Interreg
Italia-Österreich
European Regional Development Fund

EUROPEAN UNION

GOODride

DOWNHILL PROTECTIVE EQUIPMENT

Introduction to the main PPE that can be used and comparison of the international standards applied

DOLOMITICERT

UNIVERSITÄT SALZBURG

UNIVERSITÀ DEGLI STUDI DI PADOVA

GOODRIDE: the project

The growing number of winters with limited snow in the project's regions requires a shift towards summer tourism where active, fun activities are of great importance. Mountain bike (MTB) parks are becoming increasingly important and enable winter infrastructure to be used in the summer. However, there are no common standards for route waymarking, optimal rider protection, and concepts for sustainable use. These deficiencies pose a safety issue, given the increasing number of inexperienced users try the sport on their holidays. Consequently, this project aims to develop a shared Introduction to the main PPE that can be used and a comparison of the international standards applied for waymarking, jump construction, and rider protection standards. The project's activities focus on: an analysis of state of the art in MTB park and rider safety strategies; the acquisition of rider kinematic and dynamic data during jumps; the development of jump assessment; and construction methods and protection device analysis. The project results will serve as guidelines in the construction of new bike parks and routes and will be an opportunity to promote of summer tourism in the project's regions.

Follow all the project's progress on the page "GoodRide - Interreg V-A Italia Austria 2014 2020" @GoodRideInterreg

Project leader

SALZBURG UNIVERSITY - Department of Sport and Exercise Science

The researchers of the University of Salzburg have a long experience in biomechanical motion, force, and load analysis in various sports. The Department has an international reputation in this research area and published a considerable number of publications: http://www.sportwissenschaft.uni-salzburg.at/spo/forschung/publikationen/publikationsdatenbank/ This experience and biomechanical analysis were key elements in developing new rider safety concepts in mountain and downhill biking. Furthermore, the sport sciences department has wide-ranging experience in planning, coordinating, and implementing international projects.

UNIVERSITÄT SALZBURG

Partner

DOLOMITICERT

Dolomiticert has a research area with many years of experience in regional, national, and European project development and qualified staff fully capable of managing all phases of project co-ordination and supervision, including expense accounting for the promotion and dissemination of the results achieved. In particular, in the Interreg Italia-Austria programs, Dolomiticert acted as project leader for SAFE A HEAD – Cod. ID. 5064, AIR-SKI – Cod. ID. 6362 and OUTFEET - ITAT1026.
Additionally, the company employees developed new rider safety concepts in mountain and downhill biking based on biomechanical analysis.

