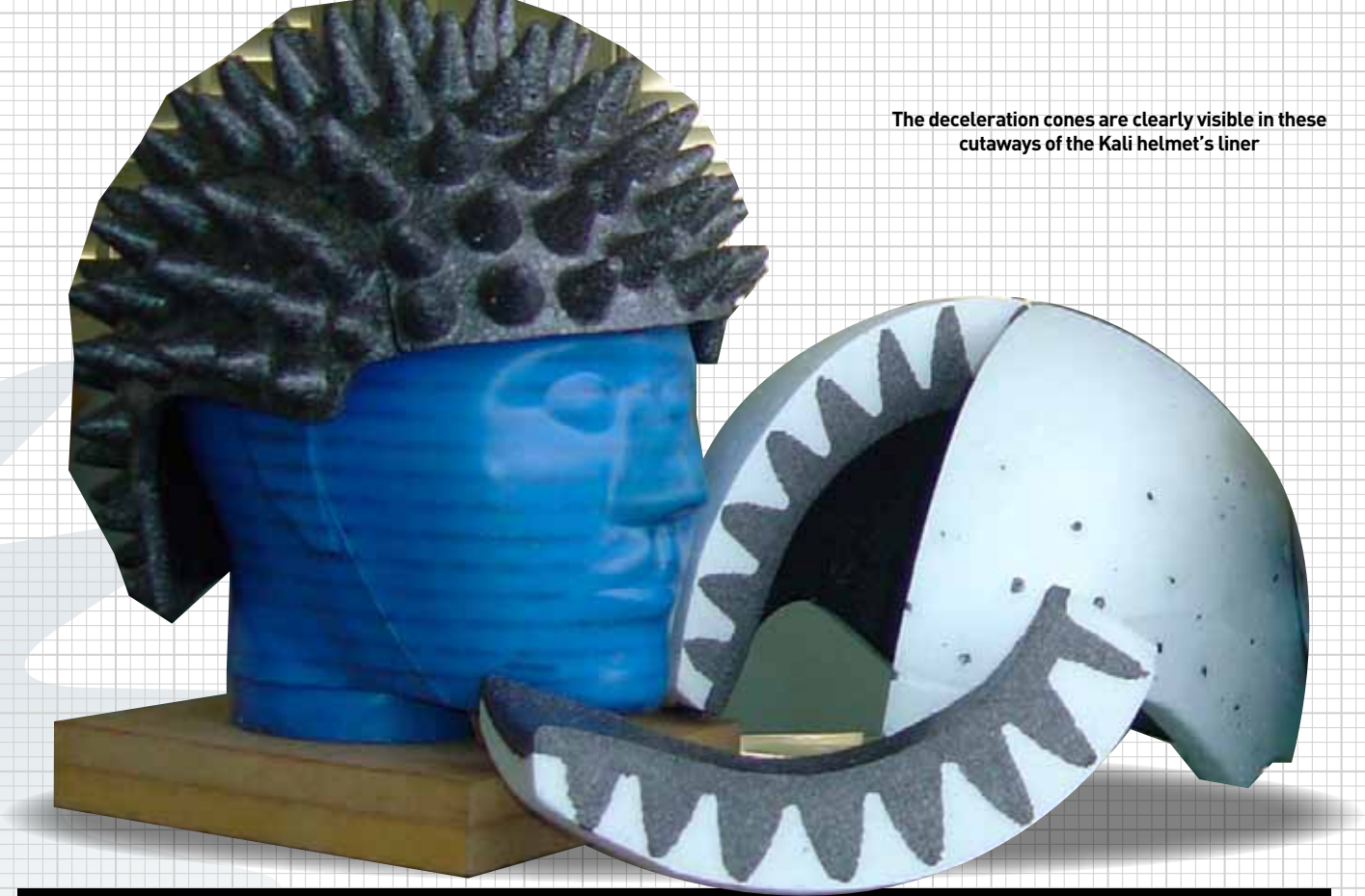


ENERGY SPREAD

This photo shows a view of the outer foam layer of a Cone-head technology motorcycle helmet after being subjected to an impact force (2010 Snell Standard). The Cone-head technology foam liner has been removed from its fibreglass outer shell.

The outer foam layer shows three distinct areas of compressions located at (A) right front, (B) left front and (C) top. The two areas of compressions at the front (A) and (B) are from the penetration tests. The black dots (D) are the apices of the low-density cones of the inner layer contiguous with the outer surface of the high density outer layer.

The compression (C) at the top is from dropping the helmet onto a hemispherical anvil for a peak deceleration test. The degree of compression observed for the helmet is considerably more than that is observed for a single density helmet. The compression indicates the impact energy has been spread sideways within the thickness of the foam liner away from the head.



