R+D for innovation in footwear and its components

IBV
INSTITUTO DE BIOMECÁNICA DE VALENCIA

COVER IMAGES

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The Instituto de Biomecanica de Valencia (IBV) is a Technology Center that studies the behavior of people in their relation to the products, environments and services they use to:

- prevent risks
- promote and maintain health
- recover health when lost
- help people with functional limitations to improve independent living and social participation
- optimize personal well–being and standards of living
- maximize performance and efficiency in all people's activities

index

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Towards business success through personal well-being

Introduction

Today's context has shown that the model of competitiveness based on providing a good quality-price ratio prevailing up to now is currently being superseded. Changes need to be made to the business approach in order to foster **innovation culture** in all the processes involved in business organisations: manufacture, management, marketing and the conception and development of products.

It is in this last process that the intrinsic values of the products lie, where the technical and functional specifications with which they were conceived and which differentiate them on the market take on their form and where innovation acquires the greatest importance.

Since the ultimate purpose of these products is to meet consumers' demands it is clear that considering the user as central element in the value chain constitutes a powerful innovation vector.

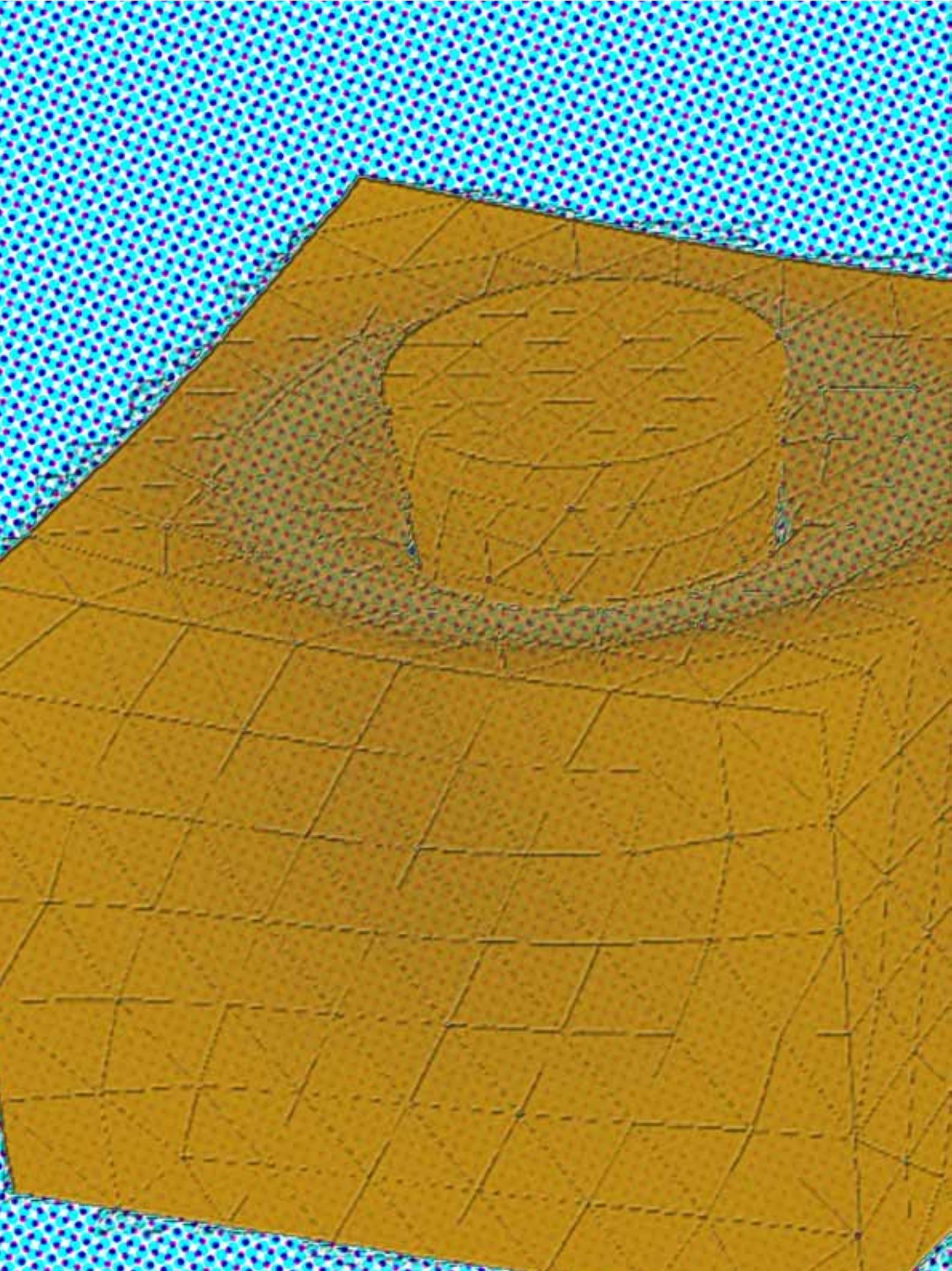
To stimulate demand, new sources for product differentiation have to be identified, centring on the more highly rated values in our society. In this respect, quality of life, health and well-being are the most dominant values in western societies, the ones that distinguish them and that other societies on the planet seek to emulate.

Progress needs to be made in a new model considering final users as an essential and inexhaustible source of information and efficiently integrating them in each and all of its phases with the final aim of obtaining products that are better adapted to their needs, capacities and preferences (a broad concept of quality in which mechanical and cognoscitive interaction are related, facility of use, understanding of the product or service, ergonomy, etc.)

The combination of knowledge stemming from spheres such as Biomechanics and Ergonomy applied to the footwear sector leads to the following equation:

TOTAL USER SATISFACTION = FUNCTIONAL SATISFACTION + EMOTIONAL SATISFACTION

The IBV's work heads in this direction, contributing to its customers' companies' success through people's well-being.



Footwear technological offer

USER-ORIENTATION

The approach implemented by the Instituto de Biomecánica de Valencia (IBV) has at all times been the incorporation of the needs and characteristics of users and the use to which footwear was to be put in its their methodology.

The use and preparation of user-oriented design techniques (Quality Function Deployment -QFD-, Saaty hierarchy analyses, TRIZ, user panels, risk analyses or usability tests, amongst others), has enabled a proper transformation of users' needs into design criteria.

Footwear furthermore is not only used for walking or moving around with greater efficiency and comfort, but is also an item for expression of values and tastes. The incorporation of techniques that had been applied in other spheres, such as automobile design, and in other parts of the world, above all in Japan, has entailed the development of methods and tools of emotional evaluation of products which have enabled a great leap to be made towards meeting users' satisfaction from an overall standpoint, combining functionality and comfort with emotion and aesthetics.

The extensive experience in research and application of methodologies and techniques for development of user-oriented products has enabled a broad knowledge base to be generated with the establishment of an extensive offer of services.

R+D UNDER CONTRACT

The IBV does R+D work under contract to generate knowledge and design criteria enabling the development of products with a great innovation content.