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UNIVERSITA' DI PADOVA

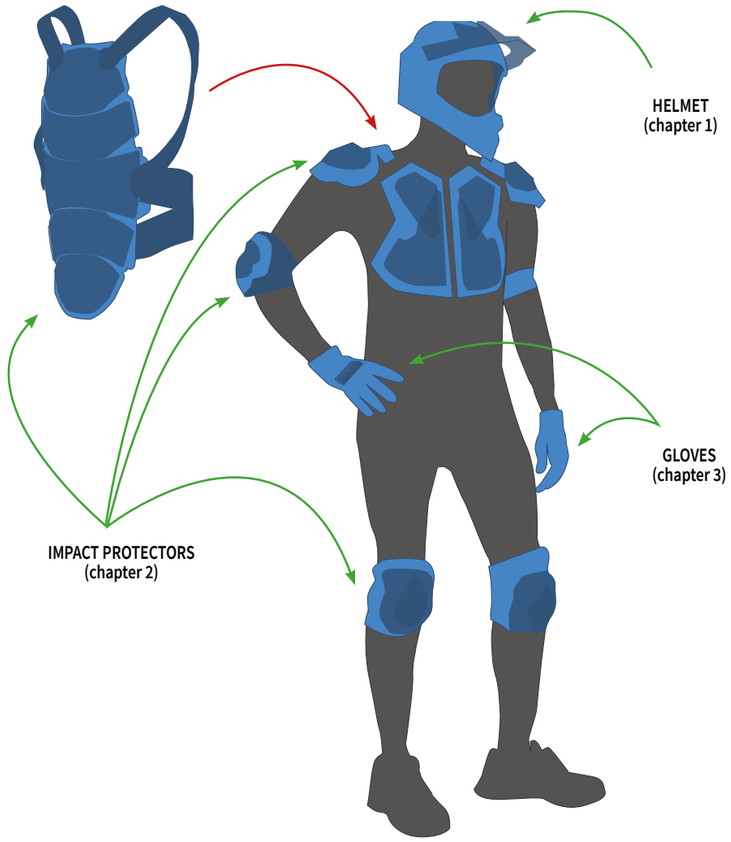
Industrial Engineering Department

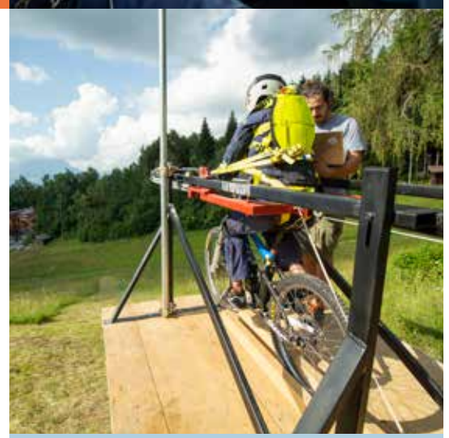
The University of Padua Industrial Engineering Department has carried out research work into various themes, ranging from mechanics to electronics, materials, chemistry and other processes. About sports equipment engineering and rehabilitation, the employees have skills in both the material choice and characterisation field as well as structural planning and characterisation and biomechanics and functional assessment. Over the years, there has developed partnerships with Austrian institutions such as Innsbruck (SkiProTech, ProFitBoot) and Salzburg (SAFE-A-HEAD, AIRSKI) universities and the OutFeet and AlpSporTec projects.

UNIVERSITÀ DEGLI STUDI DI PADOVA

INTRODUCTION

Downhill mountain biking is a discipline with a high risk of injury and can be classified as an extreme sport. While personal protective equipment (PPE) is mandatory in some situations, its use is generally recommended to avoid injury following a fall or impact. The image below identifies the most common PPE suitable for this discipline. Important: If the reader wants to learn more about the PPE characteristics, fields of use, or protection limits of his own or new products, he is invited to consult the following chapters. All the following information is intended to help the reader to understand better the information notes and markings provided with PPEs: a well-informed user is a safer user!





1. Helmets

When riding downhill, local regulations of bike parks and/or national or international sports federations prescribe the use of helmets certified to EN 1078 with a chin guard and visor. Cycle helmets on the European market comply with Standard EN 1078: this standard covers all helmets for cycling use (full-face or not), without discretising the product according to the field of use (road cycling, downhill, etc.). This standard provides for performance testing of the visors fitted to the helmet but does not include testings of the protection offered by chin guards. However, it is possible to find products on the market with double conformity EN 1078 (mandatory) and ASTM F1952:15 (mandatory for products destined for the American market), providing performance tests on the chin guard. Although a helmet certified to EN 1078 meets all the health and safety requirements of the European Union for Downhill riding, users should bear in mind when making their choice that a helmet with dual conformity is potentially safer. As an alternative to this type of helmet, in some Bike-Parks, it is permitted to use full-face motocross helmets homologated under ECE/UN 22-05. This type of helmet is undoubtedly heavier, but the mechanical tests are carried out at higher speeds and with more stringent requirements because of their intended use (motorcycling).

Regardless of the type of helmet you wish to use, it is essential to bear in mind the following requirements:

- a helmet protects the user properly only when worn correctly;
- a helmet must cover the temples but not restrict the field of vision either upwards or downwards;
- a helmet that is too narrow or too wide is potentially dangerous;
- When buying a helmet, try it on with your usual accessories (bandanas, caps, goggles and/or masks): the helmet should not be uncomfortable or ill-fitting with these.
- Helmet always fastened and well adjusted!!!!

