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Sport activity – Systematic Approach to Science, Technology and Art. Part Two: Engineering Technology and Sport

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Abstract

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Keywords

sport activity, technology, systematization

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Part Two: Engineering Technology and Sport

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Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Introduction

Science is a branch of human activity where people discover the existing natural phenomena, search for relationships among different parameters and variables, formulate hypotheses, theories and scientific laws. On the other hand, technology is a branch of human activity devoted to the study and use of applied sciences, e.g. engineering. Engineering technology is involved in creating new objects, processes, structures, dependencies that have never existed before. Whether it is a simple tool or a complicated machine, or whether it is a process of simple hand manufacturing or automated production with a help of robots, it needs to undergo a specific technological procedure of creation (production).

The engineering technology of creating new material objects or preparing spaces for different human or animal activity encompasses: 1) engineering sciences, 2) the engineering process of production, 3) products and spaces (see Fig. 1). Development of above described technology depends on basic sciences, especially on exact sciences like mathematics and physics.

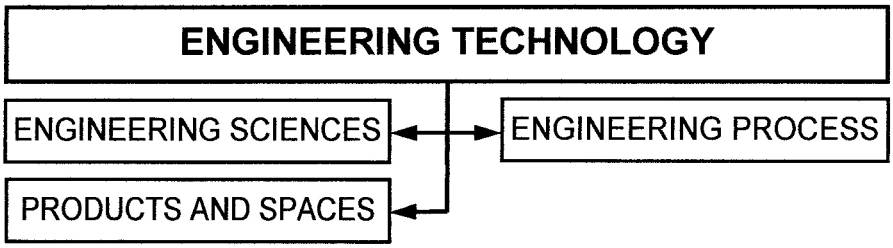

Fig. 1. Main branches of human activity devoted to engineering technology applied to sport

Engineering sciences

Engineers have developed several applied sciences. Many of them are present within sport technology. They are presented in Fig. 2.

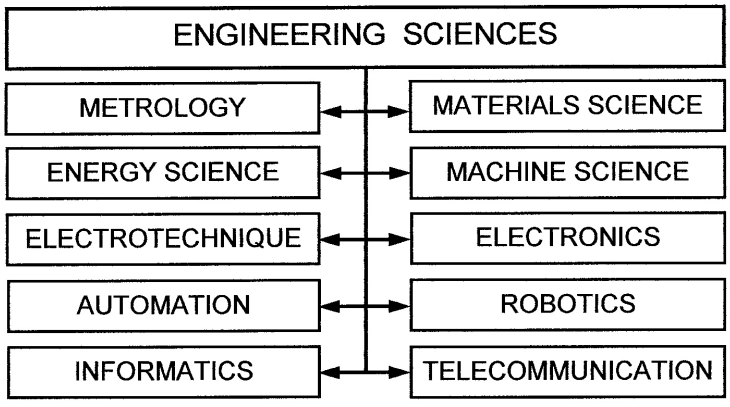

Fig. 2. Engineering sciences present in sport technology

Metrology is a science of measuring. For many years people and goods have been compared directly. Then measurement units were introduced: inch, foot, yard. Today it is called the Anglo-Saxon system of units. The French system based on a metre and decimal approach was much more convenient in measuring dimensions and distances. The General Conference on Weights

and Measures adopted the French system as the International System (SI). It consists of basic, supplemental, and derivative quantities and units of measure.

Within sports mostly those quantities are used which are within mechanical sciences: length (metre, m), time (second, s), mass (kilogram, kg). In some situations still the Anglo-Saxon system of units is used. In association football the Anglo-Saxon measures are of first importance. Also in athletics the width of lanes, the height of hurdles have their origin in the Anglo-Saxon system. There are several methods of measuring sport data: mechanical, electrical, electronic, optical. Since the end of the 20th century computerization has been used for the accuracy and speed of obtaining data.

Material science takes into account investigations of different materials such as: 1) biological – fibers, wood, skin; 2) minerals – stones, glass; 3) ceramics; 4) metals – homogeneous, alloys, 5) non-metals; 6) plastics. There are solid and fluid materials. The latter are liquids and gases [1]. Materials possess specific features like: density, hardness, granulation, colour, transparency, electrical conductivity. They have different behaviour in different physical surroundings – temperature, pressure, light, and chemical surroundings, both organic and inorganic. It is important to know how certain materials can be joined together, or what substance (glue) needs to be used to make a solid monolith of them. Another problem is the resistance of materials to loads and its deformation, mainly elongation, and also resistance to heat and fire, and to humidity. Materials are also studied according to their wear-off, their substitutes, their behaviour in contact with food and the human body.