We will now briefly describe the main lines of research that the IBV is undertaking in the sphere of footwear with examples of projects made for companies in the sector.

Shock absorption

The shock absorption is defined as the capacity of the human body or footwear to reduce the efforts generated in the impact of the foot against the ground.

Impacts and consequent vibration have been associated with discomfort and even with degenerative disorders of the joint cartilage but they also have a beneficial role for bone and muscle growth and strength. This is why it is important for the cushioning to be appropriate for the use and the user, without being either too high or too low.

What is more, the cushioning capacity of the soft tissue in the heel reduces with age, Footwear design must thus supplement the natural mechanisms of the human body through a proper design of the heel cup and/or of the proper combination of the materials located under the heel.

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> Example 1. R+D applied to the development of new insole materials (ANALCO)

This consisted in the development of new materials for insoles with optimum impact-cushioning characteristics and distribution of sole pressures. As a result of this project, ANALCO developed a viscoelastic material intended for the construction of inserts to improve the impact-cushioning capacity of insoles, TERCOLITE, and an also viscoelastic material, DORECO, intended for the whole insole, which is characterised by making a significant contribution to increasing footwear's comfort, due to the optimum relationship between the low rigidity and the high energy-dissipation capacity that it provides.

Friction

It is the friction between shoes and the support surface which generates the forces required to drive the body in the direction required and for braking or stabilisation of the foot on the ground.

Footwear without sufficient grip makes it difficult, impossible or dangerous to perform daily activity, since it does not allow application of sufficient driving or braking forces. Excessive levels of friction may increase the risk of injuries, especially in sports which include lateral displacements and turns among their most frequent movements.

Footwear's grip depends basically on the design and material of the sole, it being vital to keep a good friction coefficient on any surface, even in the presence of contaminants such as water, oil or dust.

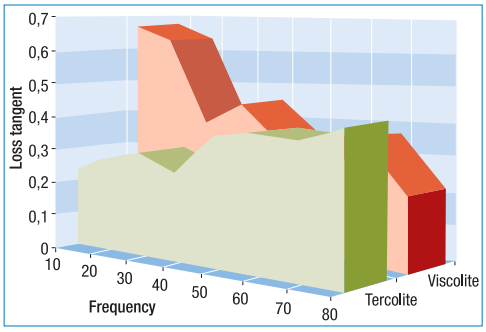

Figure 1. Above: Samples of DORECO (ANALCO). Lower: Evolution of the energy–absorbing capacity as the speed of the impact increases for TERCOLITE (ANALCO) and VISCOLITE.

Example 2. Generation of criteria for designing the studs of football boots for use on earth surfaces (KELME)

The gripping forces of each of the studs were measured by means of an instrumented boot, developed by the IBV. These records were used to identify the studs with greatest influence on grip during performance of different sports movements.

USER MEASUREMENTS

Figure 2. Instrumented boot for measuring forces in individual studs of football boots.

SIMULATION

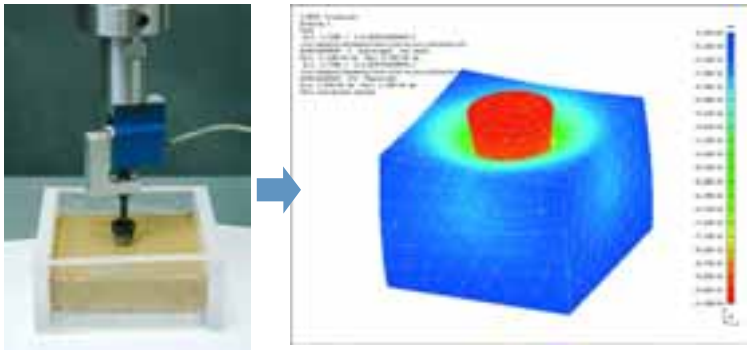

Figure 3. Study of the distribution of forces in a stud through mechanical simulation techniques on the computer.

With no need to make physical prototypes, the use of computer simulation techniques provided criteria for designing the studs and their distribution across the sole, optimising grip and resistance.

Control and adaptation of the movements of the foot

Footwear may modify the physiological movements of the foot to a greater or lesser extent. There are nevertheless some movements which ought to be controlled and others in which footwear should not interfere in the slightest.

Example 3. Generation of design criteria for developing tennis footwear (J'HAYBER)

An epidemiological study was made for detecting the most frequent injuries and the influence of footwear on these. It was observed that the incidence of injuries is 60%, the ones that effect the ankles being the most frequent type, basically due to movements which exceed the physiological range or the repetition of extreme movements.

Complementarily, a biomechanical study was made to measure the forces acting on the foot using the Dinascan/IBV force platform, on which different types of play surface were installed, and the movements of the lower limb were recorded with high speed cinema cameras, during the performance of different sports movements. The treatment of the images and forces recorded with the Kinescan/IBV system enabled results to be obtained on the capacity of the different footwear models for controlling the movements of the foot and on the friction capacity of the shoes on each different surface.

Distribution of pressures in the sole of the foot

The distribution of pressures is a factor of vital influence in comfort. While walking, the whole the weight of the body rests on the sole of the foot. Any excessive pressures may cause discomfort and even injuries through extended use.

Furthermore, the evolution of pressures in the sole of the foot through its stride is associated with the stability of the walk and with the alignment of the foot in its shoe with the ground, study of this aspect being an extremely useful tool for detecting pathologies.

Example 4. Development of design criteria for a shoe for diabetic feet (EMO)

Roughly 15% of diabetes patients develop ulcers in their feet. Appropriate footwear reduces the friction and high sole pressures and can slow down or prevent the appearance of an ulcer.

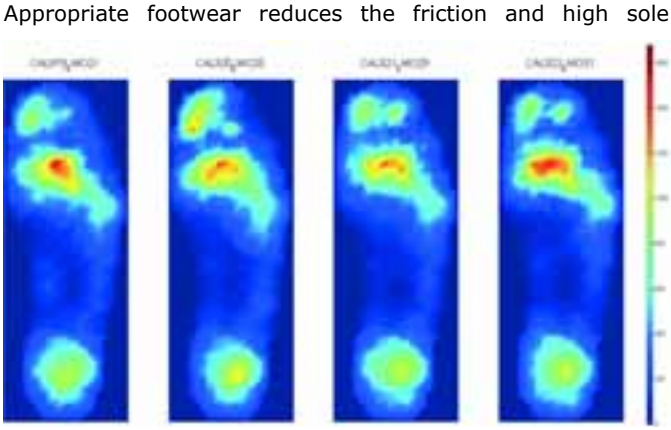

Figure 4. Map of maximum pressures in the sole of the foot for different models of footwear.

In this project a shoe was designed to reduce the pressures on the whole foot sole, mainly in the zone of the metatarsal heads, thus reducing the risks of injuries.

This was done by making functional tests on different models of footwear with subjects using Biofoot/IBV insoles which allowed pressures on the foot insole to be recorded. One of the results obtained that is worthy of mention is the influence of the spring angle and the rigidity of the middle-sole in the value of the pressures on the head of the metatarsals.