Insight

Given the increasing expansion of Downhill riding, it is desirable to draw up a specific standard for the certification of helmets. This standard should take into account the following aspects not currently covered by Standard EN 1078:

- Verification of functional and performance requirements for chin guards;
- Verification of protection against penetrating objects;
- Verification of impact protection using other types of anvils;
- Evaluation of impact velocities during tests;
- Adequacy of the protection area or possible increase.

For an interested reader, a comparative table of the above helmet test standards is given below: the differences between the test methods for the different standards are indicated.

<table>
<tr><th>Standard
Requirement (®)</th><th>EN 1078:2012 + A1:2012
Helmets for pedal cyclists and for users of skateboards and roller skates</th><th>ASTM F1952:15
Standard specification for Helmets used for Downhill mountain bicycle racing</th><th>Regulation ECE/ONU 22-05
Protective helmets and visors for drivers and passengers of motor cycles and mopeds</th></tr>
<tr><td>FIELD OF VISION</td><td>® Upwards 25°; Downwards 45°; Horizontally 105° (right and left)</td><td>® Horizontally 105° (right and left)</td><td>® Upwards 7°; Downwards 45°; Horizontally 105° (right and left)</td></tr>
<tr><td>Restraint system - Strength</td><td>® Dynamic extension ≤ 35 mm and Residual extension ≤ 25 mm. After the test, ascertain whether or not the system can be released by one hand.
Mass of 4 kg falling from 600 mm.
Test performed on helmets reconditioned at ambient temperature after being previously subjected to impact test</td><td>® The retention system shall remain intact with elongation ≤ 30 mm.
Mass of 4 kg falling from 600 mm.
Tests performed before the impact test and on hot, cold and wet conditioned helmets (one per each conditioning)</td><td>® Dynamic extension ≤ 35 mm and Residual extension ≤ 25 mm.
Mass of 10 kg falling from 750 mm.
Test performed on a new helmet conditioned at ambient temperature</td></tr>
<tr><td>Restraint system - Stabylity (roll-off)</td><td>® The helmet shall not come off the headform.
A falling mass of (10 ± 0,1) kg attacched with a hook to the rear part of the helmet is dropped from a height of (175 ± 5) mm.
Test performed on a new helmet conditioned at ambient temperature (before the impact test)</td><td>® The helmet shall not come off or excessively displaced on the headform.
A falling mass of 1 kg attacched with a hook to the rear part of the helmet is dropped from a height of 600 mm. On the same sample another test is performed with the hook on the front of the helmet.
Test performed on a new helmet conditioned at ambient temperature before the impact test)</td><td>® the helmet shall not come off the headform.
A falling mass of (10 ± 0,1) kg attacched with a hook to the rear part of the helmet is dropped from a height of 500 mm.
Test performed on a new helmet conditioned at ambient temperature</td></tr>
<tr><td>IMPACT AREA</td><td>A test area for flat anvil impacts and a test area for kerbstone anvil impact</td><td>A unique test area for the impact tests with all the anvils</td><td>Not impact area but specific impact points (B: Front, X: Lateral, P: Top and R: Rear and another point S for helmets with a protective chin bar)</td></tr>
<tr><td rowspan="3">IMPACTS</td><td>® For each impact the peak acceleration shall be ≤ 250 g for a speed of (5,42 - 5,52) m/s on the flat anvil, and (4,57 - 4,67) m/s on the kerbstone anvil.
These are theoretically equivalent to 1497mm and 1064mm drop heights respectively.</td><td>® The peak acceleration, of each impact with flat, hemisferical and curbstone anvils, shall be ≤ 300 g.</td><td>® The test is considered sufficient when the resulting acceleration of each impact with flat and Kerbstone anvils, is ≤ 275 g at all times and the Head Injury Criterion is ≤ 2400. Moreover, the helmet shall not become detached from the headform.
The drop height shall be equal to (7,50 - 7,65) m/s for both anvils (flat and kerbstone), and (5,50 - 5,65) m/s for test on point S.</td></tr>
<tr><td>The testing shall be carried out in accordance with the following sequence:
<table><tr><th>Sample number</th><th>Conditioning</th><th>Anvil</th></tr><tr><td>1</td><td>High temperature
No reconditioning</td><td>Kerbstone
Flat</td></tr><tr><td>2</td><td>Low temperature
No reconditioning</td><td>Flat
Kerbstone</td></tr><tr><td>3</td><td>Artificial ageing
No reconditioning</td><td>Kerbstone
Flat</td></tr></table></td><td>The testing shall be carried out in accordance with the following sequence:

Each helmet conditioned at ambient temperature, hot, cold and wet (one for each conditioning) shall be tested with two flat anvil impacts, one with hemisperical anvil and one kerbstone anvil impact in any sequence.

The helmet shall be dropped onto the flat anvil at a speed of 6,2 m/s (corresponding to a theorical drop height of 2,0 m).
The helmet shall be dropped onto the hemisferical and kerbstone anvils at a speed of 5,6 m/s (corresponding to a theorical drop height of 1,6 m).</td><td>The testing shall be carried out in accordance with the following sequence:
Ambient: 1 helmet of the largest helmet size with flat anvil and 1 helmet with kerbstone anvil;
High: The largest helmet size only with kerbstone. For smaller headform in the size range of the helmet type either anvil may be used;
Low temperature: The largest helmet size only with flat. For smaller headform in the size range of the helmet type either anvil may be used. Only each helmet size subjected to this conditioning shall undergo the impact test on point S with flat anvil;
Ultraviolet radiation and moisture: The largest helmet size with a flat or kerbstone (to be selected by the laboratory)</td></tr>
<tr><td>The helmets is impacted on the sites selected by the test laboratory to present the worst case conditions. In each series of tests on a model, the impacts is performend on each perceived weak area (i.e. ventilation features, retention anchorages or webbing supports) which falls within the test area.</td><td>The center of impact shall be at any point on or above the test line (within the test area)</td><td>Test on point S (chin bar) shall be carried out after the set sequence of tests on points B, X, P and R for all helmets (combinations of conditioning and anvils)</td></tr>
<tr><td>Chin Bar Test</td><td>Not required by the standard</td><td>® The maximum deflection of the chin bar shall not exceed 60 mm.
Perfomed only if a chin bar is present: the chin bar is impacted with a flat strike (diameter greater than 112 mm and 5kg of mass) with a impact speed of 2,8 m/s (corresponding to a theorical drop height of 0,4 m).</td><td>Chin bar tested with an Impact test on helmet conditioned at low temperature
(Performed only if the helmet has a protective chin bar - ® See impact test)

Chin bar tested with a rigidity test: after a compression test under 630N load the deformation shall be ≤ 40 mm.</td></tr>
<tr><td rowspan="4">Conditioning:</td><td>Ambient: (+20 ± 2) °C for at least 4h</td><td>Ambient: (+20 ± 3) °C, and (50 ± 25)% rh for at least 24h</td><td>Solvent conditioning + Ambient: (25 ± 5) °C and (65 ± 5)% rh for at least 4h</td></tr>
<tr><td>High temperature: (+50 ± 2) °C for (4-6)h</td><td>High temperature: (+50 ± 3) °C for (4-24)h</td><td>Solvent conditioning + High temperature: (+50 ± 2) °C for (4-6)h</td></tr>
<tr><td>Low temperature: (-20 ± 2) °C for (4-6)h</td><td>Low temperature: (-15 ± 2) °C for (4-24)h</td><td>Solvent conditioning + Low temperature: (-20 ± 2) °C for (4-6)h</td></tr>
<tr><td>Artificial ageing: 48h with ultraviolet irradiation by a 150W xenon-filled quartz lamp + (4-6)h of spraying of water at ambient temperature at the rate of 1 l/min</td><td>Water immersion: helmet fully immersed in potable water at a temperature of (19 ± 4) °C for (4-24)h</td><td>Solvent conditioning + Artificial ageing: 48h with ultraviolet irradiation by a 150W xenon-filled quartz lamp + (4-6)h of spraying of water at ambient temperature at the rate of 1 l/min</td></tr>
</table>