In sport almost all materials are used. Most of them are used for building sport devices. Different materials are used for inner parts of a device and still other ones for the purpose of coating. Strong materials are used for the construction of buildings (bricks, wood, concrete) and sport surfaces (artificial tracks and grass).

Machine science deals with mechanisms and their compounds, i.e. machines. There are mechanisms of one movement (one degree of freedom) – along a line (e.g. load in fitness devise), or around an axis (e.g. a rudder in a sailing boat). An oar in a rowing boat or a ski binding has two degrees of freedom. The highest number of degrees of freedom is six – three translational and three rotational. Airborne equipment like in rhythmic gymnastics has this number. A man has six degrees of freedom while parachuting in air or diving in water. The technical mechanisms have bases and elements for transmitting translational and rotational movements, such as: guides, pistons, arms, shafts, tubes, and their joints, such as: hinges, bearings, gears, and clutches. Most mechanisms are used for building devices, i.e. equipment (usually movable), transporters like: carrier and vehicles, appliances (usually immovable), tools. A machine is a device that is composed of several mechanisms and has its own propeller, usually an engine.

In sports there are human engines, mechanical engines (propelled by gasoline or diesel), electrical engines, wind engines. Sometimes there are competitions of cars using light (solar) engines.

Energy science deals with all sources of energy needed to perform a movement. One needs to differentiate between fuel (source) and energy obtained in generators. For example, flowing water is a fuel and from this one can obtain mechanical or electrical energy. This energy is obtained from special energy plants. There are natural sources of energy – the gravity of Earth, sunlight, moving air (convection of air or wind), flowing water (quasi-horizontal or quasi-vertical). Special natural energy comes from stretching muscles of animals and humans. There is also energy coming from elastic biomaterials like tendons, skin. A different kind of energy is obtained from combustion. Wood, coal, gasoline can be fuel for combustion. Heat from natural fire has been in use for

hundreds of thousands of years. But the application of fire to the activity of machines started not earlier than in the 18th century (steam engines). The most sophisticated fuel is uranium or plutonium for atomic/nuclear energy.

In sport actions natural sources of energy, except the muscular one, are: gravity for a parachutist, an alpine skier and a jumper, or a water jumper; wind in sailing, windsurfing, ice-boats; flowing water for mountain kayaking. Artificial energy obtained from the combustion of chemical fuels in engines is used in motor sports – automobiles, motorbikes, motorboats. For the functioning of many sport devices electrical energy is used – for lighting, for referee equipment and appliances, for communication, for the functioning of computers.

Electro-technique is a branch of technology devoted to the utilization of electrical current. Electricity is a physical phenomenon of moving electrons within a conductor. This movement depends on the difference of potential. The movement of electrons causes resistance of the conductor. There are a few phenomena connected with electrical current: generation of heat, light, magnetism, decomposition of chemical compounds (electrolysis). Wide individual (home) and industrial utilization of electricity started with the first permanent power plant built by Edison in 1882. It was necessary to built electrical generators, converters, installations and many receivers.

In sport electricity is used for functioning of many electrical and electronic devices, for lighting (sometimes also for heating) of training and competition halls and stadiums, for the propulsion of vehicles, for charging batteries used in portable instruments like cardio-monitors, GPS, mobile telephones.

Electronics was developed as an application of emission of “electrons” from different materials in special conditions. An element built from specific material is formed as “an electrode”. Inside a lamp (a bulb with vacuum inside) electrons are moving out of an electrode (called “cathode”) when: 1) it is heated, 2) when photons of light ray reach the cathode (“photocathode”), 3) when other electrons bombard the cathode, 4) when there is a strong electrical field near the cathode. Electrons move from the cathode to another electrode called “anode”. A stream of electrons can be narrowed and accelerated and when it reaches the anode covered with fluorescent layer, it glows. Between the cathode and the anode there are deviation electrodes (inside a lamp) or magnetic coils (outside a lamp). Different voltage of deviation electrodes or magnetic coils causes different deviation of a stream of electrons. The above procedure is used, e.g., in television tubes.