Anthropometry and morphometry

This is one of the aspects with greatest influence on the comfort perceived by the users and thus one of the most important factors in footwear design.

Footwear must adapt to the foot by matching its axes of movement with the dimensional variations undergone during the activities performed, so as to accompany the foot's movements without any relative displacement between these and without any excessive pressure zones. This adaptation depends both on the interior space defined by the last and the materials used in the uppers.

For this purpose, the IBV has developed databases on the dimensions and shapes of the European population enabling it to give advice in the design of the last.

Example 5. Study of the evolution in the shape of the child's foot during growth (CUQUITO)

During childhood, the evolution in the size and shape of the foot are much greater than in any other stage of their lives. Detailed knowledge of the shape of children's feet during their growth is of great importance for making footwear with suitable comfort and health properties. Inappropriate footwear in childhood may furthermore cause serious problems in the foot in the adult stage.

In this project a study was made of this evolution in the shape of the foot during childhood, designing a new series of footwear for the younger ones.

Figure 5. Left: Evolution of the size and shape of the foot with age for boys and girls. Right: Change in the shape of the foot with age.

Thermal comfort

Thermal comfort is a factor increasingly demanded by users of any kind of footwear and the market has consequently been flooded with a huge supply of products designed with new materials (technical membranes, fibres etc.) or new concepts (ventilation systems, phase-change materials, etc.) which use thermal comfort as their differentiating item.

This line of work has enabled the IBV to develop instrumentation and an analysis methodology allowing an evaluation of the temperature and humidity of the foot provided by different materials and systems.

Example 6. Study of the thermal comfort of footwear in environments with extreme climates (FAL)

The thermal comfort of different components was analysed (sole, lining, upper, etc.) and of the different materials (rubbers, PU, waterproof/transpirable membranes, thermal insulation) to select the most appropriate types for three different lines of leisure footwear: the ones intended for desert climates (high temperature and low humidity), high mountain (low temperature and low humidity) and Mediterranean climates (high temperature and high humidity).

Figure 6. Trials in use of footwear for different climates.

Personalisation

Personalisation of footwear may be approached from three different standpoints: aesthetic, dimensional and functional, though the last two affect final comfort to a greater extent, since they consider the objective and subjective information obtained from users (personal characteristics, preferences and sizes of the foot) and they rely on in-depth knowledge of the biomechanics of human walking. Consideration of the three approaches may be defined as full personalisation.

Between footwear designed specifically for each person and mass-produced footwear there are however some intermediate solutions such as the development of several last fittings or insoles per size which considerably improve the best fitting.

Example 7. R+D applied to personalisation of footwear (EUROSHOE Integrated Project)

The EUROSHOE project tackled personalisation in all its stages: design, manufacture, distribution and sale, with a view to getting an increase in customer satisfaction by functional adaptation of footwear. Biomechanics was considered as a key point in the design of footwear along with the use of the latest communication and CAD/CAM technology, supported by the development of new systems for automating production, to give this service to the consumer from the point of sale.

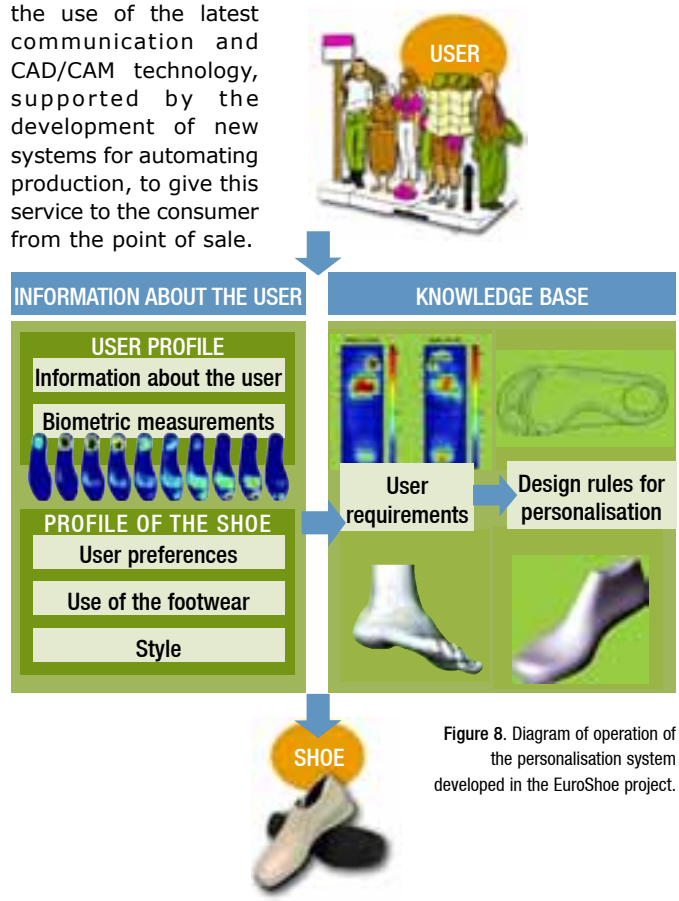

Figure 8. Diagram of operation of the personalisation system developed in the EuroShoe project.

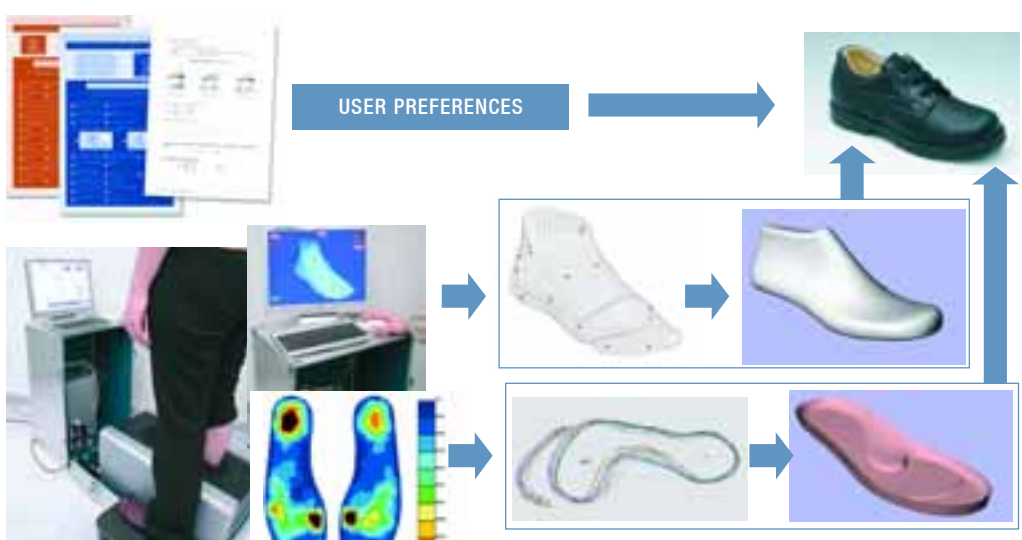

Figure 7. Diagram for personalisation of lasts and insoles from biometric information and data on user preferences.

