

## Products of Sport Engineering – Systematic Approach

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### ABSTRACT

There are thousands of different kinds of sports. Every sport with a distinct aim and form requires its own technical support. In modern sport activities, both recreational and professional, for healthy and for disabled sportspersons, there are many activities based on using products of engineering. Those products are used by competitors, coaches, referees, servicepersons, organizers, journalists, sport scientists and other personnel. The groups of engineering products that have been developed over many years and are used today within many sports are those: 1) concerning the body – coatings, garments, accessories, genetics; 2) movable – equipment, vehicles, requisites, tools; 3) immovable – appliances, stands, rooms, buildings; 4) concerning information technology – hardware, software, communication, journalism; 5) miscellaneous – security, setting, trophies, gadgets and others.

**Keywords** – sport engineering products, human body, movable, immovable, IT

### I. INTRODUCTION

The process of training, testing, and competition is complicated. In different sports one has to develop different skills. A model of optimization for the whole process is very important. This is achieved by people from many areas of interest. Besides competitors, coaches, and administrators, the sports profession needs scientists, specialists in medicine, journalists, economists, and lawyers. In the long history of sport, and especially during recent years, special group devoted to sport has played a very important role. This is a group of engineers.

There are many different kinds of sports all over the world. Lipoński gathered 8000 of them and he presented 3000 sports in one publication [1]. Every sport with a distinct aim and form requires its own technical support.

In a book edited by Kreighbaum and Smith [2] the word *equipment* was used to describe different engineering products devoted to sports. In modern sport activities, both recreational and professional, for healthy and for disabled sportspersons, there are many activities based on using products of engineering that are much more of different, specific kinds, than presented in the above mentioned book. The aim of this article is to give a more detailed, full division of many creative works of engineering devoted to sports.

In order to give to the reader better description of the problem, in this case – products of sport engineering, it is worthy to present it in a systematic form. In this way it is easier to acquire new knowledge of the investigated area.

An article would be helpful for young investigators as a guide through very large area of sports engineering products. It will be easier for them to choose a proper branch they will be interested in.

### II. SPORT REQUIREMENTS

Every sport needs some kind of technology. Engineers and technicians since ancient times have produced accessories, equipment, vehicles as well as gymnasia, stadia for utilisation during sports training and competitions. With the foundation of modern sport in the 19th century and the boom in sport in the 20th century, a need for specific sport engineering has been in great demand.

In Poland, Pawlowski [3, 4] published early papers devoted to sport engineering. In another paper [5] he gave an example of utilisation of non-sport-based technology in the production of sports equipment. Haake [6] described the impact of technology on sport performance in athletics and cycling.

For sportspersons who are of different morphology many sizes have to be produced. What is more, for elite sportspersons garments and equipment are manufactured individually to fit them precisely.

Usually, garments or equipment have to be much more resistant to stress than normal products. In particular products must be resistant to overloading forces, to constant sweat touching the product, to high or low temperatures, and to a wet environment. There are no universal products. Products should always be adapted to specific sport and needs [7].

Every engineering product has to be in compliance with the rules of a particular sport discipline. Physical data that must be in accordance with the rules are for example: dimensions, mass, moment of inertia, passing of air, and others.

### III. GROUPS OF SPORT PRODUCTS

The groups of engineering products that have emerged and sophisticated over many years and are

used today, within many sports, are those concerning the body, those that are movable and immovable, those concerning information technology and many others besides [8].

The full list of groups of sport engineering products is presented in Figure 1.

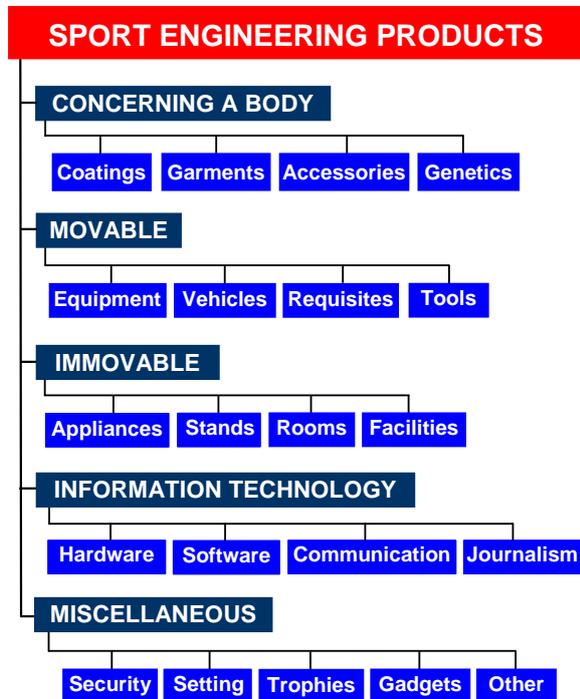


Figure 1 Groups and sub-groups of sport engineering products

For about ten thousands sports and their competitors, coaches, referees, organizers, journalists, sport scientists and other personnel, hundreds of thousands of sport products are needed.

