

Prime Minister's Science, Engineering and Innovation Council

**Report on
SCIENCE AND TECHNOLOGY IN SPORT**



1 June 2004

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Executive Summary

Australian sport has enjoyed a golden period in the past two decades, culminating with a most impressive 4th place in the medal tally at the Sydney Olympic Games and 1st place in the medal tally at the Para-Olympic Games. In this period, Australian teams have also won world championships in cricket, rugby union, rugby league, tennis, netball and sailing, and individuals have captured world crowns in surfing, golf, swimming, squash, motorcycle racing and even in winter sports.

The establishment of the Australian Institute of Sport (AIS) in 1981 with its “athlete centred” model focusing the best available sports science, physiology, medicine and psychology through the coach towards elite performance, has been the major factor driving the outstanding performance of Australian sport in the past two decades. The culture of excellence developed by the AIS in a drug-free environment has set, and is still, the benchmark for the rest of the world.

The working group has found the unique AIS model of innovation and integration has been an extremely successful “adoption pathway” for the application of Australian science and technology towards elite sporting performance and success. The science and technology utilised by Australian sport in many AIS programs has been harvested from isolated existing innovative research programs within our universities and the CSIRO with only minimal amounts of funds specifically spent on dedicated sports science research.

In the past two decades a considerable sports science, recreation and engineering infrastructure has evolved within the higher education and TAFE sectors. Currently more than 11,000 undergraduate and 1,500 postgraduate students are studying sports and exercise science at 25 Australian universities.

Despite the above successes, elite sport in Australia is at a crossroads as the comparative advantage afforded by the AIS model is being eroded by well-funded replication of the concept by our major international competitors. In many cases key Australian personnel have been attracted and recruited overseas to establish and run AIS clones. Furthermore, sports science is not covered by the national research priorities and consequently is not seen as an “honourable pursuit” within the traditional scientific research community.

Clearly if Australia wishes to maintain its position internationally as a leading sporting nation we need to take the bold initiatives necessary to ensure we are competitive in the 21st century. The working group believes that Australia needs to adopt a more proactive approach to developing and harnessing new science and technology towards continued improvement by our athletes. To achieve this proactive approach, Australia has to be innovative in bringing together the best research and the best technology in a planned integrated program to ensure that Australia continues to be at the front of the international field.

The working group recommends that a new body, the Centre for “Australian Sports Innovation, Science, and Technology” (ASIST), be established and co-located with the AIS to:

- Proactively identify the needs to enhance elite athlete performance and coordinate and fund research in sports science and technology
- Stimulate and facilitate the commercialisation of products and services arising from Australian sports innovation

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- Direct the application of the results of sports science and technology towards increased physical activity within all age cohorts of the Australian population

ASIST would be co-located with the AIS and work closely with the Australian science and technology research community to identify and fund future science and technology avenues for research that may provide a fair, ethical and legal advantage for our athletes and teams.

ASIST would also work with industry to ensure that new technologies and services are effectively commercialised to benefit both the elite and recreational sporting communities.

To ensure that the knowledge, technologies and services developed for elite sport are proactively applied to recreational physical activity for all ages ASIST would collaborate with the Australian Sports Commission, Federal and State education authorities and the Departments of Health. There is good reason to believe that increased physical activity for the general population is an essential and critical first step in combating the looming threat of obesity, its related diseases, and other inactivity-based illnesses across all ages. It is essential that the technologies, systems and processes developed to ensure continued international sporting success be communicated and made available for the benefit of the Australian community.

Recommendations

Recommendation One

Establish the Centre for Australian Sports Innovation, Science and Technology (ASIST) – a body incorporating the AIS, State Sports Institutes and Academies, Universities, ASDA, CSIRO and other relevant bodies - to provide a proactive focused approach to research, innovation and investment in the application of technology in Australian sport at all levels.

Recommendation Two

Introduce “sport” in Australia’s National Research Priorities as a fifth sub-priority – “*Sport for a Healthy Life*” - under the major priority “Promoting and Maintaining Good Health”.

Recommendation Three

Through the Centre for ASIST exploit commercial opportunities, including “spin-off” commercialisation companies, of elite and community-based sports science, engineering, technology and services through incentives for investment and coordination with industry.

Recommendation Four

Provide incentives that support the export of Australian sport science, engineering and technology to:

- Maximise business and trade opportunities, as well as
- Provide assistance to developing countries as part of our regional and global aid program

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Recommendation Five

Introduce national health and fitness standards (benchmarks) into the primary school curriculum using sports science and technology expertise to increase participation and lifelong health in the Australian population.

Recommendation Six

Mandate the Centre for ASIST to work with the Australian Sports Commission and State and Territory agencies to provide appropriate science and technology to increase participation, safety and enjoyment of the general population in sport and exercise programs.

Terms of Reference and Members

The working group will prepare a paper and presentation for PMSEIC, which will:

1. Illustrate how science and technology have contributed to Australia's sporting competitiveness and performance over the last twenty years.
2. Describe some of the current cutting edge science and technologies being used by Australia to prepare its athletes for the 2004 Olympics and Paralympics and other international competition.
3. Provide an overview of Australia's current sports science and technology infrastructure and capabilities:
 - Identifying areas of sports science and technology where Australia has a competitive advantage; and
 - Consider how to maintain and foster these advantages, including through the building of world-class sports science and technology clusters with export potential.
4. Illustrate how knowledge gained through sports science and technology can benefit the health and well-being of all Australians.
5. Recommend practical ways in which Australian science, engineering and technology can:
 - continue to play a major role in maintaining and improving Australia's position as one of the world's premier sporting nations;
 - offer opportunities for Australian businesses; and
 - benefit the health and well-being of all Australians.

Members:

1. **Professor Snow Barlow (Chair)**, President, Federation of Australian Scientific and Technological Societies
2. **Dr Joe Baker AO, OBE**, Board Member, Queensland Academy of Sport
3. **Dr Dennis Hatcher**, Assistant Director, Australian Institute of Sport, Athlete and Coach Services
4. **Professor Peter Fricker OAM**, Assistant Director, Australian Institute of Sport, Technical Direction
5. **Dr Brendan Burkett OAM**, Director, Centre for Healthy Activities, Sport and Exercise (CHASE), University of the Sunshine Coast
6. **Dr Hugh Seward**, Geelong team doctor and President of the AFL Medical Officers' Association
7. **Professor Mark Hargreaves**, Head, School of Exercise and Nutrition Sciences, Deakin University
8. **Professor David Mainwaring**, Associate Dean (R&D), Applied Science, RMIT
9. **Mr Clive Davenport**, CEO, CRC for microTechnology
10. **Mr Robert de Castella MBE**, Managing Director, SmartStart for Kids Limited

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Prologue

Australian sport has a very proud tradition of excellence and success signalled in the first modern Olympic Games by Edwin Flack, and in the first cricket test before Federation. As our sporting reputation has grown, sport has become an embodiment of Australian culture - or how we like to think of ourselves as Australians: "healthy, robust, determined, open, competitive, loyal and innovative with a bold disregard for convention".

These qualities have led to many innovations which have contributed to our sporting success and include such inventions as Ben Lexcen's winged keel, Charlie Booth's first patented starting blocks for sprinters, and other developments such as the aluminium cricket bat!

An equally important but perhaps lesser extolled ingredient in our sporting success is our ability to work together towards a common goal under leadership based on respect and performance, rather than birth. The sporting success that Australians have enjoyed over the past 20 years and particularly over the last decade has a lot to do with this attitude and relationship.

The Australian Institute of Sport which focuses a number of essential services such as sports biomechanics, physiology, medicine and psychology in a team approach within a culture of excellence, national cooperation and an international focus has been a uniquely successful model.

At the start of the 21st century the nation's sporting prowess and its health are at a crossroads. On one hand the successful AIS model of elite sport that has been essential to our recent "golden run" is under threat and is being replicated with superior resources and manpower in a number of developed nations, and as such is no longer a competitive advantage for us.

On the other hand the overall health and participation rate of the Australian population in physical activity is declining, leading to dramatic increases in the incidence of weight and sedentary lifestyle related diseases such as Type 2 Diabetes, in both our younger and older generations. As our nation moves to embrace the concept of a "knowledge economy" that not only maintains, but also improves our standard of living, we are not coming to grips with the realities of our lack of physical activity and its implications for both the social costs and the costs of our health care system. We are at risk of becoming a nation of "unhealthy, obese spectators" watching a few sporting heroes - a very long way from seeing ourselves as a nation of healthy, independent and innovative people.

The PMSEIC working group believes that there is considerable synergy in the twin aims of:

- maintaining our pre-eminent sporting reputation through continued innovation in the way we enhance elite individual and team performance and
- ensuring that our population remains healthy as the nature of work changes, through the application of elite sporting knowledge to safe enjoyable and effective physical activity.

The following report addresses the working group's terms of reference, and provides a set of recommendations which support the aspirations expressed above.

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1. SCIENCE & TECHNOLOGY IN SPORT (1980 – 2000)

1.1 Introduction - a lesson from the Montreal Games

In 1976 despite high hopes for the Australian team at the Montreal Olympic Games we returned with no gold medals, one silver medal and four bronze medals. Australia's amateur sports system (largely unfunded by Government) had finally been surpassed by the professional sport systems being implemented in other countries – particularly in Europe and the USA.

Despite earlier recommendations from various sources including John Bloomfield in 1973 and the Australian Sports Institute Study Group in 1975 it took the major disappointments of the 1976 Olympic and 1978 Commonwealth Games for the Government to implement a national sports system, including the announcement in 1980 of the Australian Institute of Sport.

1.2 Genesis of the Australian Institute of Sport

In 1973, the Bloomfield Report commissioned by the Government made a number of recommendations. These included a move to a more professional sports system, funding for programs and facilities, development of sport support programs and services such as sports management, coaching, officiating, talent identification and sports science and medicine, and the establishment of a national institute of sport (Bloomfield, 2003).

The following year, the Coles Report recommended a national institute of sport be located in Canberra with branches in the States, that a national coaching system be established, that courses for sports administrators and officials be established by the institute in conjunction with national sports associations, that sports science and sports medicine be encouraged by the institute, and that technical services relating to sports facilities and equipment be developed (Bloomfield 2003).

The Australian Institute of Sport (AIS) announced in 1980 and opened in January 1981, was focused on high performance. Scholarships were offered to athletes in eight sport programs including basketball, gymnastics, netball, soccer, swimming, tennis, track and field and weightlifting. Coaches were appointed from Australia, the UK, the USA, and Japan. Over the next two decades, more sports were added to the AIS – many in the States (for example diving, squash and canoe in Queensland; cricket and cycling in Adelaide; hockey in Western Australia).

Initially a small sports science unit was established, and medical services sourced from a private sports medicine and general practice. The AIS has grown to include a large sports science and sports medicine centre, residences, athlete career and education support, technical programs such as talent search, laboratory standards assistance, and benchmarking, together with programs such as a national elite sports research program. Partnerships have been formed with the State and Territory Institutes and Academies of Sport, and cooperation with universities and international organisations has been actively pursued.

1.3 Australian sporting performance (1956 – 2000)

1.3.1 Olympic Games

The Montreal Games in 1976 was the low ebb for Australia in sporting terms, and this reflected the relatively low levels of assistance provided to sport by Government as well as the increasing level of professionalism of sports systems in European countries and the USA in particular.

The traditional strength of Australia as a sporting nation can be seen in Table 1 which demonstrates a fairly consistent performance (in medal counts at least) from 1956 to 1972, until Montreal delivered its salutary lesson.

Table 1 Australian Olympic Medal Tally 1956-2000

OLYMPIC GAMES	GOLD	SILVER	BRONZE	TOTAL
1956 Melbourne	13	8	14	35
1960 Rome	8	8	6	22
1964 Tokyo	6	2	10	18
1968 Mexico	5	7	5	17
1972 Munich	8	7	2	17
1976 Montreal	0	1	4	5
1980 Moscow	2	2	5	9
1984 Los Angeles	4	8	12	24
1988 Seoul	3	6	5	14
1992 Barcelona	7	9	11	27
1996 Atlanta	9	9	23	41
2000 Sydney	16	25	17	58

Moscow and Los Angeles restored a little pride, but competitors were sadly depleted at both these Games through protests against Russia and then the USA and so our medal numbers were probably a little enhanced through lack of competition.

The Seoul Olympics reflected the contribution of an elite sports system and improved funding (see Table 2), and from Seoul to Sydney, there is an impressive rise in medals. The success in Sydney is a direct reflection of the national sports system and an Olympic Athlete Program funded by Government – with \$12M given to sports science and sports medicine servicing of Olympic athletes over six years.