DEVELOPMENT OF PRODUCTS

In the process of developing new user-centred products two key items can be stressed: knowledge of the needs and characteristics of the user and the user's involvement in the whole development process, especially conception and valuation.

The IBV gives design and development services from an integral approach of support for innovation, considering pre-competitive R+D such as the sort described in the previous section, strategic product design, generation of innovative concepts, conceptual and detail design, prototyping and evaluation of the new development.

The IBV's work covers:

-· *Finished footwear* for a group of users or a specific activity.

-· *Components of footwear*: lasts, bottoms or sole units, insoles, uppers, toe-puffs or tips and stiffeners, etc.

-· *Innovative systems* that can be integrated in any type of footwear, such as those of forced ventilation or impact cushioning, amongst others.

We now explain some developments for companies from the sector.

Example 8. Development of a new healthcare worker clog (ROMU'S)

In the healthcare world up to 75% of the hours of work are done standing. Furthermore the influence of footwear in falls is highly important. In these circumstances, footwear constitutes a clear factor of working health.

A new healthcare worker clog was developed starting from the design of a last appropriate for the users, an anatomical insole for improving comfort whilst standing and the design and selection of sole unit materials for obtaining optimum flexibility and grip. The design of the upper was given special care, including a rear strip to prevent the heel from falling off the clog and causing falls.

Figure 9. Healthcare worker clog by ROMU'S developed according to the users' needs and preferences.

Example 9. Development of a sole and insole for school footwear (GARVALIN)

Biomecanics is a child's shoe meant for schoolchildren. It was designed with the concept of an ergonomic shoe for everyday wear, but incorporating items of sports footwear specially designed for avoiding injuries and deformations to the child's foot. The materials and geometry of the sole and insole were developed according to their action against impacts, the improvement of stability and adaptation to the movements of the child's foot.

Figure 10. Test of cushioning impacts and analysis of movements in children's footwear.

Example 10. Development of the Adaptaction system (Grupo HERGAR)

The shoe developed enables its adaptation to changes in width of the forefoot when walking, which is where the greatest variations in the shape of the foot are found during one's stride. This is possible thanks to the design and the materials of the sole unit and sole of the shoe, which favour the transversal deformation of the whole piece.

The use of computer mechanical simulation and fast prototyping tools cuts down the time needed for development of the product and the investment in moulds.

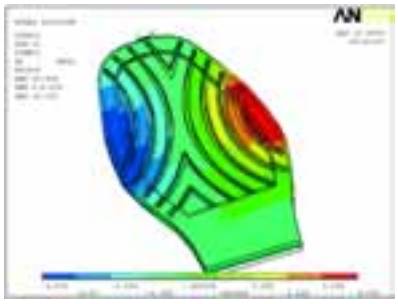

Figure 11. Above: Computer simulation of the forces of sole expansion. Lower: Test with a machine for determining the mechanical characteristics of the system.

TECHNOLOGICAL ADVICE

The IBV supplies a wide range of technological advice services **intended for footwear and component companies**. This offer is flexible and adapts to suit the needs of each customer. The consultancy can be for any stage of the process of development of user-oriented products:

-· Detection of users' needs and preferences

-· Strategic definition

-· Design of the concept

-· Design of the detail (including the selection of materials)

-· Construction of prototypes

-· Validation

-· Redesign

-· Production

-· Marketing

Intended for purchasers of footwear, there is a service for preparation of sets of technical prescriptions for selecting ergonomic footwear as well as the evaluation of the product according to the rules established.

Drafting of sets of technical specifications for selecting ergonomic footwear

Comfortable and healthy footwear must adapt to the setting and type of activity done in the job of work. **Environmental**

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> **factors** such as temperature and humidity (cool stores, ovens), for example, must be taken into account when designing and selecting suitable footwear. The **working environment**, such as the type of paving, the presence of contaminants and static charges amongst others is involved in the requirements for footwear safety. The postures assumed during the performance of the **activity** will require a functional structure of footwear appropriate for adapting to the movements of the foot, for example, squatting positions or activities requiring standing for long hours. Finally, working footwear must include **protection items** against risks existing at the job of work. This leads one to conclude that the footwear for each job of work requires specific functional characteristics.

Offices for prevention of occupational hazards or in general those in charge of buying working footwear for employees of the companies providing this need to find out what requisites or technical and ergonomic performance have to be required to guarantee their fitness for working activity, from both a safety and ergonomic standpoint.

The IBV provides a service for drawing up technical specifications for these companies and professionals to be used as a basis for establishing the purchasing procedure.

Example 11. Sets of footwear specifications for passenger cabin personnel and administrative staff (IBERIA)

In order to improve its employees' safety and health at work, IBERIA asked the IBV to draw up the sets of technical specifications of ergonomic and functional footwear for the passenger cabin crew and administrative staff.

Figure 12. Study of the passenger cabin crew's job of work.

Re–engineering and consultancy in the design of footwear and components

The company's aim is often not to develop a new product but to bring in small modifications intended to improve comfort. There are countless ways to do this, disproving the belief that comfort and fashion have to be something antagonistic, or that improving comfort necessarily entails an increase in cost.

Example 12. Advice for designing savings in the sole (The ART Company)

The redesign of the sole unit of a platform shoe (young people's fashion over the last few years) incorporated an innovative system of savings which considerably reduced the weight and thus increased comfort. The savings in material also meant lower costs.

The Biootoof/IBV system was used to record the forces exerted in the shoe's sole unit when walking. The data obtained enabled making several computer simulations in order to obtain a design optimising the strength of the footwear and savings in the material, with no need to build real prototypes.

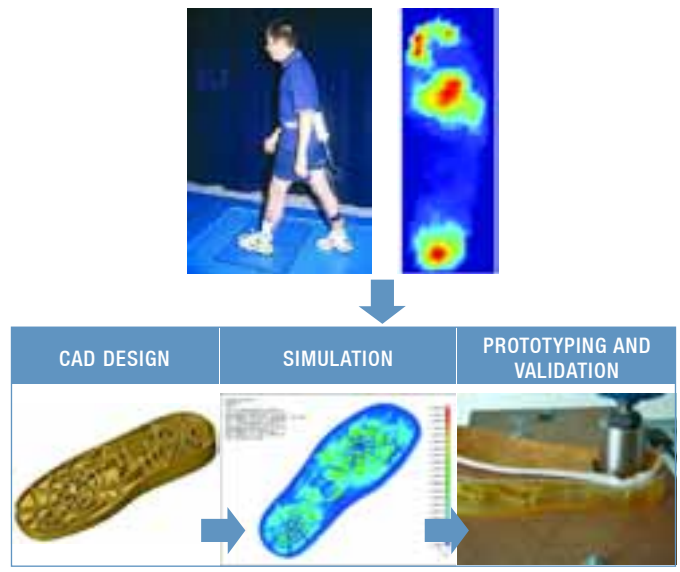

Figure 13. Integration of information about the forces acting on the sole during manufacture and use for optimisation of the design by means of simulation techniques.