#### IV. EXAMPLES OF SPORT ENGINEERING PRODUCTS

##### 1. Products concerning the body

###### 1.1 Coatings

Coatings are used for different objects. There are coatings for: a) human or animal's skin, b) equipment surfaces, c) garments.

For the human body there are many types of creams, oils, gels, greases. They are used against wind, sun, water, cool temperatures. There exist many cosmetics designed especially for sportspersons, e.g. many types of anti-perspirants and anti-UV light creams. Gymnasts, weightlifters and shot putters use talcum powder to strengthen their grip (increasing friction force and preventing skin against injury). Sometimes, as in handball, sportspersons use a special glue which is applied to the fingers in order to hold the ball more firmly. A similar substance is used by pole vault jumpers (Fig. 2A).

Surfaces of garments, usually shoes, are covered with protective substances. Leather footwear

and leather accessories (gloves, saddles, handles) are covered with waterproofing wax. Wooden accessories are covered with paint or varnish, metal is covered with protective gum or plastic endings.



Figure 2 Products used for the body: A – pole-vaulters use glue in order to grip a pole firmly; B – a judo uniform is made of a strong fabric; C – alpine skiers use protective accessories; D – gene doping resulting in excess of muscle growing is considered misconduct by anti-doping rules

###### 1.2 Garments

Sportspersons use a variety of very different garments of which a different number may be necessary – underwear, mid-layer, and external. A sport where participants wear minimal garments is beach volleyball. Only aesthetic rules require wearing anything on the body. The biggest number of garments are worn by those who operate in very low temperatures – himalaists and those who traverse the Antarctic continent.

There are many functions of garments beyond aesthetics. First of all they help to retain warmth around the body. In other circumstances, different kind of garments allow heat to escape the body rapidly. Some clothing protects the body against hits and traumas. Sometimes garments cover some protective accessories. Garments protect the body against the sun, wind, rain or snow.

From a biomechanical point of view, for many sport disciplines, garments have to be very tight, i.e. they have to be worn very close to the body in order to give very small air or water resistance (drag). In other cases, e.g., in ski jumping, garments are large in order to effect greater vertical drag. Here, clothing plays the role of parachute.

For the situation of alpine skiers who approach world record velocities an overall garment is so tight and fits the body so exactly, that this garment is used for only one run during an attempt to break world record. After that it is used only for training sessions.

In judo, a garment called a judoga must be strong enough to resist repeated tugging at big force. This happens when one judoist wants to accomplish a throw by pulling the opponent by his jacket – see Fig. 2B.

Special attention should be paid to shoes and boots. Almost every sport has its own footwear, mostly shoes or boots. They may be very light as in gymnastics or athletes' sprinting shoes. Other are heavy and stiff like those used in alpine skiing. Modern running shoes have air compartments, while the newest running shoes are even equipped with microchips in order to adapt the stiffness of the shoe according to the type of terrain. This information is gathered by special sensors mounted within the shoes.

Headwear also takes different forms. Wide covers protect eyes against the sun and against precipitation. For winter sport activities, they are sufficiently loose to cover the ears. One very common type of headwear is the baseball cap, which may be adjusted in a "one fits all" fashion, i.e. with a band with a series of holes and a fastener-stud.

Different colours of garments help to differentiate individual sportspersons or entire teams. Also, national or club emblems attached to garments help to differentiate teams, and numbers on shirts help to differentiate sportspersons.

### 1.3 Accessories

In some sports, sportspersons have special accessories, which are not necessary to take part in a contest but are nonetheless useful, e.g. for protection or a decorative extras. For example spikes added to the sole help in obtaining a better result in running events but they are not necessary for a run from the point of view of athletic rules. In team games a team's captain wears an arm band which allows him alone to speak with the referee. Some tennis players have a wrist band that works as a wrist ligament strengthening support.

Other useful accessories include helmets specially shaped to diminish air resistance, and glasses or contact lenses that enhance vision. Different colours of contact lens may, for example, assist in adjustment to changing colours. Other accessories are gloves for firm grip of objects, pieces of material for keeping the lower back of rowers warm, sun glasses, and goggles.