A photocatode is mounted in the equipment (“photocells”) used for measuring the time of movement. Photocells are placed at a finish or at other important points of the covered distance. Rays of light are directed towards a photocell. When a body of a sportsperson cuts a ray, no photons reach photocathode and no electrons reach anode. At this time a devise measuring time, which is connected with photocell, stops. Other devices use semiconductors, i.e. elements where current flows in special conditions only. For example transistors are built on this principle. Electronic elements are built in form of special sets as rectifiers, amplifiers, generators, modulators, detectors. Semiconductors (e.g. silicon) are widely used in electronic elements in computers in form of very large integrated circuits. There is no area of life, including sport, without the use of them.

Automatics is a technical branch which takes into account processing of actions without or with minimal presence of a human being. It is well known that human beings are erroneous, subject to fatigue – mental and physical. In order to automize the process one needs a program, information on the state of a process and the surroundings, decision making component, and execution mechanisms. When a given process is done with changing conditions a regulation procedure is needed. Here feedback is an important input. Having sensors of different nature giving information

to the decision making component, it is possible to regulate also on-line orders which are sent to execution mechanisms and the output is more suitable to the current situation.

In sport there are many examples of automatic procedures. One of them is measuring and showing time of sports actions, e.g. in athletics, alpine skiing, cross country skiing, with the help of photocells, electronic timer and display unit. Another example is in fencing showing a touch by the blade on the opponent's uniform. Here electrical circuit and displaying lamps are utilized. Still another example is in athletics to show the sprinter and the audience a situation of a fault start. This happens when a competitor pushes a plate within a starting block too early with given amount of force.

One of the relatively newest branches of technology is **robotics**. It started with manipulators, i.e. mechanical devices doing the same precise job for several hours and days. Then came robots with sensors – optical, sound, touch that could work with feedback and could regulate their function; then came robots with microprocessors. Robotics is a branch of technology that deals with machines operating according to computer programs but without a direct intervention of humans. They have mechanical parts, sensors, energy source, and steering compound. The range of robots is from a few meters up to nanometers (1 nm = 10^{-9} m = one millionth of a millimetre). Robots could learn some functions according to the changing environment or changing characteristics of products that they work with. Bigger robots are utilized in industry to make goods on an assembly line, to assist old or disabled people during their everyday life. The smallest robots are aimed at being used immersed in fluids and are planned to be utilized within the human body.

In sport there are robots to help sportspeople during training, e.g. stationary robots for throwing a volley ball or kicking a soccer ball at a previously set direction and velocity or movable robots that can help e.g. para-sportspersons. Contemporary robots can even climb the stairs. Combined procedures of steering, regulation, automation, robotics are subjects of mechatronics.

Telecommunication deals with transmitting of information on long distances. For many years this had been done in a mechanical way. Since the use of electricity telecommunication has been based on eletro-, and then on electromagnetic devices. Up to the end of the 19th century electricity was used only in telegraphs to send messages with the help of the Morse alphabet. In 1876 Bell the invented telephone. A wide variety of information including voice, music, still-frame and motion pictures, computer files can be transmitted at very long distances using electrical wire. Then radio was developed by Marconi in Italy and Popov in Russia for transmitting of data and it is still widely used. Another way of transmitting of information is the utilization of optical fibers. They are relatively cheap and useful in transmitting digital data.

Telecommunication has been used in sport for many years and it is especially useful when cycling or other long distance competitions take place. In these cases motorcycle, car, or even helicopter broadcastings are provided. With the development of television, especially colour and recently full high definition (full HD), broadcasting of sport events has become interesting, emotional, and equal to artistic images.

Informatics or computer science is automated processing of information. One can differentiate between: hardware, software, and special connections – nets. Hardware consists of computers (analog and digital) and peripheral equipment. A computer has four basic functional elements: the main memory, a control unit, an arithmetic-logic unit, a set of input-output (peripheral) devices. The first three make the central processing unit (CPU). Examples of input equipment are: keyboard, scanner, external memories. Examples of output equipment are: display unit, speaker, printer. The efficiency of a computer lies in its speed of calculation, the convenience of use, and its dimensions. Software is a set of instructions held in computer's memory saying what the computer has to do. It

is divided onto: system software and application software. System software controls computer's internal functions and peripherals. Application software directs the computer to execute commands given by a user [2]. There is no sophisticated work without computers.

