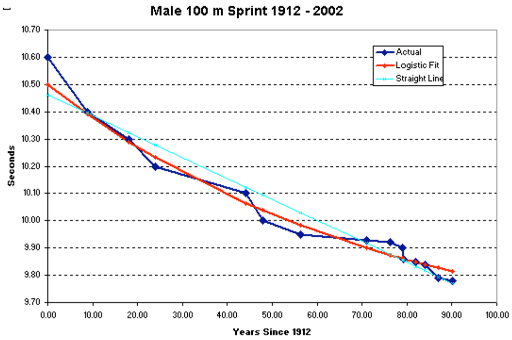
SET for Sport! London 1908 1948, 2012

How Engineering has transformed Sport

Historical examples of changes introduced to different sports

1.1. Athletics: Running



The White City Stadium, built for the London 1908 Olympics, held 93,000 and was considered a technological marvel. The stadium included a cinder track, a turf track and around the outer edge of the arena, immediately below the seats, a concrete cycle track with contours banked up at the curves to a height of 10 feet. The designers boasted, '60 miles an hour could be attained with perfect safety'. The swimming pool was fourteen feet deep at its centre to accommodate diving displays, it had the novel feature of a 55 foot diving tower.

The distance from the start of the Marathon to the finish at the stadium was established at these games. The original distance of 25 miles was changed to 26 miles so the marathon could start at Windsor Castle, and then changed again at the request of Princess Mary so the start would be beneath the windows of the Royal Nursery.

The 1948 Olympic Games were the first of the postwar era. Britain was still suffering the after effects of the war. Rationing was in operation. Bomb sites remained throughout London and other major cities. Athletes were housed in barracks and schools and were given tickets for the underground to make their own way to the stadium. The athletics track at the Wembley Stadium was covered by cinders collected from the fireplaces of Leicester.

The quality of cinder tracks is affected by weather conditions and use, which impacts on sporting performance. Competitors who used the track at the end of the day would be running on a surface that was rutted and slippery. In the London 1908 Olympics, sport shoes didn't have running spikes, and runners didn't use starting blocks.

An increase in running speed is achieved by an increase in both stride length and frequency. Athletes appear to choose stride lengths at which they are most efficient, that is, at which oxygen uptake is the least intensive. When forced to take either shorter or longer strides but to maintain the same running pace, athletes become less efficient and require an increased oxygen uptake. The celebrated Ethiopian distance runner Haile Gebrselassie is famous for setting world records running in time to the rhythmical pop song "Scatman." He selected this song because the tempo perfectly matched his target stride rate, a very important consideration for a distance runner whose aim is to establish a steady, efficient cadence. Music also provides an ideal accompaniment for training. Scientific inquiry has revealed five key ways in which music can influence preparation and competitive performances: dissociation, arousal regulation, synchronization, acquisition of motor skills, and attainment flow.

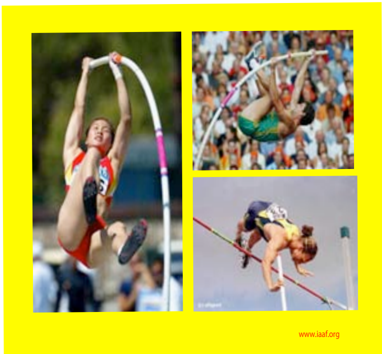
As running speed increases the contact time with the surface is reduced as maximum speed is achieved and this reduces the opportunity to develop greater driving force to improve or maintain forward velocity. Harder surfaces favour sprinters but may disadvantage 10,000m runners because of the potential to cause injury. There are now clear guidelines for track surfaces.

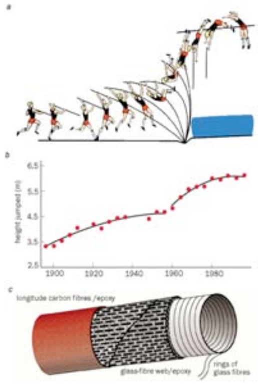
Running with and against the wind can influence time, which is relevant in particular for sprinters. The difference between no wind and 2 m/sec wind assistance can amount to around 0.1 seconds difference. If sprinters were as aerodynamically efficient like a jumbo jet wing, they'd be literally flying at their peak speeds of close to 12 m/s.