Selection and use of materials

The appearance of new materials and their applications has meant that the market has been flooded with a vast offer (viscoelastic materials, technical membranes, fibres, phase change materials, etc.), which enhance aspects such as thermal comfort or the shock absorption.

To appraise if the materials have the required effect and apply these in an optimum fashion, the IBV provides an advisory service for evaluation, selection and use of materials for improving the comfort and functionality of footwear.

Example 13. Selection of materials for insoles (CAMPER)

The IBV made tests on materials and insoles found on the market to find the combination and optimum thickness from the standpoint of functional adaptation and comfort for users and use of CAMPER footwear. Tests were made to determine the capacity for shock absorption and distribution of pressures, before and after subjecting the materials to intensive use (material fatigue).

VALUATION OF THE COMFORT AND FUNCTIONALITY OF FOOTWEAR

The IBV has a laboratory which can evaluate footwear's comfort and its adaptation to the user and to the use that this is intended for. Both finished footwear and the components that make this up can be assessed, allowing the performance of the final product to be forecast. The laboratory makes use of tests with machines which simulate the interaction of the foot with the shoe, and tests with users, to enable the evaluation of footwear in real usage conditions. The different tests making up this service will now be listed:

Tests with machines

- The **dynamic shock absorption** test allows us to determine the ability to dampen the impacts of materials, insoles, sole units or finished footwear.
- The **dynamic padding test** provides information on the ability to distribute pressures of a material, insole, sole unit or finished shoe on the sole of the foot.
- The **footwear friction test** has the aim of determining the grip or friction properties of footwear on paving. It enables testing footwear or soles in highly diverse conditions (from the lowest forces for children's footwear for the very first steps to sports footwear for the long jump) and with different soles and contaminants.
- The **friction test on lining materials** with the foot provides the value of the friction coefficient between the material used in the lining of the insole or in the upper and human skin. It also records the increase in temperature that friction has caused in the lining.

Figure 14. LecCus/IBV testing machine for studying shock absorption loads.

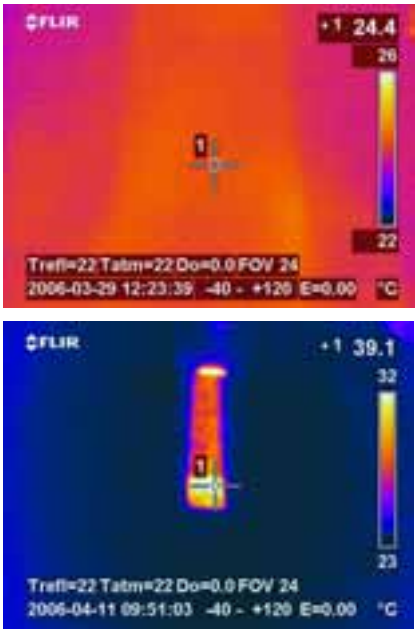

Figure 15. Thermographic image of a lining material subjected to the friction test. Above (prior to the test), temperature= 22 ºC. Lower (after the test), temperature=24º C.

- The **evaluation of the weight of footwear** means the effect of footwear on fatigue and the risk of trips and falls can be determined.
- The **footwear flexibility test** measures the resistance of footwear to bending in the zone of the metatarsal heads (toe flexion area).

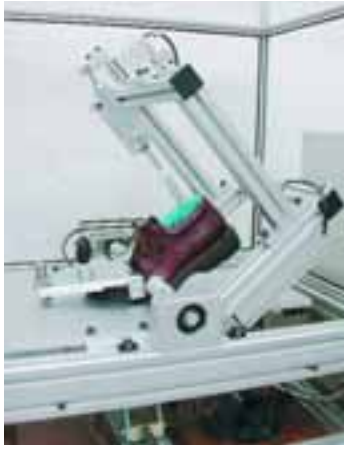

Figure 16. LecFlex/IBV testing machine for testing footwear flexion.

- The **twisting test** measures shoes' resistance to bending along their longitudinal axis, thus enabling their capacity to adapt to irregularities in the ground to be determined.
- The **upper elasticity test** allows us to establish the capacity of the shoe's upper material to adapt to the form and movement of the foot and thus to get a better fit.

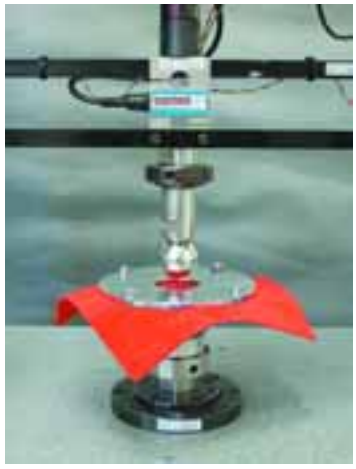

Figure 17. Upper flexibility test.

- The **dimensional evaluation of the last** and its comparison with the databases of Spanish and European people facilitates determination of how suitable a product's fit is for the users for whom this is intended. A laser scanner is used to obtain the 3D form of the last, on which different measurements and forms are taken.

Figure 18. 3D Last with different sections and measurements.

- The **dimensional evaluation of the insole** enables determining the suitability of the sole anatomy to the target population.
- In the **test on thermal transmission of footwear** the thermal insulation is determined, as well as the resistance to water vapour and the absorption of water of the complete shoe.

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> -· The **test on thermal insulation by means of infrared thermography** allows us to detect the zones in which footwear has greater or lesser heat loss. This makes it possible to assess the thermal performance of the different items of footwear designed in an isolated way, such as for example the adjustment and fastening systems, the seams, the sole unit, etc.

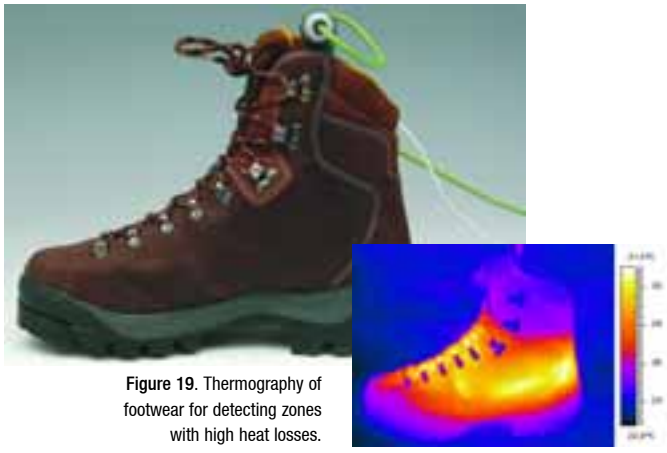


Figure 19. Thermography of footwear for detecting zones with high heat losses.

-· The **water absorption and desorption test** of the insole, upper, lining or foams is important for establishing how far these items help to control humidity inside the shoe.