2. Impact protectors

As with helmets, Downhill protectors on the European market are not certified according to an ad hoc standard but according to the following standards explicitly created for the motorbike world:

- EN1621-1:2012: “Mechanical impact protective clothing for motorcyclists - limb impact protectors”;
- EN1621-2:2014: “Motorcyclists’ protective clothing against mechanical impact - Back protectors”;
- FprEN1621-3_2017: “Motorcyclists’ protective clothing against mechanical impact - Part 3: Motorcyclists’ chest protectors”;
- EN14021:2003: “Off-road motorcycling waistcoat suitable for protecting the rider from stones and debris”.

The latter, on the other hand, only partially verify the protective characteristics declared by the manufacturers of such devices.

On the other hand, the latter only partially verify the protective characteristics declared by the manufacturers of such devices. The impact protectors used in Downhill Biking are mainly as follows:

- elbow pads: the elbows and forearms are very exposed areas in the event of a fall, especially in sideways slides. For this reason, Downhill elbow pads are rigid, longer and more impact-resistant than those used in other MTB disciplines.
- Knee pads: The knee is a very delicate part of the body. When thinking about MTB knee protectors, it is important to consider safety and mobility, because it is the joint that moves the most when pedalling. Different models exist in different disciplines: the protections for Downhill and freeride are longer, protect the shins, and have rigid parts in resistant plastic. Some DH knee protectors go all the way up to the ankle, providing more excellent protection.
- Shin guards: for those who also want to protect the front part of the leg better, there are special rigid shin guards, which are much easier to put on and take off than long knee pads.
- Back protectors: This type of protector for MTBs is mainly used in gravity disciplines, where, unfortunately, the possibility of severe back injuries is not uncommon due to the high speed and gradient.
- Harness or torso protector: for those who want even more complete protection, there are also special harnesses to be worn on the front to protect the upper body, i.e., the ribs, shoulders, arms, and back. There are different models of bibs, some of which protect only the torso, leaving the shoulders and arms uncovered, while others have many integrated protectors. For example, many bikers opt for special jackets that integrate a back protector, chest protector, and arm protectors.

Can you recognise the best device for your needs?

Protections in accordance with EN 1621:

- **Protection level:** a distinction can be made between LEVEL 1 and LEVEL 2, the second of which transmits a lower force to the user with the same impact energy.
- **Environmental protection condition:** All certified protectors offer the declared level of protection (Level 1 or Level 2) at an ambient temperature of 20-25°C. This range can be extended to approximately +40°C if T+ is marked and approximately -10°C if T- is marked.
- **Protective area dimensions:**
  - For shoulder (S), elbow and forearm (E), hip (H), knee and upper tibia (K), knee and middle upper tibia (K+L), middle tibia (L) protectors, two sizes can be distinguished. A distinction is made between type A devices that are protective over a smaller area than type B devices for the same level of protection offered. Attention: the protection area is always smaller than the size of the protector: it is not certain that geometrically larger devices offer more significant protection areas than smaller devices.
  - Three types of back protectors can be identified: central back protection (CB), back and shoulder protection (FB) and lumbar protection (LB). The size of the protective area of all three types is related to the “waist-shoulder” length declared by the manufacturer.
  - Finally, the two types (A and B) are also identified for chest protectors (C), with the particularity that they can be divided or whole. The area to be protected is the sternum.

