

# The Social Impact of Cycling as a Technology-Based Sport

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Ross D. Petty

CYCLING—THE SPORT OF THE CENTURY—mechanization which, together with the marvelous nature of man, triumphs over time and space.

*La Gazzetta dello Sport* cited in Perry (1995, p. 381)<sup>21</sup>

## Introduction

Sport is nothing more than physical activity engaged in for enjoyment. It allows us to test our skills and abilities against others to see what we are capable of achieving and learn what our limitations are. It is often an area of endeavor where we challenge ourselves to do our very best, even taking some risk of injury (Hyland, 1990).<sup>16</sup> The pleasure may derive from the thrill of competition—athletes striving to win, the challenge of breaking personal or publicly-held records, or simply the joy of physical exercise. As the title suggests, this article asserts that bicycle racing is the ultimate technology-based sport. Technology plays a significant role in many sports. As tool-making animals, the desire to win or to perform better naturally leads people to experiment to develop better sports tools. Some new tools benefit all athletes. Springier diving boards have made possible dives at one meter high boards that formerly could only be performed off a three meter board. Similarly, the requirement of jet-fighter, maraging steel instead of carbon steel for blades and new technology in safety clothes has led to increased safety for fencers. (Bjerklie, 1993).<sup>4</sup>

Other innovations in sports technology only benefit those who can afford the new technology and want to use it. For example, developments in the javelin in the 1980s allowed “finesse” throwers to significantly outperform “power” throwers. When the new javelin design was banned in 1986, the “power” throwers once again became dominant. The rules concerning technology influence which athletes are

going to perform well. Similarly, new designs of bows and arrows have increased competitive archery scores from around 1,100 out of a perfect score of 1,440 thirty years ago to 1,350 today. Yet amateurs may not wish to invest in such expensive equipment. For this reason, the Federation of International Target Archery developed the standard round which carefully specifies the technology that can be used to allow good equipment, but prohibit the very expensive top line. Competition can then occur at both levels of technology (Bjerklie, 1993).<sup>4</sup> The concepts of a spring diving board, javelin, and the bow and arrow are relatively simple. Similarly, new racket, club, and bat technology may be used, possibly in conjunction with new ball technology, to achieve further, stronger or more accurate hitting of a ball. Yet the action of hitting a ball involves the very basic technological extension of the human arm, or human body. Better shoes also may improve performance in sports involving running and jumping, but again the technology is simply an improvement of the physiology of the human foot. For many sports, technology is used as a simple extension of pre-existing human capabilities. That is not to say that the technological improvements of pole-vaulting poles or even sports nutritional drinks are not important contributors to performance, they are. But they merely improve what athletes could already do.

In contrast, other sports predominantly depend on technology. Motorcar, motorcycle, and speedboat racing all depend on the technology of vehicle and engine design. Like computer games, these activities

are based on technology and require some human skill and endurance, but provide relatively little physical exercise, since the engine does most of the work. Indeed, such activities might involve so little physical activity as to raise the issue of whether they are sports at all.

Bicycle racing is in the middle of these two extremes. This sport is obviously technology-based, since a bicycle is required, yet it also requires high levels of human skill, speed, strength, and endurance. Unlike the racing of other vehicles or horses, human power is the engine in bicycle racing. With a standard racing bicycle, a rider can travel twice as fast as a runner while expending only twenty percent of the energy per distance traveled. At 0.15 calories per gram per kilometer traveled, the cyclist is more energy efficient than any other animal or machine. A racing cyclist can achieve the equivalent of 1,350 miles per gallon of gasoline using less energy rich fuels. So-called human powered vehicles have been clocked at speeds greater than 65 miles per hour, faster than the cheetah, the fastest land animal (Kyle, 1995;<sup>18</sup> Whitt and Wilson, 1983;<sup>26</sup> Wilson, 1973).<sup>27</sup>

Bicycle racing is the ultimate technology based sport, not just because of the enhanced efficiency and effectiveness of the human engine, but because of the intimate and complex connection between bike and rider. Bouissac (1992)<sup>5</sup> asserts that the bicycle should be considered a prosthesis rather than a tool, but a prosthesis which adds unique physical competence rather than merely alleviating an impairment. He notes that when use, the bicycle is fully integrated with its rider to the point where keeping balance is largely subconscious just as it is for walking or running. Langdon Winner (1986, p. 11)<sup>29</sup> notes that the use of many technologies become "second nature" or a form of life, so the bicycle is not unique in this sense. Yet the nearly automatic use of a tennis racquet or even a computer keyboard does not rival the complexity and level of subconsciousness of bicycle riding. The system of balance and operation between a bicycle and its rider is so complex, it has yet to be accurately modeled by computer (Maddox, 1990).<sup>20</sup>

Finally, cycle racing is the ultimate technology-based sport because of the inherent technological achievement of the bicycle itself. The lightweight wire-spoked suspended wheel can support up to 400 times its own weight while withstanding braking, traction, side loads and rotating freely. Burgoyne and Dilmaghanian (1993, p. 439)<sup>8</sup> describe it as "one of the most efficient structural elements in use today." Similarly, the chain

drive of a bicycle is over 98% efficient in transmitting power. Even with gear changing devices, its efficiency is still above 95% (Whitt and Wilson, 1983).<sup>26</sup> Altogether the bicycle can carry about ten times its own weight, "a figure not approached by any bridge, automobile or aircraft" (Wilson, 1973, p. 60).<sup>28</sup> Indeed, the advertisement below brags that the Eclipse bicycle can support the weight of 16 men (at least while standing still).