The following **factors** have been identified as contributing to the aerodynamic drag experienced by the runner: shoes with exposed laces; hair on limbs; long socks; hair on head; loosely fitting clothing. By reducing aerodynamic drag as little as 2%, equivalent to a haircut, a runner would reduce his or her running time over 100 m by 0.01 seconds and in the standard marathon by 5.7 seconds. Even better results could be achieved by running in a custom-fitted speed suit with a tight-fitting hood to cover their hair and ears. Such a suit made of polyurethane-coated, stretchable nylon reduces aerodynamic drag by smoothing the airflow around the streamlined areas of the chin, ears, and hair, and by eliminating the flapping of loose clothing. Unfortunately, this clothing is impracticable for marathon runners because it's streamlining prevents heat loss. Australian 400m runner Cathy Freeman defied jibes about looking like a space-age running robot by romping home in the 2000 Sydney Olympics wearing the Nike Swift Suit. The suit helps regulate heat and reduce the drag of the runner. Swift technology has been applied to other sports such as speed skating, cycling, rowing and swimming.

Engineering the shoe has focused on the fact that each individual is unique. There are important differences in structure, movement, and gait pattern so footwear needs to vary from person to person. Efforts to meet this concern are further multiplied by the critical factors to be considered in the design of each shoe: shock absorption, flexibility, fit, traction, sole wear, breathability, weight, etc.

1.2 Pole Vaulting





The pole vault for men has been part of Olympics in 1896; for women since 2000. It required high levels of sprinting, jumping and gymnastic ability.

Originally, the purpose of the pole vault was to cross the canals and ditches filled with water in Europe. The horizontal distance and not the height were the main concern.

Until 1960, the vaulters used bamboo poles with a sharp point at the bottom. They competed on grass, planting the point in the grass (because holes were not allowed back then), vaulting over a pole and landing back on the grass. In the 1896 Olympics, the record, set with a bamboo pole, was 10 ft 6 in (about 3.2 m).

From 1960 the vaulters used a fiberglass pole, developed by Herb Jenks as a result of his research on fiberglass fishing rods. Because they were very flexible, they allowed for a new catapult technique to be developed by athletes. In 1991, Sergei Bubka jumped 6.14m using this kind of pole.

International Amateur Athletic Federation rules do not place any restrictions on the length of the pole, the materials from which it is constructed, or the energy storage capacity of the pole, but at the Munich Olympics in 1972, the IAAF confiscated newly introduced into the sport improved fiberglass pole called Cata-pole.

The pole vault may be the most exciting field event. It has been reported that the ratio of serious accidents compared to the number of competitors is higher in pole vault than any other event. The aim of modern pole vaulting it is simply who can go higher.

Until the 1960s, most running surfaces used in track and field were composed of cinder, a coal residue, or clay materials. In wet weather, these surfaces were very difficult to maintain. Plastic and rubberized surfaces began to be developed in the 1960s, and the modern tracks used for most national and international competitions are built from a combination of plastic rubber, principally styrene and polyurethane. These composite tracks are resistant to ultraviolet light radiation damage and maintain both their qualities of traction and compression in poor weather.

Most importantly to the runner, the plastic composite surface provides a much better return of the runner's energy that is delivered with each stride into the track surface. This rebound effect tends to produce greater running efficiency and faster times.

1.3 Slalom Kayaking/Canoeing




While canoes and kayaks are similar crafts, they have significant differences. Kayaks are closed crafts paddled from a sitting position, while canoes are open (except in the slalom events) and are paddled from a kneeling position. The paddles used in the two crafts are also different. Canoe paddlers use a single-bladed paddle while those in kayaks have blades at either end of their paddles.

Flatwater Canoe/Kayak competition was first demonstrated at the Paris 1924 Olympics. It wasn't until 12 years later at the 1936 Berlin Olympics that it became a full, medal Olympic event. With the advent of engineered courses and man-made rivers, the Olympic Canoe/Kayak Slalom events were first introduced and contested at the Munich Olympic Games of 1972. They became part of the Games, 20 years later at the 1992 Barcelona Games as Slalom Canoe/Kayak.

In Athens, the course was built next to a man-made lake to provide water. 80,000 cubic meters of salt water from the Mediterranean filled the lake. The course used 6 concealed pumps, each with a maximum capacity of 18 cubic meters per second. Together, the pumps could supply 5,000 gallons of water per second through the 500m course. An on-site electrical power station provided power to the pumps, enough electricity was provided to supply 3,500 families as well. Climate was a big issue because extreme temperatures would cause constant evaporation in the lake. The use of the salt water had implications for athletes as part of the course were so salty they named the course Margaritaville.

In the 1960s and early 1970s, boats were made of heavy fiberglass and nylon. (Prior to that they were made out of wood.) The boats were high volume and weighed over 65 pounds (30 kilos). In the early 1970s para-aramid synthetic fibre (Kevlar) was used and the boats became lighter as well as the volume of the boats was being reduced almost every year as new designs were made.

A minimum boat weight was introduced to equalize competition when super light materials began to effect race results. Usually boats are made with carbon fibre, Kevlar, and fibreglass cloth, using epoxy or polyester resin to hold the layers together. Foam sandwich construction in between layers of carbon, Kevlar, or Aramid is another technique in use to increase the stiffness of slalom boats.