Protections by EN 14021:

Protectors conforming to the EN 14021 standard provide protection ‘only’ against stones and raised debris: of motocross derivation, these consist mainly of a chest protector, which may be combined with or may include shoulder protectors and other protectors such as biceps protectors and a back protector. These types of protectors will offer limited impact protection compared to protectors certified to EN 1621 standards. However, compared to the latter, they are also tested for the effectiveness of the fastening and retention system.This ensures that the protector does not move out of the area to be protected. In recent years, ‘multi-standard’ devices have come onto the market. In addition to meeting the requirements of EN 14021 (debris protectors), they also meet the applicable EN 1621 standards (limb, back, or chest impact protectors for motorcyclists). Such devices will certainly be more protective than devices certified to only one standard.

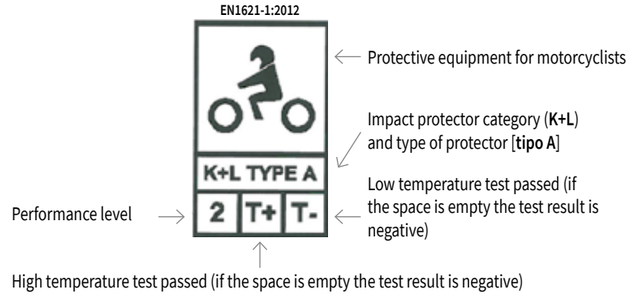
Note: WARNING! Whatever type of protector is used, it will only work properly if it is correctly positioned and remains on the designated area without hindering movement.

Insight

If an ad hoc standard were to be drawn up for Downhill protectors, it would be desirable to include tests for abrasion resistance (e.g. for devices made of ‘soft’ materials without a shell) and tests for the restraint system to assess that the protectors cannot be easily displaced from the areas they are intended to protect during habitual movements and/or when subjected to impacts.

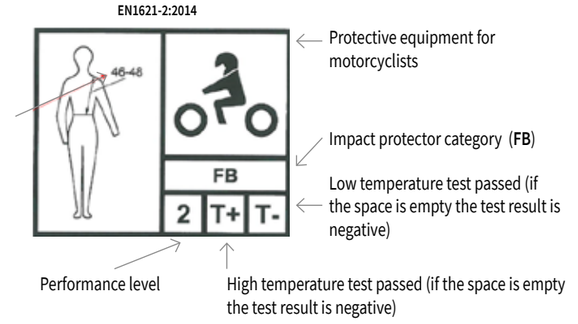
- *NOTE: Impact protectors marking examples EN 1621-1, 1621-2, 1621-3 e 1621-4*

- **EN 1621-1**

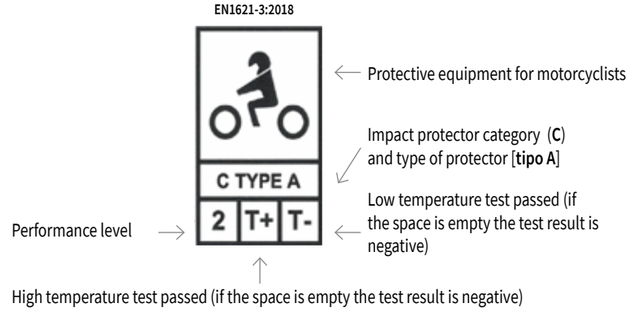


- **EN 1621-2**

Head to shoulder: measurement, along the back, of the distance between the highest point of the junction of the shoulder with the neck and the line on the iliac crest



- **EN 1621-3**



3. Gloves

Although not as essential as helmets or impact protectors, using a protective glove is highly recommended: further improving grip on the handlebars and reducing vibrations transmitted to the hand, a glove can be helpful in protecting the hands from abrasions and minor impacts. Although there are many types of gloves on the market (fullfinger or fingerless, with or without knuckle protectors, with or without palm padding), all of which are declared by the manufacturers to be suitable for DownHill use and/ or certified, it is advisable to prefer gloves that have been tested to specific standards, for example:

- EN 388:2016: “Protective gloves against mechanical risk”;
- EN 13594:2015: “Protective gloves for motorcycle riders”.

This information can be obtained by reading the information note of the device.