The deceleration cones are clearly visible in these cutaways of the Kali helmet's liner

The unique cones collapse first, directing the energy laterally within the foam instead of linearly down to the rider's head

harder to compress or crush. Cones are great shock absorbers. I call them deceleration cones." A key feature of the Cone-head is that it has five different zones that each feature cones with different densities to better protect different parts of the skull based on Don's extensive research findings.

"The Naza incorporates three innovations which I call the Cs in making the helmet lighter and safer – cone-head technology, composite fusion and contego foam," Morgan said. He added that the helmet will be available in Australia later in 2011. Kali's Composite Fusion Plus design incorporates cones of different foam densities within the EPS/shell connection. As energy is transferred from the shell to foam during impact, the unique cones collapse first, directing the energy laterally within the foam instead of linearly down to the rider's head. This disperses the impact energy over a greater area, allowing the use of softer foam to better protect the rider.

"Our move into Australia is in no small part due to Don," says Kali founder Brad Waldron. Waldron spent nine years in the US aerospace industry in the area of composites,

RAISING STANDARDS

He might be a physicist and research academic, but Don Morgan has a very good handle on the workings of the real world. This Queenslander has some strong opinions on helmet design based on nearly 30 years of research. According to Morgan, there have only been two innovations in helmet design over the last four decades. "There have been only two real significant changes to the design of helmets since the introduction of the full-face helmet 40 years ago: the new Cone-head shock absorbing foam liner and the Phillips Head Protection System (PHPS) to protect the brain from the dangers of rotation. To put it bluntly, apart from these two innovations, helmets are still pretty much in the dark ages and have not kept up with modern thinking and development. For example cars had crumple zones years ago. The motor vehicle industry is very progressive with developing new passive and active safety measures. This situation is not entirely the fault of the helmet manufacturers since they must manufacture helmets to meet the rigid demands of outdated helmet standards."

"The current standards (Snell, European, Australian and other world standards) are very outdated. For example, the testing of a helmet to the Australian or New Zealand standards requires a helmet to be attached to a hard magnesium headform (same shape as an average adult skull) and dropped through a height of 1.8m onto to a hard flat or hemispherical steel anvil. The problem is there is nothing realistic about this test. This is the main reason why helmet liners are too hard and stiff and do not effectively absorb an impact force. The standards should be using a humanoid headform which has similar bio-mechanical properties as a human head, which should be dropped onto different real-life impacting surfaces such car pillars, bonnets, or bitumen road and concrete gutters. In fact, I have used these objects in my own empirical research.

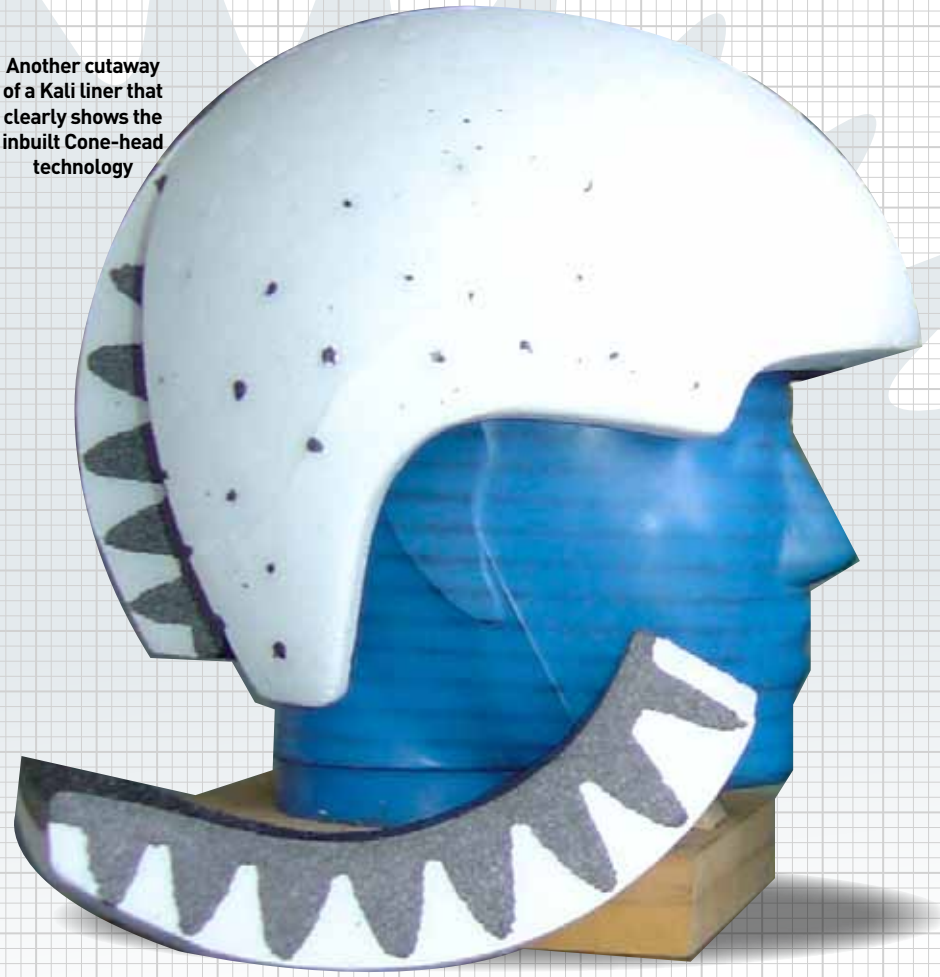
"New standards along these lines would encourage helmet manufacturers to be more innovative in improving helmet designs by using new absorbing materials and configuring the liner to better absorb impacts, like cone-head. Europe has moved to improve its helmet standards – I hope the others follow."