Table 2 Federal funding to high performance sport since 1981

Year	Funding	% Total Govt. Spending	Year	Funding	% Total Govt. Spending
1981	\$1 077 780	0.003	1992	\$20 784 582	0.02
1982	\$4 504 700	0.011	1993	\$23 062 217	0.021
1983	\$5 560 000	0.012	1994	\$25 865 453	0.022
1984	\$8 920 000	0.016	1995	\$29 050 000	0.024
1985	\$11 000 000	0.017	1996	\$84 320 000	0.064
1986	\$12 455 000	0.018	1997	\$89 977 000	0.067
1987	\$13 490 876	0.018	1998	\$89 284 000	0.066
1988	\$10 800 000	0.018	1999	\$109 944 000	0.077
1989	\$14 781 507	0.018	2000	\$88 077 000	0.058
1990	\$18 967 041	0.021	2001	\$97 272 000	0.063
1991	\$21 215 457	0.022	2002	\$101 688 000	0.062

1.3.2 Commonwealth Games

Tables 3 shows similar trends to those seen for the Olympic games, with a trend up from 1954 in Vancouver to a home games in Perth, followed by consistent performances through 1970, 1974 and 1978, and a dramatic rise in medal counts from 1982 to 2002. The mid-70's "decline" at Olympics is not reflected at the Commonwealth games because the latter do not carry the same depth of international competition. Nevertheless, improved funding and an ever-improving delivery system for national sport are reflected in the results.

Table 3 Australian Commonwealth Games Medal Tally 1954 – 2002

COMMONWEALTH GAMES	GOLD	SILVER	BRONZE	TOTAL
1954 Vancouver	20	11	17	48
1958 Cardiff	27	22	17	66
1962 Perth	38	36	31	105
1966 Kingston	23	28	22	73
1970 Edinburgh	36	24	22	82
1974 Christchurch	29	29	25	83
1978 Edmonton	24	33	27	84
1982 Brisbane	39	39	29	107
1986 Edinburgh	40	46	33	119
1990 Auckland	52	54	56	162
1994 Victoria	87	52	43	182
1998 Kuala Lumpur	80	61	57	198
2002 Manchester	82	62	62	206

1.3.3 Other sports successes

In recent years Australia has enjoyed significant success in non Olympic sports including cricket, rugby and golf to name a few. Table 4 highlights some of the successes that Australia has experienced over the past four years in a variety of these non Olympic sports.

Table 4 Recent results in non Olympic sports

Sport	2001	2002	2003	2004
AFL	Won International Rules Series v Ireland	Won International Rules Series v Ireland	Won International Rules Series v Ireland	
Baseball		Won Women's World Series		
Cricket Men's	Ranked number 1 test playing nation, Set record for most consecutive test victories at 16, won inaugural ICC Test Championship trophy for test match cricket.	Ranked number 1 test playing nation	Won World Cup and number 1 ranked test playing nation. Retained Ashes and Frank Worrell Trophy	Won 3 test series in Sri Lanka 3-0.
Cricket Women's	World Cup runner-up	Won 2002 One-day Rose Bowl series against New Zealand, England and India. Retained Ashes.		
Golf Men			Amateur Men's World Cup - Team Bronze, Individual Gold - Marcus Fraser US Amateur Championships - Nick Flanagan	
Golf Women	LPGA Championship and US Women's Open - winner, Karrie Webb	British Open - winner, Karrie Webb	Women's World Amateur Championships - Gold	
Motor Cycling	Troy Bayliss 1st in Superbike W/C Andrew Pitt 1st in Supersport W/C Chad Reed 2nd in individual 250cc Motocross W/C	Australian Speedway Team won World Championships and FIM Speedway World Cup Final. Jason Crump 2nd and Ryan Sullivan 3rd in individual World Speedway Championships Troy Bayliss 2nd in Superbike W/C	Supercross World Championship - 1st Chad Reed Supersport World Championship - 1st Chris Vermeulen Individual Speedway World Championship - 2nd Jason Crump Team Speedway World Championship - 2nd	
Netball	Won Tri-series vs South Africa (2000) and 3-test tour vs England (2001)		World Championships - Silver	
Rugby League		Won series against Great Britain 2-1 and a international test against New Zealand	Won Test series against Great Britain 3-0	
Rugby Union	Retained Bledisloe Cup , retained Tri-nations Trophy and won Tom Richards Trophy against the British Lions	Retained Bledisloe Cup	World Cup - runners up	
Squash		Qatar World Open winner, Sarah Fitz Gerald. World Open - winner, David Palmer.	World Team Championships - number 1 team	
Surf Lifesaving	World Championships - Gold medal team Goodwill Games - Gold medal team		Won Tri-nations Championship	

1.3.4 The AIS and the State Institutes and Academies of Sport

A key factor in Australia's sporting success to date has been the formation of the State and Territory based institutes and academies of sport (SIS/SAS). These were developed to meet the needs of sports who wanted facilities and support services in the capital cities and

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who did not want athletes to leave home to train at a residential institute like the AIS. The South Australian Sports Institute was established in 1981, and over the next decade and a half all States and Territories founded their own facilities with some emphasis on local needs and the capacity to deliver training and support to athletes and their coaches. The National Elite Sports Council (NESC), which is comprised of the Directors of the AIS and the SIS/SAS, coordinates the activities of the national elite sports network with emphasis on national objectives and harmonisation of programs such as athlete career and education support, talent identification, servicing and research.

1.3.5 Research

A national research program for sport was established at the AIS in 1984. The average annual research budget available for conducting applied research, within strategic guidelines, from 1984 to 1992 was c. \$230,000 p.a., and from 1993 to 2004, this figure was c. \$520,000 p.a. Thus, a total of approximately \$8.3 million has been allocated for the conduct of around 450 research projects. The average cost for each study was c. \$19,000.

Under the Olympic Athlete Program (OAP), some money was allocated for sports specific research in preparation for the Olympic Games in Sydney, and this totalled c. \$12M over the period 1995 – 2000. Similarly, the Australian Olympic Committee (AOC) established a Special Initiative Fund over the 1997 – 2000 quadrennium, and advertised a total of \$7.4M for the conduct of specialised research and development projects to enhance athletes' performances at Sydney. Both these programs ceased after 2000.

Other sources of funding for elite sports performance research are meagre. The Australian Football League made \$100,000 p.a. available for research in 2000, and this has been increased to \$150,000 p.a. recently. Similarly, the Australian Rugby Union has offered \$100,000 p.a. for research – again, a recent initiative.

Larger funding bodies such as the Australian Research Council and the National Health and Medical Research Council do not see research in sport as a priority area for funding.

1.3.6 Other material contributions

Historically, industry has developed products for sport in an isolated, project-based manner, and the uptake by sport has been rather patchy. Examples of this are the development of "Sportwool" by the CSIRO and the "Superbike" which was produced by Bike Technologies together with RMIT in Melbourne. The "Superbike" was so good it was banned from international competition, and doubtless the new technologies it introduced are being incorporated into today's racing bicycles.

More recently, products such as those developed by "GP Sports" for tracking individual athletes have been produced, and these are being marketed to a wide range of consumers in sport – elite and recreational – and games analysis software packages have contributed to products such as "Fair play" and "Sports Code" which are now reaching a wide market in sport.

These products have perhaps lacked an overarching coordinating body which could have promoted the widest possible uptake by Australian sport.

A recent significant contribution to the development of sports technology has been by the Cooperative Research Centre (CRC) for **micro**Technology – established in 1999 – which has brought together a number of universities, industrial organisations and the AIS and SIS/SAS scientists to develop sophisticated devices for real-time monitoring and measurement of activities such as rowing, swimming, boxing, running and team play. With

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an emphasis on commercialising the products developed, the drive to develop novel technological applications for sport has helped to ensure the preparation of Australian athletes is world's best. The investment in this CRC comes from Government and the participants, and the sport applications area runs at a cost of about \$450,000 p.a. At the time of preparation of this report, a new CRC is being proposed with an emphasis on sport, defence and health. The benefits across these three areas are potentially huge, but strategic investment and coordination are needed.

1.3.7 Return on investment

With reference to Tables 1 – 4 and figures 1 and 2 it can be seen that our performances at sport internationally have matched increases in funding to the national sport system. The strategic use of relatively small amounts of money has paid dividends at Olympic Games, Commonwealth Games, World Championships, World Cups and Paralympic Games, to name a few. Importantly, much of this technology is flowing into the broader Australian community.

Figure 1
Australia's Olympic Games Performances 1976 to 2000

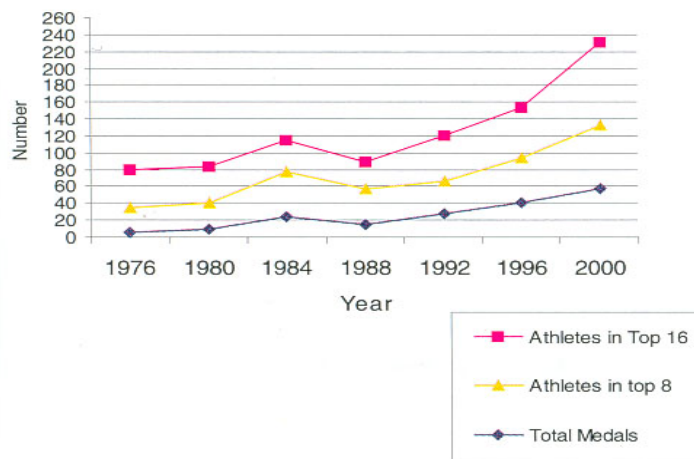
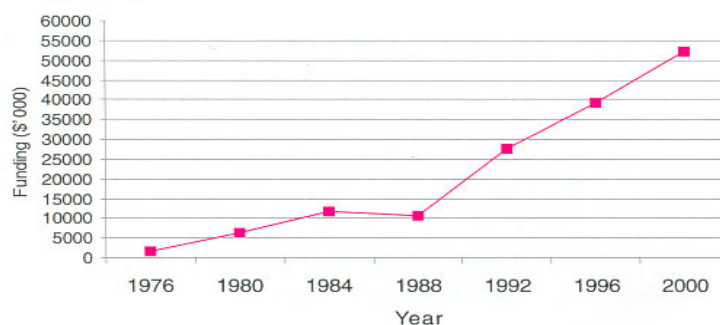


Figure 2
Commonwealth Government Funding to Olympic Sports in Olympic years 1976 to 2000



The drive from successful programs to improve performances and thus maintain our national profile as world's best has resulted in the development of better sports scientists, sports doctors, sports researchers, sports administrators and officials, and, essentially better coaches. Beyond professional education programs have been technological developments which lead the world. A critical mass of scientists and clinicians at the AIS has produced internationally acknowledged biomechanical swimming analysis, research on immune function and exercise, a world's best system for talent identification and the development of equipment such as smart fabric cooling jackets and performance tracking devices for "virtual

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reality” training. An impressive and internationally acclaimed result of sophisticated sports know-how was the development of the drug test for erythropoietin (EPO) by scientists at the Australian Government Analytical Laboratories, the AIS and their research partners which was adopted by the International Olympic Committee for use at the Sydney Olympic Games, and introduced into Australian anti-doping testing programs.

1.4 Summary

It is clear that Australia has capitalised on the modest investment in sport over the past two decades. The strategic application of Government funds, supported by initiatives at key periods by bodies such as the AOC, has paid dividends in terms of international medal winning performances. It is important to acknowledge the roles played by the national network of SIS/SAS and the AIS in leadership and facilitation of national objectives in sport. The establishment of this system has galvanised industry, the tertiary sector and Government bodies to see sport as a critical area for social or economic investment. Underpinning these achievements is the sense of harmony which all Australians have when parochial interests are put aside and the athletes are supported for Australia.

Australians are quick to innovate, research and apply; and the list of technological achievements, developments in programs and services for coaches and athletes, and the sophistication of our sports science and sports medicine testify to the capacity of Australians in sport to provide a return on investment.

2. AUSTRALIAN SPORTING SCIENCE & TECHNOLOGIES FOR ATHENS AND BEYOND

“Go for Gold – Fast followers only compete for bronze”

To prepare for Athens in 2004 and beyond Australia is depending on cutting edge science and technology that can be applied to sport.



2.1 Coordinated use of Science and Technology

In recent years Australia's improved sporting performances on the international stage can in many cases be attributed to the application of science and technology to a particular sport or individual athlete. However, while a contributing factor to our success, this science and technology has been applied in a rather ad hoc way and only arisen in response to specific identified needs.