## Historical Evolution of Technology and Sport

### Technology and Sports Generally

Sports historian John Rickards Betts attributes the rise of modern sport and mass spectator sporting events to technological development as the U.S. transformed from a rural-agrarian to an urban-industrial society starting in the 1850s. He notes, for example, that the development of the steamboat led both to steamboat racing as a sport and steam-boats used to carry spectators to other sports, typically horse racing.

Soon railroads served a similar role. Both also were used for athletes to travel to distant locations. By 1870 intercollegiate and professional sports teams were traveling regularly, often with fans. Telegraph enabled sporting news to travel rapidly throughout the country and high speed printing presses allowed newspapers to include the latest sporting news. By the turn of the century, mass transit allowed many more spectators to attend urban sporting events (Betts, 1953).<sup>2</sup>

Technologies beyond transportation and communication also contributed to the rise in sports according to Betts (1953).<sup>2</sup> Electric lights stimulated both spectator and player interest in indoor sports and later in night games and contests. The phonograph allowed the mass popularization of songs about sports. Sewing machines reduced the cost of uniforms. Cameras were used to capture exciting moments and show them to others who did not attend. Mass production and marketing allowed the sale of low-cost, high-quality sporting equipment. Individual inventions played a direct role in the play of sports.

Vulcanized rubber led to better balls and sporting equipment. Stop watches and percussion cap starting pistols were used in races of all sorts. The pneumatic tire and ball bearing, developed for bicycle racing, spread to horse racing and later to

automotive racing. It was in this exciting era of technological change that the bicycle and cycle racing developed.

## Bicycle Racing

While the origins of the modern bicycle can be traced back numerous medieval carts and machines, some of which had two wheels, the breakthrough leading to modern bicycle occurred in 1817 when baron Karl Friedrich Drais zu Sauerbronn invented the Laufmaschine or running machine. The operator of this machine straddled the wooden beam that connected the front and rear wheels and "ran" or pushed off the ground to propel the machine forward, much like some toddler riding toys of today. On a nine-mile test run on 12 June 1817, Drais beat the mail coach (Dodge, 1996).<sup>10</sup> While this machine contained a primitive brake, the real innovation was a steerable front wheel. Bijker (1995, p. 25)<sup>3</sup> credits the Englishman Denis Johnson with improving the steering mechanism and providing coasting pegs for the feet to enable riders to maintain balance while coasting with their feet off the ground.

This set the stage for experiments with using the feet and legs to drive the machine directly. The first commercial success at attaching pedals to drive the front wheel was achieved by Pierre and Ernest Michaux in the 1860s. Traditional cycle histories (e.g., Bijker, 1995)<sup>3</sup> assert that these two developed the design in 1861. Recent research suggests this story may have been fabricated by Pierre's son Henry to insure that his father and France could claim credit for inventing the bicycle. Pierre Lallement appears to have a stronger claim to this honor when he first attached pedals in Paris in 1863, then went to America and received a patent in 1866. Despite considerable efforts, his patent, obtained as the inventor, has not been invalidated. Lallement never achieved the commercial success of Michaux. Although America enjoyed a slight bicycle boom, Paris led the world in its love for this new machine, affectionately called the boneshaker.

Not surprisingly, the first documented formal bicycle races began in France beginning in 8 December 1867 with a fourteen mile race from the Champs Elysees to Chateau de Versailles. A second race was held in Paris on 24 May of the following year, but the race receiving the most attention was held on May 31, 1868 in a suburb of Paris and was won by Englishman James Moore. On November 7, 1869, *Le Velocipede Illustré* began the famous 76-mile bicycle race from Paris to Rouen which is still held

today. This was a grueling rain-drenched race that began with over 400 riders of which only a third finished and only thirty-three finished within 24 hours. The twenty-ninth place finisher was "Miss America" Turner, the only woman to complete the race, earning the ladies' prize. This began an era of bicycle racing by women (Dodge, 1995)<sup>10</sup> and female bicycle riding that contributed to the emancipation of women (Petty, 1997).<sup>22</sup>

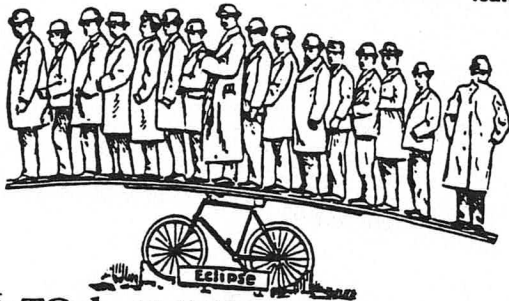
The first place winner of this race was James Moore. He rode a French Suriray velocipede with the latest technological improvements: ball-bearings, solid rubber tires over metal rims (patented in November 1868 by Clement Ader, who later became a pioneer aviator), and a forty inch front driving wheel with a free wheel mechanism to allow coasting with the feet on the pedals. In essence this was an early high wheel bicycle.

The following month, Suriray advertised the victory achieved on this model, making him the first manufacturer to capitalize on race-proven bicycle technology (Dodge, 1995, p. 49-51).<sup>10</sup>

The second place finisher, Jean-Eugene-André Castera rode a bike equipped with all-metal spider wheel, developed by Eugene Meyer, that had individually adjustable metal wire spokes that screwed into the rim. Moore won the Paris championship and almost won the British Champion Bicycle Contest at Molineux with these wheels in 1870. His Meyer bike also incorporated pedals that

Fig. 14.1  
Advertisement claiming to demonstrate the strength of a manufacturer's bicycle (about 1897).

