SPORTS ENGINEERING

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The historical nature of sports engineering is considered and an attempt for the recent popularity of sports engineering is given. The development of sports engineering in the 1990's is described and the interaction of technology and sport assessed with the conclusion that technology causes step jumps in performance while coaching, nutrition and training produces for larger increases in performance. The global sports engineering community is described and the size assessed as approximately 1000 researchers. Finally, a warning is given on the dangers of the misuse of technology in sport.

KEYWORDS: Sports engineering, technology, economics of sport.

INTRODUCTION: Sports engineering is a new area of study that has existed for many years. This contradictory comment is explained if it considered that the mechanics of tennis was discussed by Sir Isaac Newton over three hundred years ago (Newton, 1671) and by Lord Rayleigh over a hundred years ago (Rayleigh, 1877). Indeed, many of the world's great scientists have used sport to explain science and vice versa. Sir JJ Thomson (discoverer of the electron) gave a treatise on the dynamics of golf balls to the Royal Society earlier this century (Thomson, 1910). It is only recently, however, that the term 'Sports Engineering' has been used. The Oxford English Dictionary gives the following definitions,

sport n	Pastime, game, outdoor pastime
engineering n	Application of science for the control and use of power, esp. by means of machines.

The term 'sports engineering', therefore, implies the design, development and research into external devices used by athletes, sports men and sports women to enhance their performance. Sports engineering is sometimes confused with sports science which does involve sports engineering but is more concerned with the analysis of the athlete than the equipment. Obviously, there is overlap between Sports Engineering and Sports Science (Figure 1). The best Sports Engineering research applies sound engineering principles to equipment and uses Sports Science expertise to assess the improved performance of both the athlete and the equipment.

THE REASONS FOR THE RISE OF SPORTS ENGINEERING: As stated earlier 'sports engineering' has existed for a long time. It is only recently that the phrase has been defined. The reason for this might be due to the large personal financial rewards associated with sport. This relationship has also existed down the ages. However; sixteenth century games of tennis were usually played for substantial wagers making the 'out' call extremely important (Morgan, 1989) and so in some games of Real Tennis in the 1500's, a wire running through eyes was used as the dead ball line such that when it was struck by a ball it gave out a distinctive noise.

It is more likely that the reason for the rise in Sports Engineering is the increased participation in sport and the financial gain to be made by equipment manufacturers. Some estimates put the global sports equipment market at $80 billion (SGMA, 1997). Individual companies such as Mizuno, Nike, Callaway and Decathlon easily have sales in excess of $1 Billion. The Sporting Goods Manufacturers Association (SGMA, 1997) estimates that adult sports participants spend approximately $700 per year on sports equipment (Figure 2).

In the UK, participation in sport has increased from 39% in 1977 to 64% in 1996 (defined as % of adult population participating in four weeks previous to survey; Taylor, 1998). Activities that have made the biggest gains are walking, swimming, keep fit and cycling. Total spending on sport in the UK comes to I 0.4 billion pounds with equipment at 896 million

pounds, clothing at 1448 million and footwear at 938 million. Interestingly, more than all the sports products expenditure put together (3,174 million) is spent on gambling! This still means, however, that UK citizens participating in sport spent on average over 200 pounds per year each on sports products.
Figure 3 shows the number of participants in the Olympic Games from 1896 to 1992 (Chronicle of the Olympics, 1996). Apart from world wars and other disputes, participation at the modem Olympics has seen a continual rise since its inception in 1896. This indicates a significant financial incentive for manufacturers of sports products.