In most instances the original concept and idea emanated from either the coach/athlete or a scientist with an interest or experience in the actual sport. Projects have been usually been developed in partnership between the AIS and State Institutes, universities and industry.

There is currently no nationally coordinated and strategic approach to the identification of sport's needs, developments currently underway, innovative projects being used, or the commercial and “other industry flow-on” potential and benefits as a result of the technology and outcomes achieved.

What follows are a small number of case studies and examples where science and technology is being utilised in our preparation for Athens.

2.2 Recent Innovative Australian Science and Technology Projects

2.2.1 AIS – RMIT Thermoregulation Garments

Statement of the problem: A rise in core body temperature is recognised as one of the limitations to elite endurance performance. In hot and humid conditions, the environmental heat load adds to the rise in deep body temperature, and so the upper critical body temperature is reached sooner. Pre-cooling can reduce circulatory and thermoregulatory strain, reduce the reliance on intramuscular glycogen stores, as well as reduce the appearance of psychophysical indicators of physical or emotional stress, therefore enhancing exercise performance and increases time to exhaustion under hot and humid conditions.

Background: Following earlier work at the AIS indicating that pre-event cooling can ameliorate increases in body temperature that occur during warm-up, AIS Ice Jackets were produced for a number of sports for the 1996 Atlanta Olympics where the need for acclimatisation to the hot and humid conditions was well known.

At the 2004 Athens Olympics and beyond in Beijing in 2008, hot conditions are likely and could result in reduced performance without adequate pre-cooling. In the period since the Sydney Olympics, the AIS and RMIT have been developing improvements to provide both

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sport specific cooling protocols and new cooling jacket technologies to overcome inherent physiological limitations of ice and frozen gel based cooling vests.

Extreme cooling of the peripheral body regions results in two physiological responses detrimental to efficient pre-event body cooling. One is vasoconstriction which minimizes surface blood circulation as a protective mechanism against cold and maintains or even increases core body temperature. The other is shivering which consumes muscle glycogen stored for increased metabolic rate during the event. Hot athletes using ice vests during games can experience a quite dramatic increase in blood flow to the head, causing discomfort and headaches. There are also practical difficulties with the need for packaging of ice (or frozen gel) into a vest and then replacing it when exhausted.

Method: RMIT and the AIS have applied the emerging technologies of molecular organic and polymeric phase change systems to allow heat to be withdrawn from the body periphery at temperatures closer to normal skin temperatures. Garments have been designed that respond to the specific heat load distribution of athletes under increased circulatory and thermoregulatory strain.

Molecular science provides network polymers that keep the thermoregulation materials (TRM) solid after melting. This is done by using copolymers of styrene and butadiene to provide glassy styrene domains forming physical binding sites linked by elastic butadiene domains to provide a structure that allows melting to occur while the material remains solid.

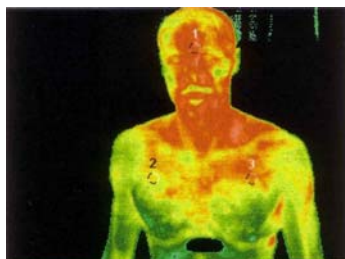
Body heat load distributions have been determined before and after athlete endurance exercise, comparing the prototype AIS-RMIT cooling jacket with the traditional ice vest using high resolution thermal imaging.

Prototype cooling jackets and vests have been produced for a number of sports including: rowing; cycling; shooting; and sport specific pre-cooling techniques designed using quantitative evaluation in heat and humidity chambers and Olympic selection trials.

Testing: A major trial of cooling strategies using teams of elite male cyclists has shown that a combination of two cooling strategies prior to warm up is the most effective in decreasing body temperature and improving time-trial performance in warm conditions of 34°C. Using a cool water plunge plus the AIS-RMIT cooling jacket in ambient conditions of about 37°C provides athletes with a core body temperature, after warm-up under these elevated temperature conditions, at or even below their starting temperature. In terms of performance in a 30 minute time trial, an increase of 2.75% in power and a decrease in time of 41 seconds over the trial has been achieved. At the level of the World Championships or the Olympic Games, the difference between a medal or not, or the colour of the medal, can be a matter of only seconds for a 30–40 km time trial. The potential benefits of pre-cooling are thus profound for our athletes.

Infrared Digital Imaging of Athlete Acclimatisation in High Temperature & Humidity Chamber Using the AIS-RMIT Jacket

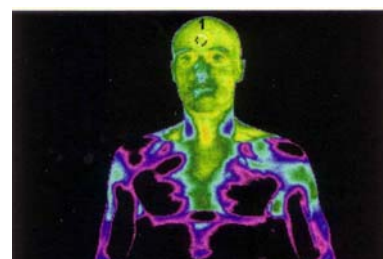
Athlete 1 Employing the AIS-RMIT cooling jacket



(a) Athlete 1 acclimated at 37°C red indicates very hot (38.4 °C)

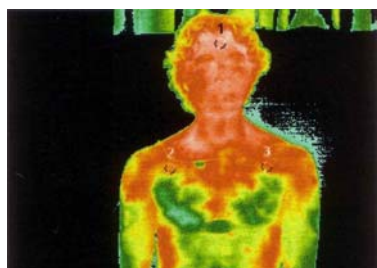


(b) Acclimated at 37°C with cooling jacket on

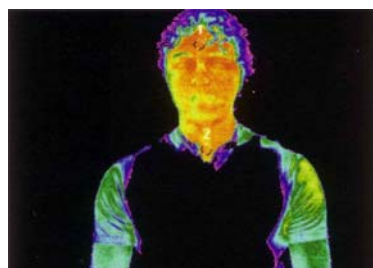


(c) Athlete in chamber after removal of jacket (green indicates cool - 36.6 °C)

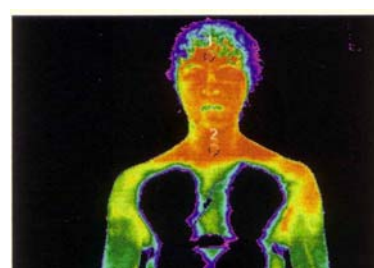
Athlete 2- Employing the AIS ice vest



(d) Athlete 2 acclimated at 37°C



(e) Acclimated at 37°C with ice vest



(f) Athlete in chamber after removal of vest, compare (c)

Prototype AIS-RMIT Cooling Garments



Rower, Dave Crawshay



Dave Crawshay during warm-up



Russell Mark: Olympic shooting Gold Medallist, Discipline: Double Trap

Spin off opportunities: the cooling jacket has other applications and benefits including alleviation of heat effects in multiple sclerosis sufferers and emergency therapeutic cooling of brain injury sufferers. Details and possible commercial opportunities regarding the jacket are discussed further in Chapter 4 of the report.

2.2.2 Virtual Cycling – Athens profiling project

Purpose: The project (a.k.a. project “Deja Vu”) was designed to:

- 1) Allow Olympic cyclists and support staff to experience preparing for, and racing on, the Athens Olympic cycling courses; and
- 2) Produce an image-based system that can be used to familiarise cyclists with the 2004 Olympic environmental conditions and race courses.

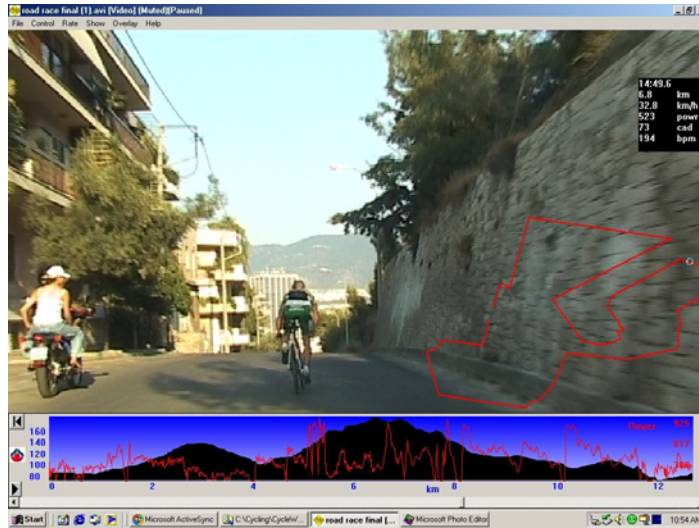
Background: Four Australian cyclists were allowed to ride a lap of the Olympic road and time trial courses at race pace immediately prior to the European Championships held in August 2003.

Methods: During Phase 1 of this project cyclists rode at race pace over the Olympic cycling courses using bicycles fitted with instrumented cranks and a pencil camera. Information on sweat rate, core temperature, environmental conditions, course profile and comments during the ride regarding gear selection and perceptions of the course were collected.

Phase 2 of the project involved developing an image-based system that presents physiological and environmental data collected in Athens with associated video footage. The AIS Performance Analysis Unit produced a DVD allowing the presentation of the course to be modified to suit the individual needs of the cyclists and coaches. This DVD feedback has allowed cyclists to gain repeated relevant exposure to the Olympic road cycling courses through an interactive, image-based feedback system utilising data collected during trial runs in Athens.

Statement of the problem: Unfortunately, the Olympic road cycling courses used for the 2004 Athens Olympics are in the middle of the city and are impossible to access at any time outside of the Olympic competition. The European Road Cycling Championships represented the only opportunity for cyclists to gain experience racing on the 2004 Olympic Course. However, Australian cyclists are not allowed to compete in this event, placing Australian cyclists at the disadvantage of being unfamiliar with a course that can only be ridden at competitive speeds on the day of Olympic competition.

Lack of course familiarity increases the chance that a cyclist will make a mistake during Olympic competition (e.g. poor selection of equipment, pacing problems, inappropriate trajectory for turns, lack of confidence). The Australian Institute of Sport utilised its equipment and expertise to develop an effective image-based feedback system that could be used to familiarise cyclists with the Olympic road cycling and triathlon courses.



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2.2.3 Routine Monitoring of Rowing Performance – The ‘Rover’

Purpose: The aim of this project has been to develop an effective system for routinely monitoring the performance of Australian Olympic rowers during training and competition. Design of the system has focused on the requirements that it must be inexpensive, unobtrusive, ostensibly wireless, easy to use, and able to be deployed on multiple boats simultaneously. Capacity for real-time feedback of information to rowers and their coaches has also been considered necessary, along with logging of the data for later detailed analysis.

Background: Success in rowing at international level requires exceptional muscular strength, endurance and technical proficiency. All major races are contested over a distance of 2000 metres, and winning times are typically between 5¼ and 8 minutes, depending on environmental conditions and boat category. Despite the relatively short duration of the races, rowers train for up to 30 hours per week to develop the necessary physical qualities and skills. Ability to quantify training loads in terms of the boat velocities attained and the levels of stress experienced by the athletes is important to coaches, as is the capacity to document physical and technical progress across periods of weeks, months and years.

Historically, the monitoring of rowers has entailed such methods as simply recording the estimated distances covered, measuring heart rates through use of wearable devices, and attaching impellers to the underside of boat hulls to enable derivation of boat velocity from water flow rates. Occasionally, more precise measurements of boat velocity have been attempted via Global Positioning techniques. Quite elaborate systems for assessing biomechanical aspects of rowing performance have been developed independently in several different states of Australia, but their results have been not been directly comparable, and they have each incorporated extensive cabling as well as components requiring significant set-up time. No system has existed that permits integrated monitoring and recording of diverse performance-related variables for numerous crews on a daily basis.

Methods: Since July 2001, research carried out through the involvement of the Australian Sports Commission in the Cooperative Research Centre for Microtechnology has led to the development of a system that meets all of the original design requirements and incorporates numerous additional features. The system has progressed through several iterations and now provides for monitoring boat velocity 100 times per second, while also enabling measurement of acceleration and deceleration associated with the pulsatile nature of boat movement, stroke rates, the yaw, pitch and roll of the boat and the heart rates of the rowers. Data can be transmitted within the boat and also to a coaching dinghy by wireless mechanisms. Specific variables or groups of variables can be independently selected by rowers and coaches for display during sessions. Software has been produced that enables comprehensive post-processing of the information and its integration with video.

Outcomes: In May 2003, third-generation Rover prototypes were delivered to all senior Australian rowing crews and to two kayaking crews preparing to compete at World Championships, and were extensively used over the following 3½ months. Based on feedback from coaches from athletes, some modifications were subsequently made and more sophisticated devices with upgraded software have now been provided to the crews selected for the 2004 Athens Olympic Games.