Recently, the minimum length of these boats was reduced from 4 meters down to 3.5 meters, causing a flurry of new, faster boat designs which are able to navigate courses with more speed and precision. The shorter length also allows for easier navigation and less boat damage in the smaller man-made riverbeds that are prevalent in current elite competitions.

Olympic years tend to generate boat designs with specific performance characteristics tuned for the upcoming Olympic course. In white-water slalom events, the canoe must pass through several gates, including some reverse gates that have to be passed while paddling backward. Penalty time is given for hitting one pole, both poles, or for missing a gate entirely. This penalty time is then added to the canoeist's time to determine the order of finish.

1.4 Cycling





Aerodynamic drag is a significant factor in both road and track racing. **On a flat road, aerodynamic drag is by far the greatest barrier to a cyclist's speed, accounting for 70 to 90 percent of the resistance felt when pedaling.** The only greater obstacle is climbing up a hill: the effort needed to pedal a bike uphill against the force of gravity far outweighs the effect of wind resistance.

Frame builders and designers have been working on creating more aerodynamically efficient designs. Some recent designs have concentrated on **shifting from round tubes to oval or tear-shaped tubes**. There is a delicate balancing act between **maintaining a good strength-to-weight ratio while improving aerodynamic efficiency**. **Improvements to wheels have made perhaps the biggest impact**. A standard **spoke wheel has been described as an "egg beater**," creating many small eddies as the tire rotates--creating drag. **Disc wheels, while generally heavier** than their spoke counterparts, **produce less wind drag and turbulence when they spin**.

Frames are often one-piece molded carbon fiber affairs, which allows a lightweight, and aerodynamically "slippery" design. More traditional bikes might employ airfoil cross sectional shapes in the frame tubes and ever-greater attention is being paid to aerodynamics in component group design.

Given the importance of aerodynamics, the **riders' sitting position** comes very much into play. Handlebars on track bikes used for longer events such as the points race are similar to the drop bars found on road bicycles. The riding position is also similar to the road racing position. In the sprint event the rider's position is more extreme compared with a road rider. The bars are lower and the saddle is higher and more forward. **Bars are often narrower with a deeper drop. Steel bars, as opposed to lighter alloys or carbon fiber, are still used by many sprinters for their higher rigidity and durability**.

In timed events such as the pursuit and the kilo, riders often use **aerobars** or 'triathlon bars' similar to those found on road time trial bicycles, **allowing the rider to position the arms closer together in front of the body**. This results in a more horizontal back and presents the minimum frontal area to reduce drag. Aerobars can be separate bars that are attached to time trial or bull-horn bars, or they can be part of a one-piece monocoque design. Use of aerobars is permitted only in pursuit and time trial events.

Formats of track cycle races are also heavily influenced by aerodynamics. If one rider closely follows, they draft or slipstream another, because the leading rider pushes air around themselves; any rider closely following has to push out less air than the lead rider and thus can travel at the same speed while expending less effort. This fact has led to a variety of racing styles that allow clever riders or teams to exploit this tactical advantage, as well as formats that simply test strength, speed and endurance.

During the early 1990s in individual pursuit events, some riders, most notably Graeme Obree, adopted **a straight-armed *Superman*-like position** with their arms fully extended horizontally, but this position was subsequently outlawed by the Union Cycliste Internationale, the sport's ruling body. Recumbent bicycles in which the rider is placed in laid-back reclining position, can actually be ridden faster, but are banned from UCI competition.

1.5 Swimming






Materials used in swimming suits and record breaking

Wool → silk → rayon → nylon → Lycra (1972) → Compression (1996) → Polyurethane (2008)

Lycra (1972): body suits — *53 records*

Compression (1996): body suits

Polyurethane (2008): drag reducing panels — *66 records*

Swimming has been an Olympic event since the first modern Olympics in 1896. There are 16 different swimming events in the Olympics using four different strokes. Men and women do not compete against each other, though they do perform the same strokes and distances, with a few exceptions.

The London 1948 Olympics was the first time when a **purpose built swimming pool** was used. Early Olympic swimmers wore tank-top outfits that resemble today's full-body suits but were not nearly as sleek and aerodynamic. Male swimmers then began to go shirtless when they discovered that **shaved skin allowed them to encounter less resistance in the water**. However, the first dramatic swimsuit transformation came in 1974, when **tight-fitting Lycra suits** were introduced. The same year, female swimmers began to sport suits without skirts in competition. As records began to fall, swimsuit design continued to progress. At the 1996 Olympics Games in Atlanta, Speedo put out its **"Aquablade" suit, which reduced resistance while covering more of both male and female swimmers' bodies.** Seventy-seven percent of the medal winners in Atlanta wore the Aquablade. Speedo then bettered itself by introducing **the Fastskin, which covered even more of a swimmer's body**. In 2000, USA Swimming approved the use of full-body suits in races. In 1999 and 2000, Speedo's full-body, **sharkskin-like suits** caused a stir in the pool as leading coaches warned that it was making it too easy for swimmers to shatter world records.