**THE STRENGTH OF THE**  
**ECLIPSE BICYCLE** is one of  
its best  
features



**16 TO 1—16 MEN ON 1 BICYCLE**  
From a Photograph taken at our Factory  
**THE NEW '97 MODEL IS A BEAUTY**  
The Prices: \$100, \$75, \$60, \$50  
SEND FOR OUR CATALOGUE  
**ECLIPSE BICYCLE COMPANY, Box B, Elmira, N. Y.**

used the pressure from the ball of the foot rather than the instep. Although earlier inventors in both England and France had built suspended wheels in which the weight of the wheel is borne by the spokes suspending the hub from the top rather than the spokes supporting the wheel through compression from the bottom, Meyer's was the first suspension wheel that achieved success at racing and, due to revocation of his patent for selling wheels before it was granted, was soon widely copied.

The light weight of this wheel made the high wheel bicycle practical (Dodge, 1995, p. 52-53;<sup>10</sup> Clayton, 1997).<sup>9</sup> Eighteen-seventy also was the year in which the all-metal "Ariel" was patented by Starley and Hillman, which featured suspension wheels where the tension of spokes could be adjusted. The wooden and iron bicycles of carriage makers and blacksmiths had been superseded by the bicycle of machinists (Bijker, 1995).<sup>3</sup>

While the light-weight suspension wheel made the high-wheel bicycle practical in the sense that the advantage of the additional size of the wheel was not outweighed by the bulk of the wheel, the high wheel bicycle otherwise was anything but practical. Wheel diameters were made as large as leg inseams allowed in order to maximize the distance traveled with each wheel rotation. Riders perched as close to the top of the wheel as possible in order to maximize the use of body weight and to be able to pull down on the handlebars to counteract the pushing up force of pedaling. Pushing down on the pedals did not push the wheel to one side and then the other as occurred when pedaling forward on a boneshaker thereby reducing the effort needed to keep the wheel pointed in the desired direction. While the large wheel absorbed shock from rough roads reasonably well, "headers" were quite common, particularly when going downhill. In addition, racers felt these machines were not particularly effective in traveling uphill because the rider's weight was no longer directly over the pedals.

To address these problems, many novel designs were developed (Bijker, 1995).<sup>3</sup> The safety issue was remedied by the development of the more stable tricycle. These machines, however, were heavy, difficult to store, and had two or three separate tracks that were vulnerable to the vagaries of the poor roads. A second solution was the development of the safety ordinary. These bicycles has smaller wheels with chain gearing or levers to gain the mechanical advantage of larger wheels. One, the American Star even reversed the wheels, putting the large driving wheel in the back. The solution that

turned out to be successful was the development of the so-called safety bicycle with a rear chain drive and two approximately equal sized wheels. The rider continues the upright riding position of the high wheel bicycle from a saddle between and above the two wheels instead of returning to the lower position of the boneshaker with feet in front of the cyclist rather than below. Ironically, the Rover bicycle, the first commercially successful safety, was designed for greater efficiency on hills, not safety (Dodge, 1996, p. 99).<sup>10</sup>

The Rover's frame design is similar to the modern safety bicycle except that it initially lacked a seat tube from the seat to the pedals. In contrast, the cross frame safety had a seat tube crossed with a single down tube from the steering tube to the rear wheel. The modern safety has elements of both designs: the seat tube for stability between the saddle and pedals and the diamond frame for greater strength between the steering tube, saddle and rear wheel. Although the chain drive allowed the safety to be "geared up" to match a high-wheel bicycle in distance covered per pedal revolution, the safety's smaller wheels offered a less comfortable ride and some what greater rolling resistance on the rough roads of the time. This problem ultimately was solved by the re-invention of the pneumatic tire by John Boyd Dunlop, patented in 1888. Not only did the new tire dampen vibration, but in May 1889, a pneumatic-tired bicycle swept all four races at the Queen's College Sporting Games in Dublin. In 1891, French racer Charles Terront finished 8 hours ahead of his rivals in the brutal Paris-Brest race on a Michelin detachable clincher-tired bicycle, despite having to repair a flat (Bijker, 1995;<sup>3</sup> Dodge, 1996, p. 112).<sup>10</sup> The value of pneumatics in racing had been established and the modern bicycle was essentially complete.

These technological improvements led to dramatic increases in bicycle speeds and racing records. Between 1878 and 1896, the mile record in cycling was cut in half from 3:57 to 1:55. Bicycle weight in 1896 was one sixth of what it was in 1878 (Betts, 1953, p. 252).<sup>2</sup>

James Moore set the first recorded hour record of 14.4 miles (23.331 km) in 1873, followed by F. L. Dodds on a high-wheel bicycle riding 15.91 miles (25.598 km). Twenty-five years later, in 1898, the record was held by William Hamilton of the U.S. at 25.2 miles (40.781 km) (Perry, 1995, p. 517).<sup>21</sup> Yet these technological improvements also gave those who used them an advantage over those who did not. This led to a demand to control the technology of bicycle racing.

## Technology and Bicycle Racing: a Love-Hate Relationship

After James Moore's 1869 Paris–Rouen victory on a velocipede with a forty inch front wheel, other manufacturers began to build larger front wheels. This led certain French race organizers to establish the maximum front wheel size of forty inches in early 1870 and require that wheels be measured before each race (Dodge, 1995, p. 58).<sup>10</sup> By the fall of 1870, wheel size was a factor used in Britain to arrange starting time handicaps (Clayton, 1997).<sup>9</sup>

In 1869, US riding halls were restricting wheel size for both fairness and safety reasons (Dunham, 1956).<sup>11</sup> These were the first restrictions on bicycle technology imposed by race organizers.