THE RELATIONSHIP BETWEEN SPORTS ENGINEERING AND PERFORMANCE: Figure 4 shows the gold medal winning times in the 100 m sprint at the Olympics since 1896. The gold medalist of 1996 (Donovan Bailey of the USA) would have beaten the winner in 1896 (Thomas Burke of the USA) by approximately 20 m. The times for this event have seen a gradual improvement and it is likely that this is mostly due to improvements in training, coaching and nutrition.
The pole vault gives a good example of how technology and sport interact. (Wegst and Ashby, 1996; Froes et al. 1998). The winning heights for the pole vault at the Olympics is shown in Figure 5. As with the 100 m sprint, performance has shown a gradual improvement over the last 100 years. The requirements, for the material of a vaulting pole is that it should have a low density, high stiffness, have large strain before plastic deformation and be resistant to twisting.
In 1896 poles were made of solid hickory wood. An advantage of about 200 mm in height was gained in 1904 through the use of bamboo poles which are lighter for the same stiffness than the solid wooden poles. Figure 5 shows that the gains were made continually over the next 50 years until they started to reduce in the 1950's. A brief use of aluminium poles produced little change until a significant change was seen in 1964. A gain of about 250 mm was caused by the introduction of glass fibre composites which were lighter and of lower stiffness. This allowed the athlete to change style and perform the complex manoeuvre of rotating upside down to go over the bar feet first. Figure 5 shows the gains starting to level off with slight improvements through the introduction of carbon fibre reinforcement in the 1980's. Since these are starting to disappear, history dictates that a new design is not far around the corner!
Although technology can change performance in terms of step changes, Figure 5 indicates that larger gains are achieved from the coaching and training in the use of the new technology.

DEVELOPMENTS IN SPORTS ENGINEERING: The phrase 'sports engineering' was probably first coined in the 1990's with the initiation of a series of conferences in Japan. (JSME, 1990) The I st and 2nd International Conferences on the Engineering of Sport were held in Sheffield, UK in 1996 and 1998 respectively. The 3rd conference will be held in Sydney in 2000 and the 4th in Japan in 2002. A fledgling association has arisen from the conferences - the International Sports Engineering Association (iSEA). One of the aims of the ISEA is to co-ordinate sports engineering research and to act as a global discussion forum. The ISEA also promotes a new journal 'Sports Engineering' published by Blackwell Science in the UK.
In the UK, sports engineering is seen as being an important economic regenerator and the Department of Trade and Industry and the European Regional Development Fund is funding initiatives in this area worth around 500,000 pounds. The UK government has also recently funded the UK Sports Institute, based in Sheffield, and set up along the same lines as the Australian Sports Institute.
Sports engineering - type research is ongoing in countries around the world. Figure 6 shows the country of origin of papers and their proportion of the total presented at the Ist and 2nd International Conferences on the Engineering of Sport (Haake. 1996; Haake, 1998). It can be seen that the UK, Japan, USA and France are by far the largest contributors. The UK proportion is over emphasised due to the good networking of the sports engineering

community in that country. Figure 7 shows approximate GDP for the countries in Figure 6. If sports engineering is related to sports product manufacture and this is related to overall performance of the country then it can be seen that the UK is over-represented in sports engineering activity in Figure 6. Conversely, the USA is under-represented. Significantly Germany has not been represented at sports engineering conferences so far. If activity in the UK is taken as the norm then this kind of analysis indicates that the research active sports engineering global community might be at least 1000 strong.
Conferences in Japan and the USA will expand the International Sports Engineering Association to levels similar to the societies in the biomechanics communities.

THE PROS AND CONS OF SPORTS ENGINEERING: Sports Engineering has the ability to help athletes and sports men and women improve performance. The rules of sport exist, however, to protect the integrity of sport. Technology can be dangerous if the implications are not considered and often ruling bodies find it difficult if not impossible to reverse decisions (Gelberg. 1998). Sometimes technology goes too far and changes the sport so much that legitimate sporting comparisons become impossible. Sports Engineers have the ability both to enhance and destroy sport and care must be taken that they do not do the latter. In some ways sports engineering is the new cold war - it only works if everybody has it.

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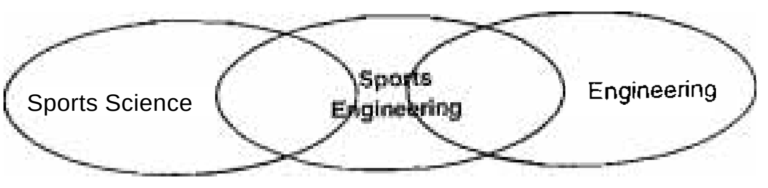

Figure I - The relationship between Sports Engineering and Sports Science.