In Beijing, "Italy's 100m freestyle champion Filippo Magnini incurred a fine and the wrath of his sponsor, Arena, when he broke his contract to switch to Speedo shortly before the Olympics…However, upon closer scrutiny, startling evidence emerge from the Olympic pools — evidence that shows that the total dominance claimed by Speedo's bodysuit, might well have been a superb marketing effort. After all the sponsorship controversy, Magnini did not even reach the 100m freestyle finals in Beijing. He came twelfth. German star, Britta Steffen, who stuck by the team's adidas sponsor, set three Olympic records and won two gold medals. Seven swimmers broke fifteen individual Olympic and world records wearing the Speedo LZR racer full body suit. But four male swimmers, breaking twelve individual Olympic and world records, only wore Speedo pants, not the full body suit. Seven swimmers broke thirteen individual world and Olympic records in the Beijing pool, wearing other brands. The records set by Alexander Dale Oen (Arena half suit), César Cielo Filho (Arena full-suit), Milorad Cavic (Arena full-suit), Aaron Peirsol (Nike half suit), Zige Liu (Nike full suit), Federica Pellegrini (Adidas Techfit Powerweb swimsuit) and Britta Steffen (adidas Techfit Powerweb bodysuit) questioned the supposed total superiority of the Speedo LZR full body suit in the pool."

Experts say that, "the claim of superiority of one suit over another cannot be measured, "because we never got to see the performances of swimmers like Phelps or Adlington in anything but Speedo. There is a problem with simply concluding that Speedo was the superior costume. It seemed to add something to performances, but whether it was better than other suits is a debatable one."

The supposed added advantaged that is provided by a full body suit, is less evident over longer distances and in certain disciplines like breaststroke and butterfly…. "Breaststroke is the obvious example - it's just a slow stroke, which means the suit would be least effective for it," experts add. "Also, consider that in breaststroke, the range of movement around the joints (shoulders, elbows and knees) is the greatest, and perhaps a number of swimmers decided that the full-suit would restrict this movement. "That's why you'll find that most of the top swimmers wear an "above-the-knee" short suit for breaststroke. "In the case of butterfly…the choice of only the pants is because the upper body comes out of the water quite a lot, and because the range of movement required from the arms makes the suit restrictive. "For backstroke, the tumble-turn and the slower speeds might be the reason that some swimmers went only with the pants. "So the stroke affects the speed, and also the mechanics of the swimming stroke…that those two factors combine to determine whether a swimmer would wear the full suit".

There are also other factors - the **Beijing pool was deeper than ever**, **the side areas were designed specially to reduce wash**, and so the pool was also faster. That contributes to performances as well. So we can't say that the spate of records was due to the Speedo. It could also have been the pool, with other costumes providing at least a similar effect."

Omega tried to introduce a **revolutionary swimming starting block** at the Beijing Olympics that was said to improve times by up to one-tenth of a second. This became the center of international debate in the lead-up to the Beijing Olympics. Officials feared that some swimmers will be disadvantaged if the new block featuring an angled piece at the rear of the platform that resembles a track starting block were to be accepted because Omega didn't offer sufficient number of the blocks to all teams to practice on.

1.6 Archery

TRS Hand Prosthesis

The target stands at 70m and the object is to hit the yellow bullseye, which is about the size of a CD, for which you get 10 points.

This difficult task is made easier by the significant use of technology in the Olympic bow. Olympic archers use the recurve bow, which is so called because the top and the bottom of 'the limbs' curl back away from the archer, which helps to increase the bowstring tension and increase power.. The bows have sights and stabilisers to reduce torque (twisting) in the arrows upon release, and are usually made of carbon fibre or fibre-glass. Bows generally are constructed of wood, fiberglass and graphite or carbon composites. Bows have sights to aid in aiming and arrow rests to help align the shot.

The bowstring is synthetic and strung to a maximum of about 50lb pressure (if you're a real toughie). When an arrow leaves the bow, its initial velocity can be as high as 240ft per second, or about 160 mph..

Most strings are made of Fast Flight, a hydrocarbon product, or Kevlar, the material used to make bulletproof vests. Arrows are made of aluminum or carbon graphite.

Archery first appeared in the Olympic Games in 1900 and was contested again in 1904, 1908, and 1920. Women competed in the 1904 Olympics, making archery one of the first sports competitions to include women. Archery was re-introduced to the Olympic program in 1972 with individual events for men and for women.