As cycle racing gained popularity, organizations were formed to set rules and sanction events. In 1878, the Bicycle Union was formed in the U.K. to sponsor amateur races, becoming the National Cyclists Union in 1883. The NCU's banning of road races led to the formation of the British League of Racing Cyclist to govern road events. The two were merged to form the British Cycling Federation in 1959. Similarly, the Union Velocipedique de France, now the Federation Française de Cyclisme began organizing races in 1881. Also in 1881, in the U.S. the League of American Wheelmen started its Racing Board but ceded racing jurisdiction to National Cycling Association in 1900. In 1912 an amateur group was formed which became the Amateur Bicycle League of America in 1920 and the United States Cycling Federation in 1975. Similar racing

organizations were formed in Belgium (1882), the Netherlands (1883), Italy (1884), Germany (1884), and other countries (Perry 1995).<sup>21</sup>

In 1892, the International Cyclist Association was formed by these countries and Canada. After a dispute over the definition of amateur status, the French and Italians formed the Union Cycliste Internationale (UCI) in 1900 which today includes over 150 national affiliated national cycling federations and covers all types of cycle racing, track road and offroad, other than those sponsored by the International Human-Powered vehicle Association that allows technological design freedom.

By the time of the formation of the UCI, several technological speed-enhancing bicycle improvements had been eagerly adopted by racers interested in cycling as fast as possible. Drop handlebars were common by 1891 and the standard racer's crouch can be seen in photographs as early as 1894. Similarly, disk wheels and wheels with a few aerodynamic spokes also were known, but too heavy to be practical until recently (Kyle, 1995).<sup>19</sup>

Even recumbent designs, where the pedals are substantially in front of the cyclist, were developed beginning in 1896 (Wilson, 1995).<sup>27</sup> These improvements all focus on reducing aerodynamic drag. At about 8 miles per hour, wind drag is greater than the drag created by rolling resistance. At 20 mph, wind drag is more than 80% of the total drag on a conventional bicycle and rider. As a result, many innovations and restrictions on innovations address this crucial limitation on cycling speed (Kyle, 1995).<sup>19</sup>

The first patent for a bicycle fairing, used on a standard safety bicycle, was granted in 1913, to Frenchmen Etienne Bunau Varilla. It was used that year by French hour specialist Marcel Berthet who

Fig. 14.2

Marcel Berthet with streamlined bicycle (*Bicycling*, May 1982 / Radsportarchiv Wolfgang Gronen, Germany).

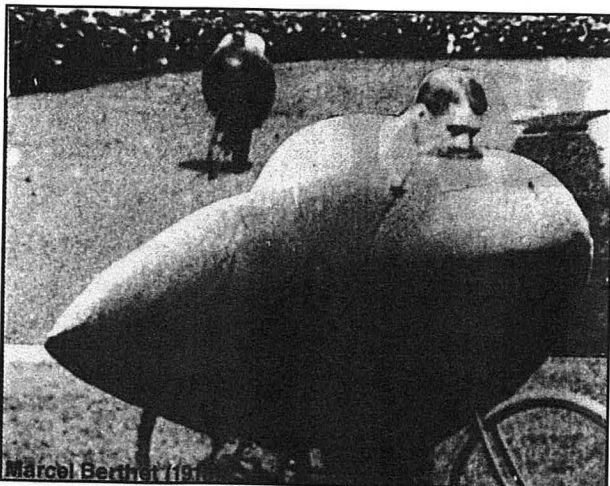


Fig. 14.3

Mochet's Vélocar enclosed recumbent. (from *Bicycling*, May 1982 / Radsportarchiv Wolfgang Gronen, Germany).



rode it at 32.5 miles per hour for 5,000 meters, 4 miles per hour faster than he could ride a standard bicycle over the same distance. In 1914, a streamlined bicycle race was held between Dutch champion Piet Dickentman and German champion Artur Stellbrink. When Dickentman crashed after a side-wind caught his aero wheels, Stellbrink won, covering the 5,000 meters at 34.63 miles per hour. In this same year, the UCI banned aerodynamic devices for use in racing (as well as any use of arm power). World War I prevented additional competitions and controversy (Kyle, 1995).<sup>19</sup>

Just before World War I, Oscar Egg of Switzerland set the UCI-sanctioned hour record at 27.49 miles (44.247 km), breaking arch rival, Marcel Berthet's record of the previous year of 27.1 miles (43.775 km). In 1932, Egg invented a tail cone with which Francois Faure raced 29.8 miles (48 km) in one hour. The following year, François Faure almost matched this performance in a Vélocar, designed by Charles Mochet, by traveling 27.9 miles (45.055 km) in one hour. Using the Vélocar, Faure, a second-rank cyclist, also defeated the champion professional Henri Lemoine, in a 4 km pursuit race. Marcel Berthet shared his rival Egg's interest in technology and did not want to be excluded from this competition. In 1933, at age 47, he rode his streamlined bicycle, the Véloodyne 31 miles (49.992 km) in an hour to set a record that was not bested on a conventional bike until fifty years later, in 1984 when Francesco Moser set a new hour record of 31.5 miles (50.808 km) at high altitude in Mexico City, where air resistance is lower than at sea level. He also used disk wheels so the bicycle was not strictly conventional (Kyle, 1995;<sup>19</sup> Perry, 1995;<sup>21</sup> Wilson, 1995).<sup>27</sup>

In 1934, after much controversy, the UCI decided it could not allow second class racers to defeat champions, and so banned recumbent bicycles from competition, disallowing records that had been set on them. This ruling is credited with stabilizing bicycle design and curtailing technological innovation for the next fifty years. There were isolated experiments, however. In 1938, Faure set an unrecognized hour record of 31.3 miles, the first person to break 50 km (50.527 km) and Oscar Egg continued to build streamlined bicycles through the late 1950s. Eventually, California experimenters Chester Kyle and Jack Lambie formed the International Human-Powered Vehicle Association which held its first championship in 1975 (Kyle, 1995).<sup>19</sup>

The IHPVA created competition for the UCI. Human-powered vehicles have traveled over 47.9

miles (77.123 km) in one hour, more than three times as far in kilometers as the earliest records. The current (1996) UCI hour record, set by Chris Boardman in Manchester is substantially less, 34.8 miles (56.375 km), just over twice as far in kilometers as the earliest records. Furthermore, HPV designers were brought into racing bike designs by the 1984 Olympics when the U.S. cycling team won 9 gold medals, victories attributed in part to technology (Kyle, 1995).<sup>18</sup> Since this time, the UCI has faced much controversy in its ruling concerning new technology.