2.2.4 Faster Wheelchairs

Purpose: At the Sydney 2000 Paralympic Games the Australian team emerged as the number one nation on the medal tally. The Australian athletics team was the number one nation in this specific discipline. To maintain this ranking the Australian team depends on the application of sport science knowledge to develop equipment that functionally matched the requirement of the individual, and ultimately makes them go faster.

Background: The Paralympic Games are the highest level of competition for elite athletes with a disability. To perform at their best Paralympians utilise sport science and technology to obtain an edge on their opposition. These unique athletes need to precisely execute their movement patterns for the sporting activity, a task that can be complicated by their level of function, and in some cases further complicated by the interaction of their artificial aid such as a prosthesis or wheelchair. In the endeavour to go higher, faster and longer, athletes have found the standard devices can inhibit their sporting performance. Radical equipment designs such as the J-Leg, seated throwing chairs, and running arms have revolutionised the way of thinking in sports science.

Methods: Research has utilised the standard biomechanical measures of technique including range of movement, cadence, interval velocity, angular velocity, average acceleration, start and finish times, and energy expenditure. These measures are made during competition and/or in a controlled laboratory environment.

Statement of the problem: The wheelchair design is a complex issue, having to match the unique physical dimensions of the athlete into a wheelchair that can transfer the generated power from the athlete onto the track in a controlled and efficient manner. Typically wheelchairs are designed to allow locomotion for people who have lost the function of their lower limbs, and the emphasis is on safety. Racing wheelchairs need to be safe, but they also push the boundaries on mechanical efficiency. This can be quantified in both energy expenditure and velocity of the chair.



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2.2.5 Improved prosthetic devices

Purpose: The sporting performance of the Paralympic athlete is highly dependant on the interaction between themselves and the equipment required to compete in their sport. The need for a new generation prostheses was evident with the divergence from standard devices to the "radical" prostheses displayed at the 1992, 1996 and 2000 Paralympic Games. It is expected that at the 2004 Athens games a new generation of prosthetic components will be utilised.

Background: Research on amputee gait has found the standard prosthesis is not appropriately designed and functional, with several limitations such as asymmetry in swing patterns, and a slower walking velocity. Through the use of mathematical models researchers have studied the inertial characteristic of the prosthesis, in an attempt to improve gait symmetry and therefore reduce energy expenditure.

Method: The methodology for this study was divided into four specific sections: (a) To collect baseline biomechanical data on the walking and running gait for trans-femoral amputees. (b) To monitor how the performance of the standard prosthesis changed as the speed increased from walking to running. (c) To develop a mathematical model that simulated the swing phase of the trans-femoral prosthesis, and to provide guidance for a modified prosthetic configuration. (d) To test the modified prosthetic configurations suggested by the model, and compare the performance of each modified configuration against baseline biomechanical data.

Statement of the problem and results: The results of this research found that the standard prosthetic configuration inhibits the running performance of the trans-femoral amputee. With each subject using their same prosthetic components, the configuration of their prosthesis was modified by lowering the prosthetic knee axis. This intervention resulted in improved symmetry between the prosthetic and anatomical limbs, and consequently a significantly faster running velocity. This research has resulted in the enhancement in sports performance due to technological developments in equipment.

The athlete's performance and safety can be improved by applying sport science to guide the direction for modification of their technique and equipment design in a simple, but effective manner.



2.2.6 Analysis of swimming performance

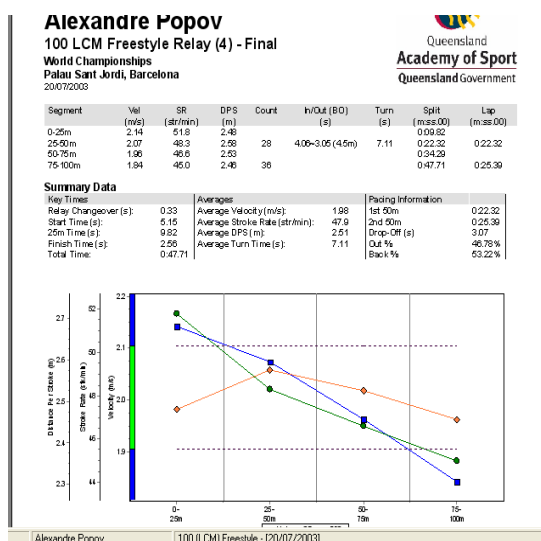
Purpose: To obtain feedback that can ultimately improve swimming performance the coach and swimmer rely on swim race analyses. Such analyses identify what factors contribute to swim performance, and when compared to an opponent, highlight critical performance differences. The purpose of this study was to identify the race strategy used by Olympic and Paralympic swimmers when competing at international competition. This information will enhance the training programs for all swimmers and add to the pool of knowledge for elite swimming programs.

Background: As with other sports, swimming performance is dependent on a number of performance indicators. For example, swimming velocity and stroke length have both been found to decrease throughout the race. Of particular interest to the swim coach is “why does this happen”; is it due to a deficiency in the swimmers level of fitness, or does the problem lie in the race strategy adopted by the swimmer?

Competition or swimming race analysis has become a regular feature at most international swimming events with official video recordings conducted above water during the Olympic Games since 1988. Information on starting, turning and finishing speeds, various race section times and on stroking variables not included in the usual lap spit times provided by the official results are obtained. The factors contributing most to successful performance can then be identified and compared.

Method: A biomechanical video race analysis (Australian format) has been conducted regularly at international competitions. The data are collected using digital video cameras (Sony DCR TRV 900e, shutter 1/125) both located around the swimming pool and if possible suspended from the catwalk 16 m directly above the pool surface. This analysis measures in real time swimming speed, stroke length (SL) and stroke rate (SR) and is used to identify individual race patterns. In addition the analysis captures on video the swimming performance of both the athlete and the opposition.

Statement of the problem: The swimming race strategy that is employed on the day of racing can ultimately dictate the outcome of the swimming performance. Information on what occurred during the event is invaluable for future training and competition preparation. In addition to the objective biomechanical data the visual feedback to the athlete is important. Key issues with this project are access within the pool complex, and a faster way to analyse the information. Real time analysis is currently possible, but this is limited to one swimmer.



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2.2.5 Other innovations

The following table lists some of the innovative projects undertaken in Australia sports science and technology in recent years. It is not exhaustive, but is included to indicate the diversity of areas and industries covered and some of the potential flow on that exists to other areas in Australia and overseas.

Table 5 Recent Innovative Australian Science and Technology Projects

Projects	Potential Application and Markets			
	Elite Results	Public Health	Commercial Potential	Other Industries (eg defence)
Cooling Vests and technology	✓	✓	✓	✓
Virtual Cycling	✓			
Remote monitoring – rowing	✓			
Wheelchair design and construction	✓	✓	✓	
Talent Identification	✓	✓	✓	✓
Electronic Knee Brace	✓	✓	✓	
Cricket biomechanical analysis & technique modification	✓		✓	✓
Nutrition for recovery	✓	✓	✓	✓
Disabled ski design	✓		✓	
Game play analysis	✓		✓	
Injury tracking and prediction	✓		✓	
Remote biofeedback monitoring	✓	✓	✓	✓
Surgical rehabilitation techniques for joint and ligament damage	✓	✓		✓

3. Remaining Competitive Post Athens - Australia's Sports Science and Technology Infrastructure and Capacity

3.1 Introduction

The last three decades of the 20th century marked the complete transformation of Australian sport from an amateur pastime that celebrated and defined the Australian character and culture to a fully professional industry that carries national expectations on its shoulders. These dramatic changes in sport worldwide were driven by the vastly increased revenues that television made available to sport and the associated advertising and promotion that became possible for business as sport dominated television. Both the Olympic sports and Australia's traditional team sports, cricket, netball, tennis and all codes of football have become fully professional.

The establishment of the AIS was a bold step to move Australian sport from amateur to professional status in a focused and organised way with an emphasis on excellence. There is no doubt the AIS has served Australia well as sport has moved to a fully professional era.

A quarter of a century later, Australian sport is again at an important crossroads. The challenges for this new Australian industry in the 21st century are more complex and equally daunting. There is an expectation that Australia will continue to excite us by producing excellence on the world stage.

Sport has also become an industry in the past quarter of a century with vastly increased television and spectator revenues flowing back into individual sports and a huge new market for branded sports products related to elite sportsmen and sportswomen. These markets will continue to develop as an increasingly affluent world chooses to spend its discretionary income on sport and recreation.

In addition the essential Australian lifestyle of a fit, healthy population committed to an active outdoor lifestyle is being challenged by changing work practices and diet. There is emerging expectation that we should apply the knowledge, expertise and organisational skills developed in elite sport to the emerging health problems in the Australian population which largely revolve around decreasing physical activity and an unhealthy diet.

This chapter describes the current Australian sports science infrastructure, its arrangements for commercialisation and proposes the actions necessary to ensure that Australia continues to take a lead role in elite sport - utilising its science and technology to make strong contributions to the health, wealth and well-being of its population.

Clearly equally bold moves to those of 1980, are required to meet these dual challenges to our national sporting identity and lifestyle. The working group believes that these challenges can be met by a greater commitment to sports science research and a new national organisation to plan and deliver this new knowledge to elite sport and the population at large.

3.2 Australian Sports Science Infrastructure

The application of "science" to sport in Australia is generally believed to have commenced with the work of Prof. Frank Cotton, Professor of Physiology at the University of Sydney, who undertook various physiological investigations of sporting performance, developed sports-specific ergometers, and pioneered the use of physiological testing in identifying

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potential sporting talent. He taught and inspired Forbes Carlile, a successful swimming coach who applied scientific principles to his coaching practice.

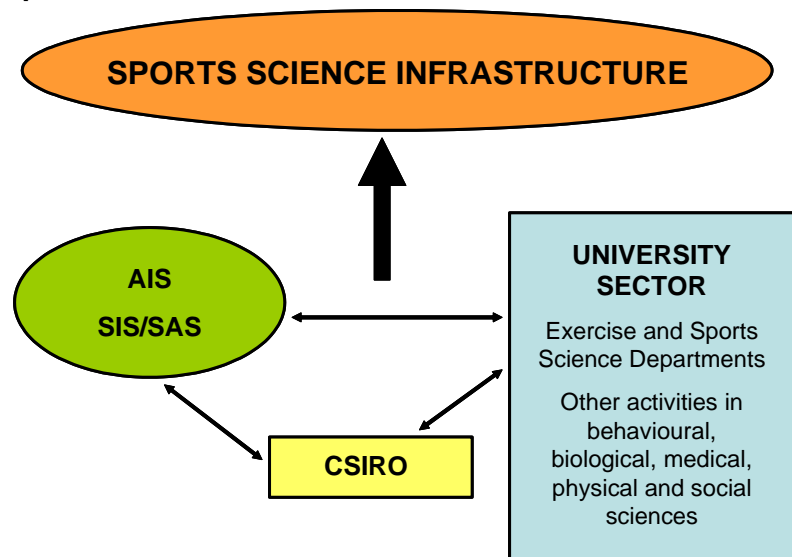
Numerous physical education teacher training programs within the university sector recruited sports scientists in the 1960s and 1970s.

The establishment of the Australian Institute of Sport (AIS) in 1981 and the various State institutes and academies of sport (SIS/SAS) in subsequent years provided increased employment opportunities for sport science graduates and no doubt contributed to increased interest in exercise and sports sciences degree programs within the university sector.

Finally, although CSIRO does not have a discrete sports science division, its expertise in materials sciences, climate monitoring, information technology and health and functional foods has potential application to the exercise and sports sciences.

The current sports science infrastructure is illustrated below.

Figure 3 Sports Science Infrastructure



3.2.1 AIS/SIS/SAS Network

Each of the institutes and academies around Australia are autonomous organisations in the main responsible to their respective State, Territory or Australian Government. As such, there is no formal organisational and operational links between each. However, as a sub-committee of the Standing Committee on Recreation and Sport (SCORS), the National Elite Sports Council (NESC) operates as a communication and facilitation body. NESC allows for the directors of all SIS/SAS and the AIS to meet and work together, ensuring that the high performance sports system can operate effectively across many jurisdictional boundaries. This network of sport science centre capacity contributes to elite sports performance through its athlete testing and monitoring services, high performance analysis and research and development activities.

Within each SIS/SAS and the AIS there are discipline specific national groups established to exchange ideas, share resources and collaborate in research.

A summary of the staffing across the entire SIS/SAS and AIS is presented below.