Accessories also play a role in body protection. The most common protection used in many sports is a helmet. There are helmets for alpine skiers, hockey players, American football players, boxers, taekwondo fighters, rally car drivers among others.

Some other protective accessories are: chest protection and the mesh face shield used by a catcher in baseball, the masks used by hockey goalkeepers,

transparent face shields used by hockey field players, weightlifting belts for waist support, leather or plastic covering of palms used by gymnasts, or protective gloves used in many sports, shin protection in football and alpine skiing, back and joint protection in alpine skiing (Fig. 2C), joint padding worn by roller skaters, and others.

Protective accessories are made mostly from plastic material. They are resistant to large forces, they are light, and they have some elasticity. Other materials used for accessories are: leather, metal, plant fibre materials.

Special accessories are built for disabled sportspersons. The most known are artificial feet. They are built as springs, enabling sportspersons to run at high velocity. Disabled sportspersons equipped with such elastic elements want to participate in competitions where healthy sportspersons participate. Unfortunately, in this case, disabled sportspersons have a technological advantage over other competitors.

### 1.4 Genetics

Engineering of biological tissues, especially genes, is one of the newest branches of science. Its interdisciplinary character typifies the modern approach to acquiring knowledge.

Tissue manipulation for the purpose of achieving new biological phenomena, especially faster muscle growth, entered sport via medicine. Although injection of genetic substances may allow for additional muscle mass and helps patients in some diseases, it also helps sportspersons to achieve greater strength [9]. Nevertheless, as regards anti-doping rules it is considered misconduct (Fig. 2D).

Another application of gene / tissue engineering can be found in modern orthopaedic sports medicine practice. Tissue engineering, which may be combined with gene therapy, results in creation of tissues or scaffolds for regeneration of tissue defects following trauma [10].

## 2. Movable products

### 2.1 Equipment

Equipment used in sports may be divided according to:

- 1) Sport disciplines or groups of sport disciplines, e.g. athletics, games, water sports, etc.
- 2) Purpose of utilization within the sport discipline: e.g. equipment for throwing, hitting, lifting, shooting.
- 3) Kinds of space where it is used, e.g. on or under the surface of the ground, on or in the water, in the air, in outer space.
- 4) Part of the body that uses the equipment, e.g. attached to upper or lower extremities (this kind of equipment is called endings).
- 5) Persons that use the equipment, e.g. a sportsperson, coach, or referee.
- 6) Purpose of use during exercising, training or during a sport event, e.g. for preparing a pitch, a track, or a water arena, to measure an accomplishment, for

administering spectators, for providing press, radio, or tv coverage, for cleaning a sports arena.

There are many examples of equipment used for throwing, hitting or kicking. First of all there are many kinds of ball, i.e. a) soft, usually made of leather or plastic material, usually hollow spheres, or b) hard, solid, plastic or metal. Balls are used in: football, team handball, volleyball, basketball, golf, baseball, polo, waterpolo, tennis, table tennis, hockey, billiards, boules, bowling, floorball, cricket, croquet, lacrosse, rhythmic gymnastics, and in other sports. Beyond round, empty balls there are: oval balls for rugby, pucks for ice hockey, shuttlecocks for badminton, frisbee discs and other game items. Other examples of sporting equipment are as follow: barbell, weights, shot put, athletic hammer, discus, javelin, baton, clubs, rope (for tug-of-war), darts, and others.

Equipment attached to the upper extremities includes: rackets (for tennis, table tennis, paddle tennis, badminton, lacrosse), hockey sticks, side-arms (foil, epee, sabre), ski poles, ice-axe for himalaism, bat for hitting a ball and glove for catching a ball in baseball, and others.

Equipment attached to the lower extremities includes: skis used on snow, grass, and water for riding and jumping; skates for ice-skaters, ice-hockey players and figure skaters; roller skates for roller-skaters and roller-skiers; boards for snowboarders. This equipment is used in sports utilizing a sportsperson's muscles or utilizing the force of gravity.

Equipment used for shooting is as follows: bows and arrows, rifles, pistols and bullets, targets, and binoculars or telescope.

Sportspersons also use, during training sessions and competitions, individual equipment not attached to their body, e.g. oars, rudder, poles, Orienteering runners are equipped with maps and compasses, or with global navigation satellite system (GNSS) data-loggers. Race walkers, runners and others use sport-testers for counting heart beats.

Coaches use: chronometers, tapes for measuring distances, flags, whistles, magnetic tablets and magnets, and palmtops.