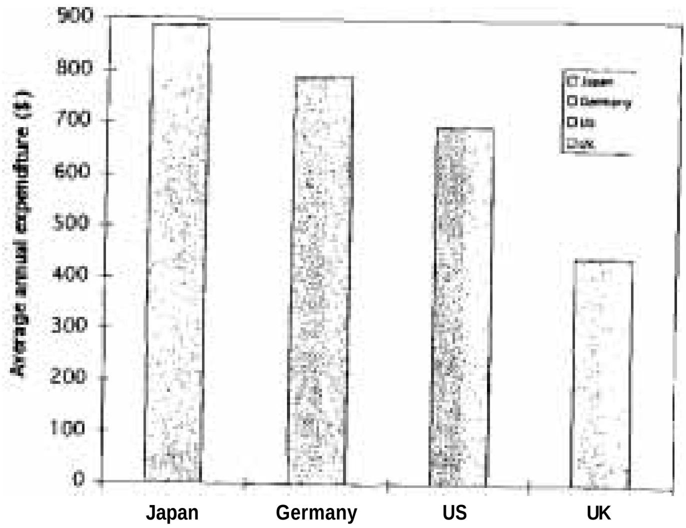

Figure 2 - Average annual expenditure for adult sports participants (SGMA, 1997).

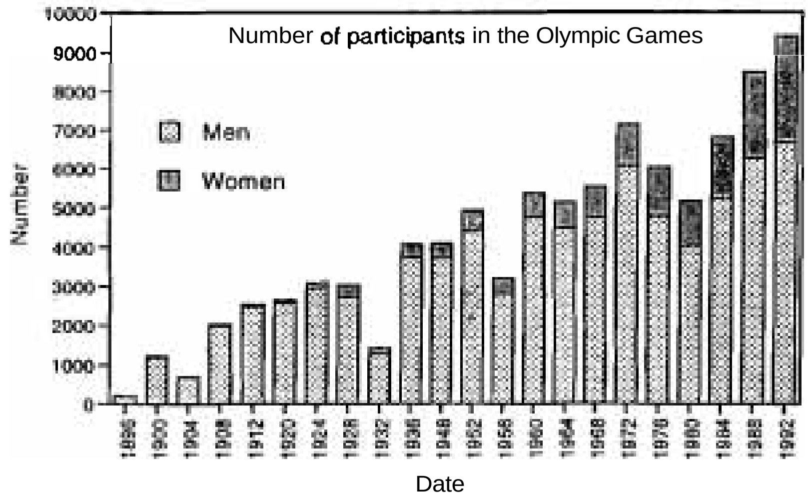

Figure 3 - The number of participants in the Olympic games since 1896.

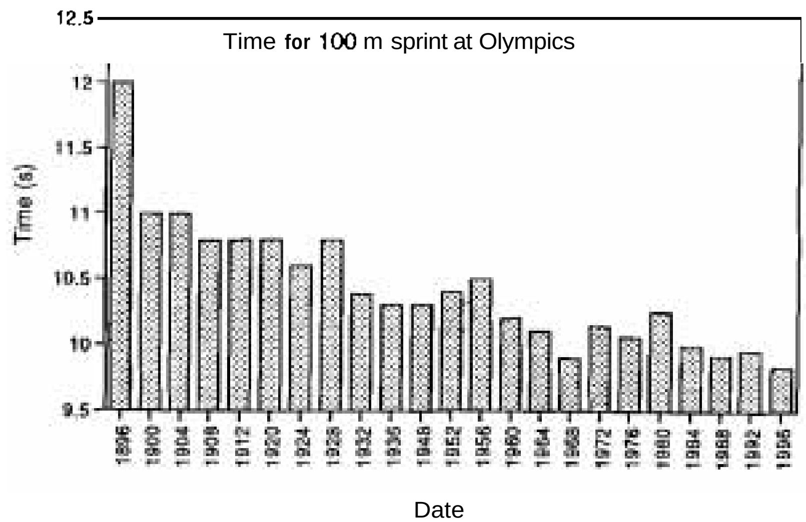

Figure 4 - Gold medal winning times in the 100 m sprint at the Olympic games since 1896.