Paralympic Archery was originally developed as a means of rehabilitation and recreation for people with a physical disability. It was part of the programme for the 1948 Stoke Mandeville Games (the first paralympic games). Paralympics Archery received international fame as a paralympic sport when at the 1992 Barcelona Games, Paralympian Antonio Rebollo lit the Olympic and Paralympic flames with an arrow.

1.7 Fencing

Modern fencing is a sport with rapid, subtle movements and fast actions. Often the action in an engagement is over within seconds. **Perhaps the most striking feature of Paralympic fencing events is that all athletes are competing in wheelchairs fastened to the floor.** But fencers still have the freedom to execute rapidly alternating movements as they aim to land hits on each other. Developed in 1953, the sport made its Paralympic debut seven years later.

Fencing includes individual and team events in: **foil** (only the tip of the sword is used to score points, with torso as the target); **épée** (also only the tip of the sword is used but the entire body is the target); and **sabre** (can use edges of the sword, target area is above the waist, including arms and head) .Competitors were protective clothing designed to keep them safe.

Electronic scoring of touches started in the Berlin Olympics in 1936 . For electric scoring, a foil fencer must have a metallic vest (**lamè**), an **electric foil** and a **body cord**. The lamè is worn over his jacket and covers the target area. An electric foil has a button on the end with three wires running down the blade to a connector behind the **bell guard** -- the round, silver part of the foil that protects the hand. The body cord connects the foil and lamè to the reel. Also, the piste strip is covered with a metal grid.
The scoring equipment includes a retractable cord that runs from the tip of a sword to a reel at each end of the piste. Although the cord is designed to reel-out and reel-in as the fencers advance and retreat down the strip, it does present some restriction to a fencer's movement. The electrical circuit set-ups for foil, epee and sabre are the same. The body cord of the fencer attaches to a lightweight, transmitter-receiver pack, which is worn on the back at the waist. This pack is about the size of a cigarette pack and is much like those packs worn for portable microphones. The pack transmits radio signals to the electric scoring box with the lights. In addition to the wire system, a lightweight, clear, plastic (Lexan) mask with lights inside is also being tested for foil and epee. **When a fencer is touched, lights light up inside his helmet as well as on the scoring box.**

To make the fencer totally unencumbered, **a reel-less, electrical system** has been developed and was tested in the 2004 Athens Olympics.

1.8 Basketball






Basketball was invented in 1891. It is a team sport in which two teams of five active players each try to score points against one another by placing a ball through a 10 foot (3.048 m) high hoop (the *goal*) under organized rules. Basketball is one of the most popular and widely viewed sports in the world. Through time, basketball has developed to involve common techniques of shooting, passing and dribbling, as well as players' positions, and offensive and defensive structures. Typically, the tallest members of a team will play *center* or one of two *forward* positions, while shorter players or those who possess the best ball handling skills and speed, play the *guard* positions.

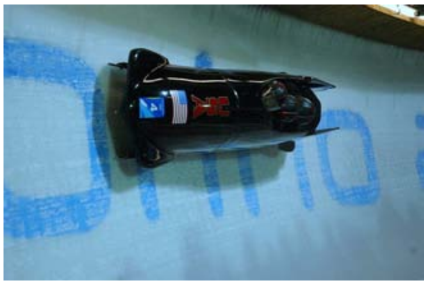
Basketball first found a place in the Olympic Games in 1936 in Berlin. That year, the tournament was held outdoors on **revamped tennis stadium, with a sand and clay surface**. Unfortunately, **the final was played underneath a heavy rain**, which turned the court into a quagmire and markedly limited scoring. Since that modest start, however, the game has remained a very popular addition to the Olympic lineup, and has continue to grow.

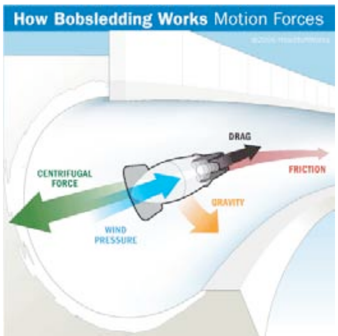
Flooring systems are engineered to provide athletes with a safe, top performing basketball surface, and to **reduce stress and injury to a player's joints and limbs**. The flooring is also engineered to **improve ball response** . Flooring can be fully suspended and provide a cushioned surface **developed for player safety and injury prevention**. **Superior traction** for player performance and confidence during aggressive play is also accommodated into the design.