Referees also use chronometers and tapes for measuring distances, whistles, and a set of colour cards (in football), a notebook and pen, tables with numbers for displaying scores, and other equipment.

Sport scientists use equipment for measuring the geometry of sportspersons' bodies (anthropometer, goniometer, fat caliper, photo-camera), equipment for investigating a sportsperson's muscle strength (dynamometers, rulers) and movement (video-cameras, tape, chronometer, reference system, plates with numbers for coding trials, tripod for camera, etc.). Cameras are also used by organizers of sport events in order to show a long skiing course (Fig. 3A).

Many examples of sport equipment are computerized. They have microchips that gather kinematical or dynamic data. These data can be read out by a sportsperson, e.g. on a liquid crystal display,

or by a coach on his computer screen. This can be done online or after the completion of a training session.

In Arab countries it is prohibited for youngsters to ride on camels during sport competitions since gambling takes place. In this case engineers built computerized robots which ride those animals, attached to their backs as would be real riders. There are also other robots helping sport community, e.g. as sparring partners or coach's assistants [11].



Figure 3 Movable products: A – skis and video camera; B – sailing boats as water vehicles; C – cones as requisites; D – grinding machine as a tool

## 2.2 Vehicles

Vehicles (or locomotion devices) may be divided into: ground (surface and underground), water (on water and underwater), air, and space vehicles. They may also be divided into those propelled by humans (human-powered vehicles), and propelled by natural forces and by engines (non-human-powered vehicles).

Vehicles used on the ground can be divided into those with wheels – bicycles, motor-bikes, cars, and those with runners – sleighs, bobsleighs, ice boats. Special ground vehicles (robots) have legs and proceed in a manner of gait.

On water vehicles are different kinds of rafts, boats (Fig. 3B), catamarans, trimarans. Their hulls may be partly submerged underwater and partly above water surface. Underwater vehicles are entirely submersible constructions able either to pull a man or contain him inside the vehicle.

The first air vehicles which carried a man underneath were gliders attached to a person's body. Unfortunately they were not able to carry a man for any considerable distance, and there was no possibility

to steer such a glider. The first glider which allowed a passenger to fly about 200 m was that built by Lilienthal. The first successful air vehicle (airplane) propelled by an engine was used for the first time by Whitehead (Weisskopf) in 1901. But the first airplane propelled by an engine and able to turn was that constructed by the Wright brothers in 1903. There are also many kinds of gliders which resemble an airplane, but are propelled by air currents.

The first successful human powered air vehicle able to proceed for a longer distance (few hundred metres) and to turn in the air was the *Gossamer Condor*. Subsequent constructions were able to fly many kilometers, including over the English Channel (La Manche) [12, 13].

There are many special vehicles built for disabled persons participating in sports. The most known are specially designed wheel chairs. They are operated using upper extremities by persons having disabled lower extremities. Sportspersons are reclined in such chairs to an almost laying position. The construction resembles bicycle. Disabled persons also use water crafts – sailing boats, rowing boats, kayaks. These boats are specially equipped. Rowing boats are divided into those for people disabled in lower extremities and those disabled in the vertebral column and lower extremities (rowers operate here with upper extremities only). Additionally there are normal boats which are operated by blind rowers and where the course is maintained by the coxswain.

### 2.3 Requisites

In order to organize training or competitions many requisites are needed. When two teams are playing sport games during training, loose, light vests are used to differentiate players of each team. In athletics, both high jumpers and long jumpers use small wooden or plastic blocks to mark acceleration points. There are also requisites used to mark tracks in rowing and kayaking (buoys), in race walking (cones, Fig. 3C), and in football training (flags).

Numbering of competitors is done with the help of numbers printed on a piece of fabric. These numbers are attached to the body with glue and to the garments with safety pins. Such a safety pin was also used in the case of a competitor's jacket with broken zipper during one of the FIS World Cup ski jumping competitions in 2010.

### 2.4 Tools

Almost every kind of engineering device needs to be adjusted, regulated or repaired. For transportation, devices sometimes need to be taken to pieces and then re-assembled. For these purposes different kinds of tools are used, e.g. hammer, pliers, screwdriver and wrench. For some particular uses, such as in maintenance of boats, a grinding machine is used (Fig. 3D).

Simple tools are operated using human muscle force. More complicated tools are operated by

electric current or by air pressure. This can be seen at pit stops in automotive sports, where wheel bolts are screwed and unscrewed with the help of air pressure tools.

