Choosing a Helmet

by James Freeman - March2013

In a recreational activity like hang gliding , there are significant risks of injury or death. Helmets on the market today offer varying degrees of protection. The purpose of this article is to provide a guide on how helmets work and what to look for when choosing one.

You need a helmet whenever you fly. Almost all pilots will crash eventually. Even a low-speed crash can scramble your brains. Gravel rash and broken bones heal; brains often do not. Exact figures are not available for hang gliding however research shows that ~90 per cent of cyclist's brain injuries can be prevented by a properly fitted bicycle helmet. Although helmet use has been shown to reduce head injuries significantly, there are limits to a helmets protective capability. No helmet can protect the wearer against all foreseeable accidents. Therefore, injury, death and permanent impairment may occur in accidents which exceed the protective capability of any helmet. Use your superior judgement to avoid situations where you will have to use your superior skills and perhaps your superior helmet.

The physics of how a helmet works

Head injuries aren't caused by speed, but by the sudden stop when our head hits a hard surface. The way to prevent the injury is to bring the head (and the brain) to a more gradual stop. A helmet reduces the peak force applied to the head in a sharp impact. The force applied to an object can be calculated from the equation :

F = m.a where F = force, m = mass, a = acceleration
As acceleration is the rate of change of velocity we can write:
a = (Vf ,Äì Vi) / t where Vi = initial velocity, Vf = final velocity, and t = time
hence by combining these two equations we can write:
F = m.(Vf ,Äì Vi) / t
In a crash situation the initial velocity (Vi) is whatever speed the pilots head is moving at. The final velocity (Vf) is 0. Thus the equation becomes:
F = ,Äì m.Vi / t
As both m and Vi are constants (i.e. fixed and unchangeable) we have:
F = k / t or F ¬µ 1 / t

This equation is at the heart of how a helmet works and simply states that the force in a deceleration is inversely proportional to the time taken for that deceleration to occur. The only variable in a crash situation is the time the change in velocity occurs over, as this determines the deceleration and hence the force applied to the head. If we can increase this time by a factor of 2 the deceleration (and thus the force) is halved; If we can increase this time by a factor of 4 the force is reduced to 25% of what it would have been without a helmet. A human brain can withstand ~ 400G without ill effect. From 400-700G causes concussion with a variable period of loss of consciousness. 700G+ results in permanent brain damage.

To increase the critical time over which deceleration occurs requires a material that brings our head to a safe stop by gradually crushing under load. It should not bounce back too quickly. If it does, the energy stored by crushing will be released and it will not have protected us as well. It also needs to be thick enough and stiff enough to not totally collapse (bottom out) before our head comes to a stop. A material which can do this was developed in the 50s and today nearly all helmets do this with expanded polystyrene (EPS), the same foam used for Eskis and packing electronics. Once crushed, the foam does not recover. Spongy foam is added inside for comfort and fit. Another foam, expanded polypropylene (EPP), does recover, however, it may have some undesirable "rebound". A stronger EPS called GECET appeared in 1992 and is also widely used. A third foam called EPU (expanded polyurethane) is used for helmets made in Taiwan. It has a uniform cell structure and good crush without rebound, but is difficult to manufacture and not used much. The desired effect is that instead of your head coming to a near instantaneous stop the crushing of this foam slows the head down over an extended period of time.

But, were not finished. What if the surface we hit is not flat. Rounded surfaces concentrate the force of the blow in a smaller area. The smaller the radius, the greater the concentration. To compensate, we can add a hard outer shell to spread the force over a wider area and reduce the concentration, or we can increase the stiffness of the crushable material to prevent it from collapsing, or we can make the crushable material thicker, or combinations of all three. The hard shell will make it heavier. If the crushable material is too stiff, it might not crush enough when it hits a flat surface. Thickness has to be controlled in order to wear the helmet comfortably. Each of these effects the usefulness of our helmet.

What type of helmet do I need?

A helmet consists of an outer shell, crushable foam, a comfort liner, and a retention strap system. There are at least four critical elements that effect a helmet's protective properties:
Impact management - how well the helmet protects against collisions with large objects.
Helmet stability - whether the helmet will be in place, on the head, when it's needed.
Retention system strength - whether the chinstraps are sufficiently strong to hold the helmet on throughout an impact.

Extent of Protection - the area of the head protected by the helmet.
The EPS foam layer is absolutely critical to impact management as explained above. The thicker the layer of foam the greater its ability to absorb impact forces. The firm rubber found in some helmets is a very poor substitute and not recommended.
The shell also plays an important role in impact management in that it (1); holds the EPS together during impact/s; (2) helps prevent objects penetrating the helmet and spreads the load to the foam; and (3) helps the helmet skid easily on rough surfaces to avoid twisting your neck.

Obviously a helmet must stay on even if your head hits more than once so it needs a strong strap and an equally strong fastener that cannot be accidentally opened. The comfort liner and straps help hold the helmet in correct position. With the strap fastened you should not be able to get the helmet off your head by any combination of pulling or twisting. If it comes off or slips enough to leave large areas of your head unprotected, adjust the straps again, add some padding or try another helmet. Keep the strap comfortably snug when flying.