In sport computers play a leading role in the management of clubs and federations, in executing a training, organizing a competition, diagnosing sportspersons. They help to process a very large amount of data – reliably, quickly, in a friendly way. The miniaturization of hardware allowed implementing microprocessors into the sport equipment and attaching them to the sportspersons' bodies and uniforms. Computer nets – between computers within the same institution (intranets), and between servers all over the world and through them between all computers connected with them (the Internet) are very important part of informatics.

Engineering processes

Within engineering there exists a long and complicated process in order to obtain the final product. It starts with an analysis of needs and preliminary concepts and ends with a constant development of the product. During many stages of processing computerized assisted design (CAD) and computerized assisted manufacturing (CAM) are utilized. Branches of the engineering process are presented in Fig. 3.

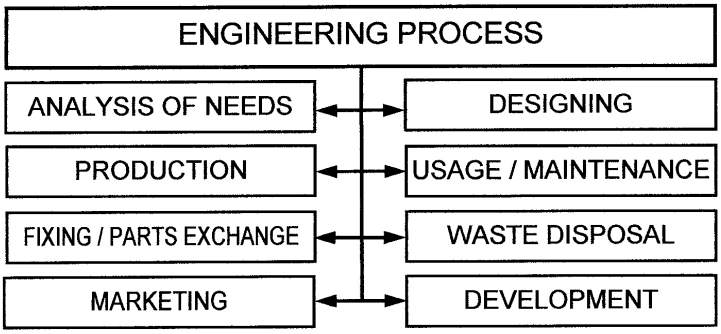

Fig. 3. Branches of the engineering process

It is important for the cooperation of engineering sciences with humanistic sciences – they show **human needs**, directions of development; with economics sciences – they establish financial and economic possibilities or realization of engineering projects; and with natural sciences – they present morphological, functional, and steering conditions of matching of humans or animals and a technical construction and its action within the specific environment (temperature, humidity, the composition of air and other features).

While starting preparations to make a project, an engineer needs to take into account the following main problems of **designing**: preparation of a drawing model, a description of materials of which a product will be made, making a physical model and a prototype and testing them.

Kreighbaum and Smith [3] edited an important book devoted to sports and fitness equipment design. This monograph presents an introduction on a designer, a retailer and a user; then it describes: foot-ground interfaces – running and court shoes, hiking and climbing boots, cross-country and downhill skis, boots and bindings; striking implements – tennis rackets, racquetball rackets, golf clubs, baseball and softball bats; personal fitness equipment – bicycles, aerobic exercise equipment, resistance training equipment, watercraft.

For many years **production** was based on manual work. This was done previously at home (handcraft), then at specially prepared buildings (factories). At the beginning of the 20th century assembly lines were introduced. Next came automation, manipulators and robots. Production is based mostly on physical or chemical processes. At first there is introductory and then mass production. All problems of administration, materials, production machines, energy, personnel, and finance need to be solved. Then storage, transport, and distribution of all products is needed. Every product must be accompanied by manuals and warnings against malfunctions. This is especially important with sport equipment because a sportsperson acts at the edge of possibilities, at the stage of the toughest conditions.