-· The **test on water transmission** of the insole, upper, lining or foams means one can determine the materials' capacity to carry sweat in liquid form away from the skin for this to evaporate outside the shoe or boot.

Tests with users

-· The **comfort test** consist of subjective trials which are made during and after the use of the product in controlled conditions, reproducing usage conditions.

-· The **test on pressure distribution** lets us measure the distribution of pressures in the sole of the foot directly through the advanced system of instrumented insoles - Biofoot/IBV.

Figure 20. Biofoot/IBV equipment for recording foot sole pressures.

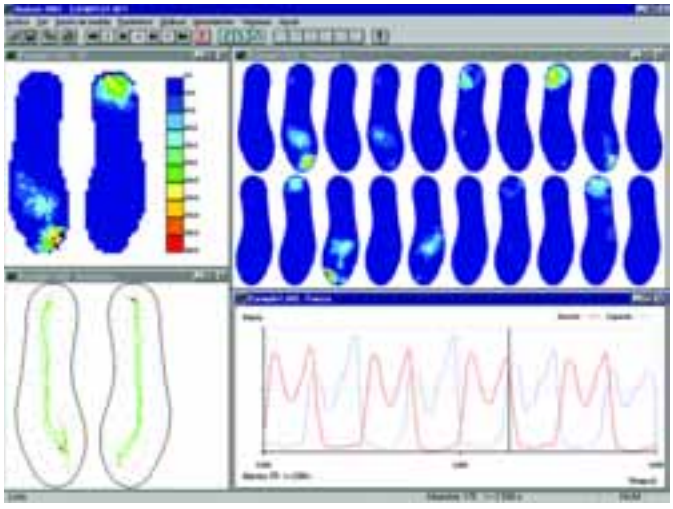


Figure 21. Graphic result of Biofoot/IBV recording a user's sole pressures while walking.

-· The **test on shear forces in the sole of the foot** records the increase in temperature in the sole of the foot after wearing a particular shoe, insole or material. The temperature rise is associated with cutting or friction forces between the foot and the insole, and thus with comfort, blister-forming or even ulcerations in diabetic feet.

-· The **test on distribution of pressures in the upper** enables us to measure the pressures formed between the back of the foot and the footwear upper associated with its adjustment and with its capacity to adapt to the movements of the foot.

Figure 22. Sensor for measuring the pressure in the shoe upper.

-· The **shock absorption test** allows the assessment of a system or shoe's capacity to lower the forces involved in impact with the ground and the vibration transferred by the muscular-skeletal system. The laboratory for functional valuation of footwear has force platforms (Dinascan/IBV) and accelerometry equipment developed by the IBV.

Figure 23. Test on shock absorption by means of accelerometry techniques and force platforms.

-· The Kinescan/IBV **system for analysis of movements in 3D**, based on digital video technology, enables us to determine the influence of footwear on the movement of the foot and on the walking or running pattern.

Figure 24. Analysis of the influence of footwear and ground surface in sports movement.

-· The ErgoEMG/IBV electromyography system lets us **analyse the muscular activity** connected with the use of a particular shoe, insole or system. The muscular activity can provide information, for example, about the fatigue produced by a particular shoe after performing an activity.

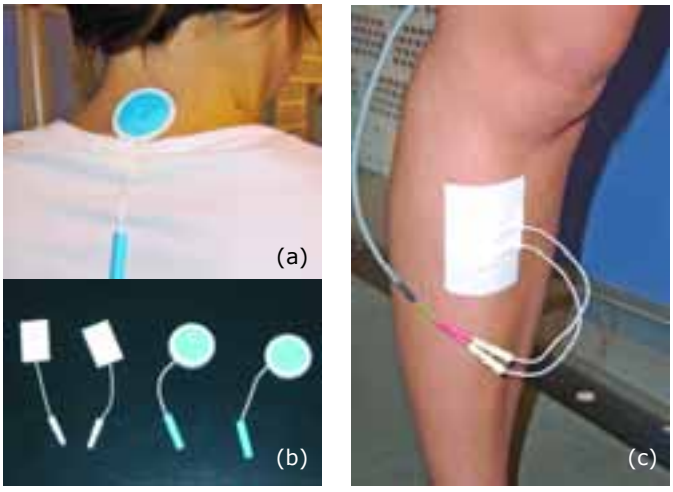


Figure 25. (a) Reference sensor for measuring null EMG activity; (b) Used EMG sensors; (c) Fitting of the EMG sensor for measuring muscular activity in the leg.

-· The **thermal comfort test with users** provides a measurement of the temperature and humidity inside the footwear and the users' perception of this in a real usage situation. The equipment allows the users freedom of movement and can be used in extreme environments (high mountain, sports, long days' activity, etc.). The IBV also has a climatic chamber which enables any environment to be reproduced (temperatures from -20º to 50ºC and relative humidities ranging from 30 to 98%).

Figure 26. Left: capsule for measuring the microclimate (temperature and humidity) in the foot. Right: sensor for measuring the surface temperature of the skin.

Figure 27. Instrumented foot for thermophysiological tets (temperature and humidity in the foot).

EMOTIONAL EVALUATION

The application of Emotional Engineering to find out about, evaluate and control in advance how different designs are going to be perceived by users becomes a decisive factor, giving companies greater guarantees of success in the innovation process.

The services that the IBV offers in the framework of emotional evaluation of the product are:

-· Personalising design and differentiating this in respect of other products on the market.

-· Finding out which concepts are used by consumers to define the products forming a particular market segment and which are associated with their intention to purchase.

-· Finding out which emotions are generated by a product in the consumer. Finding out the strong and weak points of the products, enabling correction of the weak points (planning of redesign) and bolstering the strong points which will affect the purchase of the product (support for planning of communication).

-· Differentiating products in different ranges (high/low) according to consumers' criteria.

-· Finding out how a change in the design of a product will affect the image that the consumer perceives.

-· Locating a product or line of products in respect of the market segment to which this belongs (positioning).

-· Forming pre-sample collections.

-· Detecting changes and discovering new tendencies in traditional conceptions of product designs.

>

> Apart from the contributions of Emotional Engineering to the product design, its application can be to provide strategic information for the company such as:

- Identifying opportunities and threats connected with the diversification of designs.
- Finding out which aspects the products of a brand have in common, i.e. finding out the brand image and what products distort this.
- Boosting the image of the product on the purchasing scenario.

The IBV has developed a portal for product evaluation which allows fast and flexible application of Emotional Engineering over the Internet.

Figure 28. IBV portal for user–oriented product design.

Example 14. Emotional Engineering applied to casual footwear (European Project KENSYS –PIKOLINOS–)

KENSYS is a combined research, demonstration and dissemination project intended to introduce Emotional Engineering in the footwear sector. It consequently considers non-technical action to enable extensive implementation of the methodology in the industry by overcoming barriers to communication and organisation.