1. A test rig for measuring impacts
2. Don uses a humanoid headform for more realistic testing of impacts

most notably on the FA-18 fighter plane when it was decided to convert the jet's tail from aluminium to carbon-fibre. For that last 12 years, Waldron has been designing helmets, then testing them through to manufacture after founding Kali. He grew up in California, riding the skateboarding spillways of San Jose as well as mountain biking and surfing, but his number one passion is motorcycles. "We found Don's invention to be a great addition to our own technology," Waldron says. "The combination of Cone-head in our Composite Fusion designs reduces the G-forces experienced during impact."

Discussing the launch of Kali Down Under, Brad says, "We have plans to start a push in Australia – it has been a tough nut for us to crack, yet we have strong connections through Don of course. I am proud of our products and honoured to be associated with Don, and we will move forward without a distributor and do it ourselves. We have started production of products that pass the Australian standards and as I mentioned, we will self-distribute in the Australian market."

Kali is not the only brand to use Don's technology. An agrement with Strategic Sports Limited sees the Hong Kong-based company licence Cone-head technology to brands including SMS, Motovan Zox, No Fear, and a number of bicycle and snow gear suppliers. When asked how lucrative these licence agreements will be, Don said he wasn't really interested in the money adding, "My accountant keeps telling me about the possible returns, but I've learnt you've got to keep focusing on other things than money."



Another cutaway of a Kali liner that clearly shows the inbuilt Cone-head technology

The combination of Cone-head in our Composite Fusion designs reduces the G-forces experienced during impact – Brad Waldron

OZ NO-GO ZONE

It was Don's dream for Cone-head to be established in Australia, but the idea never got traction with local investors or government. The last Australian motorcycle helmet manufacturer was El Dorado, whose full-face helmets featured in the 1974 movie *Stone*, but the brand disappeared a few years later.

Don is the first to admit that the idea, while conceptually brilliant, lacks the visual wow factor of trendy gadgets. "The difficult thing with presenting Cone-head to investors is that it was just a piece of foam sitting on a table, and they were trying to envisage how it works when it is inside the helmet. It wasn't a product whizz-bang phone or an iPod." Don made overtures to Arai and Shoei without much joy, and to AGV which replied several months later. You could just about write a book on Don's frustrations dealing with the Beattie Government in Queensland, who three times rejected Don's applications for assistance under its Government Innovation Start-Up Scheme. "The third rejection was the lowest point of my journey," Don says. "I was really disheartened and I nearly walked away from it, but my family urged me to continue." He might've been ready to throw in the towel but like millions before him, he went online to find the right partner.

Don says that props for bringing the idea to fruition must go to Doctor Philip Cheng and his son Norman Cheng who head up Strategic Sports Limited, one of Asia's largest manufacturers. Frustrated with the lack of response in Australia to bring Cone-head to market, in 2004 Don Googled 'helmets' and came up with the website to Strategic Sports Limited. He sent them an email outlining his idea, and within 30 minutes he had a reply. "That was the start of Cone-head becoming a reality thanks to the innovative attitude of the Chengs. They deserve much of the credit for helping make the idea happen, and helping me develop it. Their quick response to my email was a good sign and I eventually signed a licence agreement with them."

What followed were many trips to Hong Kong that ultimately led to a meeting with Brad Waldron, founder of US helmet brand Kali. "I met Brad at a dinner hosted by the Chengs, and I explained the Cone-head idea to him. You could see he was immediately interested, and then he challenged me on various aspects of the concept which was great. After that, I was confident that I would have a relationship with Brad and Kali, and that's how it turned out.

"Brad had the idea of fusing the liner with the EPS which made a lot of sense because sometimes the bonding isn't consistently strong, and separation can also take place. The Chengs had developed Contego foam, which would really advance the Cone-head idea as well. The two innovations came together."

Don Morgan with Norman Cheng

Kali helmets founder Brad Waldron