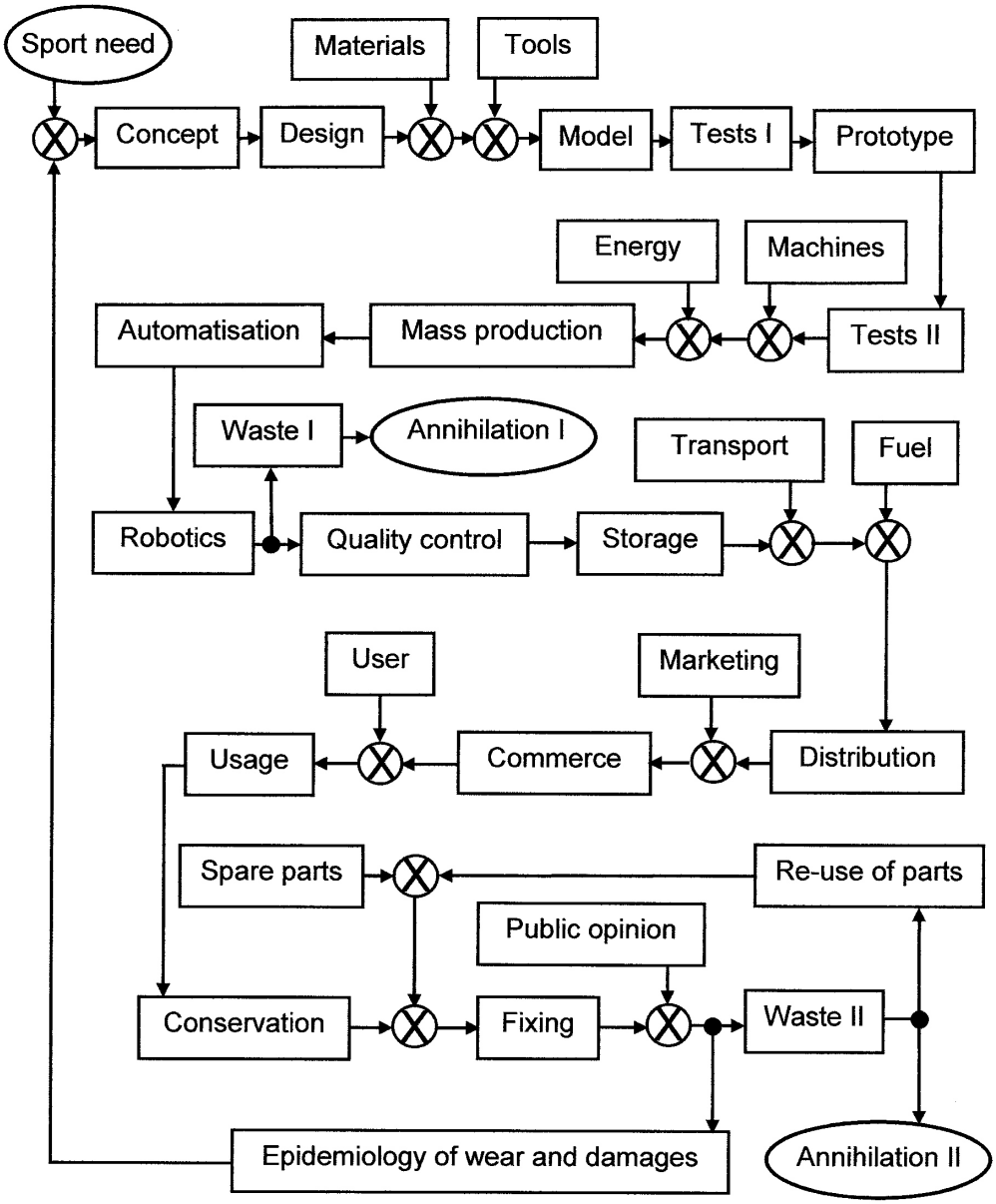

Fig. 3. Connections between areas of engineering process.

A user must remember about the proper **usage and maintenance** of every product, i.e. not to overload, overheat, or to treat with active, hazardous fluids. Conservation should be made, i.e.

cleaning, covering with proper grease or fluids. Also periodical control of the product's work have to be made.

A producer must organize service workshops for check-ups and **fixing and/or exchange** of broken parts. A client should have a possibility of warrant and post-warrant check-up and service.

A producer should also envisage **waste disposal**, i.e. storage of non-used products, recycling of materials and parts, physical annihilation (squeezing, milling, burning).

It is important to provide **marketing**. A producer needs to know how the product is used, what its strong and weak parts are, and how sport rules and technique of movement are changing.

Based on marketing feed-back a producer needs to rearrange his production. In order to improve the quality of products and to withstand action of concurrent producers a constant **development** of products should be made.

All areas of the engineering process, their connections including some feed-back are presented in Figure 3.

Sport and its technical assistance

Sport equipment has been used since ancient times. Greeks used discs, javelins, gloves, chariots. Also special buildings were built – gymnasiums and stadiums. When in the 19th century modern exercises and sports were developed, especially in Germany, Scandinavia, and England, special equipment and pitches were constructed for gymnastics, football, and athletic disciplines. Also special terrains and aquains were prepared for horse races, sailing and rowing regattas, and later on automobile tracks were built.

Along with the development of engineering also sport engineering was developed. Bamboo poles in athletics were substituted by metal poles, then by fiberglass poles. In running shoes with spikes were introduced, then starting blocks, artificial surface; mechanical chronometers were substituted by image equipment, then by photo-microprocessors. In football there were animal bladders, leather balls, balls made of artificial layers.