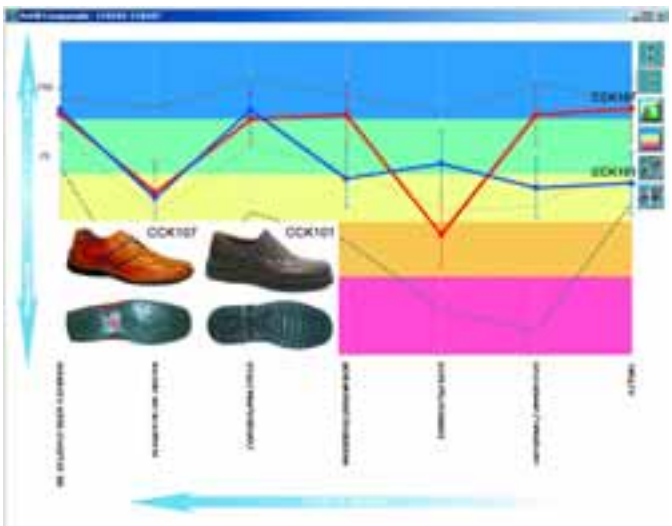


Figure 29. Comparative semantic profile of two casual shoes.

TRAINING AND DIFFUSION OF RESULTS

The IBV provides services for classroom, remote or mixed training schemes, in which contents adapted to the customer are designed.

Aspects connected with the study of walking and of the foot, biomechanical study techniques, functional aspects and points in footwear and component design or personalisation of footwear and components form part of an offer adaptable to the customer. Custom-designed training action is also taken on management of innovation in product design.

In this same section, as support material for the activities of training and diffusion of results, different publications with high impact on all the agents in the sector have been published.

In 1990 the text *El Calzado para Carrera Urbana. Criterios Biomecánicos de Diseño* (Footwear for Urban Running. Biomechanical Design Criteria) was published. This text, currently out of stock, may be considered the first book published in Spain on the application of biomechanics to footwear design.

Later on the *Guía de Recomendaciones para el diseño de calzado bajo criterios de la Biomecánica* (Guide with Recommendations for footwear design under Biomechanics criteria) was published in 1995. This is a unique text covering recommendations for functional design of footwear for different activities (sports, urban, labour, domestic) and populations (children, the elderly). It also includes anthropometric data on different populations (France, Germany, U.S.A.), the regulations affecting footwear and test methods used for design and evaluation of footwear from the standpoint of health and comfort.

The first *Guía de recomendaciones de selección y uso de calzado para las personas mayores* (Guide with recommendations for selection and usage of footwear for the elderly) was published in 1998 as a tool for diffusion of results of the research project on footwear for the elderly.

Later on, through an awareness of the importance of training for footwear sales staff, a set of guides for selection of footwear was published for sellers and opinion leaders, which included specific guides for children's footwear, the elderly, delicate feet, orthopaedic, adults and sports footwear, amongst others.

Lastly, a *Leonardo da Vinci* project has allowed the generation of a telematic course on the selection of footwear intended to improve training and enable the professional qualification of footwear sales staff.

NEW CHALLENGES

Companies have traditionally had to face constant challenges to increase their competitiveness, reduce the costs of developing products and the time for their launching. At present these factors are particularly important due to the delocalisation of business activities, mass imports and globalisation all drastically affecting the sector.

Businesses must exploit the opportunities offered them by new technologies, innovative concepts and processes and the new needs and demands of users. In this respect, user-oriented design and the introduction of new technologies, concepts and processes based on Ergonomy and Biomechanics represent now more than ever a permanent source of innovation and improvement of companies' competitiveness.

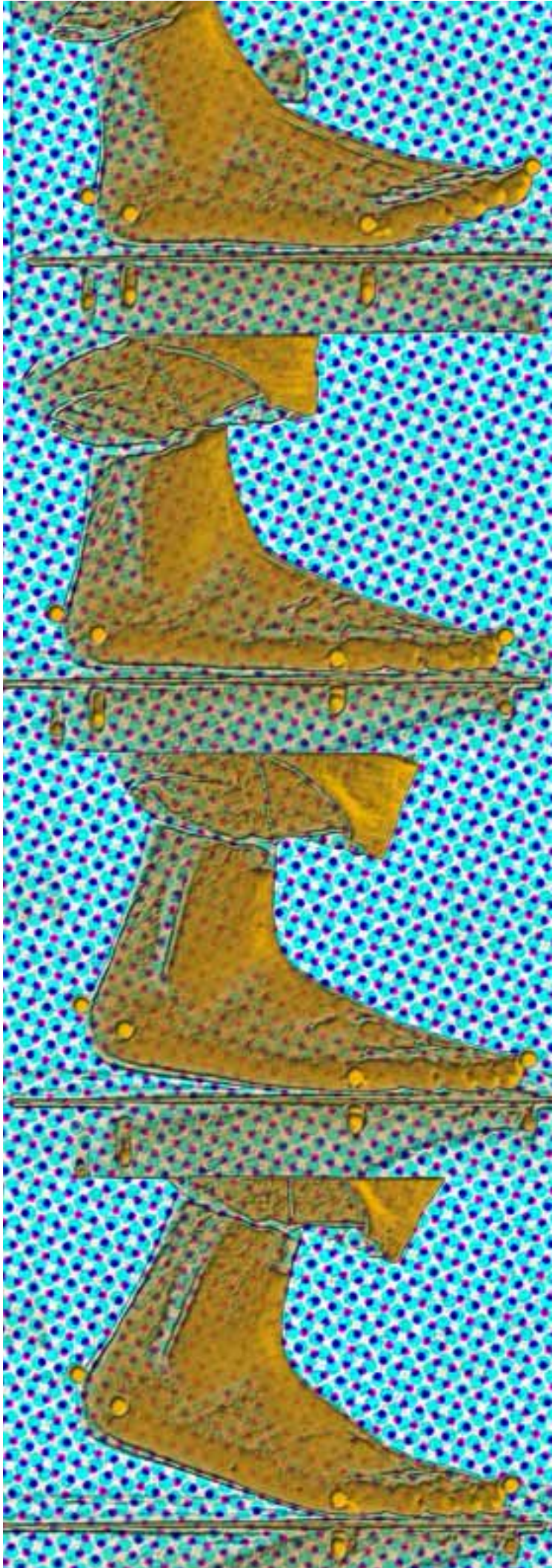
We now give examples of some of these challenges which are in different ways oriented towards improving comfort, health, protection and the aesthetic acceptance of the product in different areas.

Footwear as service. Personalisation. In the development of personalised products each user is the source of design objectives. Personalisation means clear added value, especially for those persons whose needs lie further away from average requirements.

New technologies in the process of footwear development. Modelisation and simulation of the interaction between shoe and user. The development of a virtual model of the foot and the dynamic modelisation of the interaction between the user and the product would enable predictive estimation of the results of this interaction to be obtained with no need to make and test new prototypes.