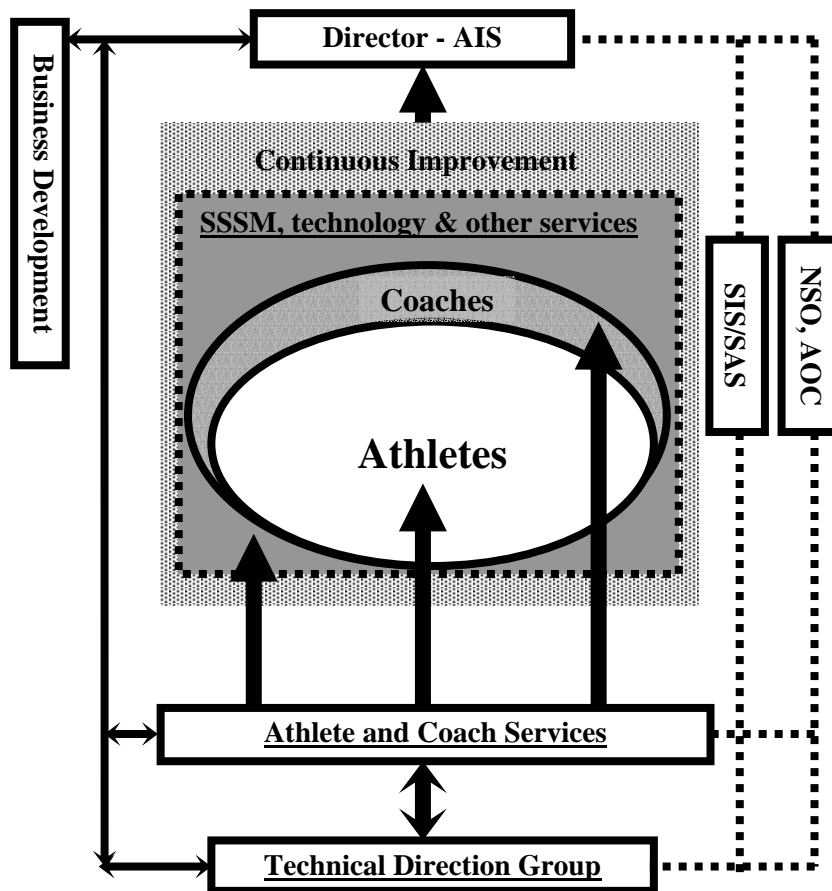
Table 6 SIS/SAS and AIS staffing

Athletes	2003-2004
Full Scholarships	
Individual	270
Program	3715
Total Full Scholarships	3985
Associate/Restricted Scholarships	
Individual	209
Program	287
Sport Programs	
Major	152
Secondary	44
Staffing	
Coaching	
Full-time	226
Part-time*	80
Scientific	
Full-time	109
Part-time*	23.5
Medical/Paramedical	
Full-time	33
Part-time*	17
Strength and Conditioning	
Full-time	21
Part-time*	23
Athlete career & Education	
Full-time	15.1
Part-time*	8
Administrators - Sport Programs	
Full-time	55.5
Part-time*	5
Corporate Staff	
Full-time	64.5
Part-time*	11.2

Internationally the AIS is unique in its structure by having coaches, athletes (residential and non-residential) and service providers all in a single physical location. The AIS is also an ideal environment to conduct research as it is applied to the practical outcomes desired by the coach and needed by the athlete. This opportunity for an applied environment is an essential ingredient for international success on the sporting field but also for the development of technologies that work and can be readily tested.

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Figure 4 Functional diagram of the AIS



The AIS has utilised science and technology for the benefit of its athletes through identifying, developing and applying the latest scientific technologies to athletes' training. More recently this process has become more formalised with the AIS becoming a full partner in the CRC for **micro**Technology in December 2000. Through this partnership, the AIS is entering an era of research that will ultimately allow more efficient and unobtrusive monitoring of athletes exercising and competing with the aid of miniature sensors, radio transmitters and data loggers.

The AIS sports science and sports medicine staff members are some of the world's leading authorities and can be credited with many revolutionary breakthroughs in sport. Among them are the ice-jacket used at the Atlanta Olympics, the 'super bike', Athens cycling course profiling, performance analysis software and systems, the talent search program that allows the AIS to assess potential sporting talent in athletes, and the BOC Altitude House.

The AIS also currently provides undergraduate and graduate students with opportunities to develop their applied skills whilst receiving outstanding supervision and mentoring. At present there are in excess of 20 people in various stages of completing their PhD degree in conjunction with more than 12 tertiary institutions. In order to push forward with a quality assured new generation of sport science and sports medicine the AIS is also identifying ways to promote scholarship in applied contexts at higher degree level.

3.2.3 Anti-Doping Research Programs

The Australian Sports Drug Agency (ASDA) began in 1990 as Australia's first independent anti-doping organisation. While not currently undertaking drug detection research itself, ASDA deters the use of banned doping practices in sport through education, testing, advocacy and coordination of Australia's anti-doping program.

In the lead up to the Sydney 2000 Olympics the increased investment in anti-doping programs and research domestically was a catalyst for increased investment in anti-doping worldwide. This period is noted in an anti-doping context for the 1998 Tour De France and FINA World Swimming Championship (Perth) scandals, where use of substances such as erythropoietin (EPO) and human growth hormone (hGH) was implicated.

Australian researchers were instrumental in ensuring that a detection methodology for detection of EPO could be implemented at Sydney 2000. Since that time Australia has managed to sustain a relatively stable investment (~AUS \$750,000-\$850,000/yr) in anti-doping research while international investment has increased substantially. Organisations such as the World Anti-Doping Agency and the United States Anti-Doping Agency allocate funding in the vicinity of US \$7,000,000 and US \$2,000,000 per annum respectively to anti-doping research.

Currently research into sports drug detection is undertaken by the Australian Government Analytical Laboratories (AGAL) at its Australian Sports Drug Testing Laboratory (ADSTL) and some medical institutes including the Garvan Institute of Medical Research, Kolling Institute of Medical Research and the ANZAC Research Institute. ASDTL is soon to become part of the National Measurement Institute which will have as a key business objective undertaking leading edge research in sports drug detection. ASDTL is also the accredited testing laboratory in Australia with the responsibility of ensuring the excellence of dope testing carried out in the region.

Detection methodologies have developed vastly in recent years to the point where athletes prepared to use illegal performance enhancing means may consider turning away from traditional chemical methods and experimenting with biological methods for doping (e.g. gene doping). Australia's expertise in developing detection methodologies has traditionally been in the area of chemical substances. Awareness of this expertise was heightened recently when evidence of the performance enhancing properties of the designer steroid tetrahydrogestrinone (THG) was proven by Australian scientists. Such evidence is critical to worldwide sport as a means of ensuring that detection methodologies are legally defensible in doping cases.

Deterring banned doping practices is critical to maintaining community confidence in elite sport. Increased attention and investment in anti-doping worldwide has contributed to Australia's improved sporting competitiveness and performance both on and off the field of play. The field of play is increasingly becoming more level as evidenced by the relative "slowing down" in times and distances across the board at international events. Also Australia's expertise in the field of anti-doping research has been recognised internationally.

The opportunity to continue to lead the world in this area of research, maintain technological competitiveness and collaborate in the imminent development of detection methodologies for looming doping practices is contingent upon Australia's continued commitment to this issue.

3.2.4 Universities and Higher Education

The exercise and sport sciences are well represented within the Australian higher education sector and Australian universities offering discrete programs in exercise and sports sciences are listed below. In 2003, there were ~11,600 enrolments in undergraduate exercise and sport sciences programs and ~1500 in postgraduate programs (DEST, 2004). In general, these academic programs have evolved from physical education teacher training programs and increasingly teaching and research staff members are recruited from the basic behavioural, biological, physical and social sciences. In addition, other exercise science and sports medicine-related activities are scattered across the sector in medicine, physiotherapy and science faculties. Finally, there are contributions from the basic science, engineering and technology programs to various sports science applications.

The university sector is generally well connected with the elite sports science network and there are numerous examples of collaboration between AIS/SIS/SAS and universities. For example, the AIS has received ARC Linkage research support in partnership with RMIT and VUT, the VIS undertakes sports science research with several Victorian universities, the QAS has recently established a Centre of Excellence in Sport Science to promote research links between it and the university sector, numerous tertiary students undertake placements within the AIS/SIS/SAS network and most of the sports scientists employed within the AIS/SIS/SAS network are graduates of Australian tertiary institutions.

Table 7: Universities offering programs in exercise and sports sciences

Australian Catholic University	University of Canberra
Bond University	University of NSW
Central Queensland University	University of Queensland
Charles Darwin University	University of South Australia
Charles Sturt University	University of Sunshine Coast
Deakin University	University of Sydney
Edith Cowan University	University of Tasmania
Griffith University	University of Technology Sydney
James Cook University	University of Western Australia
Queensland University of Technology	University of Western Sydney
RMIT University	University of Wollongong
Southern Cross University	Victoria University of Technology
University of Ballarat	

Funding for exercise and sports science research within the university sector is derived from several sources, although it is generally not well coordinated. The ARC provides research support under a Human Movement and Sports Science category (5 grants over the last 3 years), although other related exercise research is funded in other categories (e.g. biological sciences). Similarly, the NH&MRC has funded numerous projects in the exercise sciences, usually with a more clinical and public health focus. Approximately \$600,000 per annum is allocated within the AIS/SIS/SAS network for research and some of this work is undertaken in partnership with universities.

The tertiary sector has experienced significant growth in international fee-paying students, such that higher education is a major source of “export” income. The recent establishment of an International Centre of Excellence in Sports Science and Administration recognises the potential growth in exercise and sports sciences education, linked to Australia’s track record in hosting, and performing well at, major sporting events. Commercialisation of exercise and sports science research has generally been less successful and previous CRC

bids in this area have failed. However, as mentioned previously the AIS is an active participant in the CRC for **micro**Technology.

The TAFE sector also provides training opportunities in the exercise and sports sciences, with an emphasis on sports coaching and the fitness industry. Consistent with the vocational focus of this sector, exercise and sports science research is negligible.

3.2.5 Exercise and sports science professional groups

Sports Medicine Australia has been a multidisciplinary “umbrella” organisation for a number of the exercise and sports science professional groups including the Australian Association for Exercise and Sports Science (AAESS), Sports Dietitians Association and groups with interests in sports psychology, physiotherapy and podiatry. It also holds conferences with the Australasian College of Sports Physicians. These various bodies cater for both academics and professionals in exercise and sports science practice.

3.2.6 CSIRO

CSIRO is primarily focussed on the minerals, agricultural, environmental, and health sectors. The organisation is defined by its contributions to industry delivery on major flagship programs such as *p-Health*, *Energy Transformed*, *Wealth from Oceans*, *Water for a Healthy Country*, *Light Metals*, *Food Futures* and responding to the National Research Priorities. Despite service industries contributing to around 80% of the economy CSIRO has only a limited amount of direct research in those areas, and sport has not been one of the organisation’s prime areas of focus.

However, CSIRO has a number of technologies that could, and have been applied to various areas of sport. At present CSIRO is attempting to identify a coordinator to provide oversight of its sports related research activities. With the organisation committed to running with its current set of flagships until at least 2007, it is unlikely that in the short term there would be a major targeted effort in relation to sport.

Some examples of CSIRO related research and its application to sport include:

Sportwool

A high-tech multi-layer fabric for active sports draws moisture from the skin. 5,000,000 metres were sold in 2003. CSIRO co-own the trademark with Woolmark with manufacturers needing a licence to call their product Sportwool.

Intelligent knee sleeve

Conducting fabric sensor provides “on-line” measurement of knee angle during landing training for AFL players to improve landing techniques and help prevent anterior cruciate ligament injuries, which are a frequent and very serious problem in a wide range of sports. There is potential for other joint sensors building on the knee sleeve technology

Tailored weather forecasting

CSIRO technology was utilised in high resolution forecasting of wind speed and direction for the Alinghi syndicate in the 2003 America’s Cup regatta as well as for the Holden Racing Team at Bathurst in 2003. This technology could be applied to any outdoor sporting event.

Air quality forecasting

An air quality forecasting system was developed for Sydney Olympics and potentially for the Beijing Olympics 2008.

Ocean forecasting and current modeling

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The ocean forecasting maps developed by CSIRO and used by ocean race organisers (eg: 2003 Sydney-Hobart Yacht Race) could also be applied to a wide range of marine sports.