## 3. Immovable products

### 3.1 Appliances

Sport appliances are used for: a) training, b) competition, c) referee measuring, d) diagnosis, e) body renewal, f) other purposes.

In artistic gymnastics there are floor exercises and apparatus exercises. Male gymnasts use a horizontal bar, parallel bars (Fig. 4A), a pommel horse, rings and a table. Female gymnasts use uneven bars, a balance beam and a table.

During training sportspersons and coaches can use an air gun (ball machine) for shooting balls (in soccer, tennis), a snow gun for producing snow (in alpine skiing, Nordic skiing) as well as movement simulators which replicate geometry of movement or specific resistance forces (in fitness rooms and specific training rooms). There are also audio devices used for sports with music and video devices used for checking the quality of movement.

Appliances are also used in weightlifting such as a bench and barbell holder, while tables are used in table tennis and boards in darts, etc.

Appliances used during competition are designed especially for a specific sport discipline, e.g. hurdles in athletics, apparatuses in gymnastics, electric devices used by fencers. Such appliances are built and function under the rules of a sport discipline.

There are many appliances used in sport diagnosis. They are used by coaches and by other sports personnel as well as by sport scientists: specialists in kinesiology, physiology, biochemistry, biomechanics, psychology, genetics, anthropology, hygiene and meteorology (e.g. reaction time measuring devices, gas exchange measuring portable devices, devices for investigating blood samples, video or selective camera systems). Special appliances are used in anti-doping investigations and by medical personnel. Still other appliances are used by the technical teams preparing radio, television, and Internet coverage.

Other appliances are used for management of time data – photo-cells, electronic time devices, electronic boards. Still other devices are for producing illumination during night competitions, or for capture, transmission and reproduction of sound and images to the spectators present at the competition and for home audiences.

Nowadays there are very sophisticated appliances in use by referees. These include devices that react on a foul start (start blocks), electronic timers with printers, photo-finish for time measurement and for establishing placings of sportspersons (mostly between competing runners or groups of sportspersons (e.g. in rowing or kayaking)). Other appliances are used for checking of sport garments and equipment. They must be produced and used according to discipline-

specific rules. During important sporting events, the services used to assist in refereeing are usually computerized.

Revitalization of the mind and body from the point of view of psychology and physiology is critical to sportspersons. There are appliances used by those who carry out services for the wellbeing of sportspersons both mentally and bodily.

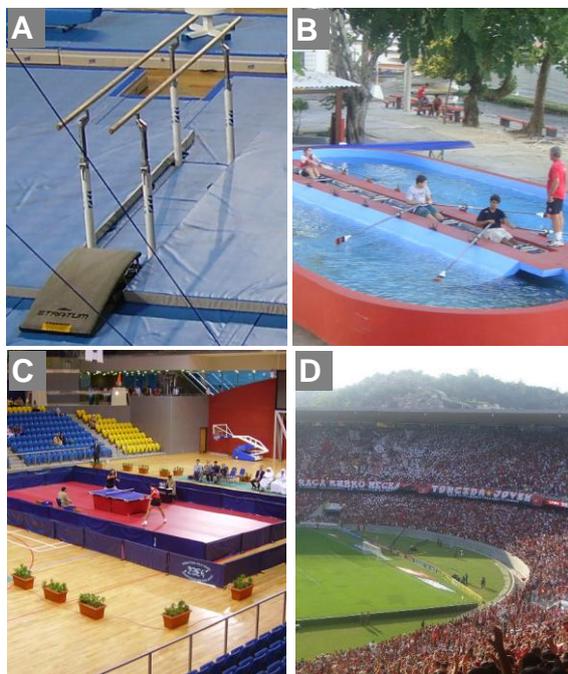


Figure 4 Immovable products: A – gymnastic appliance (apparatus); B – open air rowing stand; C – table tennis hall in Doha (Qatar); D – Ernesto Filho (Maracaña) Stadium

### 3.2 Stands

In various sport disciplines there are many sport stands. First of all there are stands used during training – intramural and extramural, especially for achievement of better strength. Other stands are for training of ‘space – time’ coordination, e.g. table tennis stand equipped with lamps simulating different position of a ball [14], still others are for training both strength and coordination, e.g. rowing stands (seats with oars – Fig. 4B), gymnastic stands (suspension ropes or bands attached to the ceiling or to a special construction on the one side and to the gymnast’s body on the other), tennis stands (walls for ball rebounding), and others.

Special stands are prepared for newspaper journalists, radio and television coverage teams and also for spectators. Here, often stands with hundreds and thousands of places are needed.