4. Eye protection (visors, masks, goggles)

To improve safety, downhill athletes should also consider their eye zone protection in order to protect themselves against:

- Wind; Air; Sun wear (Category I PPE): for example, sunglasses.

Or

- impacts resulting from impacts with small moving bodies, such as debris, dust, foliage, ... (Category II PPE): e.g. visor/motorcycle mask.

Unlike classic sunglasses, visor/mask goggles, being by construction equipped with an adjustable elastic band that holds them in place during use, “seal” the rider’s eye area, thus preventing:

- tears caused by the wind during the descent (category I PPE).

Or

- disorders caused by eye contact with external elements, e.g., debris, dust, foliage, ... (category II PPE).

Situations that could create a disturbance during the activity.

The lenses may have different characteristics, depending on the intended conditions of use. There are colourless lenses for use in low light conditions or during twilight hours or lenses with more or less accentuated colours for more dazzling light conditions. There are also photochromic lenses that darken when a certain limit of light irradiation is exceeded and lighten in low light conditions and are suitable for trails with open stretches alternating with undergrowth. For such lenses, activation is ‘instantaneous’ as it is caused by a chemical reaction that occurs at the moment of a change in brightness. However, there is no defined time within which the filter must darken or lighten. Visor goggles/masks are attached to the face so that they do not fog up and can have lenses with anti-fog treatment. In addition, the materials used are usually stronger and more resistant than Mountainbike goggles and road bike goggles, even though they may use the same plastics. The choice of the device should therefore be based on actual needs.

5. New devices (neck-brace & airbag)

In addition to the ‘classic’ devices mentioned above, it is worth mentioning some newly developed devices that have become increasingly popular in recent years:

- Neck-Brace;
- Airbag.

NECK BRACE

The neck support is essential to limit the helmet’s movements in an accident, preventing hyperflexion and hyperextension of the neck muscles. In the event that the rider suffers a head impact, the helmet transfers the force of the impact to the neck support, which distributes it to the shoulders and chest, saving the neck from a pressure it could not handle without trauma. Thanks to its system for dissipating vibrations in the presence of potholes and uneven ground, this device also helps support the spinal column. It should be noted that these devices can only be used in combination with a full-face helmet.

CAUTION Sometimes, the Neck-Brace is only functional when combined with a specific full-face helmet. Neck protectors cannot guarantee 100% accident prevention, but they can certainly be very useful in reducing injuries due to accidents. The main function is to protect and support the neck and cervical area, but various models perform this function in a slightly different way. Some of them simply protect against impact damage and limit the unnatural movement of the neck during an accident. More advanced types also offer support and protection for the chest and shoulders.

ALWAYS CONSULT THE INFORMATION NOTE!

AIRBAG

Until a few years ago, the only airbags on the market were mechanically activated.

Although this type of device can be effective in terms of protection, it has some limitations and can even be dangerous. With an activation cord attached to the bicycle, it is easy to understand how the device can be activated accidentally, making it potentially dangerous.

In recent years, it has been tried to solve this mechanical activation issue via electronically activated devices: mechanical fastenings to the bike were replaced by ‘intelligent’ electronic sensors that can activate the device only when the need arises. This type of device has had a strong expansion as protection against shocks and falls in the world of sport and work: the wearable airbag in its evolution could also represent for downhill a light, comfortable and very effective solution for the protection of the body (except for the head, for which the use of a helmet is always recommended!). To date, however, the state of the art in cycling is underdeveloped and therefore under-proposed. The pros and cons of such PPE are listed below.

Advantages:

- Several anatomical parts can be protected simultaneously with one device;
- It can also offer protection to anatomical parts not currently ‘covered’ by the various EN 1621 standards (see section 2);
- Better ergonomics, freedom of movement than solid protectors;
- For the same area of protection provided compared to a traditional protector, it is certainly lighter.

Disadvantages:

- Definitely more expensive than traditional solid protection;
- Failure to activate the system could leave you without adequate protection;
- The devices must be inspected before each use to exclude possible lacerations and/or abrasions that could affect their correct functioning.