3.3 Commercialisation of Sports Science and Technology

If Australian sports science and technology is to be widely adopted it needs to be effectively commercialised.

The rapid adoption and take-up by a broader base, far beyond the elite athlete into the realm of the amateur and enthusiast creates an outstanding opportunity for export business activity. Commercialisation enhances the opportunities for “spill-over” opportunities with the roll out of new technology approaches in schools and in healthcare to include the well being of the broader population and ultimately health and activity management of the aged.

Australia commands a world leading position in technology beyond that directly employed on athletes. Australian value-add sports technology and equipment is in high demand on the global stage with notable examples of internationally successful SME businesses such as:

- Sykes Boats and Croker Oars - world leading manufacturers of rowing equipment;
- Bike Technologies Australia - manufacturers of carbon fibre racing bikes and ergometers;
- GP Sports and Citech for position and performance monitoring; and
- Motec wireless instrumentation in Formula One motor racing.

Australia also leads the way with revolutionary sports television approaches in a multitude of sports including motor racing, cricket, swimming and golf to name a few.

The CRC for **micro**Technology has formed a joint venture (SportzCo Pty Ltd) with the Australian Sports Commission (ASC) to commercialise sport technology resulting from their joint research program. Early identified opportunities include devices for rowing, swimming and team sports for not only the elite athletes but the broader community including sporting media and health in the home applications.

The proposed new organisation will have a clear role and resources for effective commercialisation. This will entail a number of channels, such as:

- Working with SMEs (new and existing) to create business outcomes from the new entity;
- A preparedness to license, joint venture, partner or take equity in new businesses, while recognising that some of these entities will fail;
- The creation of export orientated products and services;
- Seek out applications into related field such as defence or health;
- Conduct educational programs around the new research outcomes; and
- Be prepared to disseminate knowledge widely.

An entity with appropriate resources focused on the research, development and commercialisation of new sports science and technology will be very attractive to the investment community.

A Practical example: Polar Heart Monitors (Finland)

- Basically simple technology, mass market, moved from the realm of serious athletes into the consumer market
- Global business
- Founded in 1977
- World leader in manufacturing sports instruments and heart rate monitoring, registering evaluation equipment
- Polar products represent the state of the art in heart rate measuring devices for athletic training, fitness, rehabilitation and weight management
- Operates in 50 countries
- Employs 1,400 people
- Net sales in 2002 Euros144M, approximately A\$300M
- Main markets are in Europe and North America

3.4 The Next Generation of Australian Sporting Excellence

The establishment of the AIS in 1981 is acknowledged as being one of the most significant steps taken in the last thirty years to re-establishing Australia as an international sporting force, following the disastrous performance of the Australian team at the 1976 Montreal Olympic Games.

As often occurs the failures of our 1976 Olympic team proved to be the impetus needed to stimulate and drive change. Other areas in this report cover the specific contributions made by the AIS over the last two decades, but the strategic deployment of specific resources such as athlete support, elite full-time coaching and dedicated sport science and medicine, in an environment quarantined and protected from the petty politics and amateur administration of sport at the time were significant elements that contributed to today's successful elite sport structures and systems.

If Australia is to maintain its internationally enviable position as a leader in elite sports systems and structures we must never rest on our success, but rather strive to seek new areas to improve and develop. Our international competitors are currently redeveloping their own structures and systems based on the "Australian Way", and since the Sydney Olympics dozens of Australia's elite coaches, scientists and administrators have been recruited and headhunted for positions overseas. It is only a matter of time before our international competitors replicate the elements of success we have benefited from for the last decade.

3.4.1 The Next Steps

Despite the undoubted successes of the last two decades the working group sees some similarity between the operational elements of our sporting system of the 70's and the current approach we are using in areas of sports science.

There is little coordination, poor strategic development, a lack of resources, limited accountability and an ad hoc approach to the identification, development and commercialisation of innovative ideas.

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The challenge of the 21st century for Australian sport is how to maintain our pre-eminent position in the world's elite sports systems.

Just as the AIS provided a structure for sport to focus, direct and manage resources, it is now accepted by the working group that Australia needs to establish a similar entity responsible for the strategic coordination of sports science and research.

Clearly, bold moves equal to those of 1980, are required to meet the dual challenges to our national sporting identity and lifestyle. The working group believes that these challenges can be met by a greater commitment to sports science research through a new national organisation. This entity will distribute increased resources, oversight all elements of sports science, including identification of innovative concepts, development of projects, facilitate communication between all stakeholders including academia, industry, Governments, sports and other research institutions, and the commercialisation and deployment of successful research outcomes to plan and deliver this new knowledge to elite sport and the population at large in the following way.

3.5 Centre for Australian Sports Innovation, Science and Technology (ASIST)

One of the outcomes of the science and technology in sport working group is the realisation that there is not a focus for the development, commercialisation and implementation of sport and technology developments in Australia. Much of the development has been ad hoc or (as is more often the case) the result of personal contacts and collaboration. While Australian success in this area is not disputed, the current process has meant there is no strategic development, expansion and building upon current and past success.

It is proposed that the Centre for Australian Sports Innovation, Science and Technology (ASIST) be established.

It is further proposed that ASIST be co-located at the AIS in Canberra so as to capitalise on its world renowned programs and reputation.

ASIST model

Aims

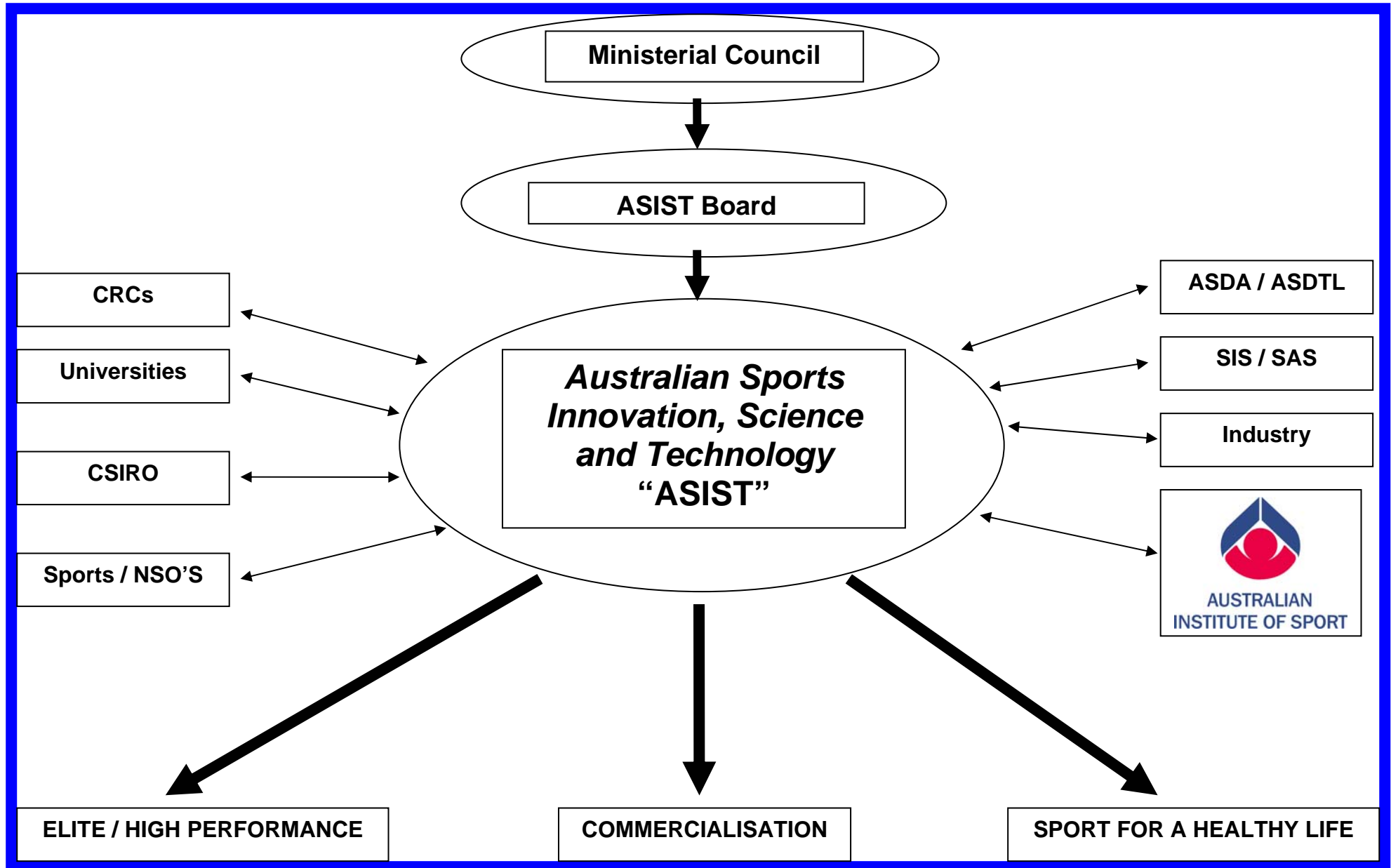
1. To provide members and stakeholders with strategic direction and support in the development of sport and technology
2. To enhance Australia's international reputation in sport and technology
3. To recognise and promote sport and technology benefits for the community

Roles

- Positioned as a centre for a coordinated approach to research, innovation and application of technology in sport
- Deliver a nationally coordinated approach which provides a unique focus for Australia and the rest of the world
- Establish a national sport and technology critical mass for the development, commercialisation and dissemination of benefits to the community
- Work with the ICE for Sports Science and Administration
- Facilitate, direct and promote:
 - Research;
 - Communication;
 - Commercialisation; and
 - Community practice
- Promote Australia's interests in staying at the forefront of elite performance and providing flow on benefits to Australia as a community
- Promote the commercial opportunities and benefits of the Centre's activities whilst valuing social and cultural gains
- Allocate research and business grants for administration, education, commercialisation, and other operational functions
- Establish three primary areas of co-operation:
 - Elite sport;
 - Commercialisation; and
 - Sport for a Healthy Life

Structure

- The Centre will have a Board of Management with a mixture of skill based members and those representing sport, science, medicine, technology, commercialisation and research.
- Partners in the Centre shall be drawn from the AIS, SIS/SAS, universities, sports such as AFL, Rugby Union (and others with a commitment to the promotion of applied science in sport), ASDA, CRCs, industry (such as CSIRO, Telstra, sport apparel manufacturers), amongst others with similar objectives.
- Co-located with the AIS in Canberra - trading on the profile of the AIS as the world's premier national institute which applies science to sport, in partnership with a national network of State and Territory based institutes and academies of sport



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Figure 5 ASIST Model

Recommendations

Improved Science and Technology Application and Elite Sports Performance

Recommendation One

Establish the Centre for Australian Sports Innovation, Science and Technology (ASIST) – a body incorporating the AIS, State Sports Institutes and Academies, Universities, ASDA, CSIRO and other relevant bodies - to provide a proactive focused approach to research, innovation and investment in the application of technology in Australian sport at all levels.

Centre for Australian Sports Innovation, Science and Technology (ASIST)

Fund the Centre for ASIST to direct, coordinate, develop, commercialise and implement sport science and technology developments in Australia.

Currently the considerable amount of sports science and technology infrastructure in Australia is uncoordinated, with little or no strategic planning capacity to capture future opportunities. In most cases (minimal) successes have resulted from personal contacts and collaboration. An adequately resourced national body is urgently required to take a proactive role in the strategic planning, funding and direction of research, its commercialisation and the adoption of Australian sports science and technology.

The Centre for **ASIST** will:

- Plan, coordinate and distribute funding for sports science and technology research across its members for the enhancement of Australia's elite sporting capacity
- Identify and promote the commercial opportunities and benefits of Australian sports science and technology
- Facilitate and promote the use of appropriate elite sports science and technologies in physical activity to benefit the health and well-being of all Australians

Prioritising Sports Science Research

Recommendation Two

Introduce “sport” in Australia’s National Research Priorities as a fifth sub-priority – “*Sport for a Healthy Life*” - under the major priority “Promoting and Maintaining Good Health”.

Sport for a Healthy Life

Utilise sports science and technology to ensure that the Australian population achieves and maintains the level of physical activity necessary to reverse the current trends towards obesity and weight related diseases.

Levels of physical activity within Australian society by both our young and ageing subpopulations have decreased dramatically in the last decade and threaten to adversely affect the nation’s health and medical expenditure in the next two decades. These decreases are believed to be a strong contributor to the alarming rise in obesity within the Australian population. Continuing developments in exercise physiology, sports medicine, psychology, and sporting equipment at elite levels in sport have the potential to encourage safe, healthy participation in activities across the broader community. Such participation has the potential to dramatically decrease the incidence of diabetes, osteoporosis and heart disease attributable to obesity, and perhaps to enhance the mental health of our population.