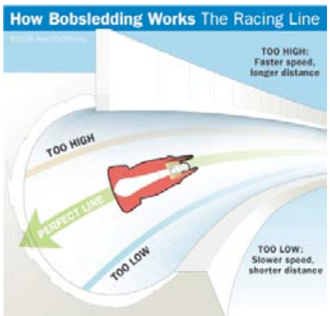
In Paralympic sports, the **wheelchair is considered to be part of the body**. Unlike standard wheelchairs, those used in sport have rigid adjustable structures that do not fold, thus increasing their strength and solidity. Their unique camber offers greater stability when turning sharply, and reduces injuries from falling or tipping. **Sports wheelchairs are made of composite, lightweight materials that are stronger and more versatile.** Their **lighter weight saves athletes from having to spend more energy to move around in them, reducing shoulder and wrist injuries and also making the chairs easier to transport**.

1.9 Tobogganing









Tobogganing refers to a variety of activities involving sliding down steep ice-covered track of banked turns and straightways using a sled. The tree main types of toboggans used in competitions are skelton (competitors lie head first, face down, with hands back on the skelton); luge (competitors lie on their backs); and bobsled. Luge and bobsled are two of the most exciting Winter Olympic sports.

Skeltons measure 3 feet in length and 16 inches wide, and weigh 70-100 pounds, depending on the slider's body weight. They are **made of fiberglass and steel**. Competitors wear **skin-tight Lycra-polyester suit for better aerodynamics**, and special **spiked boots** which are used to gain momentum out of a running start. They are also used to steer the sled.

A luge has two runners, connected through a fiberglass bridge, with two steel blades, and a "sling" seat. Competitors spend hours **polishing their blades with different wax compounds to reduce friction between the sled and the track**. Competitors steer their sled by applying pressure with their legs on the curved part of the end of the runners and by pressing their shoulders on one side of the sled ot the other.

Four-man bobsled become a medal sport at the 1924 Winter Olympics, and the two-men was added to the programme in 1932. A four-men bobsled team consists of two pushers, a breakman and a pilot who steers the sled. The weight of a bobsled team (including the sled) is limited to 390 kg for two-men and 630kg for four-men. A four-men bobsled team consists of two pushers, a breakman, and a pilot, who steers the sled; on a two-men teams, both members must push in addition to either breaking or steering. Sport physiologists found that the **art of pushing the sled at out of the start and "loading it"** was extremely important. In general, a 0.1 sec lead following the 50m spent/push at the start translates to 0.3sec advantage at the finish. Top speeds reach 80 miles per hour. Most medals are determined by hundredths of a second.

Acceleration due to gravity is the same for all of the bobsleds in the race -- it's the physical constant of 9.8 meters per second squared. **Drag, friction, and momentum**, on the other hand, all vary based on bobsled design and can affect how much the bob actually accelerates. The strongest, fastest, most skilled team in the world cannot compensate for a bob design that ignores these factors.

Modern tracks are made of concrete and artificial ice. The development of **artificially refrigerated tracks** in the late 1960s and early 1970s would greatly enhance speeds. Tracks are required to have at least one straight and one labyrinth. Ideally, a modern track should be 1200 to 1300 metres long and have at least fifteen curves. Speeds may exceed 130 km/h, and some curves can subject the crews to gravitational forces of as much as 5 *g*

1.10 Volleyball

Volleyball was invented in 1895. The name comes from the act of ball being volleyed over the net. From the outset, volleyball was a game unafraid to change. A specially designed ball was introduced in 1900. In 1920, the rule mandating three hits per side and a back-row attacks were instituted. Volleyball made its Olympic Games debut in Tokyo in 1964, with the Soviet Union winning the men's gold medal and the Japanese women being crowned as champions in front of their home crowd. Since then, volleyball has continued to witness the rise and fall of great international teams, with countries as diverse as Cuba, Brazil, the Soviet Union, China, the United States, the Netherlands, Poland and Japan collecting gold medals.

The sport **requires determination, cooperation and good strategy** from the participants. While **power and height** have become vital components of international teams, the ability of teams and coaches to devise new **tactics, strategies** and skills have been crucial for success at the Olympic Games.

Beech volleyball made its Olympic debut in 1996 at the Atlanta games.

Since the 1996 Olympics the volleyball championships include twelve men's and twelve women's teams representing twelve participant nations. The host country teams (one men's and one women's) is automatically entered into the tournament. The second spot is reserved for a randomly chosen “wild-card" country. All other teams have to qualify based on their performance. The qualification process takes about 18 months. Each of the five continental volleyball confederations has at least one affiliated national federation involved in the games. If one of the continents is not represented, the highest ranked team from that continent qualifies for the tournament.