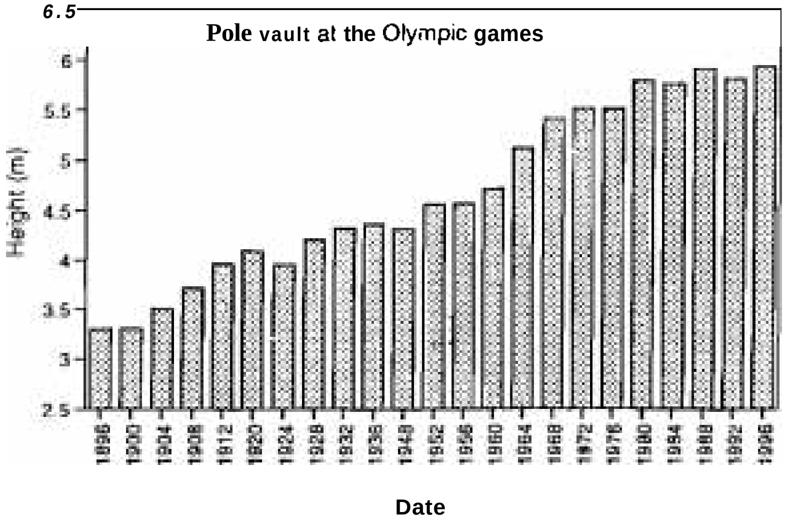

Figure 5 - Gold medal winning heights in the pole vault at the Olympic games since 1896.

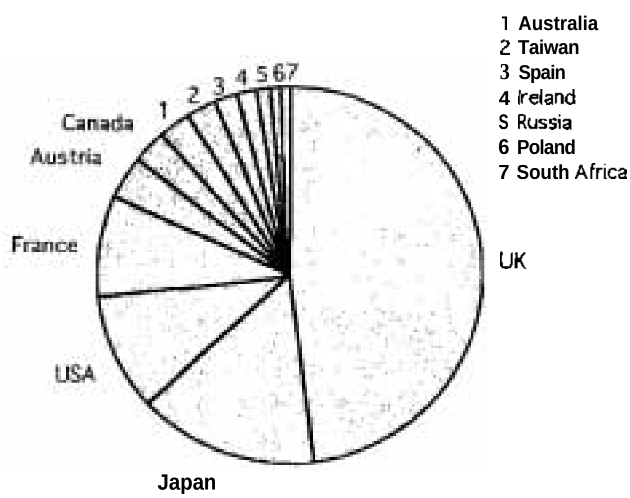

Figure 6 - Country of origin of participants at the Engineering of Sport conferences since 1996.

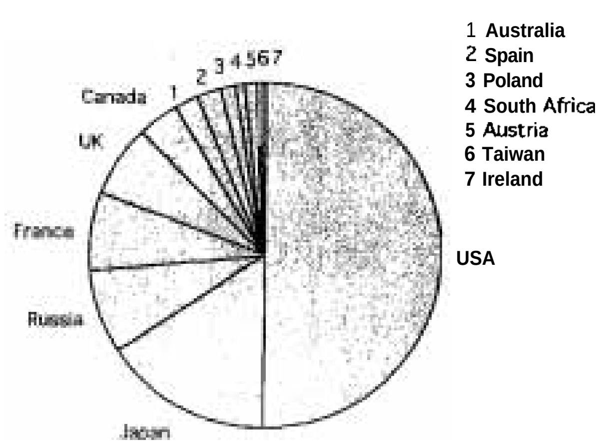

Figure 7 - Approximate GDP of countries present at the Engineering of Sport conferences.