Commercialisation

Recommendation Three

Through the Centre for ASIST exploit commercial opportunities, including “spin-off” commercialisation companies, of elite and community-based sports science, engineering, technology and services through incentives for investment and coordination with industry.

Commercialisation of Australian Sports Science and Technology

Australian sports science and technology, developed to enhance elite performance, has untapped potential to be effectively commercialised through wide adoption within the workplace and recreational sporting communities globally.

The rapid adoption and take-up by a broader base, far beyond the elite athlete into the realm of amateur and enthusiast offers outstanding opportunities for export business activity. Commercialisation enhances the opportunities for “spill over” opportunities with the roll out of new technology approaches in schools and in healthcare to include the well being of the broader population and ultimately health and activity management of the aged.

The commercialisation arm of the Centre for **ASIST** will:

- Identify and facilitate commercial opportunities for Australian sports science and technology
- Engage with SMEs in developing commercial opportunities
- Promote the adoption of these sport-based services and technologies to other physically demanding industries including defence and agriculture; and
- Accelerate innovation, competitiveness and growth among its member businesses and organisations

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Recommendation Four

Provide incentives that support the export of Australian sport science, engineering and technology to:

- **Maximise business and trade opportunities, as well as**
- **Provide assistance to developing countries as part of our regional and global aid program**

Sport Science and Technology in the Asia-Pacific region

Adopt a global perspective to maximise the potential benefits of commercialising Australian achievements in sport science and technology.

The export of products and services derived from developments in Australian sport science and technology generate income for Australian businesses and individuals and also generate returns in the form of an enhanced reputation for Australia as a country of excellence in sport science and innovation. As well as direct trade in sport products and services these commodities can support Australia's aid programs by being provided to developing countries and contribute to a positive image of Australia as a healthy, innovative and responsible regional or global citizen, eventually translating into longer term spin-off benefits.

In recent years the Australian Sports Commission has been active in the region, undertaking work in Nigeria, Malaysia, Singapore and India. However, further opportunities exist for Australian sport science and technology in South East Asia where there is considerable interest not only in the AIS as a model for increasing performance at Olympic Games and other international competitions but also in our school sport programs.

Australia is already capitalising on the success of the Sydney Olympics with a number of contracts for goods and services being provided for the Beijing Olympics - including the design contract for the new Beijing Olympics swimming centre and surfaces for the soccer playing fields in China. A number of Australian firms are also focusing on opportunities in China.

The Centre for ASIST should work with the International Centre of Excellence (ICE) in Sports Science and Management, (announced in the 2002-03 Budget), to build further on these opportunities.

4. Sports Science and Technology Benefits for the Health and Well being of All Australians

4.1 Introduction

Australia as a nation is facing the threat of a widening gulf developing between the levels of excellence in physical performance we expect of our elite athletes and a declining level of health and fitness in the general community. This chapter in addressing the group's terms of reference explores the opportunities to apply knowledge and technologies developed in the elite sports programs to the improvement of the general health and well being of the community.

Australian sports science has made a significant contribution to community sports participation in recent years by making sport safer, rehabilitation from injury quicker and involvement in activities more rewarding regardless of the standard of the participants.

The working group believes that current and future developments in sports science and technology can make significant further contributions to the health of Australians by encouraging participation in physical activity through:

- making sport and physical activity more enjoyable and rewarding
- reducing the incidence of sports injuries
- improving the treatment and rehabilitation of sports injuries using the best medicine available
- using sports science and technology to strengthen the link between physical activity and health
- ensuring the latest sports science and technology is available in the workplace and community through efficient commercialisation (*Chapter 3 above*)

4.2 Health and Fitness Challenges to the Australian Community

4.2.1 Obesity Crisis

Australian Society is facing a rapidly expanding health crisis of increasing obesity that will become a major community and societal cost over the next 10 to 20 years.

The rising levels of obesity appear to result from both exercise and dietary factors. Over the last two generations, activity levels have been reduced by technological changes in the work place and the domestic environments, together with more sedentary recreational habits. Dietary influences of well promoted processed foods and drinks have led to a higher readily available energy intake through consumption of refined carbohydrates with a high glycemic index. Coupled with an increased overall energy intake this type of diet can, and has contributed to obesity, resulting in an increased risk of heart disease and diabetes. (Jenkins et al. 2004).

4.2.2 Rising Levels and Costs of Obesity

In the decade leading to 2001 there was an alarming rise in obesity within the Australian population. The proportions of males classified as overweight or obese rose 26% from 1989 to 2001, while for females it rose 31%. The rate of increase of

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obesity rose with age. In the 45 to 74 year old 'baby boomer' cohort, 68% of men and 59% of women were overweight or obese (2001 National Health Survey).

Childhood obesity is of even greater concern. The last data collected in 1995 showed the trend in childhood obesity had doubled over the previous 10 years. A recent survey of 1000 Victorian country children, aged 4 to 12 years revealed 27% were overweight or obese, including 30% of the children aged 4 years (Bell et al 2003).

The economic costs of obesity are high and rapidly increasing. In 1992-3 the direct cost of treating obesity was estimated to be \$840 million, or over two percent of the Australian health budget (Segal 1994 in NHMRC 2003; NHMRC 1997). Updated estimates for 1995-96 suggest obesity costs between \$680 – 1,239 million in Australia (NSW Health 2000). This does not include the indirect costs of associated loss of income and productivity or the intangible costs to individual health and reduced quality of life.

In 2000 the Australian Institute of Health and Welfare (AIHW) calculated that obesity contributed to four percent of the total burden of ill health in 2000 (NSW Health 2000).

The long term health implications of these dramatic increases in the proportions of the Australian population that are overweight or obese have some serious implications for the health system. This obesity crisis needs to be tackled on all fronts including diet, but increasing levels of physical activity for all ages appears to carry the greatest benefits. The nature of these benefits is outlined below.

4.2.3 Participation in Physical Activity

The 2002 Participation in Exercise, Recreation and Sport Survey reported an encouraging 77.8% Australians over 15 years engage in at least one physical activity a week. This level decreases with age but over half participate in an organised activity (club or association). Comparisons with other countries are difficult due to statistical differences.

Despite these figures, fewer than half of the Australian population meets the lower threshold of 150 minutes of moderate activity per week that can produce a health benefit. About 15% of the population is completely or almost completely sedentary. The proportion of the population undertaking sufficient physical activity has been declining. About 90% of Australians believe their health could be improved by being more active (Bauman et al 2002).

Reduced activity levels are a major contributing factor to increased obesity in our society. Lowered numbers engaged in sports participation can impact on the general health of the community, and it also reduces the general talent pool from which our elite athletes are chosen.

4.3 Long term health benefits from early and continuing participation in health enhancing physical activity

Participation in physical activity can have significant benefits for the health and wellbeing of individuals in the community. However, it is only recently that physical activity has been recognised as an important public health issue. In 1996 the US Surgeon General (USDHHS 1996), collated the evidence available to support the

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role of physical activity in improving health, endorsed and further expanded existing levels of acceptance of physical activity as an area of major concern to public health.

The report on Ageing to the 10th PMSEIC Meeting also noted “Physical activity can contribute to healthy aging in a variety of ways, reducing the impact of age related physiological changes, reducing the risk of common chronic diseases, and assisting with management of certain chronic diseases and the prevention of disability”.

Physical activity reduces the risk of heart disease, stroke, diabetes, high blood pressure and colon cancer. It can assist in the prevention of osteoporosis and obesity (and associated risk of diabetes and heart disease), improve muscle strength, balance and flexibility and reduce falls.

At all ages, people who participate in moderate to vigorous levels of physical activity have lower mortality rates than those with sedentary lifestyles. The effects of physical activity on reducing premature mortality have been shown to be both strong and consistent, across studies and diverse populations (Lee & Skerrett 2001; Stessman et al 2000; Villeneuve et al 1998).

The particular benefits are outlined below:

Disease Prevention - Physical activity is an important factor in the prevention of many chronic diseases. Indeed participation in physical activity can reduce the risk of mortality and morbidity from cardiovascular disease, type 2 diabetes, breast and colon cancers, and morbidity from some injuries. It has also been shown to have a beneficial effect on mental health, reducing the symptoms of depression, anxiety and stress. (Population Health Research Centre, ACT Health, 2002)

Cardiovascular Disease - The relationship between physical activity and decreased risk of coronary heart disease is extremely robust (Manson 2002; Williams 2001; USDHHS 1996; Berlin & Colditz 1990; Powell et al 1987). Participation in as little as 150 minutes of moderate physical activity is ‘sufficient’ to reduce risk of coronary heart disease by up to 40% (Bull et al in prep; Williams 2001) and participation in more sustained, or vigorous activity, may further reduce risk.

Type 2 Diabetes mellitus - Benefits of physical activity are strongly supported in the prevention and treatment of type 2 diabetes (Kelly & Goodpaster 2001; Ivy et al. 1999). It is estimated that 30 to 50% of new cases of type 2 diabetes could be prevented by appropriate levels of physical activity (Manson & Spelsberg 1994).

Cancer - A large number of cohort and case studies provide evidence for a relationship between physical activity and reduced risk of developing some forms of cancer. Participation in at least moderate levels of physical activity results in a decrease in the risk of site-specific cancers among men and women, and a reduced risk of cancers amongst men (Thune & Furberg 2001; McTiernan et al 1998). Meta-analysis shows that the relative risk of colon cancer among inactive men and women is around 1.7 times that of physical active men and women (Bull et al, in prep). Like wise, meta analysis also demonstrates that women who are moderately active can reduce their risk of breast cancer by over 20% (Bull et al in prep).

Osteoporosis - Osteoporotic fractures and falls are on the increase. It is predicted that, at the current rate of increase, a doubling in the number of hospital beds will be required by 2020 in NSW (NSW Obesity Forum (1999). Bone cross sectional studies show that participation in physical activity is positively associated with bone density (Drinkwater 1994) and weight bearing activity is important in the development of peak

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bone density in adolescents (Welten et al. 1994) and for middle aged women (Zhang et al 1992).

In 1992 the annual direct costs to Australia associated with osteoporotic fractures were assessed, and estimated to be \$779 million. Rehabilitation comprised the largest proportion of costs for hospital-treated fractures, and community services were the largest cost for outpatient-treated fractures. These estimates do not include the personal costs of loss of independence and mobility.
(www.mja.com.au/public/guides/osteo/magntude.html).

Mental Health - Studies consistently show that participation in physical activity reduces symptoms of stress, anxiety and depression (Hassmen et al 2000; Glenister 1996; Paffenbarger et al 1994; Petruzzello et al. 1991) and physical activity is recognised as an evidence-based treatment for clinical anxiety and depression (Bauman & Owne 1999). Participation by individuals can help improve quality of life in children and adults (Hassmen et al 2000; Laforge et al 1999; Morans & Mohai 1991), promote positive self image amongst women (Mazwell & Tucker 1992), enhance social skills in children (Evans & Roberts 1987) and build self-esteem (Sonstroem 1984).

4.4 Role of Sports Science Technology and Medicine in encouraging greater participation in Physical Activity

Fear of permanent injury and the time taken to rehabilitate sports injuries are major impediments to participation in sport and physical activity. Sports science, technology and medicine have contributed much to making sport safer and treating sports injury when they occur.

4.4.1 Sports Safety

Specific examples of the applications of elite sports science for safer sport at the community level now and in the future are:

Cricket

The analysis of fast bowlers' lumbar spine injuries has led to identification of the bowling styles that create greater risk for spinal injury. Coaches at all levels can reduce injury rates by correcting bowling styles or teaching young cricketers safer technique from the beginning.

Cricket helmets were developed in Australia following a modified motorcycle helmet design brought to the country by English Cricketers in 1977/78 when the World Series Cricket added a new emphasis on professionalism to International Cricket. It was Australian innovation and technology that developed an accepted, functional and safe helmet that led to the common usage at all levels of cricket today.

Netball

Netball has traditionally had a high incidence of ankle sprains and anterior cruciate ligament ruptures in the knee. Extensive work on jump-landing and balance techniques have created preventative programs for all netballers that will make this popular sport safer.