In 1976, the UCI outlawed skin suits and aerodynamic tubing. In 1978, it reversed itself and allowed them. In 1984, it permitted the use of disk wheels, which contributed to Francesco Moser's breaking of the 50 km in one hour record. In 1989, the UCI allowed Greg Lemond to use aero-handlebars in the time trials of the Tour de France. His use of those bars and an aerodynamic helmet allowed him to defeat Laurent Fignon by eight seconds in the final time trial. In the 1986 Tour, Fignon was denied the use of a tear-drop shaped saddle back that would have allowed both increased leverage and an aerodynamic advantage. The next year, the UCI allowed wheels, other than disk wheels, with fewer than 16 spokes and removed its frame tubing requirements. It also eliminated restrictions on saddle placement relative to the pedals (Perry, 1995;<sup>21</sup> Zahradnik, 1991).<sup>32</sup>

The most recent series of controversies over bicycle technology concern Scottish cyclist Graeme Obree. In 1993, as an amateur and after making some modifications for the UCI, he beat Francesco Moser's 1984 hour record by traveling 31.9 miles (51.956 km) in one hour on a bike of his own design. In 1994, he bested rival Chris Boardman's 1993 record, set on a Lotus aerodynamic monocoque bicycle improving to 32.8 miles (53.040 km).

Later that year, his famous ski-tuck riding position was declared "an unsporting interpretation of the rules" (Goodbody, 1994).<sup>15</sup> As a result he developed an 18 inch handlebar extension that allows him to ride with arms stretched out in front, the "superman position." This position was used in 1996 to allow Chris Boardman to regain the world hour record by covering 34.8 miles (56.375km). Newly announced UCI rules, effective on 1 January 2000, will disallow this position as well and revert back to the diamond frame and equal sized wheels (Bryan 1997).<sup>6</sup>

Thus for track and road racing, the UCI, after twenty years of slowly becoming more permissive of technological innovations in cycle racing, perhaps in

part because of the IHPVA, has recently taken a conservative approach culminating in a dramatic step backwards from the technological perspective, in restricting bicycle designs used in racing.

The UCI wants to sanction bikes that use only affordable technology and it wants to eliminate the question of who won the race, the cyclist or the engineer? The UCI consistently treats cyclists that it considers to be second class such as Faure and Obree harshly concerning technology, but is willing to be more permissive for proven champions.

Interestingly, the UCI has recently begun sanctioning off-road events, and has expressed similar concerns regarding mountain bike technology, but has no plans currently to restrict off-road technology.

The effects of the UCI's technology rulings can be shown dramatically in Figure 14.4. Technological innovation allowed the hour record to increase until 1914 with Egg's record of 44.247 km. At this point, the UCI banned the use of aerodynamic devices and arm power. When Marcel Berthet's record of 49.992 km was disallowed by the UCI in 1934, the hour record for conventional bikes improved very slowly to the legendary Eddie Merckx's record in 1972 of 49.432 km. At this point the conventional bike record had almost caught the starting point for streamlined bikes. With the use of disk wheels (and the thinner air of Mexico City), Francesco Moser significantly improved Merckx's record to 51.151 km. From then, as detailed in the text above, technology contributed to significant increases in the record on conventional bikes. Figure 4 also clearly demonstrates, however, that the modest technological concessions of the UCI were no match for the unrestricted IHPVA efforts. The hour record on streamlined bicycles has dramatically outpaced the UCI record since 1980. Thus, it is clear that the UCI's restrictions on technology have significantly limited the speeds attainable in sanctioned events. Before attempting to analyze the merits of the UCI's restrictions, it is useful to examine the societal benefits derived from bicycle racing.

### **The Social Impact of Bicycle Racing Technology**

The goal of the UCI is to increase the popularity of bicycle riding and racing. Yet not everyone races bicycles, so it would like to develop spectator interest in cycle racing as well. There is little doubt that cycle racing is popular among spectators. The Tour de France, for example, attracts over one billion

followers and about twenty million roadside spectators. Its popularity is exceeded only by the Olympics and the World Cup of soccer (football outside the U.S.) (Perry, 1995, p. 399).<sup>21</sup> Even in the U.S., bicycle races at the turn of the century drew crowds of tens of thousands. During the turn of the century at least, some of the thrill was derived from watching the latest technology, which the bicycle represented. As noted above, bicycle racing represents a unique combination in sports of people with machines. While much of the interest in bicycle racing is derived from the simple pleasure of watching athletes compete, available from any number of sporting contests. It also is true that some of the excitement is derived from the speed of cycle racing. Indeed another approach taken by cyclists to overcome air resistance is to "draft" behind not only other bicycles and multicycles, but motorized vehicles as well. Before the turn of the century, Charles "Mile-A-Minute" Murphy earned his nickname by traveling sixty miles per hour behind a locomotive of the Long Island Railroad. John Howard set the current motorpaced land speed record of 152 miles per hour in 1985 (Perry, 1995, pp. 422-24).<sup>21</sup>

Paul Rosen (1995)<sup>24</sup> notes that Chris Boardman's victory in the 1992 Olympics was attributed to the Lotus bicycle he rode by the general press, to Boardman himself by cycling colleagues, and to the aerodynamics of the rider/bike combination by the engineers at Lotus who designed the bicycle to match Boardman's characteristics as a rider and helped him teach his body how to ride the "superbike" as fast as he could. This unique blending of rider and machine, people and technology, is what Rosen refers to as "cycling cyborgs," and it undoubtedly contributes to some of the spectator interest in cycle racing.