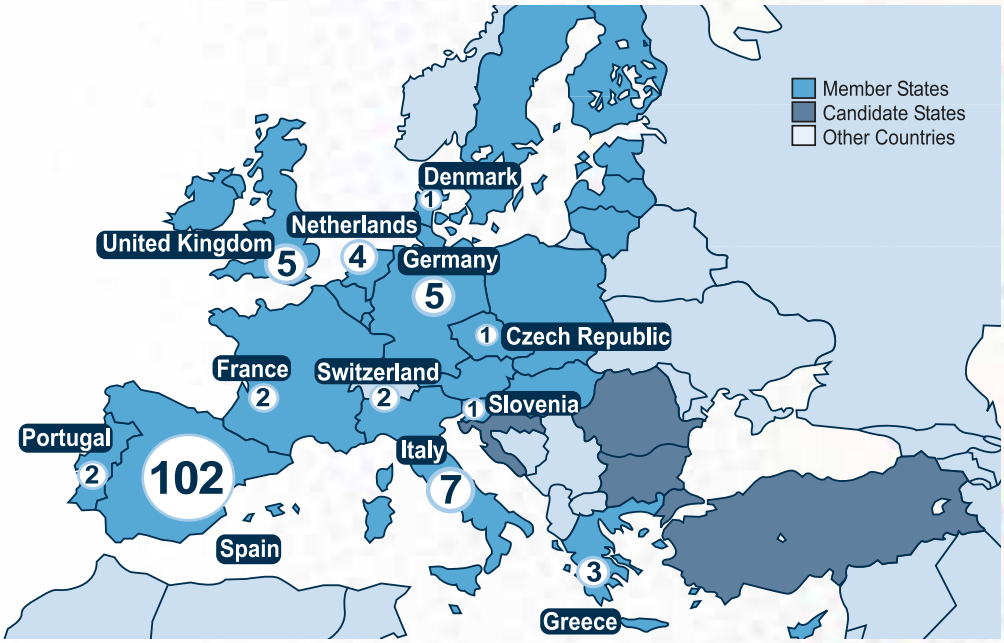
New concepts of product. Footwear as an active device. The new intelligent materials and the development of increasingly small sensors and actuators make it possible to conceive footwear as an active system.

Adaptation to the user's emotions. A measure of the symbolic perception of footwear. Emotional design is essential to ensure that the products meet the expectations of users in emotional factors, symbolic, social and fashion factors.



European projects

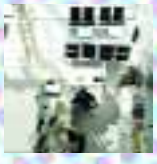
Partners of the Instituto de Biomecánica de Valencia (IBV) in projects connected with footwear (1996–2006)



- *Development of reliable anatomic insoles for children's shoes: Assessing and improving functional properties of children's shoes (CHILDREN).*
  Cooperative research project in 4th Framework Programme (BRITE/EURAM 3). |BRST-CT97-5140|.
- *Generation of design criteria of footbeds for the European Population (FOOTBEDS).* Cooperative research project 4th Framework Programme (BRITE/EURAM 3). |BRST-CT98-5346|.
- *Development of the current European standards for firefighters' footwear: Focus on the compatibility of functional and prospective properties (FIREFIGHTERS' FOOTWEAR).*
  Cooperative research project in 4th Framework Programme (Programme of Stimulation Measures/SMT) |SMT4-CT98-2275|.
- *Biomechanical approach to the design of footwear for the elderly (ELDERLY).*
  Cooperative research project 5th Framework Programme. Competitive and sustainable growth (GROWTH). |GIST-CT-2000-50024|.
- *Development of a new type of advanced early walking shoe. (ARCHIBALD).*
  Cooperative research project in the 5th Framework Programme. Competitive and sustainable growth (GROWTH). |CRAF-1999-71023|.
- *Development of the processes and implementation of the management tools for the Extended User Oriented Shoe Enterprise (EUROSHOE).*
  Cooperative research project in the 5th Framework Programme. Competitive and sustainable growth (GROWTH). |GIRD-CT-2000-00343|.
- *Development, implementation and dissemination of a new methodology for User-centred products design using Product semantics and Kansei Engineering (KENSYS).* Combined R +D and Demonstration project under the programme "Innovation & SME (IPS-2000)" of the 5th Framework Programme. |ISP-2001-42075|.
- *Custom, Environment, and Comfort made shoe (CEC-MADE-SHOE).* Integrated Project in the 6th Framework Programme of the EU. |NMP2-CT-2004-507378|.
- *Development of a cost-effective adjustable damping sole based on magnetorheological fluids to provide diabetics with a customizable product-service which reduces foot stress and diseases, while decreasing National Health Services expenditure(..) (LIQUIDSOLE).*
  Co-operative Research Project in the 6th Framework Programme of the EU. |COOP-CT-2004-512670|.
- *Innovation, Advancement and Competitiveness of the Footwear Sector (INDICO).*
  Community Initiative Programme INTERREG III B Southwestern Europe. |INDICO – SO2/1.3/E59|.
- *Pilot project for electronic learning meant for footwear salespersons on ergonomy, health and quality (FORCAL).*
  Leonardo Da Vinci European Programme. |2005-ES/05/B/F/PP-149306|.
- *Development of an innovative recycling process based on cryogenic and water jet grinding and sintering techniques for extending the use of recycled rubber in the development of high quality products (CRIOSINTER).*
  Co-operative Research Project in the 6th Framework Programme of the EU. |COOP-CT-2005-017958|.

Infrastructure












IBV's headquarters are located in the Polytechnic City of Innovation, a 140.000 m^2 science park that concentrates on the one hand the best research initiatives of the Polytechnic University (UPV).

The Polytechnic City of Innovation consists of institutes, and on the other hand R+D centres. They have as their main objective the transfer of technology to their industrial environment and to contribute, with their technical and scientific ability, to the demands of society.

The 6.000 m^2 IBV building is architecturally divided into two areas administration and scientific–technical activities.

It is a very versatile building with a large double–height area for laboratories and testing areas.

The building is equipped with advanced communication, technology and security systems, and special care has been paid to make it completely accessible.

Innovation and Technology Center registered (n° 8) in the CICYT.

Research results transfer office registered (n° 88) in the CICYT.

Member of the Spanish Federation of Innovation and Technology Organisations (Known by its spanish initials FEDIT).

Member of the network of technological institutes of the Valencia region (Known by its spanish initials REDIT).

Member of the spanish network for safety and health at work from the Ministry of Labour and Social Affairs.

Scientific body member of the International Association for Sport Surface Sciences (ISSS). Accredited laboratory to test sports surfaces.

Member of the forestry, wood and furniture research and training network.

Member of the european design for all e-accessibility network.

Accredited laboratory by the Fédération Internationale de Football Association (**FIFA**) to test artificial turf fields.

Accredited laboratory by the International Association of Athletics Federations (IAAF) to test synthetic athletics tracks.

Accredited laboratory by the International Tennis Federation (ITF) to test tennis surfaces.

Accredited laboratory by the national accreditation body (known by its spanish initials ENAC) to test sports surfaces and playgrounds.

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