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Controlled Exercise using Heart Rate Monitoring

Heart rate monitors were initially used to assess the physiological effect of physical performance on the heart. Elite athletes subsequently used them as a guide to maximise the benefits and efficiency of training. Now this technology and application has reached the recreational athlete who wishes to monitor exercise levels to gain greatest benefit within a specific zone of cardiac performance.

Alleviation of Heat Effects in Multiple Sclerosis Sufferers and Emergency Therapeutic Cooling of Brain Injury Sufferers

AIS-RMIT cooling jackets are being evaluated for alleviation of the adverse effects of heat found in up to 80% of MS sufferers. In a preliminary trial, the AIS-RMIT cooling jacket has shown to be advantageous without the disadvantages of conventional ice vests. Currently the first purpose-designed cooling jacket is being fabricated to carry out an initial study of the beneficial effects on a MS patient, in preparation for a detailed trial.

The athlete cooling jackets will also be evaluated for their potential to provide an initial reduction in the core body temperature during on-site and emergency transport and improve outcomes for head trauma and stroke patients.

New Technologies for Safer Sport and Physical Activity

Some of the above technologies are currently being used in recreational sport and physical activity. There is a new generation of monitoring technologies being developed for elite sport utilising microtechnology and wireless communication that will have equal applicability to recreational sport if properly commercialised. A sample of these technologies is outlined in table 8, which largely deals with monitoring technologies.

Table 8 Monitoring Technology

Current technology for remote real time monitoring:	
<ul style="list-style-type: none">• Heart rate• Distance travelled – number of paces/steps• Duration of activity• Velocity and position of athletes (and their equipment) in training and sporting events	
Future remote real time monitoring:	
<ul style="list-style-type: none">• Blood Pressure• Sugar levels• Temperature – core and skin• Degree of perspiration• Breathing rate• Respiratory gases• Breathing efficiency• Sprightliness – spring in step• Point of fatigue	<ul style="list-style-type: none">• Brainwave activity – (loss of interest/fatigue)• Duration of activity• Intensity of activity• Total activity/work• Energy consumed• Ambient environmental conditions – temperature, humidity, wind, etc• Global position• Terrain (up hill down hill)

These new monitoring technologies identified above will not only make physical activity safer through providing real time feedback to participants on their position and physiological state but will also emphasize the links between physical activity and health. The real time health measurements that will become a reality in the near

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future will bring health measurements routinely into the domestic environment and make them a greater part of everyday life.

4.4.2 Sports Injuries

The National Health Survey in 2001 found that 1.9% of the population reported a recent injury as a result of participating in sport. Medibank Private Sports Injuries Report quotes that sports injuries are costing Australians \$1.5 billion annually. The report also states that men and women aged between 15 and 29 are twice as likely to incur a sporting injury that requires medical attention. In Victoria alone there are at least five deaths, 6500 hospital admissions and around 30,000 emergency department admissions every year due to sporting injury.

To quote the report: “The football codes, cycling, cricket, basketball and netball ranked as the most injury prone sports. Surprisingly some sports generally perceived to be of lower impact, like dancing, are among the causes of hospital admission, demonstrating that just because a sport is not “high impact”, the chances of injury are not eliminated.”

The report further found that \$20 million is claimed by Medibank Private members each year for knee surgery alone. Therefore provision of good medical support for the sporting community is important

4.4.3 Professional Treatment and Prevention of Sports Injuries

The creation of specialised professional groups such as the Australasian College of Sports Physicians (ACSP) and Sports Physiotherapists of Australia (SPA) has dramatically improved the provision of medical expertise to the general public. Many members of these groups work with elite teams, but also provide services for the recreational athlete that enable a high level of expertise together with ACSP’s and SPA’s educational training programs to be available to the community at large.

The ACSP was established in 1985 and has developed the first comprehensive sports physician training program in the world. This is now used internationally as the preferred model for the specialty-training program of doctors in sport. The ACSP provides and demonstrates world leadership in this field.

Surgical support for athletes incorporates all the significant improvements developed internationally to return the athlete to participation promptly. The use of arthroscopy and fracture internal fixation facilitates recovery and reduces morbidity.

Australian physicians and researchers are world leaders in the development of innovative treatments for patella tendonopathies, chondromalacia patella, hamstring injuries and osteitis pubis. These procedures have all been generated from elite sports institutes but are now available to all community sports people or injured workers. A key factor in the implementation of these treatment regimes has been the holistic approach of the medical and paramedical personnel involved.

Injury prevention and management practices developed at the elite level have considerable potential to increase the safety and enjoyment of community participants in sport. The well accepted methods such as warm-up and stretching, maintenance of optimal fluid intake or the first aid use of the RICE regime (Rest, Ice Compression and Elevation) all have originated from science and medical experts attempting to improve the performance of champions.

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4.4.4 Education of Coaches and Sports Trainers

The Australian Sports Commission has recognised the importance of education programs for coaches and sports trainers to improve the safety and enjoyment of sporting programs. This provides the essential conduit for the spread of scientific improvements gained at the elite level. Team sports have developed modified rules for children to participate at an early age to develop skills in a low injury risk environment.

4.4.5 Data on Sports Injuries

Despite the above progress in sports science, technology and medicine the epidemiology of recreational sports injuries is largely unknown. The potential impact on participation rates is also largely unknown because knowledge of the incidence of sports injuries is limited to insurance statistics and hospital emergency presentations. There are also no data to identify the national incidence of sports injuries or their impact on participation rates and the health sector. To effectively identify community sports safety needs we require a more thorough understanding of injury profiles, safety deficiencies and potential barriers to the introduction of safety measures.

Epidemiology studies are required to provide evidence based injury prevention and safety programs for community based sports. ASIST could play a very valuable role in ensuring that these data are collected, collated and analysed.

4.5 Strategies to Increase Community Participation in Sport and Physical Activity

The expertise in sports science and technology that has been developed within the elite sporting system and its affiliates, such as, the CRC for **micro**Technology provide an excellent platform for bold and informed strategies to counter the current trends in the Australian population towards decreased participation in sport and physical activity and increasing occurrence of obesity and weight related disease. These strategies would involve separate but synergistic action.

4.5.1 Making Physical Activity a higher priority in schools

The measurement and benchmarking of physical fitness and body composition in schools may be appropriate for encouraging physical activity participation in some children.

The knowledge developed with the AIS for physical talent screening, (Talent Search, Sports Search) physical fitness and body composition can be utilised to develop national benchmarks for health and fitness for primary school aged children. These benchmarks would follow the current literacy and numeracy benchmarking adopted by the Australian Government and all State and Territory Governments in recent years for all children in years 3, 5 and 7. Parents, schools and Governments receive statistical reports on the performance of their students. Reports are used to identify areas of need and monitor progress over successive assessments. Reports and the simple fact that the areas are being measured, has increased the importance and priority of these areas within departments, schools and homes and are leading to improvements in our international ratings.

A program, developed in conjunction with scientists from the AIS, 'SmartStart for Kids' has adopted a similar approach. Using standard physiological assessment protocols (as developed in Sports Search), and a tightly managed delivery and

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education mechanism, *SmartStart for Kids* has measured approximately 25,000 Australian children over the last five years.

Participating schools and parents have received statistical profiles and reports analysing their physical fitness and body composition, and suggestions for improvement. Reports and feedback have been very useful for both schools and families in identify areas of fitness and health to address, and just as with literacy and numeracy benchmarking, tracking changes over successive years can be used to identify interventions that are effective.

Initial analysis of results has identified a number of significant improvements in whole of schools fitness and body composition, indicating that benchmarking of child fitness and body composition may be a significant contributor in addressing child obesity.

The SmartStart longitudinal database and software are also of significant interest and potential benefit to researchers and academics researching interventions to address these escalating trends in obesity.

The increased initial and continuing participation of the Australian population in physical activity would not only have health benefits but would also increase the talent pool available for elite sports in Australia.

4.5.2 Use of science and technology to strengthen the feedback loop between exercise and health (monitoring)

The integration of modern computing and communication technologies with micro, nano and bio-technologies in the field of sport and exercise is yielding previously unavailable monitoring and feedback on body activity and physiological parameters.

Current technology offers “wrist watch” like devices for monitoring heart rate or distance traversed. Physiological parameters are monitored and data logged by larger more cumbersome packs.

In the near future we will see miniature sensors coupled with wireless communication systems such as “Bluetooth” requiring very small amounts of power, enabling unobtrusive real time monitoring with data transmitted to a more powerful data processing “wrist watch” or a nearby computer for analysis and modeling. A further extension of this approach is to have the data transmitted from the device directly interfaced to the internet for analysis at a remote site such as a sport scientist, fitness centre or General Practitioner’s office to monitor injury rehabilitation.

With micro-monitoring systems producing real time “on-body” data, the exercise value of everyday activities will be processed into “health” factors. Activities such as lawn mowing and vacuuming, and for the young, cruising the shopping centre and nightclub dancing will contribute to an overall health and well-being quotient.

A new generation of mobile phones fitted with integral GPS chips, enable the monitoring of the owners geographical position. It is only a matter of time before the phone becomes an integral fitness monitoring and feedback device, tracking position, rate of movement and lapsed time and without too much effort monitor heart and respiratory rate, displayed for immediate access and simultaneously transmitted back to a remote computer via the cellular network.

In a “spill-over” application of this technology, the CRC for **micro**Technology, has developed an entire research program focused on reducing the cost of healthcare

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through remote monitoring of patients suffering from conditions such as diabetes, obesity, joint replacement, drug therapy, etc. This program stems from the joint research program between the CRC and the Australian Institute of Sport.

These strategies have been incorporated in the following recommendations. Their implementation would be coordinated by the relevant arms of ASIST.

Recommendation Five

Introduce national health and fitness standards (benchmarks) into the primary school curriculum using sports science and technology expertise to increase participation and lifelong health in the Australian population.

National Health and Fitness Standards

The long term health implications of an inactive life are reducing the quality of life of many Australians and contributing to an ever increasing burden on Australia's health system.

The physical fitness and health of our school children are of great importance in providing them with the best opportunity to live a healthy life and fulfil their potential as adults. Currently the importance of physical activity and fitness is frequently overlooked in an increasingly crowded school curriculum.

The National Literacy and Numeracy Plan has been influential in encouraging school systems and sectors to lay out clear policy initiatives and management processes for literacy and numeracy teaching in Australian primary schools in order to improve educational outcomes of all Australian children.

The introduction of children's fitness and activity levels would set benchmarks representing nationally agreed minimum acceptable standards for fitness and activity at particular years of primary school. The "minimum acceptable standard" would identify a critical level of fitness without which a student would significantly increase his or her chances of developing weight related illnesses such as vascular disease, with its associated risk of heart attack and stroke in adulthood. Such benchmarks would highlight the need for teaching staff to be adequately trained in the area of physical fitness and health

The "**Child Fitness and Activity Initiative**" would consist of the following key elements:

- The comprehensive assessment of all students as early as possible, to identify those students at risk of not making adequate progress towards the national fitness and activity standards.
- Intervening as early as possible to address the needs of students identified as at risk.
- The development of agreed national benchmarks in fitness and activity, against which all students' achievements in these years can be measured. This would involve:
 - The assessment of students against the national benchmarks using rigorous State-based assessment procedures
 - Progress towards national reporting on student achievement against the benchmarks; and
- Professional development for teachers to support the key elements of the Plan.

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Recommendation Six

Mandate the Centre for ASIST to work with the Australian Sports Commission and State and Territory agencies to provide appropriate science and technology to increase participation, safety and enjoyment of the general population in sport and exercise programs.

The Centre for ASIST and a Healthy Active Population

Decreasing sports participation impacts on both the general health of the community, and reduces the general talent pool available to our sporting academies and institutes.

Science and technology can increase the safety of sport through injury prevention and management using practices developed at the elite level with considerable potential to increase the safety and enjoyment of sport by the broader community.

Sports science has a real contribution to make to the general health and well-being of the Australian population and there are already many areas of Australian life where advances in training and medical treatment developed at the elite level have had widespread benefits, acceptance and uptake in the general population.

The Centre for **ASIST**, through its extension and adoption program working with the Australian Sports Commission and relevant State and Territory organisations, will facilitate the transfer of science and technology developed at the elite levels to improve safety, enjoyment and participation and thus benefit the health and well-being of all Australians. This will be achieved through:

1. Ensuring that the knowledge and technology developed for elite sport is made available to the Australian community.
2. Developing packaged programs for existing sporting and educational bodies and institutions, incorporating methodologies for the promotion of a wide range of physical activities.
3. Undertaking research on the rate of adoption and the effectiveness of this knowledge and technology in the community and the requirements of the community.

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