Volleyball for disabled athletes entered the Paralympic Games as a "demonstration" sport for amputees in 1976 in Toronto Canada. In **sitting volleyball**, the net is about 3 feet high, and the court is 10 x 6 meters with a 2-meter attack line. Players are allowed to block serves, but one “cheek” must be in contact with the floor whenever they make contact with the ball. In standing volleyball, a mix of disabilities must be represented on the court at all time to equalize the level of play. Athletes with the following disabilities can compete in sitting or standing volleyball: Amputees, spinal cord injuries, cerebral palsy, brain injuries and stroke.

The ball used at the 2008 Beijing Olympics was the result of **advanced aerodynamic engineering**, which offered **better stability and ball control** than any other indoor ball.

Tests conducted by Mikasa Corporation in close cooperation with leading Volleyball National Teams throughout the world, resulted in the following key features of the new MVA balls:

- Balls fly **more stable** due dimple surface and reduced panels
- Increased **grip** due to new dimple technology cover material
- Increased **visibility** of the ball due to new panel-shape/design
- Reduced **rebound** of the new ball = increased controllability
- Reduced **impact**-power = increased softness of the new ball.

2. Examples of different 'innovation rules' applied to improve sporting equipment for better performance

2.1 Taking-out: separate an interfering part or property from an object

Example: Mikasa Indoor volleyball

The ball is made of 8, instead of the usual 18, microfiber panels, with the seams glued together, rather than being glued to the ball's "carcass". This improves players' control as more of the hand touches the ball's surface, which is smoother and rounder without any crater like seams.

2.2. Dynamics: find optimal operating conditions and change characteristics of an object

Example: Aqua V Swim Cap

The cap is designed to reduce a swimmer's drag in the water by 5%. The cap sits low on the areas of the ears and fits around the based of the neck for a streamlined shape, which prevent the force of the water from creating wrinkles, and also reduce drag, saving precious milliseconds.

2.3 Local quality: change an object's structure, or make each part more suitable its purpose, or perform a different and useful function

Example: Sidewinder Mirrored Goggle

The Sidewinder does not have the eye-socket cushioning typical of other goggles to create a leaner look that also reduces a swimmer's drag in the water. It comes with five interchangeable nose pieces, so swimmers can choose the most comfortable, leak-free fit.

2.4 Anti-weight: to compensate for the weight of an object, merger it with other objects to provide lift, or use aerodynamics or other forces to make it interact with the environment better.

Example: BT Blade Bike

BT Blade weight just 6.8kg. It is made from the best carbon-fibre. The grades and fibre orientation for each individual element has been selected an tested to create maximum aerodynamic efficiency. The bicycle was tested in wind tunnels to develop optimal aerodynamic shape.

2.5 Mechanics substitution: replace a mechanical means with a sensory (optical, acoustic, taste, smell) means; or use electric, magnetic and electromagnetic fields to interact with the object.

Example: Change Vision 2000 Fencing Mask

The Change Vision 2000 Fencing Mask has scratch-resistant, polycarbonate plastic visor, which is coated with an anti-fog compound that was originally developed for jet pilots. The helmet was designed using contour-fit technology to fit tighter and feel lighter

2.6 Local quality: Make each part of an object function in conditions most suitable for its operation

Example: Aero Time-Trial Bikes

Graeme Obree devised a new "Superman" position, which reduced rider's frontal area by keeping his arms extended straight in front of him. In 1996, a British rider, Chris Boardman, set the World Hour mark of 35 miles, using the Superman position. The UCI banned this position too, and set aside Boardman's now-untouchable mark, opening record attempts to riders on more conventional bikes.

2.7 Merging: bring closer together (or merge) similar objects

Example: Nike Swift Suit

Track and field athletes are renowned for doing just about anything to get a little more from their performance. Australian 400m runner Cathy Freeman defied jibes about looking like a space-age running robot by romping home in the 2000 Sydney Olympics wearing the Nike Swift Suit. The suit helps regulate heat and reduce the drag of the runner. Having done the business on the biggest stage, it was not long before the Swift technology was applied to other sports such as speed skating, cycling, rowing and swimming.

2.8 Composite materials: change from uniform to composite materials

Example: Nike Hyperdunk basketball shoe

The Hyperdunk demonstrates Nike's "Flywire" technology, which creates the shoe's upper by weaving together super-light, liquid-crystal threads. Previously, multiple layers of fabric were stitched together to create a dense support system, but this system targets the areas of the foot that need the most support, and a thin layer of fabric is reinforced with the liquid-crystal threads in exactly that space. The result is a light, breathable, supportive shoe.

2.9 **Self-service** – make an object perform auxiliary helpful function

Example: Speedo LZR

The LZR is super-tight, made of a water-repellent fabric, and ultrasonically welded to remove any outside seams. But whether you think wearing one makes a swimmer a cheater or a resource-user, the suit does seem to improve times: More than 38 world records have fallen to athletes wearing the suit.