### **Cooperation within Competition**

A second unique aspect of cycle road racing as a sport is the blending of team competition with individual competition and cooperation across team boundaries. Of course all sports are cooperative to the extent that contestants must agree to compete and to be governed by a common set of rules. They agree to a judge or referee to interpret and enforce the rules. Beyond this basic level of cooperation, generally comes competition, each competitor or team trying to defeat the other(s). In some team sports, some amount of cooperation may develop at an informal level.

Linemen in U.S. football might implicitly agree not to try as hard as they might (if he hits me somewhat lightly, I will return the favor). Similarly in basketball or soccer or hockey, if the player you are matched up against, is not moving quickly, you may not either. Typically however, these cooperative alliances are very fragile and make break down at any time when a player feels needed for a particular play or situation. In bicycle road racing, however, cooperative alliances are not only recognized, but enforced by the informal social rules of the sport. Cooperation developed because the technology of the bicycle allows for speeds much higher than running so that wind resistance becomes a crucial factor. The force of wind resistance increases with the square of the velocity. A cyclist traveling at 20 mph who doubles his or her power output will only increase speed to 26 mph. The rest of the power increase is used to overcome the increased wind resistance. For this reason, drafting, riding close behind one or more riders or in a paceline of riders is commonplace in road racing today. It is estimated that drafting cyclists saves 30–40% of the energy output needed to maintain the same speed without drafting (Kyle, 1995).<sup>19</sup>

For this reason, before the final finish line sprint, cyclists very seldom individually break away from the main group of riders, the peloton. Rather, a breakaway is formed when one rider decides to break away and is followed by several other riders, often of various teams. Alternatively, a simple gap in the peloton may develop for any number of reasons. Cooperation across teams then begins with the simple shouting that there is a gap so that the leaders of the moment can decide whether to increase their speed to create a breakaway.

The breakaway group then forms a paceline where each rider is expected to take a turn “pulling” at the front of the line and then drop back to the end of the line to rest while drafting until the entire group rotates through each position in the line. Riders who take too long a turn in front are advised to “pull off,” so as not to become too tired and slow the speed of the group. Riders who do not “pull through” as the rider in front drops off are advised to do so or others are advised to go around such a “blocking” rider. Without cooperation, the individual riders would soon be caught and re-absorbed by the peloton, which is enjoying the aerodynamic benefits of drafting. These are examples of what sociologist Edward Albert (1991) describes as informal rules of conduct. Cycle racing rule books do not mention such rules, but they are essential to the maintenance of the breakaway and the conduct of the race.

If the paceline is too large, some riders may hide in it to avoid taking turns at the front. Such riders would then be better rested for the final sprint. If several riders recognize the breakaway is too large, they may just sit back and let it be re-absorbed by the peloton. In a breakaway of manageable size, “wheel suckers,” who refuse to take an equitable turn in front, would be encouraged to take their turn and might be verbally threatened, punched, or threatened with “hooking”—bumping their front wheel with another rider’s rear wheel, causing a fall. “Hooking” itself is illegal; so if it is done, it is disguised to look accidental. Alternatively, one member of the paceline might get in front of the wheel sucker and simply slow down, taking them both out of the paceline. Such a hero would earn the gratitude and respect of other riders which may pay off in a future race. Sometimes the recalcitrant rider is allowed to sit back if he or she agrees not to sprint ahead of any other members of the breakaway group. A strong rider may decide not to work in a breakaway group of less strong riders, particularly early in the race when the chances are small of remaining ahead of the peloton.

Cooperation also occurs in the peloton. The team leaders remaining in the peloton discuss whether the breakaway is a viable threat. If it seems to be too small, too early, or made up of weak riders, they may let it go, assuming they will re-absorb the riders later in the race. If factors are favorable for the breakaway, peloton leaders will encourage everyone to pick up the pace and catch the lead group. Team loyalties also play a role. If team members in the peloton think their colleague in the breakaway has a good chance of winning in the final sprint, they may ride slowly to prevent the peloton from catching the breakaway. Alternatively, team members in the breakaway may try to slow down the paceline to give a colleague in the peloton a better chance of winning. This is particularly true for professional teams where there is a recognized hierarchy among team members.

While some have suggested that these elements of cooperation confuse spectators who do not understand these intricacies and have led to the decline of spectator interest in road racing, particularly in the U.S., it can also be argued that these cooperative elements make road racing uniquely exciting. Cyclists must formulate complex judgments about the viability and desirability of a breakaway to determine their reaction. Since breakaways typically require cooperation occur across team boundaries, riders can not rely on their intimate knowledge of team members, but face far

greater uncertainty about the prospect for effective cooperation.

In a world where temporary and ever-changing "teams" are currently popular in business and have always been a part of society in other activities, cycle racing teaches valuable judgmental skills. These skills, deciding when and how much to trust others, when to cooperate and when not, etc., are valuable to other social interactions (Eassom, 1989).<sup>12</sup> For this reason, the unique cooperative aspects of bicycle road racing, caused by the technologically enhanced speed of the human athlete is an important social benefit of UCI rules. If cyclists used fairings to reduce aerodynamic drag, the value of drafting and cooperation would be greatly reduced.

### Bicycle Technology Development and Use

The history of bicycle development and cycle racing shows that racing encourages technological innovation. The discussion above indicates that the enlarging and redesign of the front wheel of the boneshaker to create the high wheel bicycle occurred first in cycle racing. Similarly, pneumatic tires, although apparently developed to cushion John Dunlop's son's rough tricycle ride on the cobble stone streets of Belfast, developed and improved rapidly because of their value in racing. Bicycle racing also stimulated innovations in steel tubing and the development of the bush and roller chain as well as gear changing devices. Indeed as Figure 14.1 illustrates, it was, and still is, commonplace for manufacturers to tout race performance in their advertising to stimulate sales among the general public.