Open face helmets generally represent an acceptable level of protection for your brain however provide less protection for your face. Full face helmets offer some extra facial protection at the expense of extra weight, decreased peripheral vision and perhaps decreased hearing and tactile sensation. It is also very important that they fit firmly. I was unfortunate enough to have to attend a recent hang glider lock-out incident in which the pilot impacted face first. The impact on the chin guard led to the helmet rotating downward causing the pilots sunglasses to shear his nasal bridge off, later repaired with plastic surgery. Of concern is the extra leverage of the chin guard on the neck, especially some designs in which the chin guard is an excessive distance in front of the chin.

Bicycle style helmet vents mean less foam in contact with your head in a crash, which could concentrate force on one point of your skull. These vents are designed to dissipate heat which is not always optimal for hang gliding where staying warm is often the main concern. They also tend to have very thin shells.

“Aero” helmets are not noticeably faster unless you fly at competition speeds, and the “tail” could snag in a fall twisting your neck.

Comfort Requirements should be considered. Fit, weight, and temperature/sweat control are the most critical comfort needs. A snug fit with no pressure points ensures comfort and correct position on the head if you crash. It may take a half hour of wearing to feel pressure points. Weight is a big issue for long flights. Airflow over the head determines warmth. Vented bicycle style helmets are designed to facilitate heat loss - OK on the coast but less use at cloudbase. Sweat control can require a brow pad or separate sweatband.

When do I need to replace a helmet?
Replace a helmet if you crash and hit your head. Impact crushes some of the foam. The helmet is less protective but the damage may not be visible. Helmets soften impact, so you may not even know your head hit unless you examine the helmet for marks or dents. If you can see marks on the shell or notice any foam crush at all, replace the helmet. You may be reluctant to replace a helmet that looks almost as good as new, but if you did hit, you don’t want to take chances. If the foam of a bicycle helmet is cracked under the thin shell, it will be more likely to fly apart in your next crash. Replace the buckle if it cracks or a piece breaks off.

Can you make it fit correctly? If not replace it.

If you still have a helmet from the 70s without an EPS liner, replace it immediately. They just do not have the protection of modern helmets.

Finally, the protective capability may diminish over time. Some helmets are made of materials which deteriorate with age and therefore have a limited life span. Most manufacturers recommend helmet replacement after five years. Realistically that depends on usage, and most helmets given reasonable care should be good for longer than that. Please note that experience indicates there will be a noticeable improvement in the protective characteristic of helmets over a five year period. Thus, the recommendation for five year helmet replacement has some merit.

Is a cheap helmet as safe as an expensive one?
Maybe. Maybe not. Maybe safer. The protective capability of a particular helmet is difficult to measure. You can quickly judge a helmet for style, price, fit and comfort. But who knows what that helmet can do when your skill, experience and every other precaution have failed, and your helmet’s the only thing between your head and a violent impact. Without lab test data it is difficult/impossible to say. A standards sticker is an indication that the helmet has at least been tested however the testing may not be hang glider appropriate. If money buys you a better fit, more stable on your head in a hard crash, then the more expensive helmet is worth it. A crushable foam liner is absolutely essential - a thick layer will offer more protection than

a thin layer. Shell strength needs to be adequate to maintain the integrity of the EPS foam and prevent penetration of objects into the foam and underlying skull. Essentially the stronger the better, however extra strength = extra weight and may not represent a significant increase in safety. Carbon fibre or Kevlar are stronger than fibreglass helmets on a weight for weight basis but cost more.

What about helmet standards?
Only the Europeans have a specific standard for hang gliding/paragliding helmets. The applicable standard is EN966. Many manufacturers of fine helmets in other countries certify their helmets to other standards. Standards for activities where accidents involve similar speeds into similar objects may include: Bicycle standards, Ski helmet standards, Horse Riding standards, Non motorised sport standards.

To give you an idea why standards certification is important consider that depending on the application and standard, the helmet must pass all or some of the following tests:
Impact Test - This test involves a series of controlled impacts where a helmet is positioned on a metal head form and then dropped in a guided fall onto various test anvils (Flat, Hemisphere, Kurbstone, Roll bar, etc.) to simulate different impact surfaces. The head forms are instrumented with an accelerometer to measure peak G force. The impact energies (determined by drop height and head form mass) differ between standards. However, in general if the peak acceleration imparted to the head form exceeds 300 G's, the helmet will be rejected.

Positional Stability (Roll-Off) Test - test straps ability to retain helmet on head.
Dynamic Retention Test - tests strap strength.
Chin Bar Test - tests strength and impact resistance.
Shell Penetration Test - self-explanatory.
Face shield Penetration Test - self-explanatory
.
Details of many of the standards are available on the internet. Useful sites are:
www.smf.org (Snell Memorial Foundation)
www.bhsi.org (Bicycle Helmet Safety Institute)
www.standards.com.au (Standards Australia)
www.sph.emory.edu/Helmets (WHO Helmet Initiative)

How to Buy
When you pick up a helmet, look for a standards sticker inside i.e. EN966
Check that it has a thick layer of EPS foam
Check that it has a sturdy shell
Put it on, adjust the straps and then try hard to tear it off.
Look at the buckle for long-term durability.
Make sure it is comfortable
Compare the price to the cost of a prolonged hospital stay.
Consider the nightmare of being a vegetable
You will never regret buying and wearing a quality helmet.
Your brain is priceless!