2.10 **Segmentation** – divide the object into independent parts

Example: Adidas TechFit PowerWeb Swimsuit

What makes this suit "unique" are the Thermoplastic Urethane (TPU) "powerbands" which are placed at strategic positions on the suit, which compress the muscle beneath them to improve blood flow and helping propel the swimmer from the blocks and off the wall at turns. Adidas says its suit can give swimmers 3.6% more power off their turns. The suit reduces the amount of energy a swimmer needs to expend to move through the water.

2.11 **Parameter change** – change an object's physical characteristics

The Beijing Aquatic Centre: Water Cube

Many people believe Water Cube to be the fastest Olympic pool in the world. It is 1 meter deeper than most Olympic pools. Up to a certain limit, beyond which swimmers will lose their sense of vision, deeper pools allow the waves to dissipate down to the bottom, leading to less water disturbance to the swimmers. The pool also has perforated gutters on both sides to absorb the waves.

2.12 **Composite materials** – change from uniform to composite (multiple) materials

The Beijing Mondo Running Track

The Beijing Olympics provided the fastest running track surface in the history of Olympics. Designed by Mondo Spa the natural rubber surface was bonded onto asphalt to make the fastest track. Several research studies concluded that the running surface made of asphalt and stone base, polyurethane surface, and a butyl rubber layer gives the best results. Finally, the track surface is finished with fixed ethylene propylene diene monomer particles for higher gripping.

Example: Ossur Cheetah prosthetic blades

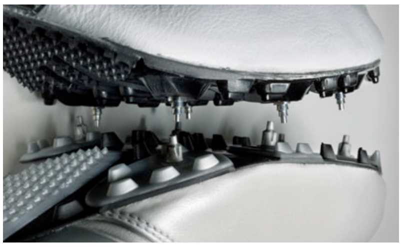
Cheetah blades are purpose-built, starting as rolls of resin-impregnated carbon fiber (this cuts down on air bubles), stored in a freezer. The rolls are cut into square sheets and pressed onto the outside of a steel mold milled in the shape of the legs' final profile. Depending on the size of the athlete the blades are being made for, anywhere from 30 to 90 carbon-fiber sheets are layered one on top of another. Then the whole thing is swung into an autoclave that melts and fuses the resin and sheets into a solid, contoured carbon-fiber plate. Once the compound cools, a robotic arm with a high-pressure water jet on the end carves the now-curved sheet into several Cheetah legs.

3.2.13 **Asymmetry**: change the shape of the object from symmetrical to asymmetrical

Example: Sport Wheelchair

In Paralympic sports, the wheelchair is considered to be part of the body. Unlike standard wheelchairs, those used in sport have rigid adjustable structures that do not fold, thus increasing their strength and solidity. Their unique camber offers greater stability when turning sharply, and reduces injuries from falling or tipping. Sports wheelchairs are made of composite, lightweight materials that are stronger and more versatile. Their lighter weight saves athletes from having to spend more energy to move around in them, reducing shoulder and wrist injuries and also making the chairs easier to transport.

Example: Adidas Lone Star shoe



After studying running pattern in the Adidas labs of the runner, Jeremy Wariner, through high-speed video and pressure mapping, Adidas worked with him to create something entirely new in long-sprint running. The Adidas team of advanced engineers, designers and biomechanists were able to see how differently Wariner uses each foot as he runs. As a result of these differences, they developed the first-ever asymmetrical spikes to cater to the specific needs and the role of each foot, and to build on the fact that long-sprint races are won in the curves. The tapered grooves of the progressive-compression spike provide the best penetration/compression ratio, thus optimizing the spring-like elastic property of the track surface.

3. Paralympics and Ethics of Sport

Oscar Pistorius, double-amputee, competed in Beijing using a pair of J-shaped Cheetah Flex-Foot transibial carbon-fibre running blades designed by Icelandic company Ossur "to **store and release energy in order to mimic the reaction of the anatomical foot/anke joint of able-bodied runners**".

Vanna Kim, a 40-year –old Cambodian, who in 19089, had the misfortune to do what more than 40,000 of his countrymen have done since the Khmer Rouge were ousted 29 years ago. He stepped on a landmine and had his right left torn off below the knee. (Cambodia has the highest percentage of disabled people in the world).

Unlike Oscar Pistorius, Vanna Kim competed wearing a **rudimentary running blade that had been donated to him by the South Korean government** because he was too poor to pay for one himself. Kim was only able to make the trip because 60% of his air fare from Cambodia was paid for by the Beijing organizers, with the rest being raised through private donations in his homeland.

The limping running gate of Vanna Kim's blade enabled performance made him last in the race with the time of 13.45 sec, compared top 11.6 sec of Oscar Pistorius's.