In Poland at the beginning of the second part of the 20th century Pawłowski published papers on sport equipment [4, 5]. Pawłowski [6] described an example of utilization of out-of-sport engineering technology in sport as follows: "An American Head used for production of skis a manner practiced within aircraft wings construction. At the same time development within the branch of glues gave the possibility application of synthetics bases. A new type of metal ski was born, much better than up-to-date wood products. Material used for base and side surfaces of a ski needs to be smooth, elastic, resistant to mechanical brakes, to have a long term sustainability of form, endurance to flexions, squeezing, elongation, resistance to braking into the layers, to aging, and low temperatures, and ability to adsorption of a ski wax. Poliethylens, poliamids, polivinylchlorides and many other are applied here. More often for bearing parts of ski construction epoxy resins reinforced with fiberglass are applied. They substitute not only a wood but also a metal."

In the 21st century sport competitions are great entertainment and business production. They are spectacles at the highest level. In order to achieve this, they must be based on the best solutions of sport engineering. It takes into account a manner of presenting a competition – from many cameras, with close-ups on faces, with the possibility of replays, with overlaps of sketches describing an image, time running even up to milliseconds, and others.

A sport of today has the same aims as earlier: competitors must be faster, jump further and higher, lift heavier loads, shoot with higher precision at the target, show better tactical solutions.

Sport must be more interesting and more emotional. Taking into account refereeing, decisions must be more objective and more precise. For participants sport needs to be healthier and more secure. Within all the above sport activities engineering technology has much to offer.

Within elaborations which describe a broad spectrum of engineering technology, since the second part of the 20th century (e.g. [1, 7]) there have been chapters devoted to sport engineering. Also whole-sport elaborations edited by Zuchora [8], Lipoński [9] or papers devoted to specific sport disciplines included fragments on sport devices. One needs to remember that inventions of engineers should not be without limits. Rules of sport federations put some limits according to applications of new technical devices. Nevertheless, by using new materials of better characteristics, better sport products are available.

Summing up, engineering development is a source of substantial improvement of sport results and higher sport security.

Products and spaces in sports

Within sport engineering products one can present those concerning a body, movable, immovable, those concerning information technology, and miscellaneous. There are also different spaces used by sportspersons – Fig. 4.

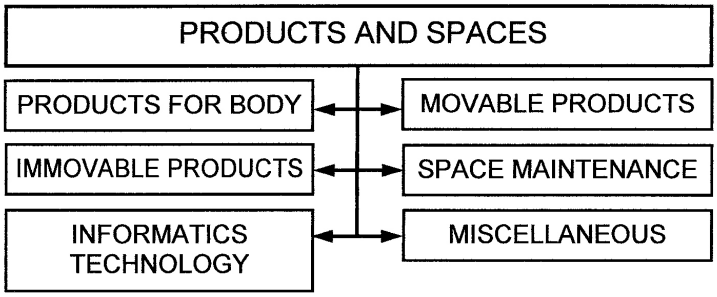

Fig. 4. Products and spaces of sport engineering

Products for a body

Goods prepared for a body include: covers, garments, accessories, and genetic products.

Direct **covers** of a body (fluid, gel, solid) are aerosols, creams, oils, talcum, etc. They are very valuable when there are inconvenient environmental conditions – strong sun shine, winds, very low temperature. They are also helpful in contact with several examples of equipment, like oars, gymnastic bars, weightlifting barrels.

There are many **garments** dedicated to sports. Beginning from underwear, then shirts, trousers, jackets, up to external garments like waterproof, windproof and coldproof ones. Still other must be very tough and resistant to pulls like in judo or to give smaller water resistance like swimmers' suits. There are many variants of shoes and boots. Their main role is to protect feet but those with spikes help in contact with surface, others give the possibility to attach skis, skates, rollers.

Accessories are elements that are not necessary according to the rules of a sport discipline but are helpful in obtaining better results. The most important are those for protecting a sportsperson's body. A hockey goalkeeper has the most of them. Also other hockey players, American football players, alpine skiers have many protecting accessories. Other accessories play a role in obtaining a higher velocity of movement, for example aerodynamic head covers. Quite a different category

are accessories for invdisabled persons alids participating in sport training and competitions. Those accessories are helpful in being closer to healthy sportspersons in the technique of movement. In some cases those accessories give the possibility of obtaining better results comparing to healthy sportspersons. This takes into account artificial feet built from elastic material.