One often-overlooked technological development stimulated by bicycle racing is the ball bearing. Ivan Illich describes the invention of the ball bearing, with the tangent-spoked wheel and the pneumatic tire, as the fourth revolution in the history of transportation after the invention of:

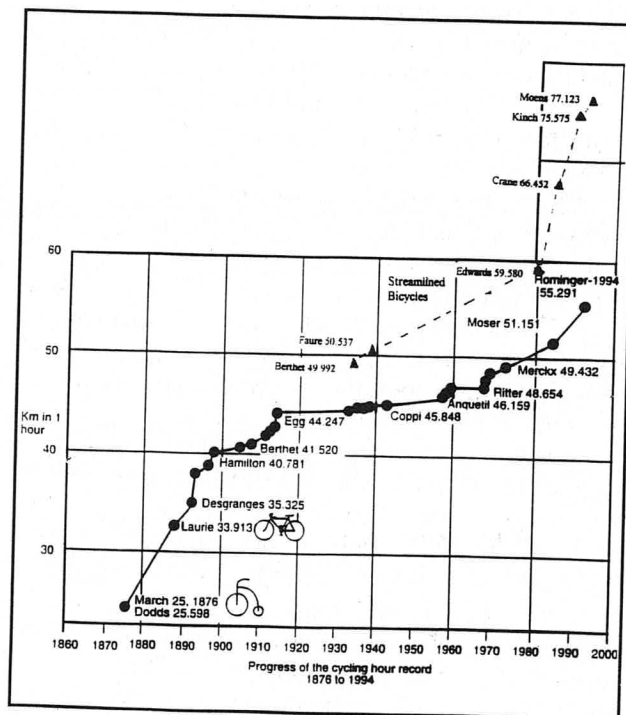
- the wheel itself;
- the stirrup, shoulder harness and horseshoe; and
- ocean-going sailing ships.

He states that the ball bearing reduces friction by a factor of one thousand and made possible the last great neolithic inventions, the bicycle (Illich, 1974, pp. 59-60).<sup>17</sup>

On a modern bicycle, ball bearings in the wheels, pedals, and bottom bracket reduce the energy loss from pedaling due to friction to less than one percent. Chain loss would add another 1.5-2 percent. The cyclist loses about two percent of pedaling energy from joint friction, and the rest of the cyclist's energy is used to overcome road and air resistance (Whitt and Wilson, 1983).<sup>26</sup> Thus, the substantial reduction is mechanical friction created by the ball bearing is an important factor contributing to the bicycle's efficiency. The use of some sort of rolling structure to reduce friction dates back to ancient times. For example, rollers were used by the Egyptians to move large blocks of stone. An early thrust bearing, using balls was constructed during the time of Caligula (12-41 AD), but these bearings only rotated on a single axis like a roller bearing. The first patent for a ball bearing to take a radial load was filed in England in 1794 by Phillip Vaughn to be used for cart wheels. The first bicycle ball bearing was produced in England by E. A. Cowper in 1868 followed by Suriray with a French patent in 1869. These early bearings were neither hard nor precise enough to be successful.

Success was achieved after the development of curved ball tracks within the bearing for bicycle use. Hughes received a British patent in 1877 for cone

Fig. 14.4  
Adapted from Kyle, 1995 to show efficiency of streamlined bicycles.



and disc adjustable ball bearings as did Rudge in 1878. Demand from bicycle racing and use led to improved steel and production methods and by the turn of the century, bearing friction was being studied and bearings were scientifically designed for their purpose. In 1887, Henry Richardson introduced a precision ball grinder and the Brown and Sharpe Universal Grinder, brought out three years earlier, was used extensively to grind bearing races. These machines, capable of grinding hardened steel to tolerances within 0.00025 inch were made possible by the patenting of artificial abrasive wheels in 1877 (Allan, 1946;<sup>1</sup> Farwell, 1996;<sup>13</sup> Woodbury, 1959).<sup>30</sup> The demand for effective bearing from cycling, and cycle racing in particular, led to these technological developments that are now enjoyed in many other machines.

## Discussion

The ultimate question in any sport that involves technology is "what is fair?" or "how much technological advantage is fair?" The UCI, in trying to answer that question, has asserted two important policy concerns. First, the determinant of victory should be the athlete, not the engineer. Second, racing bicycles should be affordable. The UCI appears to be focused almost exclusively on the human sport aspect of bicycle racing ignoring the benefits of the technological aspects. This view is consistent with concerns that technology is de-humanizing people who are viewed as biological machines. Some fear that this tendency, particularly in sports, leads society to ignore the special characteristics that make people more than machines (Rintala, 1995).<sup>23</sup>

On the other hand, UCI road racing rules for the next century limit bicycle technology largely to that of the last century. Such a restriction attempts to deny the technological history and basis for the sport. It was the pre-UCI technological innovation that allowed to achieve sufficient speeds to make wind resistance important. As a result, road racing evolved into a sport of uniquely complex competition and cooperation. UCI rules preserve this unique aspect of the sport of cycle road racing. If at least some of the interest of cycle road racing is based on "dueling" technologies, as the UCI seems to acknowledge for off-road racing, then the popularity of road racing should decline. Indeed, the UCI now seems comfortable with ceding technological competition in road and track racing to the IHPVA. To date, the IHPVA has been unable to attract much

spectator or sponsor interest. However, as HPV technology becomes affordable and available to recreational cyclists, the excitement of road racing will decline when world class athletes race at speeds close to those achievable by ordinary people.