### 3.3 Rooms

Sport rooms take many forms. There are open and closed rooms. Open rooms are those without a roof, or without walls. In such geographical locations where weather permits there is often no need for a roof or walls. There are many examples of open air sport

facilities with rooms for different games, swimming areas, fitness stands, etc.

Closed rooms are built in order to avoid the influence of climate / weather. Such a necessity is often present at the latitudes of severe climate – low and very low temperatures, strong precipitation, strong winds.

However, a roof and walls are needed not only in regions where it is cold or very cold, they are also needed where there is strong sun or dust storms. One such example would be the Arab states (Fig. 4C).

Sometime walls are partly open like in the case of Botafogo Club games hall (Rio de Janeiro, RJ, Brazil), where the walls do not reach the ceiling; instead there is a 1 m open space in between, allowing the free movement of air.

### 3.4 Facilities

The first sport facilities were built in Ancient times. In Greece they were devoted both to gods and to sport exercises. Greeks built gymnasia – buildings covered with a roof, they also built the first stadiums – open air facilities. Romans also built sport buildings with the Colosseum as the most magnificent facility. Unfortunately, at the beginning it also had non-sporting applications.

During the 19th and 20th centuries, many facilities specially devoted to sports were built. There were buildings for training and for competitions, for diagnostic procedures and for renewal, for anti-doping and for medical examinations. The majority of open air facilities were built for sport games, especially for football. Such facilities not only constitute the greatest number, they also form the largest of these facilities. For example Ernesto Filho Stadium in Rio de Janeiro, when it was built in 1950, hosted about 200,000 standing spectators. Now, after rebuilding, it provides space for about 100,000 sitting spectators (Fig. 4D).

Open-air facilities (sport grounds, stadia, sport tracks, ski-jumping ramps) were built for games, especially for football, and also for athletics, bicycle or speedway riding and car driving, as well as for ski jumping. Engineers have to predict how precipitations will be neutralized, what kind of natural or artificial cover for the ground will be applied, the effect of the sun’s course during a day and where to install floodlight masts. There is also the question of how spectators will get into and out of the facility. Usually very large parking lots will also need to be included.

Covered buildings were built for sport games, gymnastics, swimming and combat sports. Very important are the matter of what floor is to be laid (stiff or elastic), what cover is to be constructed (stationary or movable), what lighting will be operated, how air will flow inside the building, how it will be heated, where the sports arena should be situated and where spectators will be sitting or standing, as well as what security precautions will need to be implemented.

Sport organizers also use buildings built for civil purposes. There are streets and bridges utilized as

running courses, streets are also used for basketball, and airfields are used for car racing. In Dubai (United Arab Emirates), top tennis players have used the helicopter landing platform of Burj al Arab Hotel as a tennis court.

Urban planners and country planners are involved in coordinating the utilization of sport facilities in conjunction with other functions of the city and of the country. They plan possible accommodation for spectators of huge events (Olympic Games, world or continental championships), transportation (land, water, air), and possible means of recreation and leisure.

#### 4. Information technology

##### 4.1 Computer hardware

Computer hardware has undergone tremendous change. Half a century of modern information technology has transformed computers from large room size machines to pocket size gadgets and brought them from scientific laboratories to every home, sport club and even into sport devices themselves.

At the beginning of the 21st century there is no important sports competition without computers, peripheral devices, and specific software. Computers are used by competition organizers, sport clubs and federations, sport scientists and medical personnel, journalists and broadcasters, spectators, security squads and others.

Contemporary computers with large amounts of memory (counted in giga- and terabytes), along with the possibility of using computers in many places and situations has allowed competitors, coaches, and other personnel to use them during training and competitions (Fig. 5A), organizers to use them in tough meteorological circumstances and hundreds of broadcasters to use them to connect with millions of home receivers all over the world.

Microchips are installed inside sports equipment – shoes, skis, rackets, which interface with sensors to establish proper stiffness of equipment. The highest number of sensors cooperating with on board computers can be found inside racing cars, motorboats, and airplanes.

##### 4.2 Computer software

The author of this article started writing computer programs using BASIC in the 1980s. Since that time many new computer programs have appeared. These programs are used for steering of devices, calculations, word processing, images administration and treatment, cooperation with coach and referee appliances and for other purposes.

Special computer programs are used by sport scientists for recording and analysis of human or animal movement [15, 16]. A sportsperson's performance can then be modeled and optimized (Fig. 5B).