The newest problem in sport is **genetics**. This is tissue manipulation, e.g. muscle tissue. Injecting genetic substances gives additional muscle mass hence results in better functioning.

Movable products

Within the group of movable products there are: equipment (for individuals and for a group), vehicles, requisites, and tools.

The most popular **equipment** are balls. They are tens of balls used in sports. Their mass, dimensions, elasticity are determined by the rules of a sport discipline. A lot of equipment is used in athletics. There are discs, javelins, hammers, shots, poles also of different mass and dimensions. Weightlifting equipment is used not only by athletes of that disciplines but also by many others during a training.

Vehicles are used for the transport of competitors or a group of competitors. On the ground rolling vehicles are used: bicycles, motorcycles, automobiles. On the snow and ice there are sliding vehicles used: lugs, bobsleighs, ice boats. On water there are floating vehicles: sailing boats, rowing boats, motor boats. In the air there are flying vehicles: powered by muscles, by the air, by engines.

In order to use locomotion devices by para-sportspersons special vehicles are built. The most often are carts powered with sportsperson's upper extremities. Sometimes para-sportspersons compete using those carts during competitions for healthy sportspersons.

Requisites are used at the playgrounds, during sport trainings and during competitions. Children in kindergarten use many requisites during their plays often resembling sport competitions. Boxers use skipping-ropes for jumping, team players use cones or poles for training slaloms, athletic jumpers use small objects showing the place where sportsperson needs to accelerate his or her run.

Tools are necessary in every sport where there are sport devices – movable and non-movable. They are used for assembling and decomposition of devices, for their regulation, for fixing.

Immovable products

Immovable products are: appliances, stands, rooms, buildings (in-door and open air).

Appliances are immovable devices used during training and competitions. For example, in artistic gymnastics for men there are: a horizontal bar, parallel bars, a table for vaults, rings, a pommel horse, and in addition especially for women there are: uneven bars and balance beam.

For strength training there are **stands** where a sportsperson can do exercises for a specific muscle group, or for several groups. There are also stands for rowing and kayaking training, for fencing and for shooting. In athletics there are the following stands: for high jump, for pole vault, for throws (of discus, hammer, shot).

Within sports there are specific **rooms** for training and for competition. There are rooms for weightlifting, martial arts, snooker. There are halls for individual and team games, ice rinks for skating, pools for aquatic sports.

For several sports special open-air **buildings** are built. There are stadiums for association football, rugby, athletics. Other facilities are prepared for archers, shooters, biathletes. More and

more competitions are held under the roof. In-door competitions are free of rain and snow, strong sun shine and winds, low temperatures. Architects propose designs that are unique. Cities are recognized according to specific roofs of sport buildings.

Space maintenance

For several sport activities open air large **ground** facilities are prepared. It takes into account long distance running, like marathon, super-marathon, race walking. Within equestrian sports there is cross country horse riding and horse driving. In winter within alpine skiing there is a down-hill discipline which has a length of 3–4 kilometers with a vertical drop of up to 1 km. Other alpine skiing disciplines with large area are: super giant, giant slalom, and slalom.

There are **water** facilities for rowing, kayaking, sailing. The distance for rowing is 2 km. Including some distance behind the finish an aquian for this discipline should have more than 2 km in length. The same water facility is used for flat water kayaking. The other facility is for mountain kayaking. The largest ever water surface / space and port facilities are for sailing, especially for very long distance regattas like the Admiral's Cup or around the world regattas. Still another water space is needed for divers. Record diving of free divers (without breathing apparatus) is about 120 m. Here divers use a rope which is anchored to the bottom. Holding that rope it is easier to go downward.

There are a few sport disciplines that take place in the **air**. Those disciplines use balloons, parachutes, gliders, para-gliders, small airplanes. It is necessary to maintain air space free of other users, free of electrical cables, wind-mills, etc. Airfields, control towers with radars and personnel (air traffic controllers) are also needed.

Sport went also to the outer **space**. It started with cosmonauts who did simple exercises inside a small room on board of a spacecraft. In order to prevent astronauts from osteoporosis and other wrong adaptations of the body during long flights every member of the crew must perform at least 2 hrs. of exercises daily.