Furthermore, it is important to contrast the bicycle as humane technology to the de-humanizing technology of critics (Rintala, 1995).<sup>23</sup> As noted above, the bicycle requires its human rider's strength and endurance as well as judgment. The bicycle uniquely enhances human abilities, but still depends on them rather than overshadows them. Greame Obree's rise to fame and notoriety illustrates that cycle racing is not yet one big machine with riders as human "cogs." Rather, an individual with training and imagination can develop a method to compete with the sport machine has to offer. The bicycle itself is a tribute to the creativity of humans and its forms a personal bond with them beginning in early childhood. It is a prime example of humanizing rather than de-humanizing technology.

UCI restrictions on technology appear arbitrary and unfair. Why freeze technology at the safety bicycle? Why not the high-wheel or boneshaker? Does it make sense to allow improvements in gear changing and transmission technology or training technology, but not in aerodynamics? Training technology today involves careful measurement and computer modeling of effort, velocity, levels of hormones and other chemicals in the bloodstream, and form in performance. In addition to the technology needed to take such measurements, experts such as physiologists, biomechanists, psychologists, doctors and even masseurs also are used. In 1992, the U.S. Olympic Training Center had a budget of \$700,000 covering 12 full-time scientists (Shepherd, 1992).<sup>25</sup> While other countries enjoyed bigger budgets, this support is expensive and not affordable by all. Yet, the UCI makes no attempt to limit this use of science and technology, beyond banning the use of certain performance enhancing drugs. If the goal is to have athletes compete free from outside performance-enhancing mechanisms such as drugs and streamlined bicycles, then should not the scientists and technology involved in performance enhancing also be banned?

One difficulty of course, is where to draw the line. Is a coach allowed, or must an athlete train by his or her self? If coaches are allowed, how many and how specialized may the be? If coaches are not allowed, may the athlete consult published books or articles when training? The UCI does not regulate the number and specialization of coaches presumably because it wants to enhance athletic performance as

much as possible, outside the use of drugs. It therefore allows technology, too expensive to be available to all, to play an important role in the outcome of bicycle races.

This line drawing problem is evident in UCI attempts to distinguish fair bicycles from unfair bicycles. Technological innovations have been recently allowed, regardless of their streamlining advantages, if they serve some purpose beyond streamlining. Such rules leave too much room for judgment and appear arbitrarily enforced, particularly to the disadvantage of those perceived to be "second class" athletes. "Stars" on the other hand have enjoyed technologically permissive interpretations of UCI rules. Rulings have been made and later retracted, so there is little certainty concerning what is fair. Furthermore, by allowing some innovations such as gear changing devices, but not others such as arm power or wind screens, the UCI is in essence determining which athletes it will advantage over others, just like the aerodynamic javelin advantaged "finesse" over "power" throwers. When that javelin was banned, the "power" throwers regained their original advantage. At least one early inventor of safety cycles was too short to compete on a high wheel. Limiting technology to high wheel bicycles would disadvantage short people. Similarly, prohibiting drop handlebars would favor those who have short or narrow chests.

At least until its recent rule change reverting back to the diamond frame bicycle with equal size wheels, the UCI appeared to want some technological competition, but not too much. A simple approach is to follow the standard round in archery, which is practiced in Keiren bicycle track racing in Japan. Cyclists all ride essentially identical bikes to eliminate any possibility of technological advantage (Perry, 1995).<sup>21</sup>

Alternatively, cycle racing could celebrate its unique technological nature and freely allow technological competition as does the IHPVA, subject to the requirement of human power. The UCI follows this approach currently for mountain bike racing. If pure athletic competition in bicycle racing is desired, assign all of the competitors a standard bicycle (produced by the race's sponsor perhaps), and let them all compete fairly much like the standard round in archery. The current system of allowing some arbitrary amount of technological advantage which changes with the whims of the judges, seems both unfair and denies the essence of this ultimate technology-based sport. A structure analogous to the Tour de France's variety of stages would be to require competitors in a race to ride one

or more specified stages on a "standard" bike, but also have some stages designated as "open" events where any type of human powered vehicle could be ridden. Winners for each category and an overall winner could be declared.

## Conclusion

Historically, cycle racing has been a substantial driving force behind technological innovation both in terms of bicycle technology and production technology. Technology also plays an important role in the achievement of faster bicycle speeds, the establishment of new records, and the development of the unique mix of competition and cooperation in road racing today. If not for the restrictive rules of the Union Cycliste Internationale, it is interesting to speculate how much more quickly cycling records and bicycle technology would have advanced. Would the quest for lightweight, yet strong materials have been led by the bicycle in the 1950s, instead of the space race in the 1960s? In a world where more bicycle trips are taken for transportation in China annually than automobile trips throughout the rest of the world, would society now be benefiting for new bicycle technology trickling down from racing to peasant bikes? We will never know the answers to these questions.

The development of the IHPVA and the slowly increasing popularity and availability of alternative bicycle designs suggest that the UCI will not be able to sustain its technology restrictions. It recognized in the 1980s, that it must allow at least some technological advancement to maintain its control of this technology-based support. It likely has not yet attempted to restrict off road technology for the same reason. The UCI's record for arbitrary interpretation and biased enforcement of its technology restrictions exacerbates its problems.

An alternative approach is to embrace the technological basis for bicycle racing, making it a partnership between the athlete and engineer. Athletes are important in every sport, but engineers could be uniquely important in cycle racing, if we let them. The founding of the IHPVA and the transference of some of its findings to the improvement of "standard" bicycles shows the demand for at least one class of road racing free from technological restrictions. The historical benefits from technological innovation both for sport and for society generally suggest benefits from a more permissive approach.

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