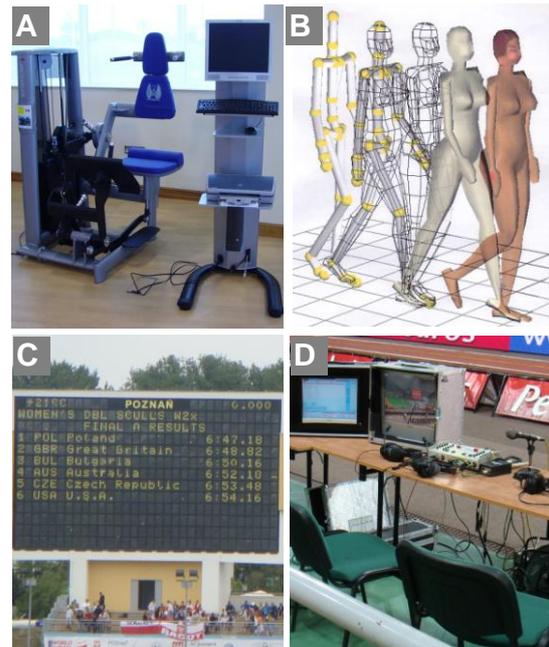


Figure 5 Information technology: A – computerized training stand; B – a model for the analysis of movement [16]; C – information board for spectators; D – journalist's post during indoor athletics competition

##### 4.3 Communication

Communication between people can be done naturally, i.e. with voice, gesture, touch. Communication may also be done with the help of numerous technical devices. There are speaking-tubes and electro-speaking-tubes, microphones and speakers or loud-speakers, different photo-, film-, and television cameras. There is also video-technology used by professionals and amateurs.

The miniaturization of communication equipment and its low cost have created the possibility for everyone to carry mobile (cellular) phones inside his or her pocket or handbag. The latest of technologies are now implemented into the small objects – telephone, photo and video camera, calculator, watch, dictaphone, radio, i-pad and other communication devices. Now coaches and competitors, coach between one another, competitors and their families, and so on can be in constant communication, both vocal and visual.

Communication between competition organizers, sportspersons, journalists and spectators is facilitated with the use of loud-speakers, large data boards and/or television screens placed at sport facilities, in front of the audience (Fig. 5C) or small television sets placed inside journalists' rooms, competitors' rooms and in other places.

Another type of communication is e-communication (electronic communication). This is carried out with the help of many types of electronic / informatic devices. This type of communication is made by short message service (sms), multimedia

message service (mms) and especially by Internet and intranet. There are several world wide web (www) pages offering, through portals and vortals (vertical portals – mono-thematic), sports information using multimedia (text, still pictures, voice, movie pictures). Here search engines are of great use, allowing desired information to be found among the huge amount of information accessible within the Internet.

Sport scientists communicate between themselves and with other interested people through journals and books, by being present at the conferences (using laptops and multimedia projectors) and by giving popular lectures at radio or television stations.

#### 4.4 Journalism

The very first technology used by sports journalists was the newspaper. They would communicate with the editor-in-chief through telegraph, telephone and regular post messages. In the first half of the 20th century radio appeared, then television. These media were and are propagated through cables and through electromagnetic waves.

Sports journalists could broadcast information live from stadia, from sport halls, from outdoor spaces (roads, water arenas) using cars, motorcycles, boats and even helicopters. Today journalists can use, besides microphones, video monitors, and computers in order to have all necessary information in front of them (Fig. 5D).

Newspaper reporters sit at the stadium with laptops and write articles online which are relayed directly to the newspaper's office. Photographers put their photographs onto laptops, edit them and send them to the office without leaving the event's press office.

Television broadcast is produced using a great number of cameras – stationary or mounted on cranes or moving on a carriage. Sometimes a special temporary television studio is built at the sport facility. All of the above procedures are now available in very good quality (full HD – full high definition, i.e. with about 2 million pixels per picture). The information is digitised and sent all over the world via satellites.

### 5. Miscellaneous

#### 5.1 Security

Safety at sports events is now one of the most important problems in training and competitions. For example, during the training of rowing crews on a river or lake there is not always a coach in the motor boat behind the rowing boat. In the case of water obstacles (bridge, port, other water unit), dangerous situations may arise. In the history of rowing, there have been tragic occurrences in which boats have collided with bridge pillars, breaking the boat and drowning sportspersons. There have also been tragic situations in other sports – motor sports, alpine skiing, ski jumping, luges, boxing, and many others. In all sport disciplines there have been accidents during training. Injuries are the plague of sport.