Informatics technology

At present **hardware** in form of stationary personal computers and movable computers (laptops/notebooks) are used in sports. With a help of computers coaches can organize a training process, look through the diagnostic data. They can archive data from many training sessions. Microprocessors mounted inside different sport equipment and appliances play a role of the steering unit. Whenever it is possible they control e.g. stiffness of the equipment – tennis rocket, ski, boot. They gather data on functioning of a sportsperson – heart rate, breathing, stride cadence. They have melodies in the memory unit and a sportsperson is able to listen to them during a training.

There is a lot of **software** for specific sport use. For example, Sozanski's group developed a program "Tre-Ob" which helps gathering data on loads in a training [10], Erdmann's group uses program "Banal" developed by Kuzora [11] and program "AS-1" developed by Aschenbrenner [12] which help to locate the position of a person's center of mass and to analyze kinematic data of human movement. Other specific programs were developed by manufacturers of devices used for monitoring of a sportsperson's heart work, movement and force analyses. Still other programs are used for the management of video images. Here multimedia cards are used.

Today by using informatics **network** every sport specialist or sport spectator can obtain a huge amount of data by connecting, also wirelessly, via the Internet to servers where sport information is

available. It takes into account web pages (portals) specifically devoted to sport or web pages of news agencies, newspapers, television networks, encyclopedias and other sources.

Communication between people takes into account visual and hearing canals. Paper work is prepared by organizers of a competition for coaches and sportspersons. All data concerning the competition are included within the announcements and results sheets. During the competition usually communication is executed through board panels. At a sport facility also speakers and screens are installed, so the voice and images can be distributed to the athletes, coaches, and spectators.

Journalism is a special type of communication. Newspapers that had chapters which covered sport problems were first edited in the 19th century. During the 20th century radio, television and the Internet appeared. All branches of journalism need specific technology. Usually this technology is maintained by special personnel – engineers, technicians, and others. Today there are several tv broadcasters, some of them devoted only to sport. TV cameras are mounted in specials places – immovable (towers, masts, roofs) and movable (motorcycles, helicopters, airplanes, cranes, rails). Color television has high definition images. Internet journalism works 24 hrs./7 days a week.

Miscellaneous

There are many miscellaneous problems of sport activity: security, sets, trophies, gadgets, and others.

One of the most important problems of sport activity is **security**. It takes into account all participants – athletes, coaches, referees, spectators, journalists, and others. Everybody should always bear in mind a possibility of accidents that can happen while practicing sports. They range from minor scratches, through sprains, dislocations or fractures of bones, up to faints and deaths. Other problems are social unrests, usually of spectators but sometimes also of athletes. Fighting, throwing of objects, running of a mob – these are very dangerous behaviors of sports spectators. Still other problems are of an engineering source. Some sport facilities cannot withstand a load of many people that are present on them. Sometimes they collaps killing many people.

Sport competition would be of much better welcome if it had artistic, colorful, interesting surroundings. There are **sets** of photographs, labels, flowers, lights, large screens and speakers. Recently also guns of confetti and color ticker tapes are used which shot-out toward the audience.

Sport **trophies** have been handed in to the winners since the ancient times. During ancient Greek games these were branches of olive trees put on the head. Today there are different medals, plaques, cups. Also artistic sculptures, paintings, and pieces of garments are handed in. Still other trophies consist of technical appliances – radios, watches, pens etc.

An important sport competition is an occasion for producing commemorative **gadgets** – stamps, mascots, flags, banners, pins. They are subjects of buying but also of intensive exchange among spectators.

Other technical products encompass such devices as entrance gates, fences, equipment for grass, sand or ice maintenance, sanitarian devices, cleaning equipment.

Closure

People working within sports engineering founded the International Sports Engineering Association. Scientific papers are published in a periodical Sports Engineering and also in periodicals from neighboring areas like biomechanics, the theory of sport, sports medicine.

Education devoted to engineering problems in sports was present within the curriculum of physical education major in Poland in the second half of the 20th century. Unfortunately, at the end

of the 20th century authorities responsible for education of physical education abolished this subject. At the beginning of the 21st century (2003) Erdmann started teaching “Engineering of sport” at the College of Physical Education and Tourism in Sopot, and then at J. Sniadecki Academy of Physical Education and Sport in Gdansk.

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