As well as the safety of sportspersons at the sport arena during the sport competition (Fig. 6A), there is also a security problem concerned with spectators. While most spectators are peaceful, happy to be part of a joyous event, some others may be aggressive, even brutal. In order to prevent hooliganism at a sports event security workers search spectators at the entrance in order to find dangerous objects that might be thrown at sportspersons and referees, or might be used in fights with an opposing team. To aid security staff in this purpose, security gates are installed with metal detectors.



Figure 6 Miscellaneous products: A – alpine skiing course protected with three net walls for safety reason; B – starting gate with special surrounding; C – trophies of football team of Fluminense Sports Club in Rio de Janeiro, RJ; D – brooches and chains for rowing enthusiasts

#### 5.2 Setting

Sporting events, especially the Olympic Games have their special settings. The setting plays important role in the cultural, educational, emotional, and economical sides of sporting activity.

Setting might have a hardware or software aspect. There are symbols used during advertisements (posters, T-shirts, programs). In other cases, the setting may be worldwide. The portable Olympic Torch is carried by thousands of volunteers running through many regions of the world. The stationary Olympic Stadium Torch burns perpetually during the Olympic Games. Emblems of the Olympic Movement, i.e. the five Olympic Rings, mottos, or emblems of other particular sporting events are placed inside or outside the stadium or sports hall.

There will often be a setting of artistic (singers, dancers, actors and their equipment) or national nature (flags, hymns) too. Celebratory symbols, e.g. fireworks are set off at the end of a big sporting event.

Sponsors who have donated money or other support towards organizing a sporting event want to show their logos to spectators or in sight of the viewfinder of tv camera (Fig. 6B).

### 5.3 Trophies

In Ancient Greece a laurel wreath was awarded as a trophy symbolising victory in a sporting event. When a victorious sportsman returned to his village, many more trophies or awards would be handed to him. In present times, a trophy might take the form of a cup (Fig 6C), medal, diploma or sculpture representing a sporting scene. A trophy might also be an everyday item, or just money.

During the Olympic Games in Berlin in 1936 a custom of presenting a laurel wreath along with medals for the winners of a sports competition was introduced and then in Athens in 2004 it was re-introduced. In addition, in almost every country every medallist was given a huge amount of money and other awards from the National Olympic Committees.

### 5.4 Gadgets

In every country, many gadgets for sport purposes are produced. They are usually made from metal or plastic. There are: pins, coins, plaques, and also posters and stamps. Spectators and collectors gather and exchange memorabilia.

Usually, organizers of the Olympic Games will introduce an official Olympic mascot, which will be displayed on posters, pins, T-shirts, etc. Still other gadgets are those which may be attached to clothes or worn as a necklace. There are also brooches, chains, pendants and other (Fig. 6D).

### 5.5 Other

It is important that there should also be medical personnel present during the sport event. This would be helpful for all present at the event, but is most important in the case of sports where there are possibilities of serious injury like in games, fighting sports, sports involving high velocity movement. Medical personnel have at their disposal first aid equipment and also more sophisticated devices available inside the ambulances which usually stay near the sport arena.

Ushering of spectators is conducted with the help of special barriers, gates, boards with posters, arrows showing direction of movement and differentiating spectators according to tickets purchased. In order to prevent spectators with false tickets from entering the sport facility, tickets are printed in a special manner and are equipped with holograms and other security markings.

Exploitation of sport facilities, i.e. cultivation of grass on the pitch, snow cover of alpine slopes, ice surface of ice-rinks, and also cleaning them after a sporting event is an important job. Special groups of people are backed by technical devices for cutting grass, painting lines, producing snow and flatten ice.

The last but not least are sanitary problems. Toilets, containers or buckets for rubbish need to be built solidly and to be in plentiful supply.

## V. FINAL REMARKS

Sport sciences and sport engineering are already well developed. There are many university laboratories devoted to sport. Many scientists work to solve problems that arise during training and during competitions. Many engineers work on designing new, safer products which are resistive to loads, more ergonomic and more aesthetic [17]. There exists strong trend to implement microchips that would help to maintain equipment in proper conditions according to circumstances into new products. Another modern area of interest within engineering is robotics. Some robots have programmed sport movements – for volleyball, football. They would serve as sparring-partners.

Another large areas of human interest beyond training and competition are services, education, medical practices. These are very important for complex conduct and development of sport.

It is the intention of the author that many of the problems existing within sports engineering could be taught at schools. In particular, students learning sport and exercise sciences, physical education and recreation, and applied engineering should learn modules of these themes.

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